

Exploring Elementary and Middle School In-service Teachers' Knowledge of Animal Classification: A Comparison of Student and Teacher Misconceptions

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Education is a vital part of today's society. As people learn more about important issues such as best practices and students' engagement, concerns arise that seem to be out of our control. Practicing teachers know the importance of an abundance of knowledge in the subjects that we teach. But what happens when what is being taught does not line up with what the students are internalizing? What happens when teachers misinform the students? This can cause erroneous content development and misconceptions. These problems will be discussed in this research study. Misconceptions are not representative of all teachers, but rather are surfacing as researchers delve deeper into the science education field.

Teacher and student alike share misconceptions. According to Sanders (1993), "identification of erroneous ideas is an obvious and important stage in the remediation of misconceptions" (p. 920). For this study, I will use erroneous ideas and misconceptions as being similar in nature, all contributing to conceptions that people have that are incorrect in some way.

In many states, it is required that teachers complete a certain number of professional development (PD) hours within one year. The requirement is to ensure that teachers have continuous PD in the content areas, to develop their content knowledge and ultimately, lead to the formation of high-quality teachers. Teachers' knowledge and skills directly affect their student's learning ("National Commission on Teaching and America's Future", 1996). The importance of knowledgeable teachers is vital to education and PD programs to help with this installment of knowledge.

The Council for School Performance (1998) believes an effective teacher professional development program includes: 1) Long-term programs that continue throughout the school year; 2) Taking an active role in learning activities such as demonstration, practice, and feedback; 3) Analyzing student learning in a collaborative way; and 4) Support for teachers to help and better teaching and learning strategies. The purpose of this study is to show how the PD program NWO TEAMS (Northwest Ohio Center of Excellence in Science and Mathematics Education: Teachers Enhancing Achievement in Mathematics and Science) is using data to enhance the achievement of the participating teachers. For this study the TEAMS research team looked at teacher misconceptions, as we see this as a significant component to better understand our teachers and their knowledge.

Theoretical Framework/Literature Review

The lens through which we looked in order to develop this study was the critical theoretical framework. As teachers are held more accountable for student learning, it has become critical that teachers self-reflect upon their teaching practices and content knowledge. Teachers also need to have a sense of efficacy and know their own beliefs and teaching philosophy. Teachers come to specific PD programs due to their desire to gain more knowledge about specific content.

This research also takes a social lens, as misconceptions are examined on how they are passed from teacher to student. When taking this social approach, it was important to pay close attention and to not misconstrue any social contexts that arose as being a branch of a misconception. The research team focused directly on teachers' responses to questions regarding science content knowledge.

Prior to the development of this study, it was important to review related studies that have already been completed and analyzed. These studies gave insight into misconceptions that the teachers in our PD program may hold and how they form. The studies also helped to see how the misconceptions are passed on to students and how to ensure the TEAMS PD program can decrease the chances of this happening.

Sanders's (1993) study was conducted in South Africa where it is considered to be very similar to other mass education systems in the world. Researchers had teachers grade students' work using a plus (+) for a correct statement and a negative (-) for a wrong statement. Sanders (1993) found out that teachers ignored errors when they graded. According to Sanders (1993), "teachers who mark an incorrect answer correct are likely to be influencing student errors whether their marking is a result of their own erroneous knowledge or of their leniency in accepting imprecise answers" (p.922). Some teachers tried to stretch what the students were construing in order to give credit (Sanders, 1993). As a result of this grading, students are made to believe that their ideas are correct. Students build upon this foundation and create the beginning of a misconception by connecting new information with their already established schema in a way that is not accepted as correct (Sanders, 1993). As long as students receive instructive feedback about their responses, they will be able to make meaning of their mistakes, which will lead to better understanding and development of their content knowledge (Sanders, 1993).

Perhaps one of the most disturbing ways that student alternative conceptions are formed comes directly from the teacher. Sanders (1993) noticed that teachers are not willing to accept changes in pedagogical and content knowledge in the science field. Teachers need to keep their knowledge base current, as changes occur every day.

Teachers also need to be attentive to what their students are saying. Listening can give teachers a sense of what the students understand or do not understand (Sanders, 1993). While what has been mentioned above relates to written feedback, verbal feedback is important as well.

On another study, Yip (1998) gave teachers a test, which was graded for accuracy. Teachers were given a week to complete the test and were allowed to look up answers that they did not know. The reasoning behind this is the idea that teachers will probably only look up answers that they believe they may not know. "Thus, wrong answers given by the subjects will be a clear indication of the existence of some deep-rooted misunderstandings or conceptual problems" (Yip, 1998, p. 464). The results of this teacher test proved that misconceptions are evident.

Yip (1998) had similar reasons, when compared to Sanders (1993), as to how these misconceptions form. However, many of Yip's (1998) suggestions dealt with how teachers can help students learn in a way that misconceptions can be minimized. It is important to ensure that the students have the necessary knowledge before advancing onto more complex concepts (Yip, 1998). Sometimes, cognitive conflict can cause students to struggle with adjusting their ideas internally as well (Yip, 1998).

Oversimplification can also cause concepts to be misconstrued (Yip, 1998). Yip (1998) suggests that by using age-appropriate inquiry, students can find connections within their schema and build upon their knowledge. It is up to the teachers to ensure that inquiry is done properly.

Unlike the previous two studies, Mintzes and Trowbridge's (1985) study involved direct testing of students' conceptions. Each answer to the questions that were asked was classified as being correct or incorrect, while giving potential reasons as to why. This study dealt mainly with misconceptions of animals and animal classifications. While this study showed the individual misconceptions held, conclusions were similar to the other studies. Students may struggle with generalizing, which results in an incorrect meaning of the concept (Mintzes & Trowbridge 1985). Correcting students is important because the longer these alternative conceptions are held, the stronger they become, and the harder they are to reverse (Mintzes & Trowbridge, 1985). According to Mintzes & Trowbridge (1985), "teachers must begin recognizing alternative conceptions at an early stage and developing new techniques to counteract them (p. 305).

Another tool that can aid in causing erroneous ideas and misconceptions is textbooks. Textbooks are not always the best tools for "facts". Many have imprecise expressions that can mislead students (Yip, 1998). Teachers need to have an active role in their students' learning by being aware of how the textbooks are guiding the students (Yip, 1998). Sometimes overgeneralization can occur within the

context of the book to make the readings age-appropriate. Vagueness can potentially lead to misconceptions (Mintzes & Trowbridge 1985).

Even though each study was considerably different, they all had underlying similarities related to misconceptions that were worth looking into. All three studies gave strategies to eliminate the passing on of these alternative conceptions and eradicate the false ideas altogether.

As seen by these studies, misconceptions seem to be prevalent in today's science classroom. Each study focused on a different way of obtaining information, but concluded with similar findings. Many people believe the first step to solving the problem is to make sure teachers are knowledgeable as they become certified to teach science and stay knowledgeable throughout their teaching years. Many states require a certain number of hours of PD to increase teachers' content knowledge. More tenured teachers need to keep up-to-date with the ever-changing world.

The idea of documenting and finding the sources of misconceptions is a relatively new topic. Many PD programs now do research related to the effectiveness of their program. However, not many link teacher knowledge with student knowledge. Mary Kennedy (1998) was interested in the substance of the programs and implications on student learning. Even though there is an immense amount of literature on in-service programs, once focused on the teacher/student misconceptions relationship, literature is scarce.

Kennedy (1998) reviewed programs that are available for mathematics and science PD in order to improve student learning. These programs were supposedly effective in developing teacher and student content knowledge, but failed to address the idea of misconceptions. Studies relating misconceptions with teacher and student content knowledge are not readily available, however some inferences can be derived from Loucks-Horsley et al.'s discussion of the importance of teacher learning in PD. These inferences are criteria that PD should implement in order to have teachers effectively learn about their own cognitive processes and how their students comprehend new material:

1. What learners already know influences their learning.
2. Learners acquire new knowledge by constructing it for themselves.
3. The construction of knowledge is a process of change that included addition, creation, modification, refinement, restructuring and rejection.
4. Learning happens through diverse experiences.

(as cited in Bober, 2004, para. 1)

Bober's (2004) study dealt with a PD program, but focused on the teacher's reflections of the program. Upon review of numerous articles about PD, Yip (1998), Mintzes and Trowbridge (1985), and Sanders (1993) were of the few dealing with general content knowledge. The search for articles was by no means exhaustive, but rather just the higher profile articles available. As can be seen here, there is a definite need for research regarding the similarities between teachers' and students' misconceptions. For this study, the goal was to find teacher misconceptions that are imbedded in animal classification. One study was particularly intriguing, as it related to a common theme we have found; that students, elementary through high school, struggle with the classification of animals as vertebrates or invertebrates (Braund, 1998). It is seen in the articles above that this is a critical aspect of teaching in today's society. Since our preliminary research is geared towards teachers, we connected some of our findings to Braund's (1998) article, which dealt with student conceptions.

Research Focus

With animal classifications being a highly misconceived topic, the PD research team decided upon the following research question: What misconceptions do third grade teachers hold about animal classifications?

Research Methodology and Rationale

Research Design

This study was derived off of pre-existing quantitative data pertaining to third grade teachers in the PD program, TEAMS. The original data collected were from a pre-test given to teachers on the first day of their academic year PD. The test questions dealt with science knowledge of third grade content, according to the Ohio Academic Content Standards. To keep the anonymity of the teachers taking this test, a unique code was made for each teacher according to their birth date (without the year) and the first two letters of

their mother's maiden name. The research team wanted to qualitatively assess via interviews where the teachers stood prior to their animal classification session in order to get a clearer picture of the quantitative data that we had obtained in September regarding the teachers' knowledge.

Background to TEAMS PD

TEAMS provides PD for third through sixth grade teachers in the Northwest Ohio and Southeast Michigan area. Teachers met for eight days in the summer of 2008 for 56 contact hours of PD. In-depth training occurred dealing with numerous science topics. Teachers then met once a month (in the academic year) for a total of 31 hours of science PD. Five of the eight sessions were classroom time where a content facilitator presented grade-level appropriate hands-on inquiry lessons that matched the Ohio Academic Content Standards for each specific grade. The other three sessions were dedicated to keynote speakers and content testing, with one session being the Northwest Ohio Mathematics and Science Symposium. Teachers will conclude the program in June of 2009 with a 4-day institute consisting of more in-depth training.

Selection and Access to Teachers

On October 23, during the monthly PD event, third grade teachers were asked to participate in the research. These teachers were offered a small incentive (a science children's book to be added to their classroom library) as gratitude for their time.

Data Collection Methods

Pre-existing Data

All pre-existing data, namely the grade-level content pre-tests, were collected during the first day of the academic PD. We summarized the results of each grade level. The test the data were quantitatively analyzed, allowing for recognition of patterns in teacher answers, and ultimately the discovery of which questions were critically misconceived. The pre-existing data led to the animal classification misconceptions focus.

Pre-test Animal Classification Items

We focused on two items that led us to delve further into animal classifications conceptions. Item one had teachers classify a bat, frog, penguin, snake, crab, and turtle as a vertebrate, invertebrate, fish, amphibian, reptiles, bird, or mammal. Teachers were to mark all groups to which the organism belonged. Item two had teachers correlate amphibians, birds, fish, mammals, and reptiles with listed characteristics (have fur, live in water, have a soft skeleton, have a backbone, have scales, have gills, have structures adapted for swimming, and lay hard-shelled eggs).

Interview Methods & Questions

The data for the qualitative piece of this research were collected in the face-to-face interviews conducted on October 23, 2008 during the PD event. Semi-structured interviews were important because it allowed us to see non-verbal emotions and connections that the teachers experienced. This helped with this qualitative aspect of the research. Eight teachers, who were willing to participate, were taken into separate rooms and interviewed individually. The pre-test item answers, which were originally anonymous, were correlated to their name in order to ask the interview questions properly. Teachers signed a written consent form to ensure documentation of their permission to allow the anonymity to be no longer, and that responses would only be used for research. Teachers were assured that only the research team would see the directly correlated responses.

The interview questions were tailored to each teacher's pre-test response in order to get the best data possible. Elaboration and getting off topic was permitted, as it gave insight into the thoughts of the individual participant. However, the interviewers' discretion was used to decide when discussion needed to get back on track, as time was limited. The responses to the interview questions were answered to the best of each individual teacher's ability. The teachers' responses are instances of their verbal portrayal of their content knowledge.

Interview questions were specifically focused on animal classification, as it was seen that the majority of teachers did not classify animals correctly on the pre-test. Time allotted for the completion of eight interviews, which comprised of approximately 20% of our third grade enrollment. Even with this small percentage of teachers, strong themes emerged, as will be discussed in the data analysis.

Data Interpretation

After the completion of the eight interviews, the audio recordings were transcribed. In the transcripts, all “umms”, “uhhs”, “hmms”, pauses, and other non-word expressions were included. This gives insight into the participants’ thought processes. According to the context of the expression, it sometimes seemed to mean hesitancy, frustration, or unsure feelings. The transcripts were then coded to find reoccurring ideas amongst the teachers. For some of the following analysis, vignettes were used to properly embrace the thoughts of the participants.

Data Analysis

Two main themes emerged while synthesizing the pre-test data with the interviews: 1) struggling to determine whether an animal is a vertebrate or invertebrate and 2) confusion between amphibian and reptile characteristics.

Theme 1: Vertebrate verses Invertebrate

Backbones seem to be a highly misconceived component of classification. The pre-tests were only dealing with fish, mammals, reptiles, amphibians, and birds, so although the correct response is that all those animals are vertebrate, many teachers do not believe this. On the pre-test, 23% of teachers thought that frogs were invertebrates. Teachers also considered snakes and sea turtles invertebrates, with 65% and 54%, respectively. When considering whether amphibians and fish have backbones, one participant stated, “I guess I was just thinking of the, the, you know, metamorphous that would not have backbones, maybe they do? I don’t know”. Others believed is that if the animal has a shell, it does not have a backbone. In a study conducted by Braund (1998), students of all ages believe the tortoise is an invertebrate because they think the shell is the support, replacing the backbone. We found this as well. Both teachers and students have incorrect conceptions of vertebrate and invertebrate animals.

A few other teachers believed that all animals have a backbone, but that there were exceptions to the vertebrate rule. One participant said that “there would be certain exceptions”, for example, that not all mammals have backbones. “Perhaps a whale [doesn’t have a backbone]. I’m not sure”. Many teachers danced around some form of an answer, and then ultimately said that they did not know. Through informal conversations, some teachers have admitted that there is so much science content to remember, so they rely on alternative methods of information (besides their own brains) as they go from lesson topic to lesson topic. Teacher’s manuals and the internet are some of those methods. We do not know how the teachers go about their teaching in the classroom, but if they are simply relying on their memory, and their thoughts are incorrect, concerns may arise.

A different participant stated that snakes do not have backbones “Just ‘cause they’re slithery, the way they curl up, they don’t have bones”. This seems to be the misconception that many people hold, including students. According to Braund (1998), since a snake can curl up, many students believe a backbone cannot allow for this. The research team found similar findings from the teachers. This could perhaps be a connection between teachers and students. As Sanders’s (1993) points out, teachers may be propagating faulty information, or do not correct students’ incorrect answers.

Theme 2: Confusions Between Reptile and Amphibian Characteristics

A wide range of misconceptions surfaced related to characteristics of amphibian and reptiles. When referring to reptiles, one participant answered, “the first thing I think of is slimy”. Others believed that reptiles have moist skin so that they do not dry out and die (which is actually a characteristic of amphibians). A few teachers also stated simply that they did not know. Most of the answers given by the participants were not characteristics of reptiles. Upon looking at the responses of the interviews and the responses of the pre-test, many teachers used reptile and amphibian characteristics interchangeably. “Slimy” animals are seen more in amphibians, while reptiles (such as snakes) may look slimy, but really are not.

On the pre-test, teachers were asked to classify a frog, crab, and sea turtle. Ninety-one percent of teachers (n=43) thought frogs were amphibians due to their capabilities to go in and out of water. However, 19% thought frogs were reptiles. The percentages show that some of the teachers marked both amphibian and reptile. One question asked in the interviews was: “Can an organism belong to more than one group? For example, can an animal belong to the amphibian AND reptile group? Why or why not?”

The teachers interviewed stated that animals could not be part of two groups. However, no teacher could adequately explain why not.

All participants knew that amphibians live both in water and on land at some point in their life. While this is one of the major characteristics, as amphibians basically lay between the fish and reptile categories, only a few teachers stated that they are cold-blooded. The cold-blooded characteristic is one that the research team thought teachers would have stated.

The research team also thought that teachers would be able to name off more than one or two characteristics for amphibians, such as the fact that they breathe through gills early in their life, and then breathe through lungs once the metamorphosis has taken place. Perhaps this lack of recollection of characteristics is because of the nature of amphibians, being so different from ourselves. The pre-test showed that 59% of teachers (n=41) thought that amphibians have a soft skeleton, while only 45% thought they have a backbone. Forty percent believe a crab is an amphibian while 24% thought a sea turtle was an amphibian as well. A few participants had similar thoughts- that a turtle was not a reptile, but was an amphibian. Maybe teachers think that since amphibians spend part of their life in water and part on land, that turtles and crabs are amphibians because of the ability to go into water and onto land. Teachers may not be thinking that amphibians start out in the water, breathing through gills, then develop lungs to be oxygen-breathing animals. Turtles and crabs simply have adaptations to allow for the ability to spend time on land and water.

When teachers were responding to the interview questions, they would somehow try to make connections, even though hesitancy was very prevalent. The incorrect connections can be misconstrued if attempting to explain such concepts to students. A negative impact can occur if misconceptions are common. While it may be hard to eradicate these conceptions completely, to try to lessen them would be a step in the right direction.

Conclusions

Through this study, the research team found that teachers have great difficulty grasping the animal classification topics that all third grade teachers are required to teach. This is concerning due to the idea that this material may be passed on to the students. The literature allowed for relationships between teacher and student misconceptions to become visible, as similar experiences surfaced when administering the pre-tests and teacher interviews. With animal classifications being only one topic, future research could go into greater depth by interviewing a larger number of teachers on a multitude of content topics. Overall, this study shows insights into the minds of third grade teachers in northwest Ohio and southeast Michigan and how it connects to student learning. With the information our study yielded, the research team can improve their PD programs, one topic and one misconception at a time.

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