Misconceptions on Seasonal Change

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Children come to the classroom with many conceptions about the world molded from literature, experiences and the people in their lives. Oftentimes, these beliefs are accurate, but sometimes students learn and hold on to ideas that are erroneous. While many educators are quick to correct and dismiss these beliefs as wrong, ideally, they would be utilized as a starting point on the journey to conceptual understanding. That was my goal when I decided to address and teach about the common misconception that seasons change because of earth's varying distance from the sun. In my experience, seasonal change is one of the most mystifying science concepts to understand and additionally, was noted as a "common science misconception" (as cited in the New York Science Teacher, 2010). I teach about seasonal change each year, but this year was the first time I implemented three formative assessments throughout the process to inform my teaching before, during and at the end of the unit, which was immensely helpful in revealing my students' understanding.

The most common misconception regarding seasonal change that I've experienced is the belief that the earth's orbit travels further away from the sun in the winter and gets closer again in the summer. Thus, the learning goal I chose to focus on was my students' ability to demonstrate and explain why we have changing seasons. For the first formative assessment, I asked my students write a journal entry in response to the prompt, "Your friend tells you the reason our winter is so cold is because we are further from the sun than we are in the summer. Do you agree or disagree? Explain." This same prompt was used again to culminate the unit to assess growth in understanding following instruction and inquiry. Shannan McNair, author of *"A" is for Assessment* states, "Postassessments that closely match preassessments are excellent "windows" into student learning," and more specifically with regards to journaling that this

process of repeating the first assessment "provides an opportunity for students and their teacher to reflect on the extent of learning" (McNair, 2004, p. 25).

When assigning the first task, I assured students their responses would not be graded, but were merely for me to understand what knowledge they currently had on the topic. Furtak explains, "if students know they are being evaluated, they will do everything they can to give you the information they think will get them a good grade rather than telling you what they really think" (Furtak, 2012, p. 30). I expected to find that many of my fourth graders would agree with the prompt, that in fact that earth does move further away in the winter. Of the sixteen students in my science class, eight of them agreed with the prompt leaving eight who disagreed. Of those who disagreed, none could accurately explain the factual reason that we experience seasonal change as a result of the earth's tilt and the changing directness and intensity of the sun throughout the year. Interestingly, a new misconception I had not yet come across in my teaching of this concept was common among those who correctly disagreed with the prompt, which was the idea that the earth "spins faster in the winter" and "slows down in the summer so we get more hot sun" which also accounts for more hours of daylight. One student mentioned the earth rotating on its axis and stated the "winter is cold because the earth is not facing the sun completely but we get sunlight because the sun is bigger than the earth." This response was the closest to correct I received but all the individual responses helped guide the direction I wanted to take the lesson. As Gooding and Metz point out, "Each student is an individual learner, with individual misunderstandings. By listening carefully to our students' responses, analyzing them, seeking clarification, and demanding explanations and discussions, we can determine whether their understanding of content is superficial or deep" (Gooding & Metz, 2011, p. 36). Because students' initial ideas revealed they were limiting their understanding of changing seasons to our

location and what they're familiar with around the Illinois area, I wanted to explore what they knew about weather and seasons in the southern hemisphere. My hope was that through modeling and discussion, students would begin to challenge their preconceived beliefs. In order for this scientific practice to be meaningful, "It requires creating a climate that is safe for students to be wrong as they work toward more complete explanations. It also requires asking students rich questions that have multiple plausible answers so that students can discuss and reconcile them, developing consensus explanation" (Reiser et al., 2012, p. 11)

Following the preassessment task, the next day I asked students to reiterate their ideas about why we have seasons and as they did this, I had a student model what they said using a Styrofoam sphere with a stick through it representing earth's axis, a drawn on equator, a pin representing the location of Illinois, and a lamp without the lamp shade. As expected, students said in winter the sun gets further away and in summer, it gets closer with fall and spring moving "in between" the distances of winter and summer. The student moved the model with the axis pointing straight up and down around the light in this manner and I confirmed that was the belief of his peers. They enthusiastically shared that it was, seemingly feeling reaffirmed in that logic. Even some of the students who initially disagreed with the prompt had, after seeing the demonstration, decided that possibly that was the reason we have colder winters than summers. I found this to be a good opportunity to shift the discussion and below is the dialogue that followed.

> Me: "When we have winter here in Illinois, is everywhere else in the world also experiencing winter, and is that also the case when we have summer?" As I said this, I modeled again in the exact way my student had to show them what I meant.
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> Student: "No, the equator is always hot."

Me: “Do we all agree that locations near the equator always tend to be warm?”
(Many of my students moved here from Northern Africa, so this is very familiar to them.)

Students: “Yes!”

Me: “Okay, but what about down here?” (pointing to southern hemisphere of Styrofoam sphere) “Do these countries here experience winter when we do?”

Students take a moment to think about it, but then reply with either no, yes, maybe or probably simultaneously.

Me: “Is there a way we could prove your idea?”

Student: “Look it up!”

I asked students what we should look up and one suggested picking some locations that were almost equally as far south from the equator as were are north here in Illinois. Then I inquired if we should check the weather for just today, and while some of them thought that would be sufficient, others argued that we need to see their weather for our winter and summer months. Students used the globe and decided that Viedma, Argentina was almost equally distant south from the equator as we are north. With that information, they used the computer to research Viedma’s climate, noting average temperatures throughout the year. They grew increasingly excited as they realized this discovery challenged some of their initial beliefs and began calling out that Viedma’s winter and coldest temperatures are in June, July and August and their warmest months are December, January and February.

We returned to our discussion about varying distance from the sun causing the seasons and I again modeled this with the Styrofoam sphere. Students now recognized this no longer

aligned with our newly discovered knowledge so I asked them to think about how we could adjust the model to reflect our new findings. One student shared that the southern hemisphere's seasons were essentially opposite the northern hemisphere which led him to try and hold the model in order to show that. He represented the tilt, but struggled as he revolved around the sun as his inclination was to keep the tilt always pointed towards sun, which would mean the northern hemisphere is always in summer. I posed this dilemma to the class and elicited suggestions for how to properly demonstrate the revolution. One student suggested to stop "turning it in" which prompted me to ask him to show what he meant. He came up and modeled the tilt and correctly moved around the light so as to show four seasons. At each stop, we discussed how much direct light the northern hemisphere was receiving in comparison to the southern hemisphere and if that correlated with our new information. The class seemed to agree it did so I ended the session with a daily learning log (Holzmiller, 2008) to assess where my students were individually. They were asked to draw the earth in its orbit around the sun, labeling the four seasons according to position. This task revealed there was still some confusion, at least in drawing, regarding how the tilt impacted the seasonal change. Seasons were mislabeled relative to position and there was still one student who continued to draw the tilt in towards the sun. For some, this new knowledge did not fit into their schema of seasonal change and, "If new this new information does not fit the learner's established pattern of thinking, it is refashioned to fit the existing pattern" (Wesson, 2001, p. 61). This continued to present a problem throughout the unit as students occasionally reverted back to initial beliefs.

My next formative assessment task was to have individuals demonstrate seasonal change with the model as I observed and discussed their thought process with them. With this, understanding was more apparent as students were able to actually hold the model, and it seemed

to make more sense. Most were able to correctly identify the seasons and move to the accurate position with the tilt when asked. Discussion helped facilitate why having the tilt always pointed towards the sun does not align with the weather patterns we have here nor with what we know about the southern hemisphere having seasons opposite our own. I also had to ask questions to help one student redirect his thinking when the earth model moved closer to the light to represent summer. For the most part, however, students had certainly made progress in this phase of the unit and almost all had begun to shed earlier misconceptions.

For the final formative assessment, students were asked to respond to the same question as in the first assessment so I could measure their growth in thinking. In addition to responding in writing, students had the opportunity to draw the seasons and explain the thought process next to each season on an elliptical orbit I provided around the sun. The only difference in the assessment this time was that I included a word bank of terms we had come up with together to help guide their thinking.

The results of the final assessment revealed the students not only had a solid understanding, but could also explain it very scientifically in writing. Even though not required, some of my students mentioned the difference in the hours of daylight between the northern and southern hemispheres at each seasonal location. I was very impressed by the knowledge they had gained, especially when compared to what they had written in response to the identical question just days earlier. Unfortunately, while all could accurately explain in words why we had seasonal change, when it came to drawing the diagram, six of the students drew the seasons incorrectly by labeling the northern hemisphere in summer or winter when it's clear that both hemispheres are in the phase of the revolution that they'd receive equally direct light. Additionally, two students did not draw the earth on a tilt at all despite mentioning it their writing as the main cause for the

seasons changing. Overall, I was satisfied with the learning that was evident through the writing, but somewhat discouraged when I examined the diagrams that did not fit with conceptual understanding of the topic.

When I teach this lesson next year, I will definitely utilize formative assessments again throughout the unit to inform my own instruction. The tasks students were asked to perform gave me a glimpse into their individual thinking, which was immensely helpful in guiding my questions, the discussion, and the topics that required more attention. Especially with regards to the first assessment, I was enlightened on just how many false ideas students had about this topic, and the difficulty involved in correcting these over time. The Gooding and Metz article discusses this issue and includes that the Sadler et al. documentary *A Private Universe* "found that both Harvard graduates and middle school students held false beliefs about [causes of the seasons] – misconceptions that, regardless of their time in school, remained deeply embedded in their brains" (Gooding & Metz, 2011, p. 35). This may remain a topic that my students continue to struggle with, especially if they're inundated with inaccurate information regarding causes of seasonal change in the future.

My second and third formative assessments were also useful in guiding instruction. Having my students individually model seasonal change, as I did in the second assessment, allowed me to follow the thought process without any influence or knowledge from other students. While the third assessment journal entry certainly revealed my students had made large strides in their understanding, the drawings some of them included were inaccurate. However, as I measured their progress against the rubric from the first assessment, I was happy to see that most students had corrected their earlier misconceptions. Next time I teach this, I think I would repeat the journal entry as I did, but have the students' modeling of seasonal change with the

sphere and the lamp serve as the accompaniment to the writing. Perhaps the elliptical orbit I provided to the students with the third assessment created confusion as a few students seemed to revert back to the thinking that in summer we're closer to the sun than in the winter with their drawings.

One way I would modify my instruction in the future following the preassessment would be to provide each student with their own materials to model seasonal change and begin by inquiring how we could create the model in order to imitate earth's relationship to the sun. Additionally, I would give students time to "work in groups structured like scientific communities to develop, revise, and defend models or beliefs" (NRC, 2012, p. 538), which is an important part of the science experience. I think their curiosity to learn and desire to understand a topic that's an integral part of our every day lives would make this type of interaction possible and beneficial in a fourth grade classroom. Also, having more models would allow for all four seasons to be represented at once around the light source which may have helped students visualize the change more easily than when we used one earth model to revolve, pausing at each seasonal start point.

I learned a lot about myself as an educator through the planning and teaching of these lessons as well as the difficulty in correcting deeply imbedded misconceptions surrounding a topic. Developing a unit around a misconception that is held by children and adults proved to be challenging, especially for me, as I sometimes struggle to accept misguided or incorrect responses as a learning opportunity on the journey to the "right" answer. I realized the power of discussion, fueled by rich questions, and in providing wait time for my students to ponder how what they had just learned fit in to their current belief system. Given the results of what my

students gained in knowledge from beginning to end of this unit, I would certainly deem it as a success, even considering the minor changes I would make in the future.

References

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APPENDICES

APPENDIX A

FORMATIVE ASSESSMENT SCORING RUBRICS

Formative Assessment #1 and #3 (Journal Entry) Rubric

Question: Your friend tells you the reason our winter is so cold is because we are further from the sun than we are in the summer. Do you agree or disagree? Explain.

Task	Yes	No
Agrees with prompt- Earth moves further away from the sun in the winter and closer again in the summer.		
Correctly disagrees with prompt - that Earth does NOT move further away at different times of the year Can explain factually		
Uses correct terms to explain seasonal change: • tilt/axis • revolve/revolution • northern hemisphere/southern hemisphere • direct sunlight/indirect sunlight • rotate • more/less hours of daylight vs. longer or shorter days	 ____ ____ ____ ____ ____ ____	 ____ ____ ____ ____ ____ ____
If cannot explain well in words, adequately draws diagram and explains seasonal change next to each picture.		
Discovered misconceptions:		

Formative Assessment Task #2

After discussion and inquiry about seasonal change with sphere and lamp, each student should be able to accurately demonstrate the seasons in Illinois individually. Students are assessed in the following ways:

1. measures the tilt using a protractor and holds Styrofoam earth sphere in same tilt (pointed in same direction) during the entire revolution.	
2. begins revolution and identifies season correctly	
3. continues CCW around the lamp keeping sphere as equidistant as possible from the lamp and naming seasons in order	
4. explains why the position represents the season it's in	
5. can, at any point, tell me the season the southern hemisphere is in and explain why	