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Pre-service Teachers' Science Misconception: A Study in USA

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Abstract:

A growing body of research shows that students' prior ideas and beliefs create critical obstacles to learning science because new concepts compete with the misconceptions of our students (Metz, 2011)[1]. It poses a serious bottleneck in teaching and learning science with understanding in particular when a teacher himself/herself holds the unscientific view on the concept he/she is teaching. Although there is a popular body of research on the common existence and implications of science misconceptions among science students, very few studies focused on pre-service teachers' misconceptions of science. This study used two sets of formative probes to identify 56 preservice teachers' science misconceptions from a Mid Missouri University, USA and compared with those of 34 other community members who never took any college-level science course in their life. Although preservice teachers demonstrated a fewer number of misconceptions than those of others, both samples displayed equally egregious misconceptions about a very basic biology concept. In particular, both groups provided a pattern of unscientific reasonings to support their explanation in Claim, Evidence & Reasoning (CER) process. Similar to common pattern of affability to change, the sample -- pre-service teachers of this study demonstrated a strong resiliency to change their alternative conceptions even after taking related science content courses during their K-16 education. This study used conceptual change pedagogy to remediate their misconception on living & non-living objects and on melting. Implications of these findings and strategies for overcoming science misconceptions of these samples and in teaching at large are discussed.

Students come to the class not as empty vessels in their ideas about how the world around them works - the way it does. These ideas come from different sources such as grandma's story, friends, novels, and many religious texts and believes that interfere with learning of evidential basis of science. A large volume of research is there on science misconception among both

[1] Metz, S. (2011). Private Worlds. NSTA: *The Science Teacher* 78(4): 6.

teachers and students across the globe (Saha, 1996)[2]. According to this research, these misconceptions can stem from various factors, including everyday experiences, inaccurate information, and misinterpretations of scientific concepts. Such as, in explaining the evolution of crocodile, the belief of the story on 'Naidar Chand' - a magician who transformed himself into a live crocodile on this planet (Ref. YouTube videos, short story by Naren Mitra, film, etc.) competes with scientific explanation based on natural selection; a common misconception about day and night is that the Sun revolves around the Earth, causing the alternation of day and night; some students believe that when it's day in one part of the Earth, it's day everywhere else too, and the same for night, cause of earthquake is related to human's sins to disobey God and the narratives vary from country to country, instead of related to the movement of tectonic plates along plate boundaries of the earth [3]. https://www.usgs.gov/programs/earthquake-hazards/earthquake-legends

These misconceptions may form as individuals attempt to make sense of the natural world, or as a result of the difference between scientific and everyday language. In other cases, misconceptions may actually form or be strengthened as a result of instruction. Understanding these misconceptions is crucial for effective science education and communication.

Once formed, misconceptions can be tenacious – persisting even in the face of discrepant events or careful instruction. Research has documented that students may be able to provide the "correct" answer in science class yet still not abandon their previously formed idea.

Even though targeting student misconceptions is difficult, teachers should be cognizant of their students 'beliefs before, during, and after instruction. Formative probes/assessment can provide insight and guidance for planning lessons and meeting student need.

This study used two sets of formative probes to identify 56 preservice teachers' science misconceptions from a Mid Missouri University and compared with those of 34 other community members who never took any college-level science course in their life. Although preservice teachers demonstrated a fewer number of misconceptions than those of others, both samples displayed equally egregious misconceptions about a very basic biology concept. In particular, both groups provided a pattern of unscientific reasonings to support their explanation in claim, evidence & reasoning (CER) process. Similar to common pattern of affability to change, the

[2] Saha, G. (April, 1996). *Towards a constructivist approach to science education: A handbook for conceptual change strategies*. An unpublished dissertation submitted in partial fulfillment of the requirements for the degree of Master in Education. Brock University, St. Catharines, Ontario, Canada.

[3] https://www.usgs.gov/programs/earthquake-hazards/earthquake-legends

sample -- pre-service teachers of this study demonstrated a strong resiliency to change their alternative conceptions even after taking related science content courses during their K-16 education. The author used conceptual change pedagogy to remediate their misconception on living & non-living objects and on melting. Implications of these findings and strategies for overcoming science misconceptions of these samples and in teaching science at large are discussed. Students' personal ideas and beliefs popularly known as science 'misconceptions' or 'alternative frameworks' (AFs) about the natural events pose a serious obstacle to learning science with understanding (Metz, 2011)[4]. Purpose of this study was:

(i) to identify and find (if any) ways to overcome pre-service teachers' science misconceptions/ AFs,
(ii) to compare pre-service students' misconceptions with others who never took science in their life, and,
(iii) to introduce (teach) conceptual change teaching strategies.

3. Procedure:

A longitudinal survey method was used. Convenient sampling procedure surveyed (a) 56 samples from pre-service program & (b) 34 from those who do not have enough exposure to science academically. Age range of pre-service teachers -- 20-25. 95% of (a) sample were females and 5% were males. Each of these (a) participants took an average of 9 credit hours of science/Biology in college and had Biology as a required course in their 9-12 grades. Age of (b) samples ranged from 20-60; 98% males and 2% females and they took no science content course after grade schools.

Two instruments were used to probe participants' misconceptions if any:

a) Is it Alive? &
b) Is it Melting? (Keeley, 2005)

Reported by Keeley (2005) and many classroom teachers, these instruments have acceptable level of validity and reliability.

4. Data Analysis & Findings:

Only those items which measured common misconceptions of both categories of sample, have been reported in this study. There were 15 items in "Is it Alive" probe. Four items, "sunlight", "shadow", "moon" & "fire" were identified as ALIVE by both the groups. However, analysis of the

[4] Metz, S. (2011). Private Worlds. NSTA: *The Science Teacher* 78(4): 6.

data shows that 35% of pre-service students and 98% of group 'b' sample held these false beliefs (misconceptions). 'Is it melting' probe had seven lists in a stack of cards involving situations that cause changes in materials.

Participants had to put an 'X' next to the situation in which the *italicized* materials undergo melting. Then sort them into two groups with reasons: Changes that are examples of melting, and Changes that are not examples of melting.

In this probe, 65% of pre-service students and 98% of group 'b' sample grouped --- H card, sucking on a *lollipop* or other *hard candy* as 'Melting' demonstrating a serious 'misconception' about the event/ concept. Despite a smaller number of misconceptions among the pre-service sample, there was striking similarity in their erroneous and unscientific reasoning they made for their claims with those of non-science sample, such as:

To support "sunlight" as a living object, both groups reasoned that sunlight "moves, changes, cools and heats"; some reasoned that "it provides energy and so it is living"; while some others posited that it is living because "it is [sick] star, it is still burning. In addition, many others said "it is living because it provides life for other objects (provides life for other objects) and will die one day." Many at times media report 'sun will die' one day, some of the samples cited it as the origin of their naïveté idea. For items "shadow", "moon" & "fire" – similar misconceptions revealed in their reasoning. For checking H card, sucking on a *lollipop* or other *hard candy* as 'Melting' their common reason was that just like ice melts, candy also melts in our mouth which contains saliva providing the heat because they saw the same thing for candy left outside (car) in summer sun. This reasoning also represents a personal theory (not supported by scientific ideas – a misconception.

5. Overcoming Misconceptions:

Overcoming misconception in science is a conceptual change pedagogy. This instruction recognizes that students bring personal or naïve conceptions to the classroom, which they use to explain their world, interpret situations, and create meaning (Driver, et al, 2007). There is more than one strategy suggested for conceptual change pedagogy (NRC, 1997; Posner et al., 1982[5]; Gooding and Metz, 2008[6]; & Khourey-Bowers, 2011[7]).

[5] Posner, G.J., Strike, K.A. Hewson, P.W. and Gertzog, W.A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education* 66(2), 211-227.

[6] Gooding, J & Metz, B. (2011). From misconceptions to conceptual change. *The Science Teacher* 78(4): 34-37.

[7] Khourey-Bowers, C. (2011). Active learning strategies: The top 10. NSTA: *The Science Teacher* 78(4): 38-42.

This study used conceptual change theory of Posner, et al. (1982)[8] as a valid framework to overcome these two misconceptions of pre-service students. It's a conceptual change lesson cycle, which incorporates the phases of *dissatisfaction*, *intelligibility*, *plausibility*, and *fruitfulness*. Accordingly, to set the condition of *dissatisfaction* with these pre-service students' preexisting idea about living things, the author challenged the participants with question how the growth of a multi-storied-building in height & volume is different from that of a plant seed. The author gave them a short project with seeds to germinate, observe, measure and make sense of growth as a cellular function. Data collected and inference helped the concept of 'living' *intelligible* and *plausible* to them. The plants they grew provided them evidence on the attributes of 'living' different from 'non-living' objects to re-examine their false idea about 'sun' as living. The concept became *fruitful* for them to define 'living' different from 'non-living' objects.

To overcome the false concept of 'melting' participants were given ice cubes and wrapped candies. They measured temperature of these items at different intervals and inferred that ice cube not candies are affected by temperature (NTP) to change its physical condition to liquid phase. They were challenged: If a candy melts when sucked, it should do so inside our mouth (with higher temperature of the mouth) even when wrapped – how would you find it out? They tested the hypothesis and found that candies when sucked while still wrapped, do not melt inside their mouth. Then they sucked the candy unwrapped and found that candy gradually disappeared. They connected this observation to their experiences with sugar when added to water. These activities helped them overcome their misconception about 'melting' as contrast to 'dissolving.'

However, to avoid or minimize the retention of misconception (resiliency), science should be taught in an inquiry mode using CER model as the basis for measuring students' understanding of a concept and science terms/ vocabularies must be taught in context.

6. Discussions:

Parents, folklore, TEACHERS, media & multimedia, science curricula and textbooks and even learners themselves are responsible for cultivating and fostering misconceptions (Gooding & Metz, 2011)[9]. In particular, if teachers themselves possess misconceptions, they unintentionally perpetuate it among the future potential STEM workforce. Lack of conceptual understanding of science is one of the deciding factors for recent decision to change many teacher education certification programs to focus on science content-literacy (e.g., MOCA). This study thus points

[8] Posner, G.J., Strike, K.A. Hewson, P.W. and Gertzog, W.A. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education* 66(2), 211-227.

[9] Gooding, J & Metz, B. (2011). From misconceptions to conceptual change. *The Science Teacher* 78(4): 34-37

fingers to those of us who teach science to pre-service students. "Teaching is easy; by comparison, *unteaching* is extremely difficult" (Mtz, 2011, p. 6)[10] when students' misconceptions are resilient to change. Often misconception or unscientific pre-conception in science remains unchanged even after teaching if the students' prior knowledge is not diagnosed during instruction and addressed during instruction. "The most important single factor influencing learning is what the learner knows" (Ausubel 1968, p. iv)[11] and so science teaching should use Inquiry instructional strategy preferably adopting 5E format (Bybee, 2006). The very first E of this lesson format draws on an activity to diagnose what students already know on the topic or concept. Teaching should incorporate these non-science preconceptions if any into the teaching process in order to remediate it.

Further Research:

Experimental research with randomized sampling method and control may shade more light on the issue. A gender and racial comparative study might be essential to further these findings.

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PS: Although in different format, the abstract of this research was presented at the Missouri Academy of Science Annual Conference in 2018.

[10] Metz, S. (2011). Private Worlds. NSTA: *The Science Teacher* 78(4): 6.

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