Identifying and Categorizing nonscience students' ideas of waves in a course on radiation

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Introduction

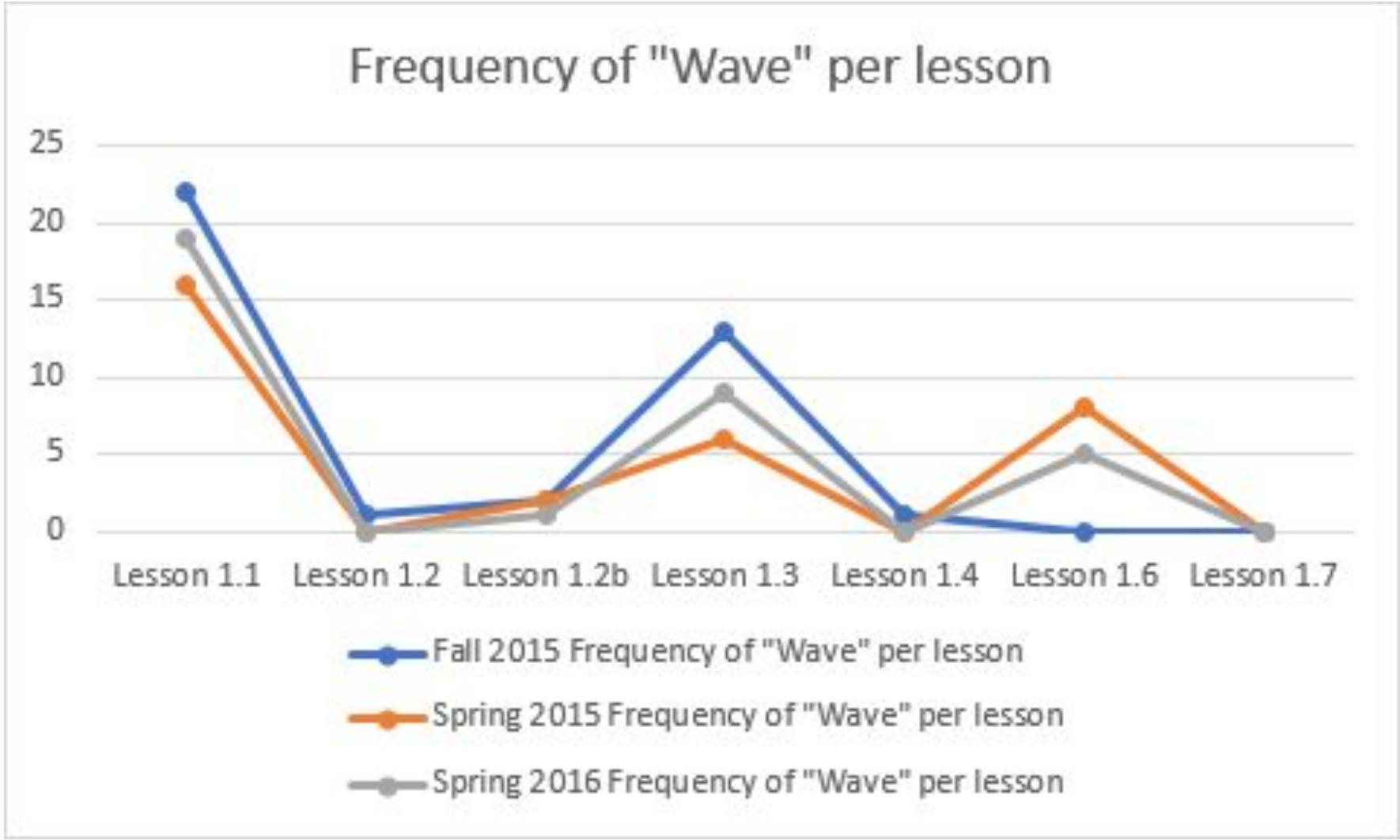
This summer I studied student papers from a Survey of Physics class over several semesters. In this inquiry class into radiation, the goal was for students to understand radiation as a particle, not as a wave. In looking at many different papers, I was able to see how student thinking about radiation changed over the course of the unit, and how different students understood the word "wave" to mean different things. The goal of the class was to think of radiation as "ice cubes" rather than "water." Where ice cubes drop out of a pitcher and are finite events, water pouring from a glass is a continuous event. To observe radiation as a wave (students often think they are continuous and infinite), a person would need expensive equipment, more advanced physics knowledge, and more time. It is easier to observe and explain radiation as particles (finite events). In Cycle 1 data, many students are stuck on "waves". For the purpose of the class, it is important that students think of radiation as particles, to further understand radiation through the remainder of the semester.

Research Method

To research this topic, I first reviewed homework papers from cycle 1 from four different semesters of student work, transcribing student answers if the word "wave" appeared in the work or was pictured in the work. Next, I counted how many students used "waves" to describe radiation in each lesson over the course of Cycle I (the unit). I created a graph of this information for each semester studied. Then, Dr. Johnson helped me to categorize how each student in one of the semesters (Fall of 2015) used the word "wave". Again, I graphed this information. With more time, I would continue the categorization of the word "wave" in other semesters.

Results

In determining the difference between beginning lessons and ending lessons in Cycle 1, I found that there were less students still determined to think of radiation as waves at the end of the unit than at the beginning of the unit. In fact, in Fall 2015, the word wave decreased in frequency from 22 people in the beginning lesson to 13 in the middle. At the end of the unit, no students were still describing radiation as waves. In another semester, 19 students described radiation as waves at the beginning, 9 near the middle, and five students persisted with the idea of radiation as waves at the end of the unit.

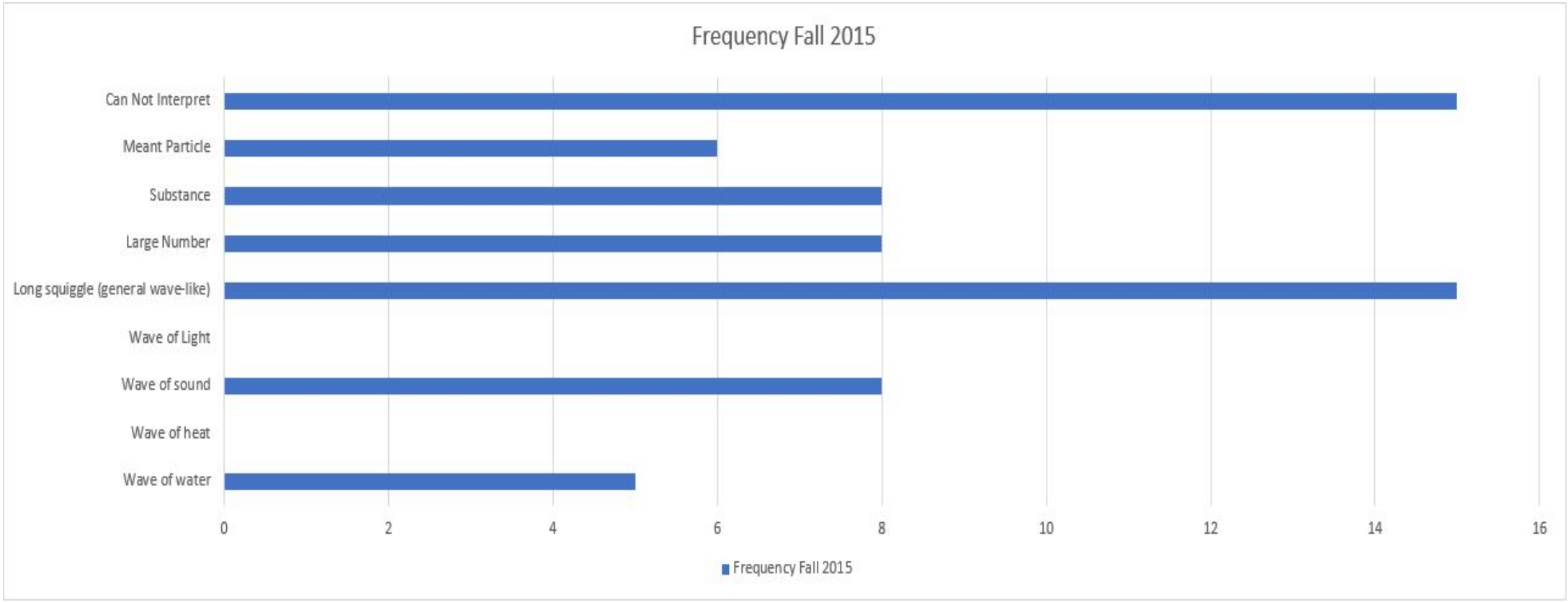

Frequency of "Wave" per lesson
25
20
15
10
5
0
Lesson 1.1
Lesson 1.2
Lesson 1.2b
Lesson 1.3
Lesson 1.4
Lesson 1.6
Lesson 1.7
Fall 2015 Frequency of "Wave" per lesson
Spring 2015 Frequency of "Wave" per lesson
Spring 2016 Frequency of "Wave" per lesson

Results

In Fall 2015 Physics Survey class, students mentioned the word "wave" to describe radiation 65 times during the course of the unit. However, there was little agreement among students, and across the unit as to how the word "wave" was used. The categories found in the student work included:

wave of water, wave of heat, wave of light, wave of sound, long squiggle, large number, or when the student meant particle. Some students wrote the word wave, but the meaning could not be interpreted.

TYPE OF WAVE MENTIONED IN ANSWER	Frequency Fall 2015
Wave of water	5
Wave of heat	0
Wave of sound	8
Wave of Light	0
Long squiggle (general wave-like)	15
Large Number	8
Substance	8
Meant Particle	6
Can Not Interpret	15


Frequency Fall 2015
Can Not Interpret
Meant Particle
Substance
Large Number
Long squiggle (general wave-like)
Wave of Light
Wave of sound
Wave of heat
Wave of water
0
2
4
6
8
10
12
14
16
Frequency Fall 2015

Categories

KEY		
WOW	Wave of water	(gives properties to waves that are like water waves such as... flow, up and down,high and low moments ..)
H	Wave of heat	(includes EM waves and EM spectrum drawings and cases where waves cause a continuous sound, and ripples that start at the source only)
S	Wave of sound	mention of sound
L	Wave of light	mention of light
LS	Long squiggle (general wave-like)	drawing like a long wave train, or described as something regular like a long wave train, or like it's continuous All the drawn waves begin at the source, student doesn't specify much detail
LN	Large Number	(Similar to a "wave of activity - explains the variation in counts)
S	Substance	Describes the radiation / wave as if it is a substance
MP	Meant Particle	(drew squiggles not always starting at the source or description is more consistent with particles - more waves means more clicks? Blocking means particles?)
CNI	Can Not Interpret	
NW	No Wave	
P	Not waves but particles	
N/A	Not Applicable	

Why This is Important

When teaching Physics Survey, Dr. Johnson noted that two different students could be talking about waves of radiation, but the two were not talking about the same type of wave. It turns out that he was right. There were many different definitions of the word "wave" as students were explaining radiation. The importance of this research was to determine if there was one particular wave type that students were thinking about. If so, Dr. Johnson might be able to use another assignment to guide their thinking away from that type of wave and into thinking of radiation as particles. The results showed that there is no consensus on what category of wave students are thinking about when they say "radiation wave", so the general assignments that are now being given continue to be appropriate for this class.

Conclusion

From the beginning of the unit to the end, most students were able to abandon the thought of radiation as waves and to begin thinking of radiation as particles, which is the goal of this Cycle I unit. The methods used in the class to allow for this change in thinking included inquiry learning and labs, with hands on research and collaboration among student groups. Some semesters were more successful than others in this goal of abandoning the thought of radiation as waves.

As far as what category of wave students were describing as they were thinking about radiation "waves", there was little agreement between students, and even one student often changed what he/she meant by "wave" between the beginning and the end of the unit.

Bibliography

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