Abstract
Rationale: The difference and relationship between theories and laws is commonly misunderstood by both secondary and post-secondary students (Lederman, 2010). People often hold the misconception that theories are more tenuous than laws, and that once a theory has been properly “proven” it can become a law (McComas, 1996). Simply explaining the difference and relationship to students is not particularly effective in removing this misconception (Howe & Rudge, 2005). Explicit and reflective instruction is best for the teaching of NOS concepts (Khishfe & Abd-El- Khalick, 2002).
Novel Method for Teaching the Difference and Relationship Between Theories and Laws to Pre-Service Secondary Teachers and High School Students

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Rationale
- The difference and relationship between theories and laws is commonly misunderstood by both secondary and post-secondary students (Lederman, 2010).
- Theories provide explanatory frameworks for scientific phenomena
- Laws describe regular patterns in natural phenomena
- Non-hierarchical in nature
- People often hold the misconception that theories are more tenuous than laws, and that once a theory has been properly “proven” it can become a law (McComas, 1996).
- Simply explaining the difference and relationship to students is not particularly effective in removing this misconception (Howe & Rudge, 2005).
- Explicit and reflective instruction is best for the teaching of NOS concepts (Khishfe & Abd-El-Khalick, 2002).

Methods
- Qualitative action research on preservice teachers and high school students attending schools in the Southeastern US
- Pre-and post-tested by writing an answer to the following question from the VNON-C questionnaire (Lederman et al., 2002):
  - Is there a difference between a scientific theory and a scientific law? Illustrate your answer with an example.
- Pre- and post-tests were coded by authors with interrater reliability of 83%.

Pre-service Teachers

High School Students

Students took a whole school day to research and develop their knowledge of the similarities and differences between scientific theories and scientific laws. They started with the pretest and also filled out a Venn Diagram stating what they know about theories and laws and how they intersect. The students recorded all of the theories and laws that they already knew, as a class they discussed what makes a scientific theory or law and created a large Venn diagram together. Students then read two articles about what defines scientific theory and a scientific law (Bradford 2017a & 2017b). In groups of four, students worked together to research one scientific theory or one scientific law. They created a poster about their theory or law, and included the essential features of a scientific theory or law. Students gave mini-presentations about their posters to their peers. As the students heard the presentations they filled out a T-Chart listing differences and similarities between the theories and laws. At the end of the day they completed the post-test and filled out a Venn Diagram about scientific theories and laws.

Results
- Both college and high school students were able to gain more informed views of the difference and relationship between theories and laws as a result of explicit and reflective discussions to produce Venn diagrams.
- High school students needed more scaffolding than college students.
- Definitions of scientific theories and laws were provided by articles that were short and to the point, and considered explicitly and reflectively by using annotation and discussion of the articles.
- They learned the Big Bang theory, plate tectonic theory, and Kepler’s laws of planetary motion prior to the scientific theories and laws activity.

Conclusions and Recommendations
- It was beneficial for both college and high school students to choose the theories and laws to use to produce their Venn diagrams, because it increased interest in the activity.
- College students can improve their conceptions when they complete the activity in a 50 minute class period.
- High school students need more than one class period to process the information.

References