

Introduction

Learning-by-Teaching

- There is much inconsistency in teachers' roles in learning-by-teaching research.
- Meta-analytic evidence has shown that tutoring is an effective learning activity (Cohen, Kulik, & Kulik, 1982). However, little research has examined teachers' learning outside of tutoring. Tutors typically have more prior knowledge and also may learn more from interactions with tutees.
- Bargh and Schul (1980) were the first to define 3 different stages of the learning-by-teaching process, as summarized in Figure 1.
- Some research has found that simply preparing to teach can produce advantages greater than preparing to take a test (Benware & Deci, 1984; Fiorella & Mayer, 2013; Nestojko et al., 2014). Research has therefore noted a need to further examine the cognitive processes that are occurring while preparing to teach.

1. Preparing to Teach	2. Generating Explanations	3. Interaction
<ul style="list-style-type: none"> Organizing information Increased preparation and motivation 	<ul style="list-style-type: none"> Verbalization Self-monitoring 	<ul style="list-style-type: none"> Responding to questions Receiving feedback

Figure 1. Theorized mechanisms in each phase of the learning-by-teaching process.

- Fiorella and Mayer (2013) measured phase 2 in the process by having teachers explain on video. After a one-week delay, those who taught performed better on the post-test than those who prepared to teach and prepared to test. This is likely because generative learning techniques, such as teaching, are most evident after time delays.
- Fiorella and Mayer (2014) attempted to examine the interaction between preparing to teach and teaching. They found that those who expected to teach and did teach had the highest performance of all groups.
- Teachers tend to not engage in deep cognitive processing and often summarize or memorize rather than use generative learning techniques, such as regulating and assessing their learning (Roscoe & Chi, 2007; 2008).

Concept Mapping

- Concept mapping has been shown to be effective by fostering generative learning. A review of 25 studies utilizing concept mapping and knowledge tests found positive effects of concept mapping versus other learning activities with an effect size of $d = 0.62$ (Fiorella & Mayer, 2015).
- Muis (2015) explored the use of concept maps and talking aloud while preparing to teach and found those who used more self-regulatory strategies, such as assessing knowledge and goal setting, developed better concept maps and learned more.
- Concept mapping has been shown to be even more beneficial for low-performing students (e.g., Haugwitz, Nesbit, & Sandmann, 2010; Liu, Chen, & Chang, 2010; Stensvold & Wilson, 1990). A meta-analysis found an effect size of $d = 0.44$ for low verbal ability students versus $d = -0.33$ for high verbal ability students (Nesbit & Adesope, 2006).

Hypotheses

The proposed study will incorporate concept maps into learning-by-teaching experimentation to determine the cognitive organization that is occurring while preparing to teach, as well as to increase the effectiveness of teaching by enabling teachers to engage in deeper processing through mapping.

- H1:** There will be a main effect of teaching on learning and retention scores.
- H2:** There will be a main effect of concept mapping on learning and retention scores.
- H3:** Those who teach will show more accurate and complete concept maps than those who do not teach.
- H4:** The main effect of teaching on learning will depend on the effect of concept mapping, such that the effect is stronger when a concept map is used and weaker when a concept map is not used.

Materials & Measures

- Expository text about the Doppler Effect of about 600 words with pictures
- Multiple-choice questions assessing the content in the text
- Participants will receive an incomplete concept map with blanks based on research showing incomplete maps are better for beginners (Chang et al. 2002; Katayama & Robinson, 2000).
- Participants' reading ACT scores – measure of verbal ability

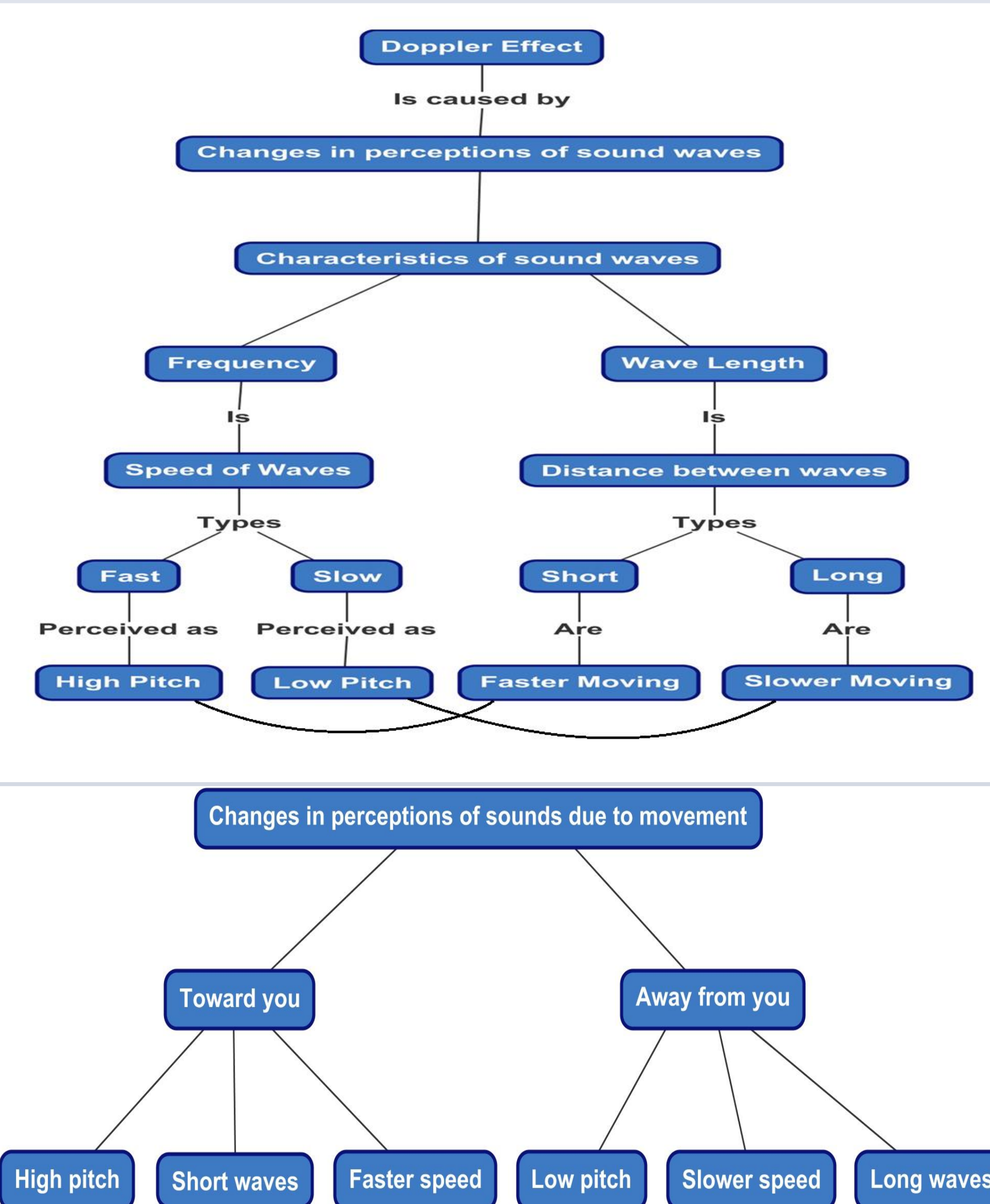


Figure 2. Complete version of the concept map participants will be receiving.

Methods

Experimental conditions:

- Only Testing
- Teaching
- Concept Mapping
- Teaching and Concept Mapping

Participants:

- Participants will be students from General Psychology and Social Psychology at Middle Tennessee State University. They will receive extra credit in their courses for participating.
- The target sample size is 100 participants.

Part One:

- Participants will be randomly assigned to one of the four conditions.
- All participants will take a pre-comprehension test.
- Teachers will record their lessons on video, as if they would be watched by a learner later.
- The time for reading, concept mapping, and teaching will be adjusted in each condition so that each participant has a total of 25 minutes' time with the learning material. For example, condition 4 will read for 10 minutes, then concept map for 10 minutes, and then record their lesson for 5 minutes.
- Participants will then take a different form of the same comprehension test.

Part Two:

- The proposed study will extend that of Fiorella and Mayer (2014) to measure retention after one month rather than after one week. Participants will return to the study approximately four weeks after part one.
- Participants will take a different form of the same comprehension test.
- A post-experimental survey will be given measuring demographic information such as GPA, class standing, age, and gender.

Participants' concept maps and 3 comprehension tests will be scored with a rubric.

Analysis Plan

- A 2x2 ANCOVA will be utilized with teaching condition (teaching or no teaching) and concept mapping (mapping or no mapping) as between-subjects factors.
- Participants' reading ACT scores will serve as a covariate based on past research (e.g., Haugwitz, Nesbit, & Sandmann, 2010; Liu, Chen, & Chang, 2010; Stensvold & Wilson, 1990) finding concept maps more beneficial for students with lower verbal ability.
- Pre-comprehension test scores will also serve as a control.
- Means between the three comprehension tests will be compared to determine changes over time.

Discussion & Implications

- If the combination of teaching and concept mapping shows the greatest learning and retention benefits, it would be advantageous to utilize both activities in learning settings.
- The learning-by-teaching method has shown success in a variety of settings, such as education (Grzega, & Schöner, 2008), medical and nursing training (Gregory, Walker, McLaughlin, & Peets, 2011), and the workplace (Cortese, 2005). The method could be utilized in additional settings, such as in formal school curriculums and on-the-job training programs in organizations.
- Future research should examine the effectiveness of the method in these various settings and with different populations.
- Future research should examine and compare Stages 2 and 3 in the process (explaining and interaction), as the present research only examines Stages 1 and 2 (preparing to teach and explaining).

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Contact Information

Lindsey Murry: lm5g@mtmail.mtsu.edu

Dr. Michael Hein: Michael.Hein@mtsu.edu

Department of Psychology
Middle Tennessee State University