Contemporary Educational Psychology 38 (2013) 281–288

Contents lists available at SciVerse ScienceDirect

Contemporary Educational Psychology

journal homepage: www.elsevier.com/locate/cedpsych

# The relative benefits of learning by teaching and teaching expectancy

Logan Fiorella *, Richard E. Mayer

*University of California, Santa Barbara, United States*

ARTICLE INFO

*Article history:*
Available online 7 June 2013

*Keywords:*
Learning by teaching
Multimedia learning
Explanation
Generative learning
Teaching expectancy

ABSTRACT

The purpose of this study was to explore the hypothesis that learning is enhanced through the act of teaching others. Specifically, two experiments aimed to disentangle the relative effects of teaching expectancy (i.e., preparing to teach) and actually teaching (i.e., explaining to others for instructional purposes) on learning. Some participants studied a lesson on the Doppler Effect without the expectation of later teaching the material and then took a comprehension test on the material (control group). Other students studied the same lesson with instructions that they would later teach the material; of those expecting to teach, some participants actually taught the material by presenting a brief video-recorded lecture before being tested (teaching group), whereas others only prepared to teach before being tested (preparation group). Results of Experiment 1 indicated that both the preparation group and teaching group significantly outperformed the control group on an immediate comprehension test (Teaching vs. Control: $d = 0.82$; Preparation vs. Control: $d = 0.59$). However, when the same test was given following a one-week delay (Experiment 2), only the teaching group significantly outperformed the control group (Teaching vs. Control: $d = 0.79$; Preparation vs. Control: $d = 0.24$). Overall, these findings suggest that when students actually teach the content of a lesson, they develop a deeper and more persistent understanding of the material than from solely preparing to teach.



## 1. Introduction

Imagine that a beginning graduate teaching assistant is asked to present a lecture on the Doppler Effect to a large introductory physics class. The assistant knows the material well but does not yet feel confident in his ability to *teach* it to others. He decides to spend his preparation time devoting more effort towards selecting the most relevant information from the textbook and organizing it into a meaningful representation that he can later retrieve while teaching. During his lecture, he explains to the class how the Doppler Effect works by elaborating on the representation he constructed during preparation and by drawing on his prior knowledge to provide concrete examples. Finally, by the end of the class the teaching assistant has developed a much deeper understanding of how the Doppler Effect works. This is an example of what can be called *learning by teaching*–learning new material more deeply through teaching it to others.

It is sometimes said that teaching others is a powerful way to learn, but how does learning by teaching actually work? For instance, in the above example, at which point did the teaching assistant acquire a strong understanding of the material: after preparing to teach or after actually presenting his lecture? Alternatively, it may be that his understanding developed across both stages, receiving additive benefits from preparing for and actually teaching. There is a considerable amount of research indicating that teaching others can be an effective way to learn (Allen & Feldman, 1973; Bargh & Schul, 1980; Chi, Siler, Jeong, Yamauchi, & Hausmann, 2001; Cohen, Kulik, & Kulik, 1982; Coleman, Brown, & Rivkin, 1997; Ehly, Keith, & Bratton, 1987; Ginsburg-Block & Fantuzzo, 1997; Graesser, Person, & Magliano, 1995; Griffin & Griffin, 1998; Morgan & Toy, 1970; Palinscar & Brown, 1984; Robinson, Schoefield, & Steers-Wentzell, 2005; Rohrbeck, Ginsburg-Block, Fantuzzo, & Miller, 2003; Roscoe & Chi, 2007; Webb, 1982); however, the reasons for this effect are much less clear (Galbraith & Winterbottom, 2011; Ploetznerl, Dillenbourg, Praier, & Traum, 1999; Rohrbeck et al., 2003; Roscoe & Chi, 2007). In particular, this ambiguity is likely due to the diversity of learning by teaching approaches available (e.g., cross-age tutoring, reciprocal tutoring, teachable agents), the many teaching-related activities potentially responsible for learning (e.g., preparing to teach, explaining to others, providing feedback), as well as other aspects of teacher-student interactions that are not necessarily unique to teaching (e.g., answering questions). Consequently, research on learning by teaching—particularly within peer tutoring contexts—has produced quite mixed results (Rohrbeck et al., 2003) and overall learning effects that are relatively underwhelming (Cohen et al., 1982; Roscoe & Chi, 2007). Given learning by teaching is at the core of

* Corresponding author. Address: Department of Psychological and Brain Sciences, University of California, Santa Barbara, CA 93106, United States.
*E-mail addresses:* fiorella@psych.ucsb.edu (L. Fiorella), mayer@psych.ucsb.edu (R.E. Mayer).

0361-476X/$ - see front matter © 2013 Elsevier Inc. All rights reserved.
http://dx.doi.org/10.1016/j.cedpsych.2013.06.001

many popular educational practices, including small group discussions (e.g., Webb, 1982), reciprocal teaching (e.g., Palincsar & Brown, 1984), and cooperative learning environments (e.g., Slavin, 1983), it is important for research to identify which features of the teaching process contribute to learning.

Another limitation of past research is its focus on learning by teaching in the absence of teaching expectancy—that is, prior to learning participants may not be told that they will later teach the material (e.g., Roscoe & Chi, 2008). In other words, the effects of learning by teaching and learning by preparing to teach have largely been examined separately (e.g., Bargh & Schul, 1980; Benware & Deci, 1984; Roscoe & Chi, 2008; see Annis, 1983 for the one exception). This divergence causes difficulty in determining the role of preparing to teach within the broader spectrum of learning by teaching. In particular, little is known about the relative benefits of preparing to teach and actually teaching, whether these activities reflect the same or different cognitive processes, and whether or to what extent actually teaching goes beyond simply preparing to teach (and under which conditions). In short, research is needed to disentangle the potential contributions of preparing for and actually teaching to learning.

The goal of the present study is to begin addressing these issues by directly testing the relative learning benefits of preparing to teach and actually teaching academic content to others. In the current study, students in two experiments were asked to study a brief paper-based multimedia lesson on the Doppler Effect. Some students studied the lesson without the expectation of later teaching the material and then took a comprehension test on the material (control group). Other students studied the same lesson with instructions that they would later teach the material; of those expecting to teach, some participants actually taught the material before being tested (teaching group), whereas others only prepared to teach before being tested (preparation group). The teaching activity consisted of students providing a brief video-recorded lecture explaining how the Doppler Effect works as if the recording was to be used to teach another student with no prior knowledge of the subject. The rationale for using this mode of teaching was to isolate and systematically test the effects of the essential feature of learning by teaching—explaining content to others for instructional purposes—and examine its relationship with preparing to teach and studying normally.

Performance was compared across groups on a paper-based comprehension test that required participants to explain important concepts related to the Doppler Effect. In Experiment 1, participants were tested immediately following completion of their respective learning activity (i.e., normal studying, preparing for teaching, or preparing for and actually teaching), whereas in Experiment 2, participants were tested after a one-week delay following their respective learning activity. Overall, the two experiments aimed to examine the relative effects of preparing to teach and actually teaching, and further, to determine whether any potential benefits gained by preparing for or actually teaching remain persistent over time. In short, the goal of this research is to contribute towards a research-based understanding of how learning by teaching works.

### 1.1. Learning by preparing to teach

In their classic article, Bargh and Schul (1980) postulated that the cognitive benefits experienced through teaching others are a product of the preparation that takes place prior to teaching, the initial presentation of information to students, and the subsequent interactions with students (e.g., answering questions, providing feedback). Thus, they provided an early framework for distinguishing between different stages of learning by teaching, as well as for studying the cognitive mechanisms underlying each stage. In particular, their article proposed that the mere expectation of teaching others may change the way students study material, compared to studying normally for one's self (e.g., for a test). In other words, studying with the expectation of later teaching may alter one's cognitive processing during learning by priming students to devote more resources toward selecting the most relevant material and organizing it into a meaningful representation. In one experiment, Bargh and Schul provided early support for this potential difference in processing. Participants were given verbal material to study with the expectation of either answering questions afterwards or teaching the material to another person. The results found that those expecting to teach performed better on a subsequent retention test than those expecting to answer questions. Surprisingly few studies have further explored the effects of teaching expectancy (e.g., Annis, 1983; Benware & Deci, 1984; Renkl, 1995). For example, following a similar design to that of the Bargh and Schul (1980) study, Benware and Deci (1984) found that students expecting to teach performed better on a measure of conceptual learning after studying an article on brain functioning than did students who did not expect to teach. Overall, these studies provide some preliminary support for a teaching expectancy effect (although see Renkl, 1995 for an exception), presumably because preparing to teach helps students better select and organize important information from a lesson.

Annis (1983) conducted the only study found in which the effects of teaching expectancy and actually teaching were directly compared. In the experiment, participants either read a history passage with the expectation of later being asked to recall the material or the expectation of tutoring another student on the material. Of those expecting to tutor, some participants actually tutored the material to someone else, whereas some participants only prepared to tutor someone else. The results provided some evidence that expecting to tutor may enhance learning beyond studying normally, and further, that tutoring another student enhanced learning beyond only preparing to tutor. Although this finding provides early evidence of an added benefit for tutoring, there are important limitations of Annis' study that are in need of further investigation. From a theoretical standpoint, one limitation is that the students who tutored interacted with another student (e.g., answering questions, providing and receiving feedback). According to Bargh and Schul (1980), interactions with students represent an additional stage of learning by teaching beyond only explaining to others. Therefore, it is unclear whether the added benefits of tutoring can be attributed to explaining material to another student or the various interactions that take place with the other student. Thus, the goal of the current study is to isolate the effects of two essential components of teaching—preparing to teach and explaining content to others—to test whether explaining content to others offers additional learning gains beyond preparing to teach. In addition to isolating and disentangling these two stages of teaching, the current study extends previous work by including both immediate tests (Experiment 1) and delayed tests (Experiment 2). Delayed tests are particularly relevant in light of a growing research base on desirable difficulties, showing that the effects of learning strategies that create difficulties during learning such as self-testing can best be distinguished from other effects on a delayed test (Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2013; Roediger & Karpicke, 2006). Thus, any added benefit of explaining to others over preparing to teach may be most pronounced on a delayed test.

In summary, the existing literature provides some support for teaching expectancy effects, suggesting that studying with the expectation of later teaching may play a critical role in determining the overall effects of learning by teaching. In other words, the prospect of teaching others may help students better select the most important material from the lesson and organize it into a