

Tracking Recitation Instructors' Awareness of Student Conceptual Difficulties

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Abstract. As part of a broader study of the impact of teaching environment and preparation on the conceptions of teaching and learning expressed by our graduate Teaching Assistants (TAs) and undergraduate Learning Assistants (LAs), we track shifts in instructor awareness of student ideas over the course of a week of preparing for and teaching in the *Tutorials in Introductory Physics*. Since TAs and LAs interact face-to-face with introductory physics students, we are interested in the nature of their educational practice and its impact on the success of reformed teaching methods. In this study, we focus on a specific component of educational practice by asking recitation instructors to describe student difficulties with topics at various points in a week of teaching. We observe increased awareness of student difficulties on the *Tutorials* following preparation, but also conclude that resources like the *Tutorial* pre-test are not necessarily alerting TAs and LAs to the ideas they should be prepared to discuss with their students.

Keywords: teaching assistants, learning assistants, teacher preparation, professional development

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INTRODUCTION

Recent studies have paid attention to the educational practice of graduate Teaching Assistants (TAs) [1][2]. A specific component of this practice is an awareness of student ideas prior to entering the classroom. It has been demonstrated that instructors who are better prepared to implement the *Tutorials in Introductory Physics* [3] differentially support students' learning of basic concepts [4]. We are specifically interested in how our preparation methods impact instructor awareness of common student difficulties and misconceptions.

In this study, we track shifts in recitation instructor awareness of student difficulties as a result of both their weekly preparation session and teaching with the *Tutorials*. At the University of Colorado (CU), in order to address the need for high teacher: student ratio in *Tutorials*, we include undergraduate Learning Assistants (LAs) to achieve a desirable ratio (approx. 1:14) [5]. In addition to the standard *Tutorial* preparation and teaching experience, first-time LAs enroll in a course on teaching and learning [6].

In tracking the evolution of instructors' ideas about student difficulties over the course of the weekly *Tutorial* cycle, we find that current preparation methods improve instructor awareness of student difficulties addressed by the *Tutorials*. However, there may be more work to do in terms of properly framing

the use of resources and activities involved in preparation in order to achieve a more thorough awareness of student ideas.

BACKGROUND

The TAs and LAs all attend a weekly preparation session a few days before they teach. Following the model of the University of Washington, weekly *Tutorial* preparation sessions at CU are intended to guide TAs and LAs to think about and discuss potential student difficulties as they complete the *Tutorial* in small groups [7]. During this session, they complete the same *Tutorial* pre-test as their students, view sample responses to the pre-test, and work on the *Tutorial* in small groups as one of the course instructors models appropriate TA behavior.

STUDY

We describe two studies that were conducted during consecutive semesters of calculus-based introductory physics courses at CU. These courses both use the *Tutorials in Introductory Physics* in their recitation sections, with one TA and one LA serving each 50-minute section of approximately 28 students. The average enrollment for these courses is ~450-600 students per semester.

Pilot Study

A single-week pilot study was conducted during the Fall 2008 semester of Physics 2, the calculus-based introductory electromagnetism course. The study was conducted during the week of the “Faraday’s Law and applications” *Tutorial*. Thirteen instructors (7 TAs, 6 LAs) taught in recitations this semester, and each participated in the study. Immediately following their preparation session, the TAs and LAs for this course were asked to provide the top three common student misconceptions that they expected to face in their next class. After teaching, they were then asked to report the three most common student misconceptions that they observed on the day of teaching.

We chose to categorize responses by the page of the *Tutorial* on which they appeared. Fig. 1 shows the frequency of each response category among all 13 recitation instructors, as well as the central idea of that page. The first two pages of “Faraday’s Law and applications” are conceptual with no hands-on component, while the remaining four pages involve the construction of a simple galvanometer and motor. The “Other” category includes general concepts (such as the right hand rule) that apply to multiple pages, as well as non-conceptual difficulties with materials.

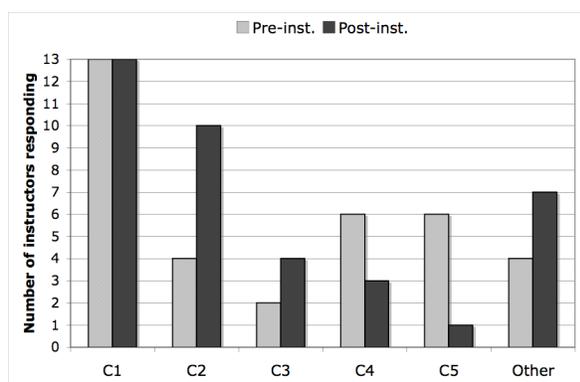


FIGURE 1. Predicted and observed student difficulties for the “Faraday’s Law and applications” *Tutorial*. (N=13) **C1:** Induced emf without conductor/current; **C2:** Comparing resistance & emf between loops; **C3:** Direction of galvanometer deflection; **C4:** Purpose of half-stripped insulation in motor; **C5:** Rotation of motor coil

A few prominent features of this graph give us some idea about how the instructors’ awareness of the ideas presented in the *Tutorial*. For instance, every instructor predicted and observed the student difficulty concerning induced emf in the absence of a conducting loop (C1). However, the instructors underestimated a common student difficulty involving a comparison of resistance and induced emf for different loops in identically changing magnetic fields (C2). The notable

aspect of this particular difficulty is that it is the only one of the five difficulties addressed by the pre-test, and it is repeated in an identical form in the *Tutorial* itself. According to the *Instructor’s Guide*, “very few students correctly relate the current, resistance, and emf of these three loops.” [7]

Our interpretation of this outcome is that while TAs and LAs may be completing the pre-tests correctly during the preparation session, course instructors may not be framing the pre-tests as addressing common student difficulties. Indeed, post-semester interviews indicate that many TAs/LAs view the pre-test as simply a “warm-up” for students (and themselves) rather than a tool to elicit student ideas. With this result in mind, a multi-week follow-up study was designed for the following semester.

Follow-up Study

A follow-up study was conducted during the Spring 2009 semester of Physics 1, the calculus-based introductory mechanics course. Fourteen instructors (7 TAs, 7 LAs) taught in recitations this semester. A few changes were made from the pilot study: the more general term “student difficulty” was used in place of “misconception” to avoid confusion, and a survey was added *before* the preparatory session to more effectively gauge the effect of current preparation methods on instructor awareness of student difficulties.

The TAs and LAs were surveyed at three points during each of four weeks, and at each point asked to list the three most common student difficulties with the current topic. The first survey was given before the weekly preparation session; the second was given after preparation but before teaching; and the third was given after the instructors had finished teaching. Each survey was administered online and completed by the participants in their spare time. The survey prompts were removed from the preparation setting for two reasons: first, it was not desirable to intrude on the normal proceedings of the preparation session; second, an exercise meant to be completed individually would run counter to the collaborative nature of the session.

Participation in the study was not mandatory; over the course of the four weeks, five TAs and four LAs participated frequently enough (at least a 75% overall response rate) that their responses could be satisfactorily followed from week to week. Participants were never given feedback about their responses. It was expected that the TAs/LAs would not view the *Tutorial* before the preparation session, hence the pre-preparation survey asked for student difficulties with a particular “topic” rather than with the “tutorial”.

RESULTS & DISCUSSION

We categorized student difficulties by reviewing the types of concepts and reasoning used in each section of the *Tutorial*. The recitation instructors' responses were then coded and separated into these categories. Only instructors who responded to every survey in a given week were included in the analysis of that week's responses.

We present results from the *Tutorial* "Conservation of angular momentum" to demonstrate the type of shifts that were observed over the course of the four-week study. This *Tutorial* has a hands-on component in the form of a bicycle wheel and rotating platform that students use to test their ideas about angular momentum. In the latter part of the *Tutorial*, students consider the outcome of various inelastic collisions to establish how a non-rotating object can have angular momentum with respect to a reference point.

Fig. 2 shows how the frequencies of various responses shifted over the course of the week. The "Other" category includes concepts that TAs and LAs listed but that were not addressed by the *Tutorial*. Before the preparation session, 78% of the instructors listed at least one response from the "Other" category; in total, "Other" accounted for 41% of all pre-preparation responses. It should not be surprising that such a large fraction of these responses fall into the "Other" category, as the instructors were not prompted to use the *Tutorial* in making their initial predictions.

The most common response classified as "Other" involved torque, which is not explicitly addressed (or even mentioned) by the angular momentum *Tutorial*. The diminishing size of the "Other" category as the week progresses suggests that the instructors are being coached in what student ideas the *Tutorial* is actually addressing. While perhaps obvious, this finding is significant in demonstrating positive impact of the preparation and teaching experiences with *Tutorials*.

A similar pattern emerges in category C2 ("Direction of L vector"), which involves the direction

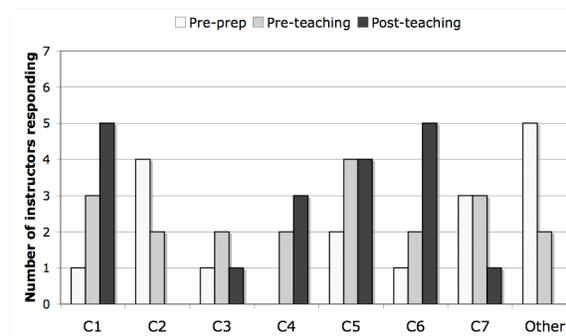


FIGURE 2. Predicted and observed student difficulties for the "Conservation of angular momentum" *Tutorial*. (N=7) **C1:** Application of L to student-wheel system; **C2:** Direction of L vector; **C3:** Conservation of L as a vector; **C4:** C.O.M. motion in collision; **C5:** Distinguishing angular/linear momentum; **C6:** Non-rotating object can have L ; **C7:** L defined with respect to a point.

of the angular momentum vector relative to motion and the use of the right hand rule. The frequency of this prediction was cut in half following the prep session, and after instruction it was not reported as a common student difficulty. Only half a page out of the five-page *Tutorial* is spent explicitly addressing this concept, and it does not appear on the pre-test.

There are three categories of student difficulties that were "underestimated," that is, they were observed with a greater frequency than they were predicted. This is illustrated in Table 1, which compares each concept's estimated representation (by length) within the *Tutorial*, as well as its frequency of prediction and observation. We describe any response listed by less than a third of the instructors as "low," and any response listed by more than two-thirds as "high". The representation percentages sum to more than 100% because some sections were identified as addressing more than one idea. The concepts in bold appear on the *Tutorial* pre-test, which is completed by the TAs and LAs as part of the preparation session.

TABLE 1. Student difficulty categories for "Conservation of angular momentum." Categories in bold appear on the *Tutorial* pre-test.

Categories of Student Difficulties	Representation in <i>Tutorial</i> (% by page)	Pre-teaching prediction rate	Post-teaching observation rate
C1: Application of L to student-wheel system	10	Med	High
C2: Direction of L vector	10	Med	Low
C3: Conserving L as a vector	20	Low	Low
C4: COM motion in collision	20	Low	Med
C5: Distinguishing angular/linear momentum	20	Med	Med
C6: Non-rotating object can have L	40	Low	High
C7: L defined with respect to a point	30	Med	Low
Other	0	Med	Low

A few observations can be made from Table 1. First, each of the three underestimated difficulties appeared on the pre-test. This is in line with the pilot study, which found that the most underestimated student difficulty on the *Tutorial* was the only one addressed by the pre-test. Second, the representation of a given concept within a *Tutorial* is not always a good indicator of how difficult the concept will be for students. For instance, the outcome of a stationary student on a rotating stool being handed a spinning bicycle wheel (C1), an idea that only takes up part of the first page, was reported to be as commonly misunderstood by students as a concept that took up nearly the entire last half of the *Tutorial* (C6).

These observations suggest that the pre-test is not playing an important role in the ability of recitation instructors to anticipate what concepts they should be prepared to discuss with their students. It may not be enough to simply work the *Tutorial* while thinking about student ideas, which makes the implementation of the pre-test critical to the outcome of the preparation session. Surveys conducted during the same semester indicate that most recitation instructors understand that the goal of the preparation session should be to think about student ideas, but few describe the pre-test as being helpful to this process. How faculty frame these preparatory sessions appears to be critical [8].

CONCLUSIONS & IMPLICATIONS

This study shows how instructor awareness of student difficulties in *Tutorials* shifts as a result of preparation and teaching. We believe TAs and LAs think about the *Tutorial* differently after having taught it, which in the case of LAs may vary widely from how they thought about the same *Tutorial* as students. From a standpoint of professional development, the challenge of preparation is then to help instructors reach a level of sophistication associated with having already taught the material. The research question that will guide subsequent studies is whether a modified implementation or framing of the use of the pre-test and other preparation resources may impact the shifts observed over the course of a week of teaching.

There are avenues yet to be explored within the context of this study, including an examination of TA/LA differences in awareness of student difficulties. The LAs have been exposed to the course content much more recently and undergo more pedagogical training than TAs, so we may expect their ideas about student difficulties to be more sophisticated than those of the TAs. On the other hand, if TAs and LAs are indeed discussing student ideas as part of their weekly prep sessions, we may expect such ideas to be shared

among both groups of instructors [1]. Our ability to distinguish significant differences between TAs and LAs is currently limited by the small number of instructors that teach *Tutorials* each semester.

Accurately predicting student ideas is hardly an easy task, particularly for instructors who have never taught in a *Tutorial* setting before. However, if we can identify resources that guide such predictions, we should employ these resources in a manner that benefits the professional development of the instructors. While the Physics department has a time-honored prescription for how preparation sessions should be run, the actual content and length of these meetings are not uniform and tend to vary with the faculty member who is in charge. We believe that the manner in which weekly preparation sessions are conducted has an impact on TA and LA practice in the classroom, and we will seek to investigate the impact of this variation in future semesters.

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