TEACHING AND LEARNING PORTFOLIO

by

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The Delta Program in Research, Teaching, and Learning is a project of the Center of the Integration of Research, Teaching, and Learning (CIRTL—Grant No. 0227592). CIRTL is a National Science Foundation sponsored initiative committed to developing and supporting a learning community of STEM faculty, post-docs, graduate students, and staff who are dedicated to implementing and advancing effective teaching practices for diverse student audiences. Any opinions, findings and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

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Introduction

This teaching and learning portfolio serves as an overview of my experiences as an educator at the University of Wisconsin – Madison (UW). Throughout my graduate career, the Delta Program in Research, Teaching, and Learning at UW has served as the foundation for my development as a science educator. The Delta Program (Delta) is part of the National Science Foundation-sponsored Center of the Integration of Research, Teaching, and Learning (CIRTL). Both CIRTL and Delta focus on improving science, technology, engineering, and mathematics (STEM) education through professional development for faculty and future faculty. I have continually sought out opportunities to become involved with Delta and with CIRTL, as their missions align with my career goal of becoming an effective physics professor.

CIRTL Mission Statement¹
The CIRTL mission is to enhance excellence in undergraduate education through the development of a national faculty committed to implementing and advancing effective teaching practices for diverse learners as part of successful and varied professional careers.

Delta Mission Statement²
The Delta Program promotes the development of a future national faculty in the natural and social sciences, engineering, and mathematics that is committed to implementing and advancing effective teaching practices for diverse student audiences as part of their professional careers.

The Delta Program is based on three main pillars: teaching as research, learning communities, and learning through diversity. This portfolio is organized around these guiding principles. While there is undoubtedly overlap between the pillars, I have selected work that highlights the pillars individually. For each of the three guiding principles, I have included artifacts from and reflections on my work in science education.

The goal of this portfolio is both to feature my work as an educator and to provide a framework to guide my future teaching.


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Teaching Philosophy

This portfolio will highlight my teaching practices through illustrative artifacts, but it will also demonstrate my teaching philosophy through reflections on my experiences. Therefore, I would like to begin with a short explanation of the philosophy that guides my practices.

While I find it impossible to point to a single event that has shaped my teaching philosophy, a few experiences come to mind as important moments in my continuing development as a teacher. My undergraduate experiences with inquiry-based learning as an assistant for a workshop-style physics course at Grinnell College helped me to consider instructional methods beyond the traditional lecture. That workshop experience, in addition to my work with the Physics Learning Center at the University of Wisconsin, also strengthened my belief in the effectiveness of guided group work and peer instruction. My experience with a student question-driven lecture in my undergraduate optics class gave me new insight into what it means for teaching to be student-centered. This helped me to realize the important role that frequent student input and feedback play in planning and revising my teaching.

These events along with numerous others, some big like these and some small like casual interaction with students, have changed how I think about teaching. In order to improve, I am constantly revising my teaching as I gain new experiences and insights. I have reflected on my ideas and practices, and I have put some thought into my teaching philosophy. By no means do I have all the answers; I am still learning, and there are many things that I would like to improve about my teaching as I grow as a teacher. However, what follows is a summary of three of the core principles that guide my evolving philosophy and practices: diversity as strength, instructor as facilitator, and teaching as research.

I strive not only to acknowledge diversity in all its forms, but to use diversity as an advantage.

Even in a seemingly culturally-neutral subject such as physics, diversity plays an important role in the classroom. Diversity takes many forms, from gender, ethnicity, and socio-economic class to educational background and learning style preferences. Although physical constants may be universal, ways of understanding and methods of problem solving are not. A diverse group of learners possesses a varied set of skills and experiences, which means that these learners can supply perspectives and approaches that might be absent in a more homogenous group.

As a teaching assistant for Physics in the Arts, a requirement-fulfilling course for non-science majors, I have witnessed the benefits of diversity in a learning community. Students have a wide range of academic backgrounds, and their complementary strengths are evident in lab. For example, a lab group with a fine arts major and an accounting major is better equipped to succeed at both the “color mixing” lab and the more mathematically-intensive “sound waves” lab than would be a group with two students with the same major. I have also seen a diverse group of students collaborate to come up with methods of learning that any single student, or even instructor, would be hard-pressed to come up with alone. An outstanding example is when students in the First Wave Program, a multi-cultural artistic program at UW, created a theatrical performance to explain the optics behind digital cameras. While not all examples are so striking, the number of unique interpretations of material almost always increases with the diversity of the group. When many ideas (some of which are more
elegant than my own) are contributed by students, it is a benefit to the class. When instruction focuses on multiple students’ input, rather than on a solitary narrative from the instructor, students are able to critically evaluate these multiple “entry ways” through which one can access the material. By increasing the number of entry ways by taking advantage of diverse talents, experiences, and points of view, you increase the number of students who are able to arrive at understanding.

Diversity is valuable because of the broad range of perspectives that a diverse group can provide. However, a broad range of perspectives is only beneficial if all points of view are heard and respected.

My role as an instructor is one of a facilitator, creating a welcoming learning environment that encourages participation and collaborative learning.

As an instructor, I see my role not only as a source of knowledge for students, but also as a guide who facilitates discussion and allows students to collaboratively construct knowledge. In order for this to work well, students need to feel comfortable sharing their ideas and perspectives with their peers and instructor. This is more likely in a low-stress environment, one where questions are explicitly encouraged and where it is acceptable to be wrong. I make a point of telling students that I will definitely make mistakes as we work together, so they should not be afraid of doing the same. The hope is that students see their peers and me as a supportive community of learners working towards a common goal. As an integrated part of a community of learners, I endeavor to make myself approachable to promote a comfortable and open atmosphere. I try to make our time together informal and fun, and I encourage friendly conversation before and after class. This is especially important when I work with non-physics majors, who are often intimidated by the idea of being in, let alone speaking up in, a physics course. I have found that the more accessible I am and the more relaxed students feel, the more likely they are to participate by contributing to discussions and volunteering answers and by sharing their opinions, questions, and concerns.

My work as a tutor with the Physics Learning Center has been an ideal opportunity for me to practice my role as a facilitator of a learning community. I sit as an equal around a table with the students, rather than standing apart at the front of the room. When we are solving a problem as a group, some students readily participate, but others are more hesitant. To encourage everyone to participate, I allow time for all students to work alone first, so that they can think through what they would like to contribute. I also encourage more reluctant students by asking for their input, especially when I know that they have a correct solution. I have found that asking such confidence-building questions encourages further participation. As a facilitator and a participating member of this learning community, I have found that often I can assess the productivity of a session by simply monitoring my participation; the better our group work is going, the less I need to speak. However, as an instructor, I need to constantly be aware to ensure that there is an appropriate balance between my desire to incorporate student perspectives and contributions and the need to reach the learning objectives of the course.

Teaching is an on-going, evolving process; I frequently evaluate student learning and revise my philosophy and practices accordingly.

Frequent evaluations are essential in my teaching. In addition to helping me to judge my students’ understanding, evaluations help to inform what I do as an instructor. My teaching practices and philosophies evolve in light of this new evidence about student learning. My teaching is like my
scientific research; I gather data that helps to test my hypotheses on the effectiveness of my teaching experiments.

My evaluations range from the informal to the more rigorous. In addition to observational informal evaluation as mentioned above, I evaluate my teaching based on direct student feedback. I am willing to listen to student frustration, and I often informally ask for student input and critiques regarding classroom practices. I have found that it is of little use to reflect on teaching without the context of student opinions and, more importantly, student learning. Due to the culture of openness and sharing that I encourage, students are frequently willing to share criticisms and suggestions for change. In case they have any reservations, however, I also request anonymous student feedback during the semester, more frequently than the twice-per-semester department evaluations. In response to such feedback, I have made changes to my teaching practices, such as instituting more explicit grading practices for lab notebooks. Students seemed to respond positively to having the power to affect course practices.

I also engage in more rigorous evaluation in order to improve my teaching. I helped to develop and then served as an instructor in a pilot group-tutoring program for the course Physics in the Arts for the Physics Learning Center. After the pilot, I helped to create a feedback survey, whose results we used in planning later versions of the program. In addition, for a final project in a course on teaching college physics, I talked with experienced professors who had made innovative changes in their classes. This helped to illustrate for me the power of collaboration between instructors as a means of improving teaching practices. I am also involved in a Delta internship project centered on an evaluation of the effectiveness of revisions to an introductory physics course. The course is now taught in a “semi-flipped-classroom” method, with significant class time devoted to student interaction and group work. Through class observations and data collection, we are hoping to both precisely describe the changes and to assess if they are worth continuing due to their positive impact on student learning.

The work that is highlighted in the rest of this portfolio has been guided by the three main principles of this philosophy: diversity as strength, instructor as facilitator, and teaching as research. My teaching philosophy has been inspired in many ways by my work with Delta, and these guiding principles are similar to the Delta pillars of learning through diversity, learning communities, and teaching as research. My own experiences in the classroom have helped to shape these general Delta pillars into my personal teaching philosophy. The following sections demonstrate how, as an educator, I have adapted and personalized the ideas of Delta and put them into practice.
Teaching as Research:
Applying research methods—idea, experiment, observation, analysis, improvement—to the challenge of teaching*

The constant reflection and revision that is an essential part of my teaching philosophy means that I continually strive to learn, to grow, and to improve as an educator. I use my past experiences in the classroom to guide my future approaches and plans. This demonstrates the Delta pillar of teaching as research. Delta emphasizes the importance of treating science education work like disciplinary science work. Challenges in teaching should be approached with the same logical and methodical rigor as are challenges in the laboratory. Just like in any scientific discipline, this careful attention can help us to avoid assumptions, to test hypotheses, and to make systematic improvements.

In this section of the portfolio, I present a summary of my teaching as research Delta Internship project. Like much of the work included in this portfolio, this project interweaves aspects of all three Delta pillars, and I have included a reflection of how the project influenced my views on each of them.

* Delta Program Website, http://delta.wisc.edu/About/delta_pillars.html
Artifact 1 Background: Delta Internship Project Report Summary

The core experience of the Delta Certificate Program is the Delta Internship Program. The Internship Program allows participants to explore in-depth an actual teaching or learning issue. Interns work with faculty or staff at UW or other institutions of higher learning. Interns and their faculty partners define and investigate a teaching as research question. The goal of the project is to improve teaching and learning practices at UW (or the host institution) and beyond.

Delta interns explore a wide variety of teaching as research questions, including developing new courses, effectively incorporating technology in the classroom, and creating public outreach events. My internship project focused on assessing the effectiveness of recent changes that have been made to an introductory physics course at UW. My faculty partner was UW Physics Professor Peter Timbie, the professor behind the changes in the course. Professor Timbie incorporated new online pre-lectures and active learning elements with the goal of making more efficient use of class time and improving student learning. Jake Feintzeig, another physics graduate student, was the third member of the study team. A summary report of the project is artifact 1.

1 Delta Program – Internship Program Overview, http://www.delta.wisc.edu/Internship/internship_overview.html
Artifact 1: Delta Internship Project Report Summary

Blended Learning in a Large Introductory Physics Course
A Delta Internship Project
Josh Weber
with Professor Peter Timbie and Jake Feintzeig

Project Abstract
The general purpose of the study was to assess the effectiveness of interactive, flipped classroom techniques in an introductory physics classroom. A “flipped classroom” technique is an established instruction style in which much of the initial learning takes place outside of the classroom, which leaves more class time free for active student participation (Ref. 1-5*). The study sought to determine whether such an instruction style improves learning in introductory physics. The study assessed Physics 207 at the University of Wisconsin – Madison (UW), a course that has recently been redesigned to include significant flipped classroom elements. Assessment of learning gains was judged by class test scores and grades as well as by performance on the Force Concept Inventory (FCI), a well-accepted assessment tool for introductory physics. In addition to looking at gains over the semester, the results were compared to aggregate information from past semesters in which flipped classroom techniques were not used. The assessment also included a study of student study habits, as determined by the amount of time devoted to out-of-class, online assignments. We searched for correlations between student usage of online flipped classroom resources and learning gains. Participants completed surveys about their perception of how different aspects of the course helped them to learn and also about their attitudes towards physics. The goal was to help to determine whether such flipped classroom techniques are effective, which will aid in planning for future versions of this course and perhaps for other physics courses at UW and beyond.

* While the concept is not new, the term “flipping” has only recently become widely used. Some references refer to the same (or very similar) practices by different names.

Introduction and Background
Numerous studies (Ref. 4-9) have shown that the traditional lecture is not necessarily the most effective mode of instruction. We attempted to address the issue of ineffective lectures in an introductory physics course by evaluating an alternative strategy based on interactive learning techniques. We explored its effects on student learning and attitudes.

There is a large body of education research on interactive learning techniques, with the most relevant literature coming from physics education research groups. An early study by Hake, which was later reaffirmed by Pollack and Finkelstein, showed that active learning techniques, which require students to discuss and to problem solve in class, led to higher learning gains for introductory physics students (Ref. 4, 6). Wieman has emphasized how such approaches are more effective than traditional lectures (Ref. 7). Although results have been more mixed, there is also some evidence that student attitudes towards the subject matter can be improved with lecture alternatives (Ref. 10). Furthermore, Hoellwarth and Moelter suggested that active instruction techniques affect conceptual understanding in particular (Ref. 8). However, Turpen and Finkelstein have stressed that not all implementations of active techniques are equally effective, so one must carefully plan and implement an active learning environment (Ref. 11). Specific active learning approaches that have been recently implemented (or whose use has significantly increased) in the new version of Physics 207, namely online pre-lectures, “clicker”* questions, and peer instruction, all have been shown to be effective (Ref. 5, 9, 12). Turpen
and Finkelstein and Pollack and Finkelstein have explored the challenges of institutionalizing such active-learning-based, physics-education-research-informed instruction (Ref. 13, 14). This study’s aim is to expand the discussion of teaching practices in the physics department at UW and to strengthen the argument for larger reforms that incorporate more active learning in introductory physics instruction.

*“Clickers” are personal response devices that allow students to answer multiple-choice questions during class. Answers are recorded and can be displayed in real time (Ref. 9).*

**Teaching as Research Question**

The teaching as research question of this project was the following: *Are the flipped classroom techniques that have been implemented in Physics 207 enhancing student learning gains?* A “flipped classroom” technique is an established instruction style in which much of the initial learning takes place outside of the classroom, which leaves more class time for active student participation (Ref. 1-5). This study sought to determine whether such an instruction style is effective enough in introductory physics courses to merit changing how the course is taught. Defining effectiveness is not simple, so we used multiple evaluation approaches as described below.

**Instructional Strategies and the Delta Pillars**

The flipped classroom elements were the main instructional strategy that we used to help students reach our learning goals. As described above, the technique moves rote learning outside of the classroom, thus saving class time for more interactive activities. Students were assigned online, interactive pre-lectures (produced by the education company smartPhysics – Ref. 15) that largely take the place of in-class lectures. In class, students worked in small groups problem solving, and they were frequently asked to respond to “clicker” questions to gauge their understanding. These questions encouraged students to remain active and engaged during class and encouraged them to teach and to learn from others in the class. The hypothesis was that this peer instruction would enhance learning gains. In addition, the professor responded to student responses and concerns with mini-lectures addressing points of confusion. The TAs were also present in lecture to answer questions as students worked on problems.

This instructional strategy is closely related to two of the Delta pillars: learning communities and learning through diversity.

**Learning Communities**

The interactive format of the class allowed for discussion and encouraged the formation of learning communities. During lecture, groups of students discussed “clicker” questions, which allowed them to gain knowledge from their peers and to share (and thus to solidify) their own knowledge. This peer instruction was meant to foster collaborative relationships that continue outside of the classroom. In addition, while student groups solved problems, the professor and teaching assistants circulated throughout the class, participating and interacting with the students. This encouraged students to become more comfortable exchanging ideas with the teaching team. The goal was for students, teaching assistants, and professors all to learn from one another as part of a diverse learning community.

**Learning through Diversity**

A main benefit of an active, discussion-based learning environment is access to a wide variety of insights. Rather than getting the information from a single, uniform source of knowledge (like a textbook or a professor’s lecture), students were exposed to multiple ways of thinking about the material. These views came from several different sources, including their peers. The idea was that
the diverse information channels provide multiple entry points for learners, allowing students with various learning styles to benefit from the course.

In addition, we worked closely with the Physics Learning Center, which especially seeks to work with non-traditional students and traditionally underserved minorities. This further increased the diversity of insights and also broadened the learning community of the course.

**Evaluation**

Under the broader teaching as research question of “Are the flipped classroom techniques that have been implemented in Physics 207 enhancing student learning gains?”, we had several sub-questions that we investigated:

- Are student usage habits for the online materials correlated with their course grades?
- Are their habits correlated with their performance on the FCI, a standardized physics test?
- Is there a correlation between student habits and their perception of their own learning?
- How do students’ habits change over the course of the semester, and does this correlate with how their grades change over the semester?
- How do students’ gains on the FCI compare with those from students in traditional lecture courses from previous semesters?

In terms of describing the flipped classroom methods, our questions included the following:

- How much lecture time is being used for flipped classroom techniques?
- Does the allotment of time to different activities change over the course of the semester?
- Will any variation in how class time is used be reflected in student study habits?

**Assessment Techniques – Student Assessments**

Student learning gains were assessed based on test and course grades as well as on pre- to post-semester gains on the Force Concept Inventory, a well-accepted assessment tool for introductory physics (Ref. 16). The results were compared to aggregate information from past semesters, in which flipped classroom techniques were not used or were used sparingly. The assessment also included a study of student study habits, as determined by interaction with assigned online content. We know when each student interacted with what material and for how long. In addition, participants filled out surveys about their perception of how different aspects of the course helped them to learn and also about their attitudes towards physics in general. Their attitudes were compared to those of professional physicists using the Colorado Learning Attitudes about Science Survey (CLASS) (Ref. 17).

The course learning goals from the Physics 207 website are listed below along with the primary method of assessment for each goal.

<table>
<thead>
<tr>
<th>Learning Goal</th>
<th>Assessment Method(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>to understand the first principles of Newtonian physics and their consequences</td>
<td>FCI, course grade</td>
</tr>
<tr>
<td>to solve problems using both quantitative and qualitative applications of these physical principles</td>
<td>course grade</td>
</tr>
<tr>
<td>to acquire an intuition for the physical world, including developing estimation skills</td>
<td>FCI, course grade</td>
</tr>
<tr>
<td>to develop observational and experimental skills, especially being able to characterize physical observations quantitatively and to understand their statistical significance</td>
<td>course grade (especially lab)</td>
</tr>
<tr>
<td>to apply physics to topics beyond what is covered by the course</td>
<td>CLASS</td>
</tr>
</tbody>
</table>
Assessment Techniques – Course Assessment

Lecture observations provided an accurate record of how class time was used. One of our internship team members (me) sat in on the lectures 19 times throughout the course of the semester. There were a total of 30 lectures during the course of the semester, two per week for 15 weeks, and I attended roughly one per week. While observing, each minute I recorded the current activity in order to generate a quantitative record of the use of class time. We were interested in how the use of time varied over the course of a semester.

These initial observations focused on classroom activities, and not on student engagement in these activities. However, near the end of the semester, I also attempted to observe student behavior. The criteria for these later student observations were based on previous studies focusing on student engagement (Ref. 18). We hoped to see how student engagement correlated with different uses of class time, especially comparing active and passive learning segments of lecture. These engagement observations were a trial only, and further observation and refinement is needed before any conclusions can be drawn.

Results

The results for this project fall into three broad categories: classroom observations, student performance, and student opinion. A summary of some of the main results follows. The project is ongoing, so all results should be considered preliminary.

Classroom Observation

Figure 1: Classroom Observation

This chart breaks down how class time was used in Physics 207. The data are based on minute-by-minute observations of 19 (of 30 total) lectures. Additional information about how these percentages changed over the course of the semester was also recorded.

Our classroom observations served to provide precise definitions for our version of a “flipped classroom” with “blended learning.” We wanted to avoid the ambiguity of those terms by carefully describing how class time was used. As shown in Figure 1, in our case, “blended learning” meant that approximately 42% of class time involved students actively participating, either solving problems or interacting with the professor. On average, there were 3.0 student questions and 3.8 student contributions (for example, volunteering an answer) per lecture. We also tracked how these percentages changed over time. The most notable result from this tracking was that student questions in class fell off dramatically. Around the halfway point, the average was just below six student questions per course meeting, and then in the second half, only four questions were asked in the last nine class meetings observed.
The FCI results for several physics courses at UW-Madison are displayed on this Hake plot (Ref 4). The x-axis indicates average class performance from the beginning of the semester. The y-axis shows the percentage gain over the course of the semester, as calculated by the difference between averages from the beginning to the end of the semester. Potential gain depends on pre-test scores, and so certain gains are not possible based on initial scores. (The inaccessible area is marked by the grey triangle.) The diagonal lines indicate roughly equal learning gains, and they demarcate regions of low, medium, and high gain (Ref. 4). Course numbers are listed in bold in the legend along with the year of the course. All courses are the first semester of two-semester introductory physics sequences, and they cover similar topics with varying levels of mathematical rigor. Physics 103 is an algebra-based course, and Physics 201 and Physics 207 are calculus-based courses primarily for engineering students and for (non-physics) letters and sciences students, respectively. The result from Physics 207 in 2013, the focus of this study, is shown with an unfilled star.

The FCI, a mechanics concept test, was administered at the beginning and at the end of the semester. The average FCI post-test scores showed a 21% increase over the pre-test scores (an increase of 12 percentage points from a pre-test score of 57% to a post-test score of 69%). The result from the semester studied, Physics 207 in 2013, is marked with an unfilled star in Figure 2 above. As shown, the learning gains from Physics 207 in 2013 are consistent with most results from other introductory physics courses at UW-Madison. These other courses were taught by different instructors using a range of techniques, most of which did not use active learning techniques or used them sparingly. See the caption for further details.

The CLASS gauges students’ “expert-like” thinking and attitudes. It is scored by comparing students’ responses to responses from professional physicists. Physics 207 students in the semester studied showed a 6% shift away from expert-like responses over the semester. This shift away from expert-like thinking, which we perceive to be an undesirable result, has been seen by other CLASS studies of introductory courses (Ref. 19, 20).
**Student Performance – Class Performance**

The smartPhysics online prelecture system provided a tremendous amount of information about how students interacted with the system. We could see how often the system was accessed, when it was accessed, and for how long the students interacted with the system. We searched for correlations between student interactions with the system and classroom performance. Two of the more remarkable results are shown below in Figure 3.

![Time spent using Smart Physics PreLectures](image1)

**Figure 3: Online Interactions and Class Performance**

Displayed are two of plots of correlations between student use of online resources and class performance. On the left, the positive correlation between time spent on prelectures and final grade is shown. Prelectures are the online videos from smartPhysics that students were assigned to view before each course meeting. They cover basic course content, which allows course time to be used for active learning. On the right is a similar, even stronger correlation between time spent on checkpoints and final grade. Checkpoints are short, online quizzes from smartPhysics that students were assigned to test their understanding of the prelectures. On both plots, the horizontal error bars represent the bin size, and the vertical error bars represent a standard deviation for the average grades. The linear fit gives a slope to the correlation, showing how many grade points students gained for each minute per week they invested in the online interaction. (As discussed below, we recognize that this correlation does not necessarily imply causation.) Note that while the y-axis scaling is the same for both plots, the x-axis scaling differs.

Figure 3 displays two types of interaction that were positively correlated with student grades. The correlation is more complicated when explored on a student-by-student basis, but the averages suggest there may be a connection between interaction time and course grades. On average, students who spent more time interacting with the smartPhysics system did better in the course. However, as discussed later, there are a variety of factors that may contribute to this, so we must be careful not to assume that this correlation implies a causative relationship.

**Student Opinion**

Note: An in-depth study of student opinion is beyond the scope of this project. However, as educators, we are interested in how students viewed the course, and we find their feedback valuable. In addition, as discussed below, we believe that gauging and improving student opinion of the course will help to accomplish our learning goals. Finally, we include this information in this report because we believe that other educators interested in the project may be curious about what students thought of the course.
Two groups of students were surveyed about their experiences in the course: the group of students who were enrolled in Physics 207 the semester of the project, and those who had taken the course the semester before. At the time, this second group was enrolled in Physics 208 (the next course in the two-semester introductory physics sequence), and they were asked to compare their experiences in the more traditionally taught, lecture-focused 208 with the flipped classroom techniques that they experienced the previous semester in Physics 207. Noteworthy statistics and comments from the two surveys are shown below.

**Of current Physics 207 students surveyed, …**

… 68% agreed or strongly agreed that the online pre-lectures helped them to learn.

- “it helped me clear up confusion with the subject material prior to class discussion, or at least to show me what I needed to pay attention to if I found a question confusing.”
- “they helped me visualize example problems better”

… 59% agreed or strongly agreed that the in-class clicker questions helped them to learn.

- “kept me on track”
- “made me think”
- “good practice of the material and provided instant feedback”

… 77% agreed or strongly agreed that group problem solving in discussion helped them to learn.

- Discussion section rated as most helpful aspect of the course (8.46/10)
- “Explaining things to others is a good way of solidifying that learning.”
- “I liked working together because everyone had different ideas how to solve the problems”

However, only …

… 43% were glad there was time for problem solving in lecture

- “It felt like a lot … was skimmed over”
- “I would rather have been shown more problems solved and had more in depth explanations”
- Lecture rated as least helpful aspect of the course

… 31% agreed or strongly agreed that they would choose to enroll in another physics course taught in this blended format

- “I can solve problems on my own; my tuition here should go towards actually being taught something”
- “[The prelectures required] Too much time spent out of class that would have [been] much better served doing problems on our own”

**Of the former Physics 207 students surveyed, only…**

… 37% agreed or strongly agreed that the problem solving in Physics 207 lectures helped them to learn better than the more traditional Physics 208 lectures

- “You cannot solve [problems] if you do not understand”
- “I prefer learning the basics and using them in problems on my own”
… 38% agreed or strongly agreed that the group work in Physics 207 lectures helped them to learn better than the more traditional Physics 208 lectures.

- “It is difficult to do group problems in a large lecture where you don't know anyone”
- “It was not efficient enough. Many problems were left incomplete.”

**Discussion and Future Plans**

The revisions made to Physics 207 show signs of positive results, yet there is plenty of room for improvement. The work done as part of this internship project should serve as a solid foundation as we continue making revisions to the course.

From our observations, we now have a good sense of how class time is being used. If we choose to further share our results, we can confidently quantitatively explain what exactly we mean by “blended learning”. This should allow others who wish to do so to replicate our methods. However, there are a few open questions relating to our observations, and things we would like to further explore. We would like to know why student questions decreased dramatically as the semester went on. Was it due to the material being covered, or due to the time of semester, or did students become disillusioned with the course format? We would also like to expand our observations to include student engagement observations. This would give us a fuller picture of which classroom activities are keeping the students engaged and learning. Most importantly, we need to decide if the balance of class time use is ideal. We have discussed attempting to increase the amount of active learning time relative to lecture time. We would like to use class time so as to optimize student learning as measured by our assessments, which so far have shown mixed results, as discussed below.

For standardized assessment, the revisions to the course had no clear effects on student learning. The scores on the FCI and the CLASS were consistent with traditional courses at UW from past semesters. We would like to explore additional standard evaluation methods. A main learning goal of the course is for students to “be able to solve problems using both quantitative and qualitative applications of… physical principles.” We wonder whether there is a more effective, standardized way to evaluate problem-solving ability. The FCI focuses on concepts, and the CLASS is more focused on attitudes. We are currently seeking to find (or to develop) an appropriate standardized measure of problem-solving ability.

For classroom assessment, our results suggest that students who spent more time with the online system did better in the course. The results were not as strongly correlated as we had hoped, but they do show a strong enough positive correlation that we hope to use the data to motivate future students. We are cautious of drawing any real conclusions from the correlation, however, as it is not clear whether the correlation reveals causation. Perhaps the students who interacted most with the system were independently the most motivated, and they would have done well without the system. Perhaps students who understood the material best spent more time with the system because they were able to enjoy it more. We are aware that there are different reasons for the varying levels of interaction. For example, we speculate that there were two very different groups of students who interacted infrequently with the system. One group may have not put in much effort to the course overall, and thus may have done poorly, regardless of the resources available. The other group, by contrast, may have been the highly advanced students for whom the extra guidance was unnecessary. Thus, despite their low level of interaction, they did well. Such factors, which independently affect interaction levels or performance, complicate our search for a direct correlation between the two.

The student opinions were the most negative results we received. While some students appreciated the extra online resources and the time to problem solve in class, a significant fraction of
students had strong negative reactions to the course revisions. Students seemed to appreciate the problem solving and group work in discussion sections, but not in lecture. Such initial negative reactions are consistent with previous studies of active learning techniques (Ref. 5, 9, 21).

Although it is not one of the main objectives, we would like to improve student opinions of the course. Improved student learning is our primary goal, but we believe that students who have a positive opinion of the course and its pedagogical methods will be more likely to put in the necessary time and effort to succeed in the course. In the future, we will strive to establish active learning as the norm in the classroom, which we believe may encourage more students to buy in to the pedagogy. We will strive to do this by making our expectations clear and by more regularly and consistently utilizing active learning during lecture. Also, as described below, we will make our motivations clearer to the students. Others have seen improvement in student attitudes after making such changes (Ref. 21, 22).

As Turpen and Finkelstein have shown, not all attempts at peer instruction and blended learning are equally successful (Ref. 11). While we are pleased with the positive results we have seen, we would like to improve the effectiveness of our blended method. In order to get more students to buy in to the blended format, we would like to more explicitly explain our motivations. This includes more clearly demonstrating to the students the potential benefits that our pedagogical methods have for them. The student population of this course is diverse, so we will attempt to motivate students in a variety of manners in order to reach as many students as possible. At the beginning of the course we will motivate our actions by explaining the positive benefits demonstrated by this assessment, and we will periodically remind students of this motivation. We also hope to incentivize buying in by making the flipped aspects of the course a larger part of the overall grade.* In addition, to encourage more student participation, we would like to make the lecture environment more welcoming. We will try to do this by having the teaching assistants more available during lecture group work and by requiring students to sit with their discussion sections so that they know their neighbors.

As our analysis continues, we would like to more closely examine correlations across different assessments of individual students, rather than just averages. This may provide us with the insight needed to discover possible causative relationships behind correlations. The examination of correlation across different assessments for would also allow us to explore connections between assessments. For example, are students’ attitudes towards blended learning correlated with their learning gains? Are students showing higher learning gains for topics covered using more active learning techniques? Are FCI results correlated with class grades?

The flipped classroom techniques that have been implemented in Physics 207 show promising signs of enhancing student learning gains. We believe that by making the changes discussed above and by continuing to evaluate the effects and to revise our approach, we can improve introductory physics instruction at UW.

* We recognize that this will likely bias student behavior, motivating more students to utilize the online resources. This external motivation will alter student behavior in such a way to complicate further study of the effects of blended learning in the course. However, we are confident that the positive effects on student learning will outweigh any complications added to the study.
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References


18. E. Lane and S. Harris, *Quantifying student behavioral engagement based on teaching practices in a large class*, Improving University Teaching (IUT) 34th International Conference, Vancouver, BC (2009).


21. M. Selen, Professor of Physics at University of Illinois – Urbana-Champaign, co-author of smartPhysics, personal correspondence (2013).

Artifact 1 Reflection: Delta Internship Project Report Summary

Internship Experience and the Delta Pillars

My Delta Internship did not radically change my perspective on the Delta pillars of teaching as research, learning through diversity, and learning communities. Although there were no shocking revelations, the experience was still invaluable because of the practical experiences that I gained dealing with the pillars as they relate to concrete educational issues. Delta coursework and workshops have helped me to understand the pillars, but there is no substitute for experience dealing with actual unresolved instructional challenges.

My Delta Internship has been by far my most rigorous venture into teaching as research. In explicitly thinking of teaching as research for the project, I have found that I asked a lot of the same questions that I normally ask when I think about teaching, such as, “How can we most effectively use our time?”, and “Is this practice enhancing student learning?”. My internship has made me realize that I often informally engage in teaching as research, even if I am not explicit about it. However, the experience has also made me appreciate the complexities involved in teaching as research. I have learned that it can be a difficult task to answer seemingly simple questions about learning.

My project focused on assessment, and I have come to realize just how multi-faceted and difficult-to-grasp assessment can be. Our teaching as research team struggled to find proper assessment tools. For a proper assessment of an instructional technique, I have learned that you must decide on clear and specific assessment goals. You must thoughtfully define learning goals and consider assessment tools in order to find the tool that best answers your specific teaching as research question.

On a more personal level, I have learned to better accept the (perhaps inevitable) disappointments that accompany progress toward educational reform. I have seen well-founded plans, based on solid educational research, fail in practice. This highlights the importance of reflection, revision, and perseverance in the teaching as research process. I have also seen students resist, sometimes quite viciously, well-intentioned changes that are meant to help them. Approaching teaching as research not only can help to develop courses that optimize learning gains, but it can also help to gauge (and hopefully to make more positive) student attitudes towards course material and towards learning in general.

The pillar of learning through diversity was evident in my internship project, both for me and for the students in Physics 207. For me, it was an opportunity to work with people with a wide range of specialties. Within my internship team, I explored educational issues with an experienced professor and a fellow grad student who is a former high school teacher. We all brought different knowledge to the group. For example, the professor has years of teaching experience in introductory physics. The grad student, in addition to his teaching high school teaching experience, is an expert in working with large data sets like the ones generated by smartPhysics. I shared my perspectives that I have gained through my experiences with Delta. I also shared the thoughts of my fellow Delta interns, who, coming from other disciplines, shared unique and valuable insights. The guidance and advice of Don Gillian-Daniel, Christine Pribbenow, Matt Hora, and Lil Tong, all of whom have expertise in fields with which our team has little experience, also complemented the knowledge of our internship team.

While it was an asset for our team, diversity in the Physics 207 student population was a challenge. As in any classroom, the diversity of students’ problem-solving speed and skill left some students struggling to keep up while others were frustrated by the slow pace. A more subtle challenge was that some students chose not to, or were not able to, benefit from the small group work. Certain
students remained isolated, perhaps in some cases because of their gender or race or cultural backgrounds. We are concerned that some segments of the population were not well served by the new format of the course. As the study continues, we would like to determine if this instructional style is unintentionally excluding some segments of the population.

Addressing isolation, or any student concern, is a challenge in a diverse classroom because certain students will loathe instructional practices that others love. We saw such divided opinions in our student surveys. Adding to the complexity of the problem, loathing a technique is not necessarily correlated with lack of learning, nor is loving a technique necessarily correlated with learning.

Different students learn best from different learning techniques. What is beneficial to one student is not necessarily beneficial for all students. For this reason, one of the main goals of the redesigned course was to create a more diverse learning environment for students. We emphasized group work in Physics 207. Beyond the professor and TAs in lectures and discussions, the students had their peers serving as additional instructors. This diverse group of instructors was complemented by a number of different modes of instruction, including lectures, online pre-lectures, and problem-solving exercises. We attempted to provide students with multiple paths to access the material. Our goal was to reach as wide of range of the diverse student population as possible.

In the context of this project, the pillar of learning through diversity was closely tied to that of learning communities. As with learning through diversity, the pillar of learning communities was reflected both in my experiences and in those of the students in 207. The internship project was a true collaborative effort, with all members of our internship team contributing suggestions, drafts, and feedback, both on the course and on the assessment effort. Our internship team, nominally three people, grew into a larger, diverse learning community. We benefitted not only from the feedback of my fellow interns and the guidance of the experts mentioned above, but also from working with the TAs from the course and with the Physics Learning Center staff. Working with this diverse group with a wide range of perspectives has undoubtedly generated a wider range of ideas than our team could have generated without the help of this larger community.

For students, the group work in the course was intended not only to enable peer instruction during lecture, but also to encourage students to work together outside of the classroom. One goal is that the in-class collaboration helped to break down barriers that may have prevented diverse groups of students from forming their own learning communities.

In addition, we wanted students to be connected to the larger community of the professor, the TAs, and the internship team. Student feedback further increased the diversity of perspectives that contributed to the project. We solicited feedback both informally and through formal channels, such as discussing submitted student concerns during lecture and meeting with a student “board of directors”. We attempted to keep them informed about the rationale behind the instructional methods used in the course. We also incorporated some of their suggestions in class. In doing so, we invited the students to join and to diversify the discussion, which contributed to the goal of increasing learning.

My work with the Delta Internship has increased my understanding of the Delta pillars of teaching as research, learning communities, and learning through diversity. I still have much to learn, but I have improved my comprehension of the pillars through valuable real-world experiences. Like the study that has expanded beyond a single semester, my understanding of the Delta pillars will continue to grow as I continue my career as an educator.
**Learning Communities:**

*Creating a community of graduate students, postdoctoral researchers, and faculty through collaborative activities and programs*

My teaching philosophy emphasizes the importance of acting as a facilitator in the classroom, bringing many different student voices into the discussion. I try to make the classroom a learning community, where everyone contributes and works together towards common goals. This reflects the Delta pillar of learning communities. Delta strives to bring together a group of educators who care passionately about improving STEM teaching and learning. Members of this community help and support one another, and this serves to increase and to spread the positive effects of individual efforts.

In this section of the portfolio, I highlight two learning communities that I have been a part of during my time at UW. One is a learning community of science educators with whom I have collaborated, and the other is a learning community of undergraduate students that I had the opportunity to facilitate.

* Delta Program Website, http://delta.wisc.edu/About/delta_pillars.html
Artifact 2 Background: College of Letters & Sciences TA Training Workshop Outline

In 2013, I was honored to be nominated by the UW Physics Department for a UW College of Letters and Sciences Teaching Fellowship. I was then selected for the fellowship by the College of Letters and Sciences, and as part of the award, I facilitated a workshop during the College’s Teaching Assistant Training in the fall\(^1\). The training is aimed at new TAs in the College, but new and experienced TAs from all UW schools and colleges are welcome. The goal of the workshop is to introduce TAs to both teaching at UW and to good teaching practices.

As a teaching fellow, I designed and then led a small group workshop on how to lead a natural science discussion section. I facilitated my workshop twice, each time with around 10 new TAs from different disciplines. I shared my thoughts on teaching, but I also wanted to make the workshop a learning community, so much of the time was spent discussing aspects of teaching in small groups. Artifact 2 is the outline of my plan for the workshop.

\(^1\) UW College of Letters & Sciences, TA Training Website, http://www.ls.wisc.edu/ta-fall-training.html
Artifect 2: College of Letters & Sciences TA Training Workshop Outline

They May Not Think Like You Do, and That’s Okay:
Teaching a Natural Science Discussion Section

10:10-10:15 (11:20-11:25) Ice Breaker
- Partner or group of three (join one)
- Introduce name, department, undergrad institution
- Go around, introduce partners
- (kind of nervous, feel free to ask questions)


You have teaching tips in your packet, and I’ll share mine later, but first talk about your experiences to come up with some of your own advice.

- Diverse group, lots of experiences
- Share some, come up with generalizable tips
- Grinnell – one of biggest moments was when I realized I couldn’t just sit down and do homework
  - needed help, friends and I started our “own discussion groups”
  - really helpful, sometimes still needed more guidance, but way more than could do alone

Think about valuable experiences in your science classes. Hard to understand moment, but then you had a break through. Not the subject that is important, but what did you do / what changed that cleared things up?

10:18-10:21 (11:28-11:31) Thinking alone
- Think about it quietly, maybe jot down a few examples (circulate)

10:21-10:30 (11:31-11:40) Small Groups
- Share with partners (different from before) look for commonalities.
- What did or could instructors do to help your learning?
- Come up with two main things instructors could (or shouldn’t) do. (circulate)

10:30-10:40 (11:40-11:50) Big Group
- Share main things on board with everyone.
  - (All these might not work for everyone, so ok if contradict)
  - (take only as many as you have time for)
10:40-11:00 (11:50-12:10) My Thoughts

- questions, comments, clarifications, want me to write anything down, feel free to interrupt

TAs – know stuff, want to just show and tell students how to do stuff
- “When students come for help, rather than showing them how to do it, it’s easier to just do it for them.”
- ?? Most of your experiences were active, you doing stuff yourselves
- Discussion sections should be about student and not about the TA

What does the TA do, then?
- Facilitate group work and elicit student contributions
- Maintain organization and highlight and clarify key concepts
- Provide structured, supportive environment

Cede control, willing to adapt
- Need broader understanding, lots of preparation (not the lazy way out)

With TA in this role, students need to actively contribute
- Set precedent for this early, make expectations clear
- Students have diverse backgrounds
- Prepared to explain things, even things you take for granted
- Ways of thinking, references will be different (not only “you’re old”, but that’s part of it)
- Something that is obvious to you may be difficult to explain (fractions?)

Peer instruction
- similar knowledge base, so explanation
- (frustrating, saying the same thing you are!)
- Might benefit from hearing from someone who recently struggled with same thing
- Students benefit from teaching each other

Adds different perspectives
- More entry points, different things work for different people

Mirrors scientific world
- Collaborators with different strengths contributing and complementing each other

Different from lecture
- Lecture, lab, discussion
- Student to teacher ratio
- Get their hands dirty
- Learning comes from working problems for yourself
- (professor does it – makes sense, got home, no idea on HW)
Limit amount of lecturing
- Allow them the practice, discuss, and question
- Less intimidating than lecture, encourage questions
- (admit mistakes and lack of knowledge, students don’t feel need to be perfect)
- (like leading a discussion about teaching)

One model of student centered discussion: Problem-Solving

Short overview of material (few minutes)
- Ask them for (even small contributions)

Give them a problem
- Don’t make up own, plenty of resources available
- Tough, but not frustratingly so (have to judge, adjust as you go)

Individual reflection time
- Get started on own
- This is how tests will be
- Allow time to think, more likely to speak up later

Small group
- Join with neighbors, discuss progress, compare ideas
- Less intimidating than large group, build confidence
- Form groups if students are isolated, mix up groups throughout semester

TA circulates answers questions, checks on progress
(some groups may be hesitant to ask questions, so ask what they are working on)

Large group discussion
- Come back together as large group
- Solve together, soliciting contributions from different groups (ask ahead of time?)
- Mini-lectures by clarifying student contributions
- Students to explain / justify assertions, often helps catch mistakes

Encourage questions throughout
11:00-11:10 (12:10-12:20) Questions and Additional Tips

- Any questions?

Additional General TA Tips

- Acknowledge your mistakes and admit it when you don’t know something.
  - It is better to say, “I’ll have to get back to you on that” than to make up an answer.
  - This can encourage students to admit when they are confused, which they may be hesitant to do.
- There is no need to start from scratch.
  - Professors and especially experienced TAs are great resources.
  - Others in the department and university are interested in teaching and willing to help.
  - Many great resources available online, elsewhere in university and department.
- Get to know the students.
  - This helps you understand what they don’t understand about the material.
  - Friendly conversation before and after discussion can help students to feel comfortable, which can make them more willing to ask questions and participate.
- Be encouraging and stay positive, even when the students are not.
  - Don’t put down the teacher or the course.
  - Even if students choose not to continue in the field, if they leave with a positive view of science, that can still help.
- Experiment and find a style that works for you and your students. It’s not the same for everyone.
Artifact 2 Reflection: College of Letters & Sciences TA Training Workshop Outline

My workshop during the College of Letters and Sciences TA training was a learning experience for me, and I hope that it was for the attendees as well. It was a great opportunity for a group of educators to come together as a learning community to share ideas. The participants seemed comfortable sharing their ideas during the workshop, as many expressed their anxieties about teaching. The workshop provided a supportive forum for participants to express their concerns and to ask advice of others.

I wanted to model active learning and student-centered teaching practices, so only about a third of my workshop was me talking about my experiences. I wanted the participants to actively contribute and to discuss things as a learning community, rather than to passively record my thoughts. I hoped that this would engage students, and based on the vigorous discussions, it appeared to work. I also wanted to make the workshop as useful as possible for the participants, so I scheduled most of the time for their questions and concerns. This modeled the importance of listening to student questions and concerns and revising plans accordingly. The two sessions that I facilitated, although guided by the same outline and ostensibly identical, ended up covering different topics. This is because the students in the different sessions (and even in different groups within a session) chose to discuss different topics, those topics that were most relevant to them.

Another reason that I chose to allow participants to steer a majority of the workshop is because a learning community can generate a wider variety of perspectives and opinions than can individuals. Teaching is challenging, and even those of us who have teaching experience still do not have all of the answers. I could not have satisfactorily responded to all of the participants teaching questions, but, working together, the group discussions appeared to help calm the participants’ anxieties. With all participants sharing their perspectives and opinions, everyone had more ways to look at teaching challenges. This is especially important in education because there is no single correct teaching method that works for everyone. Hopefully participants were able to weigh the alternatives offered by the community and to choose approaches that have improved their teaching.

I think the workshop went well, but after getting feedback from participants, I would change one main aspect of the workshop if I were to facilitate it again. I should have sought out more information on the rest of the training the participants were receiving. If I had, I would have discovered that the training did not cover the basic mechanics of teaching. If I were to offer this workshop again, I would be sure to devote some time to the basics (What happens during a discussion section? Who decides what material to cover?), in order to provide a foundation before moving on to higher-level challenges of teaching.
Artifact 3 Background: Group Learning Tutorial from the Physics Learning Center

The Physics Learning Center (PLC) at UW is an academic support service for students enrolled in introductory physics courses\(^1\). The PLC provides study materials, review opportunities, and small group learning sessions for students seeking extra practice with physics problems and concepts. The PLC strives to be a supportive learning environment for all students, especially seeking to cater to underserved student populations.

I have worked with the PLC in several capacities throughout my time at UW. I have done small and large group tutoring for several introductory courses, and I have worked as the PLC teaching assistant. In my semester as a teaching assistant, among other responsibilities, I facilitated small group learning sessions. In the bi-weekly meetings, we discussed concepts from the course and worked on practice problems.

In order to aid our discussions, we often used tutorials developed by PLC staff member Larry Watson and the rest of the PLC personnel. The tutorials require students to interact with the material in a variety of different ways. By presenting the material in several ways, usually different than those that students see in class, the tutorials provide multiple “entry ways” for students with different learning style preferences. The tutorials are editable, which allows for continual revision by the PLC staff as they reflect on how well students are learning from and responding to the material. Artifact 3 is an example of a group learning tutorial that I used with my small group in the PLC.

\(^1\) University of Wisconsin Physics Learning Center Website, http://www.physics.wisc.edu/plc/
Artifact 3: Group Learning Tutorial from the Physics Learning Center

Friction Tutorial
Static

This friction tutorial is designed to help you sort out some aspects of friction that have been shown to cause difficulty for students. This first page considers the "Not Sliding" (static) case.

Box remains at rest and throughout this page, \( \vec{a} = 0 \), \( \vec{F}_{\text{net}} = 0 \)

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1) Draw a free body diagram of the box before Paul starts pushing on it.
   a) Is there a friction force on the box? Explain.

2) Draw a free body diagram for the box while Paul pushes with a force of 5 Newtons. The box remains at rest.
   a) Is there a friction force on the box? Explain.

   b) How many Newtons is it and which way does it point? How do you know?

3) Draw a free body diagram for the box while Paul pushes with a force of 8 Newtons. The box remains at rest.
   a) Is there a friction force on the box? Explain.

   b) How many Newtons is it and which way does it point? How do you know?

As Paul pushes on the box a crate of identical mass is placed on top. Paul continues to push with a force of 8 Newtons as before.

4) Draw a new free body diagram of the lower box. Hint: The 3rd Law, with a FBD of the crate, is useful.

Does the length (size) of \( \vec{F}_{\text{net}} \) depend on the Normal force the floor puts on the box, \( \vec{N}_{\text{floor}} \)? Explain.

14 February 2011
Artifact 3 Reflection: Group Learning Tutorial from the Physics Learning Center

Tutorials such as the example above were particularly well-suited for forming learning communities within the student groups. The tutorials are designed to help students to break down problems and concepts into smaller, more manageable parts. Not only does this aid student comprehension, but it makes it easier for students to compare and to discuss results. Often students are asked to draw diagrams, as they are above, which makes it easy to quickly check their understanding by comparing diagrams with their neighbors. Also note how the tutorial repeatedly asks students to explain their work. The tutorials are intended to encourage students to compare answers, to discuss difficulties, and to explain concepts to one another.

Students seemed to appreciate the format of the tutorials. The tutorials contrasted with some of their homework assignments, which posed questions without context or guiding narration. Many students appreciated the tutorials’ step-by-step format, which presented them with many opportunities to interact with the learning community. They often would turn to their neighbor and say, “What did you get for this part?”, or “Why does my diagram look different than yours?”. It seemed easier for them to talk to one another when they could reference specific parts of the problem, rather than just saying, “I don’t know how to start #3.” This step-by-step, easy-to-compare nature of the tutorials, along with the friendly, small group atmosphere helped to grow a strong community of learners.

The group format used for the PLC study sessions is also conducive to forming a learning community. The PLC provides a “built-in” learning community for its members, and that is one reason why the PLC especially reaches out to students who may otherwise be isolated. The groups are essentially the same each week, and there are no more than eight students per group. I strove to make my group meetings comfortable and safe learning spaces, encouraging all students to participate and to ask questions. I stressed that it was ok to be wrong and that we were there to practice and to make mistakes so that we could learn.

I believe the method in which I used these tutorials was successful. I would allow students to work on their own for a few minutes to familiarize themselves with the material. I found that this allowed some of the more introverted students to gather their thoughts so that they were more likely to speak up later. I then had students compare with their neighbors, and this collaboration and peer instruction served not only to help improve understanding, but also to improve students’ confidence with the material. Finally we would come together as a group and discuss the tutorials. I would ask different students to contribute so that the learning community would benefit from hearing multiple perspectives.

The tutorial format was successful, but not without challenges, however. One challenge of using the tutorials is the different speeds at which students work through the material. Some students who worked quickly would gladly help others who were working more slowly, but others were less likely to do so. One way I would like to try to improve this is to convince all students that peer instruction benefits everyone in the learning community, both the learners and the instructors.
Learning through Diversity:
Recognizing the common challenges in teaching and learning and the strength in bringing together diverse views*

In my teaching, I strive to allow everyone to contribute, as I believe that learners benefit from hearing a wide variety of perspectives. There are many types of diversity in the college classroom, from different majors to different cultures to different learning styles. All students have something unique to offer, and a diverse group of students can provide a diverse group of ways to approach problems and concepts. This benefits the entire group of learners, as the more access points that one has available, the more likely it is that one can arrive at understanding. This is the idea behind the Delta pillar of learning through diversity. To address challenges in teaching and learning, Delta advocates bringing together people with a wide range of backgrounds and specialties in order to take advantage of their broad and varied knowledge and skill sets.

In this section of the portfolio, I display artifacts from two experiences that I have working with others whose backgrounds and experiences are different than my own. I discuss how I benefitted from working with a diverse group of educators and how cross-generational collaboration has helped me to become a better teacher.

* Delta Program Website, http://delta.wisc.edu/About/delta_pillars.html
Artifact 4 Background: UW Teaching & Learning Symposium Poster

Each year, UW holds a Teaching and Learning Symposium. At the symposium, a wide variety of members of the UW community come together to discuss challenges and innovations in teaching and learning. Faculty, staff, post-doctoral researchers, and graduate students from numerous departments across UW have the chance to meet with others who care about quality teaching. Attendees share ideas, ask questions, and discuss challenges. The event encourages collaboration between its diverse attendees and provides a supportive environment for those seeking to improve teaching and learning at UW.

The symposium features plenary speakers, networking opportunities, breakout sessions, and poster sessions. All of these provide avenues for members of the UW community to share their work with a diverse group that they might otherwise not encounter. Along with my project partners Professor Peter Timbie and Jake Feintzeig, I helped to prepare and to present a poster on the preliminary results of my Delta Internship project for the 2013 symposium, which focused on innovative teaching and learning methods. Artifact 4 is a copy of the poster from the 2013 UW Teaching and Learning Symposium.

1 University of Wisconsin Teaching and Learning Symposium website, http://tlsymposium.wisc.edu/
Blended Learning in a Large Introductory Physics Class

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Introduction
We transformed Physics 207, ‘General Physics,’ into a ‘blended’ classroom in the 2012-2013 school year. Other institutions have found significant learning gains in courses with increased student engagement in lectures [1]. We assess the impact of this style on student learning at UW.

The course:
• 1st semester of a 2-semester intro to physics, w/ calculus, 5 credits
• req’d for many science majors: AOS, Genetics, Zoology, etc.
• 350 students in the fall, 130 students in the spring

Learning goals:
• Develop critical thinking & problem solving skills
• Learn basic physical principles
• Make quantitative measurements & understand uncertainties

Assessment:
• Force Concept Inventory (FCI) pre/post test of concepts
• Colorado Learning Attitudes Toward Science Survey (CLASS)
• End-of-semester course evaluation & survey

Blended Course Set-up
Traditionally, P207 includes two 50-minute lectures from the professor per week, two 50-minute discussion sections led by a TA, and one 3-hr lab. Readings and problems come from a traditional, encyclopedic physics textbook, and homework exercises are done online.

With the blended format, students complete an online pre-lecture (~20 minutes) and reading quiz before each class. Lecture hours are a mix of teaching on the board and clicker questions/peer instruction. During lecture, students solve problems alone and in groups, with help from TAs and the professor. The large textbook is replaced by a shorter booklet that matches the online pre-lectures.

Figure 1: Use of class time in the blended-format lecture periods. On average, 42% of class time is spent with the students actively engaged with the material or the professor.

Figure 2: Student interactions with the online system over the semester. They complete pre-lectures and quizzes 2x/week. Optional homework questions were most used before exams. 150,000 interactions were collected over the semester.

Figure 3: Assessing Learning Gains
We assess student learning using standardized tests and surveys (FCI, CLASS). These are given at the beginning and the end of the semester, and the change in performance is compared to other classes.

The FCI is a mechanics concept test. The average FCI score showed a 30% increase over the semester for the fall 2012 class. This is consistent with learning gains measured by similar, traditional format physics courses at UW.

The CLASS survey measures “expert-like” thinking by measuring attitudes about physics and comparing students’ responses to responses from professional physicists. Students in the P207 (Fall ’12) showed a 6% shift away from expert-like responses over the semester. This is consistent with results from traditional lecture classes at other universities.

Student Use of Technology
Nearly every click a student makes using the course technology is recorded. This includes time spent watching online pre-lectures, answers to in-class clicker questions, and performance on online homework. We use this data to evaluate how students use each course component.

Student Opinions on Course
68% agreed or strongly agreed that the online pre-lectures helped them to learn.

59% agreed or strongly agreed that the in-class clicker questions helped them to learn.

77% agreed or strongly agreed that group problem solving in discussion helped them to learn.

Discussion section rated as most helpful aspect of the course (8.46/10)

However only...
43% were glad there was time for problem solving in lecture

31% agreed or strongly agreed that they would choose to enroll in another physics course taught in this format.

Outlook
After introducing a blended classroom format to P207, we have found mixed results. Students generally use the online materials, but as measured by the FCI, we do not see increased learning gains compared to more traditional classes. Student opinions on the new teaching techniques are mixed.

Future Goals
- Incorporate TAs more in lecture
- Encourage more student participation
- Analyze online data for correlations between use and performance
- Explore other assessment tools focused on student problem solving skills

- In light of results, continue to improve course for Fall 2013

References
Artifact 4 Reflection: UW Teaching & Learning Symposium Poster

The Teaching and Learning Symposium was my first experience at a cross-disciplinary academic conference, and I found it to be a very supportive environment with a wide range of attendees. Unlike at some disciplinary conferences that I have attended, almost everyone who visited our poster was positive and seemed sincerely interested in what we were trying to do. Although many people had questions or suggestions, no one seemed to be looking to aggressively challenge our methods or motivations. No one seemed to be boasting about (or trying to intimidate us with) their knowledge of the field. The encouragement offered by this diverse learning community was heartening.

I was able to talk about my poster with a wide variety of people at the symposium. I talked to undergraduate students, fellow graduate students, post-doctoral researchers, staff members, and professors. I spoke with a few people from the physics department, but mostly I spoke with people from other science departments, and I spoke with a few from outside the sciences. It was a great opportunity to connect with people with whom I would not normally come into contact. Without the symposium to bring this diverse community together, making these connections would have required much more time and effort, and I am not sure that I would have had the opportunity to do so.

It was very helpful to be able to share ideas with a wide range of people at the symposium, both receiving suggestions and giving advice based on our experiences. For example, we received advice on how to get more students to buy in to blended learning, and we shared our experiences getting approval for human subjects research from the Institutional Review Board at UW. Several people with whom I spoke at the conference were trying or had tried innovations similar to our project, so speaking with them was especially helpful. Interaction with this broad cross-section of college educators gave us a range of fresh, outside perspective on our teaching as research question. It was also nice to have the perspectives of people from different points in their careers. In addition to advice from seasoned professors, we received input from an undergraduate student who was currently enrolled in the course that we were studying. We also obtained technical advice from information technology staff.

It is encouraging to be around such a large group of people so motivated to improve higher education. It is reassuring to know that there is a diverse community of educators with a wide set of skills who are working toward common goals. This makes the challenges of teaching seem more tractable. More concretely, the experience put us into contact with a diverse group, from engineers to information technology specialists, with whom we may collaborate in the future.
Along with its many courses covering a wide range of disciplinary topics, the physics department at UW offers several courses with broader professional development objectives. One of these courses is Physics 603: Teaching College Physics. This workshop-style course is intended for graduate students and advanced undergraduates who have an interest in improving their teaching abilities. In the course, students work on their presentation skills, practice creating tutorials, work on improving laboratory instructional materials, and debate issues in physics education.

The final project for the course is to pick a topic of interest in physics education, and then investigate it in detail. Students research the literature to find out what is known about the topic, and then they talk to current physics faculty or staff with relevant expertise. For my final project, because I am interested in exploring proven alternatives to lecture-based instruction, I looked into factors that keep physics instructors from implementing research-based teaching strategies. As a part of my project, I talked to Professor Robert Cadmus of Grinnell College and Professor Peter Timbie of UW. Both professors had made significant changes in courses, implementing lecture alternatives as a part of their teaching. Artifact 5 is an excerpt from this final project, the section of my report that summarizes what I learned from Professors Cadmus and Timbie.
Peter Timbie at UW-Madison is one physics professor who has overcome some of the barriers described above in order to implement research-based instruction techniques. He recently explained to me what he has already done in his introductory Physics 207 course, what he plans to do, and what has impeded his innovations.

Professor Timbie has been working on implementing research-based instruction techniques for years; the changes have been incremental, and how he has taught the course has evolved over time. He began by implementing clicker questions into his normal lecture, trying to make the course more interactive. Students received extra credit for answering the questions, regardless of correctness. He received a “huge positive response” to this. Not only did attendance increase (possibly motivated by the extra credit), but Professor Timbie felt that his students thought the questions were fun. However, there were some problems with this approach. He had some trouble integrating the interactive clicker questions with his regular lecture. It took more class time and was disruptive to the class flow. He felt he didn’t have time to do both interactive activities and regular lecture due to the considerable amount of content that he was expected to cover. Professor Timbie tried assigning students more reading so that there would be less that needed to be covered in class. However, this failed, as he felt that the students didn’t do the assigned reading (as evidenced by quiz scores and clicker questions). He received extremely negative comments about [the assigned reading] as well. On one end-of-semester evaluation, a student wrote that the Professor Timbie’s “massive salary was wasted,” as he “didn’t actually teach anything.” [*]

Professor Timbie said that part of what motivated his most recent, more significant changes in his 207 course was an article shared with him by Jim Reardon [Director of Instructional Labs at UW]. The article, by Deslauriers, et al., focuses on an example of improved learning in a large-enrollment physics class [Ref. 1]. Based on these and other results, he plans to almost completely eliminate lecturing for next semester. Class time will be used almost exclusively for interactive group activities, with the professor and TAs circulating throughout the room as students work through problems and tutorials. In place of in-class lecture, students will be expected to watch short online lectures from Smart Physics outside of class [Ref. 2]. There will be accompanying quizzes to incentivize this activity. Professor Timbie hopes the interactive nature of these online mini-lectures will keep students’ attention better than assigned reading would. The course text will be a compact, inexpensive textbook from Smart Physics that is coordinated with the interactive video series. This text focuses on concepts, as opposed to the current text, which Professor Timbie describes as an encyclopedia of example problems.

Professor Timbie will enact these changes for the first time in the fall, although he has been considering changing the way he teaches for a long time. Why did it take so long? Professor Timbie identified several obstacles that kept him (and he suspects others) from innovating and trying different teaching techniques. First of all, lecturing is the easiest thing to do, and some instructors truly enjoy it. They have always done it, and some are very good at it; they give well-organized, entertaining lectures. In contrast to the assertions of Henderson and Darcy, Professor Timbie speculates that some instructors simply do not know that they could be doing better in terms of student learning. Furthermore, changing how you teach requires more preparation time. It is easier to simply use the notes and PowerPoint slides that you already have made rather than innovating and adapting to research-tested methods. Before deciding on Smart Physics, Professor Timbie had been planning on recording his own online mini-lectures. He eventually decided against that because of the time and
technical skills that would be required to create comparable interactive online lectures. In addition to preparation time for materials and planning, interactive classes require instructors to be prepared to think on their feet. Professor Timbie pointed out that when students have more input, topics are more open, and class-time is less structured. Therefore instructors necessarily cede some control, and “derailing” is more likely, so instructors need to be ready to answer a broader variety of questions.

In addition to the amount of additional preparation necessary, Professor Timbie noted several other factors that discourage changing how physics courses are taught. It is difficult to make changes alone, even if the department is supportive. Professor Timbie needs to ensure that the new instruction techniques will adequately prepare his students for Physics 208 and other classes (which may use vastly different instruction techniques and have different evaluation standards) and standardized tests. He says that coordinating with other professors can be difficult, especially in classes with multiple sections. He likened making a change in a class like 103 or 104 to “turning an aircraft carrier.” There is a lot of inertia, and changes come very slowly. Some obstacles are specific to the type of changes that Professor Timbie plans to implement. The large class size means that he cannot, as he had originally hoped, utilize the Wisconsin Collaboratory for Enhanced Learning (WisCE) an on-campus resource that “combines deliberate choices of physical environment” in order to encourage “peer-collaboration and self-paced learning” [Ref. 3]. Also, scheduling TAs will be more difficult, as they will be required to be in attendance both for class and for discussions. Finally, Professor Timbie wishes he had a definitive measure of evaluation for his new approach. He lacks an absolute evaluation that would allow him to compare student results from year to year. He believes that demonstrating results with such a tool would help him to convince others to adapt more research-based instruction, which would remove some of the obstacles described above.

Professor Robert Cadmus recently retired from active teaching in the physics department at Grinnell College in Grinnell, Iowa. Like Professor Timbie, Professor Cadmus changed how a physics course was taught in order to implement more research-based instructional techniques. I had Professor Cadmus for Physics 337, Optics and Other Wave Phenomena, an upper level undergraduate lecture and lab course. His Physics 337 class was taught in a style very different from any physics class that I had had before or have had since. Professor Cadmus says that he changed how he taught the class for two main reasons. First, he wanted students to be more engaged in class. He also wanted to reduce what he saw as a “waste of class time conveying information in inefficient ways.” He sees this second reason as being related to increased engagement. Professor Cadmus describes students in a typical physics class as stenographers, copying down notes verbatim without paying attention to what they are writing about. The students decide (and I can relate to this feeling) that if they have good notes, they can figure out the physics later. Professor Cadmus wants to engage students in class, to encourage them to participate and to begin to digest the information during class time.

Like Professor Timbie, how he has done this has evolved over many years. First of all, instead of copying his own notes on the board each class period, he distributes a full set of notes at the beginning of the semester. These same notes are projected on a screen each class period as he discusses them. Professor Cadmus feels that, without the burden of note-taking, students can pay more attention and have more time for digesting the material. The notes are very meticulously organized and complete, including figures, and they serve as the primary “text” for the class. Students are expected to read an assigned part of the notes before each class period. There are reflection questions to help the students focus on the main ideas of each reading assignment. Students do not turn in responses to these questions, but they are expected to e-mail Professor Cadmus before each class meeting with two or three clarification questions about the reading and two or three other
questions about the subject material or a related topic. These questions are graded (a completion grade), and they are meant to both reinforce the reading requirement and to “warm up” the students to the topic. Professor Cadmus feels he can go more quickly through the more “straightforward” parts because he knows that everyone has seen the material in the reading. (More accurately, he knows that almost everyone has seen the material. Some students never or rarely participate in the question e-mailing, and he finds that those are often the students that struggle in his class.) From the questions, he also knows what parts of the material students are struggling with the most. Each class begins with a dialogue with the students. In the first fifteen minutes of each fifty minute class, Professor Cadmus discusses common or particularly insightful questions that students have e-mailed him about the reading. He also later pays special attention to any topics that students indicated as confusing.

Professor Cadmus seems very pleased with the results of these changes, though he admits that he does not have a lot of hard data to demonstrate the effectiveness of the technique. He does not have survey data collected from students, but from in-class reactions and evaluations, he feels that students are “happy enough with the scheme.” Except for the previously mentioned fact that some students failed to participate in the e-mailing portion, he has never had any serious problems with student resistance or hostility to the changes. (I enjoyed the change of pace that the class offered, and I think I learned as much or more from his method than I did in other physics classes. For the most part, I think my friends had positive reactions to the instruction, except for some minor grumbling about the e-mailing requirement.) Judging by exam performance, Professor Cadmus says that students did just as well or better with the new format than students from before he made the changes.

These positive results were not easy to achieve. Professor Cadmus mentioned several obstacles that delayed the implementation of these changes and kept him from further innovating. He mentioned access to the necessary technology as one possible obstacle, but he did not consider this a major concern. It also took time to learn how to properly gauge student understanding of the material. He said that it takes discipline to not go through the material, which the students had already seen, too quickly. There is also a danger of not taking advantage of the opportunity to “wallow” in some ideas in a way that makes them clearer. The student e-mail questions that were assigned for each class period were due just one hour before class. Professor Cadmus says that reading and preparing responses to student questions right before every class was “a bit of a hassle”, which may be an understatement. However, he insists this formative assessment and the feedback he received was “worth the effort.”

There was one obstacle that kept Professor Cadmus from implementing a similar comprehensive research-based scheme in all of his classes. That “big obstacle” was the generation of a set of notes for the class. Making a complete, original, illustrated set of digital notes with guided reading questions was a “monumental task that took years to accomplish.” Since he had earlier notes on the topic, he says that the text was “pretty easy,” and the equations were not “so bad,” but the original digital figures are “a killer.” However, Professor Cadmus insists that these troublesome figures were essential for completeness, so he did not want to leave them out. After years of work, he had a useable set of notes, and things got much easier. However, he still made around 100 changes to them each time he taught the class, so there was still significant work to be done. The fact that the notes were digital made making changes easier.

Like Professor Timbie, Professor Cadmus did not encounter any institutional barriers, though he did not encounter much institutional support, either. He claims that “nobody really knew or cared” what he was doing in the class. This could be positive, in that there was no institutional barrier standing in his way, but it can also be negative. Professor Cadmus is retiring from active teaching, and since the department did not closely follow what he was doing, he speculates that the class “may never
be taught this way again.” However, I am pleased to say that Professor Cadmus, prompted by his response to my e-mail about this project, is now planning on discussing his instructional techniques at an upcoming Grinnell College faculty teaching poster session.

References

* [Note added for portfolio.]:

When I originally created this artifact, I did not thoroughly research the circumstances surrounding this comment. I have no hard evidence that this type of comment was unusual for Professor Timbie (or for any large lecture course professor). However, he mentioned this comment in the context of student resistance to changes aimed at incorporating active learning techniques, so I suspect it was related to the particular format of the course. Moreover, the fact that Professor Timbie remembers this comment years later suggests that it stood out to him, perhaps because he was unused to such pointed negative feedback before implementing active learning techniques in his classroom.
Artifact 5 Reflection: *Physics 603: Teaching College Physics Final Project Excerpt*

One reason that the final project for Physics 603 was useful to me was because it gave me the opportunity to discuss teaching issues with physicists at diverse points in their careers. Professor Timbie is a full professor in the middle of his teaching career, and Professor Cadmus is a senior faculty member near the end of his teaching career. When I did this project for Physics 603, I was a graduate student in the middle of my graduate teaching career.

The diversity of my contacts for this project gave me insight that I could not have found in a more homogeneous group. It is exciting to talk to my graduate student peers who are also excited about teaching and about the challenge of improving science education. However, talking with established professors with extensive teaching experience helped to make the challenges of teaching more concrete and real. They offered perspectives on many changes that they have actually implemented, whereas my peers and I mostly have ideas for changes that we have not yet had the chance to try. Professors Timbie and Cadmus have diverse and extensive experiences. This makes them a valuable source of advice, as they are able to anticipate the kind of challenges that I can expect when I try my own innovations.

It is inspiring to hear of the successes of Professors Timbie and Cadmus, and the thoughts they share make improving physics education seem possible. The fact that I know both professors personally makes it seem even more achievable because I know that they both were able to innovate while simultaneously being great teachers and productive researchers. It is also encouraging, in a sense, to hear about their frustrations and missteps. They both described the innovation process as a gradual one, with many revisions along the way. This shows me that I do not have to be afraid of making changes that may not yield immediate and unequivocally positive results. Their experiences demonstrate that one can bring about beneficial changes gradually and iteratively.

My conversations with established physics instructors helped me to realize that innovation in physics education is largely a gradual process. It is not necessarily done in a single semester, or by a single professor, or even by a single generation of professors. That is why communication between instructors at diverse career stages is important, and why it is helpful to address challenges as a diverse group. Not only does such a group increase the variety of perspectives, but it makes it more likely that positive changes will be continued and will be further improved upon by future generations.
Final Reflections

This teaching and learning portfolio has summarized some of my work as a physics instructor in graduate school. The Delta pillars of teaching as research, learning communities, and learning through diversity have helped to guide my teaching. My teaching practices have also been shaped by my experiences in the classroom, both as a student and as an instructor. As I have gained more experience, I have built upon the pillars, forming my own teaching philosophy. My philosophy is based on diversity as strength, instructor as facilitator, and teaching as research. These central principles are similar to the Delta pillars, but they have been personalized and shaped by my own experiences in the classroom.

As I continue to gain new teaching experiences, I will continue to revise my teaching philosophy and practices. Although the thoughts laid out here will likely evolve and be refined over the years, I hope that this portfolio will serve as a solid foundation upon which I can build as I continue to learn and to grow as a teacher.