Learning Assistant Model for
Teacher Preparation in Science and Technology
(LA-TEST)

Project Annual Report to the National Science Foundation
Year 5 Academic Year 2011-2012

Project Activities and Findings

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PROGRAM ACTIVITIES

The past year of work has focused mostly on the organization and analysis of qualitative data associated with the Learning Assistant Model in efforts of determining how LAs view, and come to view teaching and their roles within it. This is preliminary to investigating which elements are critical in the LA model for bringing about desired outcomes such as increased K-12 teacher recruitment, enhanced teaching quality, and increased learning outcomes in LA-supported courses. In addition, significant time, resources, and focus have gone to supporting the national expansion of the LA model and we have established a clear plan (with the American Physical Society) for launching a national LA Alliance and data collection campaign. Finally, we are currently synthesizing the data from the past five years of work for the final report for next year.

The past year of project activities are as follows:

1. Analyzing qualitative data to understand quantitative (RTOP) result that former LAs engage in significantly more research-based activities than a matched sample of their peers (RTOP report is in 2010-2011 LATES Annual Report). This analysis looked at the Learning Assistant Experience in attempts of building a model of what models of teaching and learning LAs establish throughout their LA experience (report attached in findings).

2. Launching the LA model in new departments (such as Integrative Physiology, Educational Psychology, and Atmospheric and Oceanic Sciences). We have also been working to provide and test new forms of faculty development using both the Online Learning Assistant Video resource (funded by PhysTEC), as well as in-house materials established for this purpose.

3. Developing materials for the expansion of the LA model within and beyond an institution.

4. Beginning negotiations to partner with the Chancellor’s Faculty Awards for Discipline-Based Educational Research, in efforts of helping non-successful faculty applicants for LAs get their courses “LA-Ready.”

5. Completing negotiations with the to-be-launched Center for STEM Learning in terms of the role of the LA Program within the Center.

6. Finalizing negotiations for sustained funding for the LA Program at the University of Colorado, Boulder at its current rate of activity.

7. Planning for the 2012 launch of the National LA Alliance along with short and long term goals for data collection.

8. Writing proposals to support the national data collection and LATEST replication of findings at other sites.

9. Planning, with the College of Engineering and Applied Sciences, a CU Teach Engineering program.
PUBLICATIONS 2011-2012

REFEREED JOURNAL ARTICLES:


REFEREED CONFERENCE PROCEEDINGS


BOOK CHAPTERS

PROJECT FINDINGS: Numbers of CU LAs, Faculty, Transformed Courses, and Departments

The STEM Colorado Learning Assistant Model at the University of Colorado Boulder is a multidisciplinary experiential learning program. Students who participate as Learning Assistants (LAs) show much higher learning gains in their majors than their peers and show very high shifts in attitudes about learning science (their peers, on average show small to large negative shifts on the same measure). In academic year 2011-2012, 206 (an increase from 161 in 2010-2011), LAs were hired and served over 10,000 lower and upper division undergraduate STEM students. LAs for Fall 2011-Spring 2012 were hired in 11 departments (3 colleges and schools): Applied Mathematics (APPM); Astrophysical and Planetary Science (APS); Atmospheric and Oceanic Sciences (ATOC); Chemistry and Biochemistry; Education, Engineering (Mechanical), Environmental and Evolutionary Biology (EEB), Geological Sciences; Molecular, Cellular, and Developmental Biology (MCDB); Mathematics; and Physics. From 2003 to 2012, a total of 93 courses at CU Boulder have been transformed using LAs, 136 CU faculty and instructors have used LAs, 1144 LA positions have been filled. In 2011-2012, 206 positions were filled and 52 faculty and instructors used LAs to transform 42 individual courses. The program is currently funded by grants, department chairs, and temporary funds provided by the Provost. We are still working toward moving from temporary funds to the operational budget.

Table 1. Summary Data CU Boulder

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<th></th>
<th>(2011-2012)</th>
<th>(Total since 2003)</th>
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<td>136 (#)</td>
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<td>Courses Using LAs</td>
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<td>LA Positions Filled</td>
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Table 2. CU Boulder Courses using Learning Assistants in 2011-2012

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<td>APPM 2350</td>
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<td>APPM 3050</td>
<td>MatLab</td>
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<td>APPM 4350</td>
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<td>APPM 4360</td>
<td>Complex Variables and Applications</td>
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<td></td>
<td>APPM 4520</td>
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<td>APPM 4650</td>
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<td>Calculus I Workshop</td>
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<td>ASTR 2000</td>
<td>Ancient Astronomies of the World</td>
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<tr>
<td>Atmospheric and Oceanic Sciences</td>
<td>ATOC 1050</td>
<td>Weather and the Atmosphere</td>
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<td>Weather and Climate</td>
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<td>Our Changing Environment</td>
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<td>ATOC 1070</td>
<td>Weather and the Atmosphere Lab</td>
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<td>MATH 1310</td>
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<td>MCDB 2150</td>
<td>Principles of Genetics</td>
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<td>PHYS 1010</td>
<td>Physics of Everyday Life</td>
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<td>PHYS 1020</td>
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<td>PHYS 1110</td>
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<td>PHYS 2130</td>
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<td>PHYS 3220</td>
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<td>PHYS 3310</td>
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<td>Electricity and Magnetism II</td>
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PROGRAM FINDINGS: Teacher Recruitment

In order to track the increase in the number of teachers that result from the LA program, we compare the changes in enrollment in three different teacher certification programs: the Master’s Plus certification program (MA+), the Post-Baccalaureate certification program (PBA), and the Undergraduate certification program (UG). The UG program is the program into which we recruit our LAs. The figure below shows the average number of secondary math and science teacher certification program completers each year (averaged over 5 or more years, before and after the LA program began to graduate teachers). As is evident in the graph, the MA+ and the PBA programs stayed the same, whereas the UG program increased significantly. This graph provides evidence that the LA program is effective in recruiting students into Math and Science teacher certification programs and that they are finishing their program.

In 2006 we launched an additional teacher recruitment method, CU-Teach, a replication of the UTeach model for teacher recruitment. Presumably, this would complicate our recruitment data reports because we would now reporting numbers of teachers that could be increasing from both efforts. This does not seem to be the case however. The numbers appear steady (at least as of now) for program completers as shown in Fig. 3, which compares average number of completers per year before LA program began graduating students (2001-2006), after LA program began graduating students but before the addition of CU Teach graduates (2006-2010), after CU Teach began graduating students (2010-2012).
Distribution of Majors of LAs

Most of the students not majoring in math or science have a math or science minor. APPM is Applied Mathematics, EBIO is Evolutionary Biology, MCDB is Molecular, Cellular, and Developmental Biology, IPHY is Integrative Physiology, and Other includes majors such as Fine Arts, English, Spanish, and Finance. Psychology was added to the graph as a category major this year because a large-enrollment educational psychology course began to use LAs.
Figure 5. Distribution of majors hired into LA positions

Figure 6. Increases in numbers of LAs hired per year
LA to K-12 Teacher Recruitment Data

Recruitment of LAs to certification programs since 2005 is shown in the graph below according to the students’ majors, a total of 70 teachers have been recruited since 2003, approximately 9 per year. Below data regarding LAs recruited to K-12 teaching is presented. However, as a result of our phase II Noyce grant, we have begun also awarding Noyce Fellowships to CU Teach students, even those who have not yet served as LAs. This has been a wonderful addition to the Noyce program but has made it very difficult to track the recruitment of LAs to teaching careers. In addition, with our numbers of LAs growing each year, it is becoming increasingly difficult to keep track of which of the students enrolling in teacher certification programs have ever been LAs. It is possible, but requires a time consuming process of searching transcripts of all students enrolling in the CU Teach program to see if each has taken the LA course. We are currently working with the Dean of the School of Education and the Associate Dean of Teacher Education to add a “I have served as an LA” check box to the application for the School of Education. Unfortunately, this has not been done yet. We expect that as we roll out the CU Teach Engineering program (called Engineering for Society), we will see growth in the number of engineering majors that are recruited to teaching.

Figure 8. Last year’s graph showing a last ditch effort to show the number of LAs going into teaching.
PROGRAM FINDINGS: Dissemination and National Scaling

The Colorado LA Program has become a national model for course transformation, teacher recruitment and preparation, and catalyzing institutional change. Over 20 institutions including Cornell University, University of Minnesota, University of Maryland, and Florida International University have received significant funding to emulate the STEM Colorado LA program and we continue to provide conceptual support and materials for these universities to emulate our program. We will be holding our 4th annual National Learning Assistant workshop at CU Boulder on October 28-30. For the second year in a row, we will be holding a parallel session for faculty from universities experienced using LAs and working toward developing a National LA Alliance. We are currently working toward funding for a national data collection campaign, where we would create a census of the nation regarding LA programs and try to replicate findings from CU Boulder’s LATEST project at other universities. As shown in the figure below, 51 universities have participated. As illustrated in the figure, faculty members are increasingly attending for a second and third time. Their reasoning is that after attending a first year they learn enough and get enough courage to start an LA program at their institutions. The second year they seek to come back because they say that, “now I now what my issues are and I know the workshop will help.”

![Figure 9. National LA Workshop Representation from individual universities, total = 51](image)

A total of 106 individual scholars have attended from 51 Universities (shown in figure 9) and 3 additional professional organizations including Association of Public and Land Grant Universities, American Physical Society, Society of Physics Students (National Headquarters). Institutions and numbers of attendees are shown below.

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<th>Organization</th>
<th># attended</th>
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<td>American Physical Society</td>
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<td>California State Polytechnic University, Pomona</td>
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<td>Florida International University</td>
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FINDINGS: Learning Assistants’ Views on Teaching and Learning: A qualitative inquiry  
Prepared 9/27/2012 for LA-TEST Research Project

Introduction

Previous studies have demonstrated that the Colorado Learning Assistant (LA) model advances education in three important ways: improved learning outcomes for students enrolled in LA-supported courses (Pollock, 2009), increased numbers or STEM majors recruited to careers in K-12 teaching (Otero, Pollock, & Finkelstein, 2010), and significant differences in the K-12 classroom practices of LAs who become teachers versus teachers who did not have the LA experience (Gray, Webb, & Otero, 2012). These studies were designed to measure differences in LA and non-LA-related experiences prior to establishing explanatory models for why such differences might exist. The purpose of the evaluation reported here is to establish a descriptive model for how LA experience the program with efforts of ultimately developing an explaining model for observed differences in their teaching practice. Inferences will also be made about why these students are recruited to teaching careers through the LA program.

Several different hypotheses have been established to explain the observation that LAs demonstrate more research-based teaching practices as K-12 teachers than their peers. For example, it may simply be a selection effect; the LA program may select the most talented students and therefore it is no surprise that they outperform their peers. Or, perhaps these talented students are attracted to the LA program because they already have philosophies about teaching and learning that are aligned with research findings and are valued by the program. Another hypothesis is that the students who go through the LA experience do not enter the LA program knowing how to teach well, or how to teach at all, but learn how to do this through their experiences in the Colorado LA program. A final hypothesis is that it some combination of all three hypotheses stated above.

The study presented here is motivated by a desire to understand exactly what the student who serves as an LA experiences the first time he or she serves as an LA. The purpose of this research is to look carefully at first-time LAs for evidence of learning and specifically changes in the ways they think about teaching and learning. Evidence of learning would suggest that the Colorado LA program is facilitating change among participants rather than just recruiting already effective teachers. Through a qualitative, interpretive study first-time LAs’ initial views can also be investigated, thereby helping to establish the extent to which, as talented students, they already had sophisticated views.

This study investigated how four physics LAs thought about teaching and learning and how their understandings changed over the course of a semester. In order to investigate this, the LAs were interviewed at the beginning and end of their first semester and their course writings from their LA pedagogy seminar were collected. An analysis of this data indicated that the LAs tended to work within two overarching philosophies of learning. The first philosophy focused on formative assessment as an understanding how people learn and teach effectively. The second philosophy focused on the role of student/teacher relationships in learning and teaching. These overarching philosophies were generalized from case studies, which were conducted for each of
the four LAs. These case studies revealed that each of the LAs tended to have personal philosophies on both formative assessment and on student/teacher relationships to some extent. The case studies also demonstrated how these philosophies developed over a single semester. From these case studies, generalized models for each of the two overarching philosophies were developed to establish an “average” or “abstracted” model that encompassed the views of all four LAs. Like all models, the resulting generalized model of formative assessment and of student/teacher relationships do not represent all of the nuanced views of a single LA at a given point in time, but are intended to serve as useful, normative representations; they are generalized philosophies that are “smoothed” and “averaged” over the four LAs and over the entire semester. While the case studies provide nuanced views of each LA’s philosophies, the models provide a way to talk about the general thinking of LAs as a group, and are useful for further investigations, and for establishing an explanatory model discussed previously.

Research on teacher learning has demonstrated the importance of situating learning in actual teaching experiences (Putnam & Borko, 2000). Learning is said to be “situated in practice” when teachers are given the opportunity to test out new ideas in their own classroom settings while they are being presented with those ideas in a professional development program. This is analogous to contemporary, research-based perspectives on student learning, whereby student learning experiences should be grounded in their experiences (National Research Council, 2000). This implies that it is not enough for future teachers to be taught about teaching; they must also, like any learner, experience the content—in this case of teaching methodology. Such experiences allow teachers to try out the theories of teaching and learning they are being instructed on, and to ground these theories in actual experiences. In his model of teacher learning, Korthagen cautions that introducing a theory of learning or teaching to a teacher before the teacher sees the need for such a theory can cause the teacher to reject the theory (Korthagen, 2010). For this reason, placing future teachers in a classroom not only gives them the opportunity to practice what they are being taught but it also provides the motivation for them to create, for themselves, exemplars of these theories of teaching and learning. Korthagen also recommends teacher reflection on their experiences as critical to their development of a theory of learning. In keeping with these perspectives on teacher learning the learning experience of LAs is designed to extend beyond the actual LA pedagogy course and into their practice in the learning environment in which they are assisting. Their learning experience also encompass their weekly interactions with physics faculty. The LAs’ interactions with enrolled students in the learning environment provide LAs with an opportunity to try out what is being taught in their LA pedagogy course. These integrated interactions in the pedagogy course, in their teaching practice with enrolled students, and in their discussions with faculty also provide the impetus for LAs to reflect on, become aware of, and develop their own theories of how people learn and how people should teach. Because reflections are a key way that LAs construct and revise their philosophies of learning, the weekly reflections that LAs submit to the pedagogy course were used as one of the data sources for this study.

Defining learning is a critical step in studying the learning of LAs during their first semester in the Colorado LA program. This study used the perspective of “community of learners” as a lens for interpreting the LAs’ experiences. This perspective is characterized by a redefinition of learning from the traditional “acquisition model” of learning to a model of “learning as participation” (Sfard, Sabella, Henderson, & Singh, 2009). This perspective is
derived from the work of influential Russian psychologist Lev Vygotsky (Vygotsky, 1986). Two examples of how this perspective as been used to explore learning are the “community of learners” perspective (Rogoff, Matusov, & White, 1996a) and the “community of practice” perspective (Wenger, 1999). Rogoff et al. (1996b) defines learning as “a process of transformation of participation in which both adults and children contribute support and direction in shared endeavors” (p. 389). In this perspective, learning is exemplified by changes in the way a learner participates in the community, specifically changes in how the learner moves from peripheral participation to full participation whereby the learner becomes integrated and active in working towards community goals. Becoming part of the community is indicated by the adoption the language, values, practices, and identity indicators of that community (Lave & Wenger, 1991). It is in this way that changes in the way a person talks or behaves are seen as evidence of learning (Sfard, 2007). Learning is not assumed to be a smooth, linear process; learners tend to “test-out” words and “try-on” identities before they have fully accepted and understood their meaning (Erikson, 1968; Vygotsky, 1986; Wertsch, 2007). It is by virtue of the process of trying on and trying out identities that learners come to understand and connect with them (Otero & Nathan, 2008). The study reported here investigated LAs talk as a window into LAs’ values and evolving perspectives on learning as they participated in the practice of teaching.

METHODOLOGY

Purpose

The purpose of this study was to understand what philosophies of learning LAs develop during their first semester in the LA program. This study employed a qualitative research methodology, which is defined as a process that builds a “complex, holistic picture, analyzes words, reports detailed views of informants, and conducts the study in a natural setting” (Creswell, 1998, p. 15). This methodology was used for two reasons. First, it allowed for the development of a descriptive model of how LAs learn about learning. Second, it allowed this process to be described in the words of the LAs. This is important because learning was defined as changes in the way LAs talk about learning and related issues throughout the semester. In order to capture the ways LAs talk about learning, the following data sources were collected – interviews with the LAs from the beginning and end of their first semester, LAs’ weekly writings about their experience, and the three larger papers that LA’s write as part of the pedagogy course. Using the data from these three sources case studies of the four LAs studied were developed, which describe the LAs’ philosophies of learning. From these case studies, two generalized models of learning were developed which describe, in general, how these LAs tended to think about learning. The participants, data sources, and analysis will be described in more detail in the sections below.

Participants

This study focused on four first time physics LAs. The focus on physics LAs was chosen for several reasons. First, the physics department at CU-Boulder is using the research-validated classroom activities Tutorials in Introductory Physics (McDermott, Shaffer, & University of Washington Physics Education Group, 2002) otherwise known as the University of Washington
While the LA program does not specify how departments are to reform their courses using LAs, many departments have been moving toward a Tutorial-like model (e.g. the Math and Chemistry departments). Therefore, understanding how LAs interact with their students in Tutorials will be of interest to many departments. Second, the Tutorials are a well-researched “curriculum” which is being studied and used across the county (e.g. Koenig, Endorf, & Braun, 2007). Therefore this research will be of interest to those in the Physics Education Research (PER) community who use LAs or those who use the University of Washington Tutorials.

The study focused on LAs in the first semester Mechanics course of the two-semester introductory physics sequence. This was done in order to study LAs who were working with students who had, for the most part, not been in a Tutorials classroom before. This meant that the enrolled students did not bring pre-conceived ideas of how Tutorials should be done into the classroom, though they obviously had preconceived ideas of how science classes should be organized and they may have heard opinions from students who took Tutorials in previous semesters. Because their students were new to Tutorials, these LAs and their fellow TAs had more freedom in creating the tutorials environment.

Since the study was intended to consider how first semester LAs experience the LA program, only the four first-time LAs working in the physics mechanics course were studied. All four of these LAs agreed to participate. The gender, year, major, and career plans of each LA are presented in Table 1. In the second column labeled Year, the LAs’ year in college is based on the number of years they have attended college and not based on the number of college credits they have received. Gen was in his first year of college but has enough college credits to be classified as a junior. Andy was in his second year of college but completed his first year of college at another university. Leah completed a bachelor’s degree in Political Science at another university and has returned to complete her pre-requisites for medical school. The LAs’ career plans were based on the careers they gave during the first interview. Gen’s career plans became more nebulous by the end of the semester. Andy and Jamie’s career plans remained undecided.

<table>
<thead>
<tr>
<th>Gender</th>
<th>Year</th>
<th>Major</th>
<th>Career Plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leah</td>
<td>Female</td>
<td>Pos – bach</td>
<td>Poli Sci / Pre med</td>
</tr>
<tr>
<td>Andy</td>
<td>Male</td>
<td>Sophomore</td>
<td>Mechanical Engineering</td>
</tr>
<tr>
<td>Jamie</td>
<td>Female</td>
<td>Freshman</td>
<td>Physics</td>
</tr>
<tr>
<td>Gen</td>
<td>Male</td>
<td>Freshman</td>
<td>BioChemical Engineering</td>
</tr>
</tbody>
</table>
**Data Sources**

In order to understand these LAs’ views on teaching and learning they were interviewed at the beginning and end of the semester and their weekly writings and course papers were collected. These data sources are explained in more detail below.

**Interviews**

The LAs were interviewed about their views on teaching at the beginning and end of the semester. In the first interview the interviewer asked about their previous experiences with tutorials and LAs, their expectations for the semester, how they planned to help students, and what they considered to be good teaching. The interviews were conducted in the first week of the semester before the LAs attended their first pedagogy class or physics tutorial. In the second interview, the interviewer focused on LAs’ experience as an LA, how they thought they were able to help students, and their future plans around teaching. The interviews were conducted during the last tutorial session of the semester while the students were busy completing end of the semester conceptual inventories. The interviews lasted between thirty and fifty minutes. The interview protocols are included in Appendices 1 and 2.

**Weekly Writings**

LAs are required to submit teaching reflections on-line each week as part of the LA pedagogy course. These reflections focused on the LAs’ general impressions of their experience that week, specific issues that arose during their teaching, and specific applications of the topics covered in their pedagogy course to their teaching experiences. An example of a teaching reflection form that the LAs fill out online is shown in Figure 1. Each week, the LAs answered different questions, though many questions were repeated during the semester. LAs who miss a reflection were asked to turn in a one-page reflection about their teaching. These make-up reflections were collected as well. All of the questions that were asked over the course of the semester are listed in Appendix 3. All questions which were asked as a part of which weekly reflection are listed in Appendix 4.

**Course Papers**

As part of the LA weekly pedagogy course, LAs were required to write three papers. The first two papers are referred to as Article Reports (AR). The Article Reports were four page papers that asked LAs to summarize two of the course readings, analyze how the two readings fit together to create a common theme about teaching, and then apply this theme to their LA experience. At the end of the semester LAs were required to submit a final paper that summarized what they learned that semester. This paper was intended to be a written summary of the poster they presented at the final pedagogy class. The posters were designed and presented by individuals or pairs of LAs. The posters were typically formatted in terms of what the LA thought about teaching and learning prior to the LA experience, what they thought about teaching and learning at the end of the semester, and the topics from the course they found most
relevant to the changes in their ideas. While the LAs tended to work on the posters in pairs, they were required to submit their own paper. The papers ranged in length from two to four pages.

Data Analysis

The LAs’ interviews and writings were coded using an emergent coding scheme that focused on understanding the LAs’ views on how students learned and how teachers could help students with that learning. From this emergent coding two themes were developed using a process similar to that described by Coffey & Atkinson (1996). The first theme focused on the philosophy of teaching that LAs tended to develop which closely aligned with the literature on formative assessment. The second theme focused on the LAs’ philosophy of teaching that emphasized the relationship between students and teachers. Based on the views of each of the four LAs, generalized models of these two philosophies of teaching were developed. From the generalized models, case studies of each of the four LAs were developed to investigate the nuances of their philosophies of formative assessment and the student/teacher relationship. These case studies not only illustrated differences between the philosophies of the four LAs they also illustrated how the LAs’ philosophies developed over time.

The themes were developed using an iterative process. First the interviews were analyzed for codes relating to views on teaching and to find differences in how the LAs talked at the beginning of the semester compared to how they talked about teaching and learning at the end of the semester. Once the coding scheme successfully captured the LAs’ views on teaching and learning as expressed in the interviews, it was applied to the LAs’ course papers. The codes and themes were then revised as necessary to capture the agreements, divergence, and nuances between the LAs’ views as expressed in the interviews and the course writings. Once the codes and themes successfully captured the LAs’ views on teaching and learning expressed in the course papers, it was applied the to the LAs’ weekly reflections. The process of modifying the codes and themes to account for the new information about LAs’ views on teaching and learning was then repeated. Once this process was complete, the interviews were returned to in order to verify and revise the themes and codes as necessary and continued the iterative process.

The themes and codes developed from the LAs’ views on teaching and learning allowed for the creation of a generalized model of how LAs thought about the two themes. A model was created for each of the themes. The models are not intended to accurately depict the philosophy of any one LA. Instead the models provide a general picture of the similarities across all four LAs. Therefore these models work very similarly to a scientific model. A scientific model may not perfectly predict a single experimental trial but provides a helpful approximation of that single trial. The models provide a helpful way of talking about the views of LAs.

The case studies are intended to describe the nuances between the views of the individual LAs and the generalized models. While the generalized models are useful, it is also informative to consider the variations in LAs philosophies. The case studies also show how LAs’ philosophies evolved over the semester.
Limitations of the Study and the Generalizability of the Research

The purpose of this research was to develop a detailed understanding of four LAs’ views of teaching and learning. The resulting case studies and the generalized models should help to inform the understanding of how the Colorado LA program helps LAs learn and how future teachers learn to teach. While this study should inform the future understanding, there are several limitations that must be taken into account based on the specific context of this study.

The LAs who participated in this study were working within the physics Tutorial environment. They were therefore part of an established program that included faculty, TAs, and returning LAs who were familiar with how the Tutorials should be run and who were able to offer support. LAs who are part of a new program may not have these advantages.

These LAs were also working with the University of Washington Tutorial activities. These are research-based and research-validated activities designed to elicit students’ ideas and address common problems students have with introductory physics concepts. Because of this these four LAs were in an optimized environment where the teaching philosophy of their practice context were congruent with the philosophy of their pedagogy course. Other LAs may be in contexts that do not have well designed activities or that have a teaching philosophy that is not closely aligned with the philosophy of the LA program.

Because these LAs were part of an established LA program, they all had previous experiences with LAs. All of the LAs were students the previous semester, in the same course in which they were teaching. Therefore the first-time LAs already had many ideas about the LA experience because of their opportunities to observe LAs when they were students. This experience shaped the LAs’ opinions as evidenced by the frequency with which the LAs referenced their former LAs during the pre-semester interviews. Other LAs who are part of a new program, will not have the opportunity to learn from their own LAs.

The physics LA program at CU-Boulder is in the advantageous position of having more LA applicants than they have LA positions. In the semester that these LAs applied, there were four applicants for every one position. This meant that the physics faculty were able to interview applicants and select students who were likely to be successful LAs. Therefore the LAs who participated in this study were some of the best applicants for the positions. Based on observations of LAs over several semesters in the LA pedagogy course by the instructors, these LAs were representative of the students chosen as LAs at CU-Boulder.

Finally, this study must be placed in its historical context. The semester of this study was the first time that the LA pedagogy course explicitly addressed formative assessment. While the concept of formative assessment has always been an important part of the LA program, the concept has been taught to LAs implicitly as a part of the resources perspective (Hammer, 2000) on student learning. During the semester of the study the concept of formative assessment was introduced in week four and the term was used several times during week five of the course. Since this semester, formative assessment has remained an explicit topic of the course, but the way it is taught has continued to evolve. Therefore some aspects of the LAs’ views on formative assessment may be unique to this particular semester.
Despite these limitations the models and case studies developed in this study have relevance to the experiences of other LAs and other future teachers.

1. LA Job Descriptions

(Points: 5)
In what course are you working? What is your main responsibility (Do you help with clicker questions during lecture; run a co-seminar, help with tutorials, labs, or recitations; work in the helproom; etc)? Are students required to participate in the part of the course in which you are working? Are you working with a TA or fellow LA? Do you have grading responsibilities?

2. Goal

(Points: 5)
What was your main teaching goal(s) for this week? These can be conceptual, motivational, metacognitive, etc. Do you feel you met this goal(s)? Why or why not?

3. Evaluation of group interactions

(Points: 5)
Did all the students appear to be participating? Any good discussion? Any problems with the group, and if so how do you plan on addressing that problem in the future?

Figure 1. Example of Weekly Reflection that LAs fill out on-line and submit.
FINDINGS

Theme 1: A Philosophy of Formative Assessment

The analysis of the LAs’ writings and interviews showed that over the semester the LAs developed a common philosophy of teaching and learning. Because this philosophy has so much in common with the literature on formative assessment, it will be referred to as the LAs’ philosophy of formative assessment. The philosophy includes four constructs that build on each other. A model of this philosophy is shown in Figure 2. The following section will describe the generalized model and the analysis section will deconstruct relevant excerpts from the LAs’ writings and interviews to demonstrate each aspect of this model.

Generalized Model

![Figure 2. A model of the generalized philosophy of formative assessment.](image)

The first element of the generalized model of the Las’ formative assessment philosophy is the construction of knowledge. The construction of knowledge refers to allowing students to build up a scientific concept using their own experiences or first principles rather than learning concepts in their final form from lectures or textbooks. The construction of knowledge is therefore an active, rather than passive, process for the student. According to the model, it is very important for students to construct their own understanding of a concept rather than being passively given the concept by an instructor. The general model considers lectures to be a passive form of learning while the tutorials are designed to make the students active in their learning process. The reason the model emphasizes having students take an active role in their learning is because the resulting understanding will be more durable and robust.
Since students are expected to construct their own understanding, according to the model, the instructor must take on a different role within the model when compared to traditional teaching. The model expects the teacher to take a facilitating role where her job is to help students construct their understanding but to not develop the concept for the students. A facilitating role means that the teacher assists students when they are struggling with the material. Yet, the student remains in control of the process and he is expected to do the mental work of building the idea. According to the model there are two general methods that instructors can use to facilitate learning – questioning students and providing explanations or hints. The questioning strategies can include asking students to explain their reasoning or asking students to consider the question in a slightly altered context. By explanations the model is referring to brief descriptions that clarify some aspect of the tutorial problem or the physics concept. It is not talking about providing student with the answers to the problem or derivations of the concepts.

The second construct in the model of formative assessment is an awareness of students’ prior knowledge. This awareness includes two aspects. First, the instructor recognizes the ideas and skills that students bring from their experiences to the physics content. This means the instructor is able to describe how the student is thinking about a concept. An instructor who did not recognize students’ prior knowledge would assume that students approach all physics concepts as blank slates with no thoughts on the topic. Second, the instructor not only recognizes the ideas but values these ideas and skills as being useful for the students when they’re learning the content. This means the instructor is not only aware of what ideas a student has on the content but realizes that these ideas can be useful in helping the student deepen their understanding of the topic and work toward the correct scientific model of the concept. An instructor who recognized students’ prior knowledge but did not value it would attempt to make students abandon their prior ideas before they worked to learn the new material. Students’ prior knowledge can include their everyday experiences, their prior knowledge of physics concepts from earlier in the semester or a previous physics course, and their knowledge from other subjects such as math. Besides conceptual prior knowledge, the model also recognizes that students bring to their learning their learning preferences and the learning strategies that they have previously developed.

The third construct of the model of formative assessment is the awareness of the individuality of students. This construct refers to the recognition that each student is different from all other students and that these differences should be acknowledged and not glossed over or destroyed. In many ways this construct builds off of the previous construct of prior knowledge. This is because the model talks about differences between students in terms of differences in prior knowledge as opposed to ability, motivation, or static characteristics of the students. A recognition of students’ individuality does not only acknowledging that students come to the topic with different ideas but that they also respond to instruction (e.g. questions) in different ways. This means that a question may trigger one student to change the way he is thinking about a concept. Yet that same question may not bother a different student and therefore it will not trigger that student to rethink their ideas.

The final construct in the model of formative assessment is really a culmination of or response to the other three constructs. While the other three constructs refer to characteristics of learning or of the students, the final factor refers to how one should teach in response to these characteristics. Because students need to create their own understanding utilizing their prior knowledge, and because students have different prior knowledge, an instructor needs to adapt her teaching to meet the unique situations of each student. Examples of teaching adaptations include
asking different questions, using a visual representation instead of a verbal analogy, using an example from sports to demonstrate the concept, or helping the student to construct a conceptual explanation rather than the mathematical explanation used in the book. The model states that adapting one’s teaching is critical to good teaching and to the job of an LA. The model holds that good teachers teach to the students and not to the content or to an idealized student. It is not enough to teach the content following the path used in the textbook or in the way that makes the most sense to the instructor. The teaching strategy that is used has to be the best strategy for the particular student. The LAs find that this need to constantly adapt their teaching makes teaching fun and challenging.

**Analysis**

The above section has presented generalized model of the LAs’ philosophy of Formative Assessment. This model was developed based on the writings and interviews of the LAs and evidence for this model can be found in the writings and interviews of all four of the LAs. The following sections will consider evidence for each of the elements of the generalized model. The later case studies will consider the philosophies of formative assessment developed by each of the four LAs and how these models present nuanced views of the generalized model. The sections below will consider excerpts from all four LAs to demonstrate the generalized model.

**Construction of Knowledge:** The first element of the generalized model of formative assessment is the belief that students should construct their own understanding instead of receiving knowledge passively from teachers. Leah explains this idea during her mid-semester reflection,

> I have noticed that the more I teach and learn about teaching, the more I have realized the importance of allowing the student to reach his or her own answer. A student learns much better through thinking, and that process is much more important than the answer itself (Leah, wk08, 1).

Leah begins explaining her philosophy of teaching by stating that she “allow[s] student to reach his or her own answer”. This excerpt indicates that it is not enough to give students answers. Instead students have to come to the answers on their own and then that answer becomes not simply the “correct” answer, but their “own” answer. Therefore the construction of learning, as described in the generalized model, allows students to claim ownership of the content. Leah goes on to explain that students learn “better through thinking” a phrase that refers to the academic concept of active learning.

The construct of students constructing their own knowledge is also evident in the tutorial environment. By design the University of Washington (UW) Tutorials are intended to elicit students ideas and to then help students construct the physics concepts. It is unsurprising that the tutorials are aligned with the theories of learning taught in the LA pedagogy course or with the philosophy of formative assessment developed by the LAs since the tutorials were designed based on research in student learning of physics by the University of Washington Physics
Education Group. The research of UW strongly influenced the creators of the LA program, the instructors of the LA pedagogy course, and therefore the LA experience. Gen describes how the tutorials create this environment that allows students to construct their own understanding in the excerpt below,

The purpose of the tutorial is to kind of like explore the idea of physics. If we, like even if it's a small thing, like even if it's a small question, you actually have to find, like, signs that would lead you to the answer. So, if I just blatantly say hey this question is going to use this thing and that thing, then they're not thinking about what they know of that would lead them to the answer, it's going to be like hey do this, do this. It's going to be, like, guided. If it's guided, if it's something guided, then why don't we have another lecture. Because like I said, 'okay for this tutorial do this, this, and this. Okay, I'll give you 15 seconds to do it. Okay, are you done? Alright, let's go to the next question.' That would be the same thing. So, like, the point about the tutorial is we actually have to let them navigate and let them think of what they're doing. (Gen, pre, 238 – 248).

In this quote, Gen credits the tutorials environment and the assigned task with the successful learning of the students but he recognizes that the TA or LA can easily disrupt this environment. He describes how the purpose of the tutorials leads students to develop their answers and requires them to think through the materials. He contrasts this with lectures, which he feels tend to be too guided for students to actually think through what is happening. Gen's phrases “you actually have to find”, “what they know”, and “leads them to the answer” indicate that Gen is focused on students’ constructing their own answers. Gen recognizes that it is not enough for students to simply do the manual work of writing out an answer as they are directed by a teacher. Instead, students have to do the mental work of constructing the process. Though Gen is using every-day language to make his argument, it is also possible to express this idea in terms of academic jargon. What Gen is saying is that it is not enough for the activity to be hands-on; it must also be a minds-on activity for the students.

The reason the general model emphasizes having students take an active role in their learning is because it leads to more robust knowledge. Leah references this idea in the following excerpt,

. . . directed questions and carefully constructed questions can really help the students come to their own understanding of the concept which is going to be a lot more lasting and a lot more solid than just hearing an answer from somebody else (Leah, post, 106 – 108).

Leah begins by emphasizing the effort LAs put into their questioning. For Leah, it is not enough to just question students; the questions must be directed and carefully constructed. She then goes on to explain why construction is important – the knowledge is “more lasting” and “more solid”. Leah is explaining that the knowledge that students’ construct for themselves will be remembered beyond the homework or tests and that the knowledge will be at a deeper level than the surface level knowledge students develop when they are just told the answers.

As expressed in the generalized model, the job of the LA is to facilitate students’ construction of knowledge. Both Leah and Gen, in the excerpts below, reference this idea by
contrasting the job of an LA with teaching. When talking about the job of an LA they define teaching as giving students information – as done in more passive learning environments. Therefore, Gen and Leah explain that good LAs do not teach.

[The LAs are] there to help you learn and so that I think to me sums it up. It’s that the LAs weren't really teaching you but like sort of pushing you to understand the concepts better. It was really helpful that none of the LAs that I had have ever given me the answers . . . [They’re there] as the guide to help you figure out what's the best way for you to learn and help you understand the concepts (Leah, pre, 109 – 115).

Leah uses the phrases “help you learn” and “pushing you to understand” to describe the facilitation role of LAs. She contrasts this with teaching which she equates with giving answers. Gen also references this point when he explained what good teachers do,

A good teacher doesn't teach like they actually facilitate learning, so teaching is something like reading out of the book, asking them to take notes, that would be teaching as well, but facilitating knowledge is having the students understand why, . . . So like hands on basis, facilitating knowledge, I think that's the most important part about teaching. (Gen, pre, 291 – 300).

In this excerpt Gen creates a dichotomy between facilitating and teaching. To facilitate learning means to have students develop a deeper understanding that goes beyond just getting the answers – as indicated by Gen’s description of “having the students understand why”. Gen equates teaching with “reading out of the book” and having students “take notes” which basically refers to lecturing.

According to the general model, one reason for having students construct their knowledge is because the process of finding the answer is as important the answer itself. Jamie describes this in the excerpt below,

The job of an LA is you know, of course, it's in the title, we assist them in learning, but I think it's a bit more than that. I mean it's being a teacher but it sounds simplistic at first but when you really go into it it's all of those aspects, getting to know them, helping them through, not step by step through a problem but giving them the right thought process, you know, so it doesn't matter if they get it done it just matters if they learn the process as long as they get some benefit out of it, because getting the right answer often doesn't benefit anyone. . . . That's what being an LA is, is kind of being that little step to helping them understand it because it doesn't seem like the teachers are willing to do that sometimes, and I think that's what our job is (Jamie, post, 114 – 132).

Jamie’s description of teaching as sounding simplistic at first indicates that she now recognizes the extensive amount of work that goes into teaching “behind the scenes”. Like Gen’s previous
quote, Jamie also recognizes the danger in teachers providing too much guidance in stepping students through a problem. Instead she wants teachers to help with the thought process since this is what matters.

In order to help students construct their own knowledge, LAs most often rely on questioning strategies. LAs often talked about improving their questioning skills in their reflections - “My main goal for this week was to try to give the students multiple ways of thinking of the problems that they faced, by asking them questions that would prompt discussion” (Jamie, wk03, 2). Jamie’s main focus here is finding ways to “prompt discussion” since she believes this will give students multiple ways of thinking about a problem. She plans to use her questions to achieve this. The LAs often wrote about using questions to guide students –

This week, students were given a situation of two blocks moving at constant velocity, and were given the task of ranking the magnitudes of the forces involved. Many students had difficulty with this concept. Generally, what worked for most students was when I went through each force and asked them to determine the magnitude relative to another force. After doing this for all of the forces, I then asked the students to compare all of the forces using what they had just learned. I think that for students who do not understand the general idea immediately, it is helpful to take them through the problem step-by-step. I have found that most students know the answers to each step, either intuitively or from instruction, but sometimes have trouble putting it all together (Leah, wk06, 2).

In this excerpt Leah describes breaking down a complicated problem for students so that they do not have to keep track of so many ideas at once. Leah’s students were able to explain how pairs of forces relate to each other, which was the goal of this problem, but they struggled when they tried to keep track of so many forces. Therefore Leah scaffolds the students by keeping track of the forces for them while they do the actual calculations or comparisons between the pairs of forces. Leah’s explanation that “student know the answers to each step” but struggled “putting it altogether” indicates that she was aware of the scaffolding or organizing role of her questions even if she did not use the education jargon. Another example of LAs talking about using questions to help students comes from Andy’s description of helping students with acceleration vectors. Andy wrote the following vignette based on his many interactions with students that week over a difficult part of the tutorial. In the problem students had been asked to draw the acceleration vector of a particle traveling around an oval track –

I: "why do you think that the acceleration is way that you drew it?" (the angle between the velocity and acceleration was greater that 90)
Student: "well acceleration points towards the center of the oval".
I: "does it?" (Sometimes that was enough for them to see their mistake)
Student: "yes when an object moves in circular motion, the acceleration points towards the center of the circle"
I: "is the track a circle?"
Student: "no." (often they would get a puzzled look)
I: "how does radial acceleration work? how is it related to velocity?"
Student: "acceleration is change in velocity over time"
I: "is the velocity changing here?"
Student: "there is constant speed, but the direction changes"
I: "so the object is not speeding up or slowing down, right?"
Student: "yes"
I: "how do u think acceleration would have to act on the object to make it turn but remain at a constant speed?"
Student: "oh. it would have to be 90 degrees?"
I: "do you think it would?"
Student: "yes, because if it was not then the object would either speed up or slow down. this makes sense now. thank you"

This one kind of conversation I had with students. (Andy, wk04, 2).

Students often struggle with this particular problem because they tend to over generalize from their experiences with particles on circular tracks instead of thinking about the relationship between the acceleration vector and the instantaneous velocity vector. Andy’s focus in this interaction is on getting students to talk about their ideas. As he had explained previously, he thinks that students will recognize inconsistencies in their thinking if they voice their thinking to others. Therefore Andy begins the encounter by asking students to explain their answer rather than simply asking them to tell him their answer. Andy keeps his questions very brief and focuses on encouraging students to keep thinking about the problem. He also focuses them on key aspects of the problem like the fact that the track is not a circle. Therefore Andy is helping the students construct their own understanding by encouraging them to continue thinking about the problem and directing their attention to important aspects of the problem. Andy explains this philosophy later in the semester –

I try to use indirect questions when I am discussing concepts with students. Indirect questions give the students an opportunity to develop the concept by themselves and that makes the learning process exciting and also more effective. For example, “What do you think about this diagram?”, “Why have you answered the question like that?” and so on (Andy, final, 49 – 53).

For Andy, the key to his vague or indirect questions is that they provide students with opportunities to develop concepts on their own which he realizes is more effective.

The LAs recognize that questions are not the only way for them to help students construct their own understanding. The LAs also recognize that explanations can sometimes be equally effective in helping students construct knowledge –

There are two ways that I normally help the students. I either ask a question or explain the concept. I try to find ways to ask questions, as a question gives more room for thought generation than an explanation and can lead to a discussion. However, a simple explanation can do wonders at times. (Andy, final, 25 – 28).

While Andy prefers to use questions because they allow students to be more active in their learning he acknowledges that explanations can be powerful. It is important to note that Andy
specifies “simple” explanations, though. Earlier in the semester, Andy is more specific about the types of explanations he uses –

I found that the combination of questions and explanations did the trick. But when I only asked questions, some of the students did not seem to know where to start. When this happened I would give some hint or read the question again (Andy, wk07, 2).

When Andy uses the word explanations he is not describing long reviews of the material or derivations of the concepts. Instead, Andy uses the word explanations to mean hints or rereading the question.

Prior Knowledge: The second construct of the generalized model of formative assessment was the prior knowledge that students bring to any topic. Andy demonstrated his awareness of students prior knowledge in his teaching goals - “my goals for next week are to build off of students’ misconceptions. I plan to do this by asking broader questions or more open questions” (Andy, wk05, 3). In this excerpt, Andy indicates that he is not only aware of students’ prior knowledge but views this knowledge as something worthy of being brought into his discussions with students. He plans to elicit these ideas using questions, especially questions that are broad or open. Leah also described eliciting students prior knowledge,

Well, definitely something that I try to do was to get students to think about problems first from things that they already knew about because physics is one of those subjects, especially mechanics, where people have pretty intuitive understandings of some concepts and sometimes not or sometimes their intuitions can be a little bit misguided but I think it can definitely be a good starting point (Leah, post, 173 -178).

In this excerpt Leah’s references to “intuitive understandings” and “intuitions” indicate her recognition of the value of everyday experiences that students’ bring to the classroom. For Leah, the idea of prior knowledge is especially relevant to her current teaching situation since mechanics is a topic with which students have a lot of personal experience. In an early excerpt, Leah also references students’ intuitive or innate understandings, “Because especially in physics, everybody kind of has an innate understanding of physics, it’s just its hard to get there from just dry lecture or reading the books and stuff” (Leah, pre, 154 – 156). In this excerpt Leah references the importance of teachers eliciting students’ ideas. It is not enough for students to have had relevant experiences, if the classroom environment does not encourage students to refer to these experiences. Leah’s comment explains that it is hard for students to apply their “innate understanding” to physics concepts when it is being taught passively using books and lectures. In this way Leah is tying the ability to elicit students’ prior knowledge to the teaching strategies used to help students actively construct their knowledge as was discussed under the first construct.

The generalized model includes multiple types of prior knowledge that students could apply to their physics instruction. The excerpts from Leah’s interviews mentioned above refer to
students’ everyday experiences as a useful type of prior knowledge. Jamie refers to a second type - “I noticed that they applied their previous knowledge in order to understand and explain the problems better. They applied previous knowledge of geometry and thought about the attribute of a circle” (Jamie, wk04, 1). In this excerpt Jamie describes concepts that students had previously learned in geometry courses as useful prior knowledge for their physics classes. A third type of prior knowledge is the learning preferences that students have developed over their years of schooling. Jamie describes this type of prior knowledge here –

I also recognize ways they learn better and try to find their primary intelligence. This helps me to assist them in learning the concept. By figuring out their primary intelligences it is much easier to relate the concepts to the students and make the material feel much less intimidating (Jamie, final, 15 – 21).

In this excerpt Jamie describes understanding students’ primary intelligences as critical to helping students. In order for her to teach well, Jamie needs to know about how her students learn best so that she can relate the material to the student.

The LAs not only mention the general idea of prior knowledge, but they also give examples of students’ prior knowledge. In the following excerpt Jamie describes a common instance of prior knowledge that she saw in her classes,

The second problem the students were having trouble with was involving the direction of the acceleration along the curve. Due to previously being told that the acceleration always points to the center of a circle, most students just assumed that was true of the oval, not realizing that would affect the velocity . . . Most students understood that the acceleration can’t have a component in the same direction as velocity, but some of the other students were baffled by the sudden challenge of their “acceleration is always towards the center” theory (Jamie, wk04, 2).

In this situation, students struggled to talk about an object traveling along an elliptical path because they were over generalizing their knowledge of circular paths. Students thought that the acceleration vector would always point to the center of the track because of their prior experience with circular tracks. Jamie describes this prior knowledge as a “theory” that the students have developed.

Individuality: The third construct of the generalized model of formative assessment is the awareness of students’ individuality. The generalized model refers to students’ individuality in two ways – differences in prior knowledge and differences in how they respond to instruction. Gen refers to differences in prior knowledge when he states, “Everyone comes from [a] different starting point; therefore we have to accept the different views and try to build upon it” (Gen, wk05, 1). Gen refers to students’ prior knowledge as their “starting point” and their “view” of the concept. He then states that LAs have to not only accept this prior knowledge but use this prior knowledge when working with students. Leah describes how students will differ in how they respond to instruction in her final paper,
It is all too easy for a teacher to view students as identical “learning units” that must be filled with a particular subject. Analyzing these two articles at the beginning of the semester helped me to understand that students necessarily learn in distinct ways. A particular form of discussion may enhance one student’s understanding of a concept, but could do absolutely nothing for another student (Leah, final, 29 – 33).

In this excerpt Leah doesn’t mention students’ prior experiences but instead focuses on how students will learn given a particular discussion. Leah contrasts her current understanding with the teaching pitfall of seeing all students as identical.

The LAs also talked about students’ individuality in more implicit ways as well. For instance, when describing students’ ideas or difficulties some of the LAs talked in terms of most students or some students – “Most understand that force always acts at the center of mass” (Leah, wk12, 2) and “some of the people thinks that they are suppose to add the vectors . . .” (Gen, wk04, 2). Most of the LAs also talked this way when describing successful interventions - “Sometimes when I was trying to help a student with something, I went about it the typical way I’d seen myself or other students do, but this lost a student a tad” (Jamie, wk07, 2) or “Generally what worked for most students was when I went through each force . . .” (Leah, wk06, 2). This language indicates that the LAs recognize that while there were common issues with which many students struggled and that there were common strategies that helped these students, these were not universal and other students had other ideas or learned from other strategies.

Finally some of the LAs saw the individuality of students’ as one of the key reasons they found teaching to be challenging or frustrating. When asked what aspects of his LA experience went well, Andy responded,

I mean I enjoyed working with students and it was always interesting to see the concept from their perspective, 'cause I tried to do that. So I would be able to explain it to them. And it was cool seeing what different kinds of questions could do. Like, in order for me to get information about what or how they're doing or in order for them to build on it, talk about it more. To discuss with them and some points, it was a challenge because I'd have to sit there and then everybody's different so some people would get the concept if I explained it one way, but other's wouldn't so I would have to think of a new way to explain it that I hadn't done before if I had tried the techniques. (Andy, post, 10 – 19).

Andy describes understandings students’ ideas about a topic as “see[ing] the concept from their perspective”. He then goes on to mention the differences in how people respond to questions and explanations. Andy also implies that seeing the different perspectives and having to develop new questions or explanations helped him to learn the content better.

Gen gave a more ambivalent comment when asked how his semester went, he replied,
Frustrating but fun. Like, I enjoyed it so much that I want to do it again. I say it's frustrating because it's hard to see, hard to make the students do one thing and because there are like 15, there are as many answers to one question as the students. You could ask someone a question and they'll give you a different answer from a person you asked a day before. So it was frustrating but fun. (Gen, post, 6 – 10).

In this excerpt Gen refers to the wide variety in how students respond to questions. He considers this aspect of teaching to be frustrating because he cannot predict how students will respond to a question based on how previous students responded. At the same time the unpredictability makes teaching fun as well.

Adaptive Teaching: The final construct in the generalized model of formative assessment – adaptive teaching - is the culmination of the other three constructs. Gen demonstrates how these constructs come together to shape his teaching,

I have learned that there are many teaching methods that exist. Since all students are starting at different starting points, everyone has their own way of learning the same material; therefore, I need to change my way of teaching from student to student (Gen, wk08, 1).

In this excerpt Gen refers to both the prior knowledge of students and students’ individuality in this prior knowledge when he states that students have “different starting points” and “way of learning”. In response to these differences in prior knowledge Gen recognizes that he has to change how he teaches in response to each student with which he works.

All good teaching and especially LAing requires that the instructor adapt the teaching to the students. Leah describes adaptability as necessary for successful teaching –

“While both articles present the learning experience in a different manner, they each emphasize the necessity of adaptability of teaching style. Certain students and situations will require the teacher to guide the learning process differently. I support the general argument of both articles – a successful teacher must be able to alter lessons or concept explanation based on the individual situation and student” (Leah, AR1, 19 – 23).

In this excerpt Leah explains that a teacher must adapt both the “lessons” and the “explanations”. These two categories can be interpreted as describing both large scale changes that teachers make to their lesson plans and moment to moment changes they make in their discussions with students. Leah’s phrase “based on individual situation and student” indicates that she does not expect one teaching strategy to always be effective for the same student. Instead a student may learn different material better using different methods. In other words, just because a visual analogy helped a student understand force pairs, does not mean that a visual analogy will help that same students understand angular momentum. Therefore the teacher has to adapt not only to the individual but also to the specific situation of that individual.
Leah later applied the concept of adaptable teaching specifically to LAs,

“I found that one of the most important roles of the learning assistant was to identify the ways in which these students struggled and to try to find alternative ways of understanding the material that did not rely so heavily on logical and mathematical intelligence” (Leah, final, 60 – 63).

In this excerpt Leah describes the process of eliciting students ideas using the phrase “identifying the ways in which these students struggled” and then describes the task of the teacher as “find[ing] alternative ways of understanding”. Leah then goes on to mention a common type of adaptation she saw as necessary. Leah found that tutorials relied heavily on logical and mathematical intelligences but that these types of intelligences were not strengths for many of her students. Therefore she often worked to better align her students’ learning preferences with the way the concepts were being explained.

In his final interview Andy described adaptive teaching as not only necessary for student learning but also fun for the teacher,

. . . teaching something like physics is definitely challenging because you have to, it’s not just you understanding, you get other people to understand and a lot of times they don’t see it the same way you see it. So, it’s sometimes like a puzzle, you’re like ‘ha’ after you get them to understand and how do I get them to understand – I tried that, I tried that, it didn’t work, so now I’ll try this. Yeah, I definitely consider teaching as an option (Andy, post, 322 – 327).

In this excerpt Andy refers to the differences in students’ prior knowledge when he states that “they don’t see it the same way you see it”. He then talks about trying out different teaching methods to find what is effective in a “guess and check” style. For Andy this process of finding the effective teaching strategy for each individual is like solving a puzzle. Because of this puzzle aspect of teaching and because he finds so much joy in seeing students finally understand, Andy ends the semester considering a career in teaching and eventually pursues his teaching certification.
The Learning Assistants placed a great emphasis on developing their relationships with students. They talked or wrote about these relationships in both their interviews and their writings throughout the semester. This chapter will present a generalized model of student/teacher relationships based on the views expressed by the LAs. The LAs talked about student/teacher relationships in similar ways whether they were talking about their relationships with their students or with their previous LAs or with their previous instructors. Therefore the philosophy described here is created from LAs’ comments about both their own teaching and their experiences with other teachers. It is not limited to LA/student relationships. This led to a generalized model of teacher/student relationships. As will be discussed later, the LAs are at a particular advantage with respect to this model because of their unique relationship to students. The following chapter will consider first the generalized philosophy of student/teacher relationships that was drawn from the LAs interviews and writings. Then an analysis of the data that was used to create this philosophy will be presented.

Generalized model

Generally, when LAs talk about their relationships with students they are focused on one of three constructs of the relationship

1. Being seen as approachable by students
2. Being seen as an authority figure by students
3. Being able to motivate students

These constructs of student/teacher relationships will be considered in the sections below.

Approachable: The most common construct of student/teacher relationships that the LAs talked about was being seen as approachable by students. For the LAs, being seen as approachable was important because it allowed them to know what their students needed. Over the course of the semester, the LAs explained how being seen as approachable by their students allowed them to help their students learn. This process is modeled in Figure 3. First, a teacher must care about her students and make students aware that she cares about them. If the teacher cares about her students, then she will get to know them. This includes knowing her students’ prior knowledge, their personal interests, their learning preferences, and with what they are currently struggling. When a student recognizes that the teacher cares about him and is willing to get to know him, the student can be comfortable with the teacher and with the classroom environment. Only when the student is comfortable is he willing to be vulnerable and share his ideas with the teacher or admit his struggles to the teacher. This type of vulnerability is necessary for the student to be able to learn. Vulnerability is used in the model to talk about a student being in a mental or emotional place where they can share with the teacher how they are doing, admit when they do not
understand something, share their ideas, and ask questions when necessary. A student who is willing to be vulnerable is able to be honest about their knowledge and their learning. Vulnerable is therefore being used in a positive light to mean a student who is willing to be open as opposed to in a negative light to refer to a student who thinks they are under attack.

While the above model creates the conditions necessary for students to learn, it does not necessarily help the student to learn. Instead, helping students to feel comfortable and willing to be vulnerable is a prerequisite for learning. The LAs recognize this and describe how a philosophy of approachability fits with a philosophy of formative assessment. Being seen as approachable by students means that the teacher is able to learn about a students’ prior knowledge because the student is willing to be vulnerable and share their thinking with the teacher. The student is also willing to be vulnerable enough to reconsider their current thinking when they know that the teacher cares about them. When a student is willing to share their prior knowledge and is willing to reconsider that prior knowledge, a teacher can use adaptive teaching to help the student learn. Therefore building a relationship with students becomes a prerequisite for the LAs’ philosophy of formative assessment.

The LAs talk about the importance of all teachers being seen as approachable by their students, but they feel LAs are at a particular advantage in this aspect of teaching compared to faculty or TAs. LAs consider their approachability as the main advantage for having LAs in the physics tutorials. They see two main advantages to their position. First, because they took the same course very recently, LAs are more familiar with the logistics of the course and the specific way the material is presented. The LAs have also experienced the tutorials from a students’ perspective. On the other hand, TAs are graduate students who have taken the course they are now teaching several years ago and who may have seen the material presented in a very different manner. The shared experience of the students and the LA means that the LA can provide more useful feedback, can give advice about logistics, and can sympathize with the students’ experiences. Second, the LAs consider themselves to be less intimidating than TAs or professors. The LAs feel that students worry about looking “stupid” to faculty or TAs if they ask a question or admit to not knowing a concept. Because LAs are peers, it is okay for students to ask “dumb” questions or to admit to not knowing material. Because students are less intimidated by LAs than TAs or faculty, the students are willing to be vulnerable with LAs. The LAs can then help students learn by building on the information about their understanding that the students are willing to share with them.

Authority

Figure 3. Model of the Generalized Philosophy of Approachability.
A second construct of student/teacher relationships that is common LAs’ writings and interviews is a focus on being seen as an authority figure by students. LAs want to be seen as an authority figure by students in two areas:

1. Their authoritative understanding of the material and
2. Their authority to enforce the classroom rules and expectations.

When LAs talk about the first area of authority they are referring to being seen as having content authority. This means they want students to see them as being a resource for their learning. The LAs worry that students may not recognize their authoritative understanding of the content because of their age or because they have not taken more advanced courses in physics. This concern is ultimately tied back to the LAs concern with student learning. LAs believe that if students do not see them as a resource or a content authority, the students will not ask them questions or seek them out for help. Therefore this aspect of authority is tied directly back into the LAs’ previous philosophy of learning. The LAs believe that students will not be comfortable being vulnerable with a teacher who they do not feel has the content knowledge to help them and the LAs do not feel they will be able to help the students if the students are unwilling to ask and answer questions of the LAs.

The second area of LAs’ focus on authority is concerned with being able to enforce classroom rules and expectations. This concern is mostly centered on being able to keep students on task so that they complete and learn from the tutorials. The LAs want students to recognize them as an authority figure so that students will listen and follow their instructions to stay on task, to curb off topic discussions, and to work diligently to complete the tutorials. Ultimately LAs’ concern with this area of authority is tied to their concern with student learning. Because the LAs recognize the tutorials as beneficial for student learning, they want students to have the benefits of working through the tutorials during class.

Both of these areas of authority refer to how LAs believe students see them not in how LAs see themselves. In other words the LAs do not question their own understanding of the material. They believe that they know the material well enough to teach it or that with a little bit of review prior to the tutorials, they will be able to teach it. The LAs’ concern is with whether students view them as having a sufficient understanding of the material. With the classroom management area, LAs are aware that they lack the official authority to enforce classroom rules because they do not have any control over grades. The LAs concern is with whether students will follow their directions despite this lack of official authority.

Motivation: The final construct of LAs’ relationship with their students is being able to motivate or inspire their students. LAs want to motivate their students to enjoy physics and to want to study physics. Besides having the authority to keep students on task, the LAs also talk about motivating students as a way to address the problem of off-task students. The LAs believe that if they can find ways to help their students come to love physics, then the students will want to work on the tutorials. The LAs talk about motivating their students by inspiring them. They believe that by demonstrating a love of physics, their enthusiasm for the subject can be contagious for students. Finally, one of the reasons that LAs apply to the program is to have the opportunity to motivate to inspire students.
Analysis

As stated previously, the above model of LAs’ philosophy of student/teacher relationships was developed through an analysis of LAs writings and interviews. This section will consider excerpts from these sources to demonstrate the three constructs of the philosophy. The excerpts presented here will come from all four of the LAs. The individual case studies, presented later, will discuss the views of individual LAs and how they provide a more nuanced view than the generalized philosophy.

Approachable: The importance of teachers being approachable is the most frequently articulated aspect of student/teacher relationships. Jamie describes the basic idea behind the generalized approachability model of student/teacher relationships when talking about what she learned during the semester,

I think I learned much more about learning itself so, I think I developed a much better way of going about a problem and I think I developed a much better way of relating to people. Like, being a teacher kind of forces you to be good at interpersonal relationships. So, I mean if you're going to be a teacher you have to be good at getting to know people . . . (Jamie, post, 53–58).

In the above excerpt, Jamie describes the basic premise of the model – a good teacher needs to be good at creating relationships with people. Jamie describes this idea in two phrases – “relating to people” and “getting to know people”. These statements refer to helping students become comfortable. While “getting to know people” can also be an aspect of the philosophy of formative assessment and specifically a focus on understanding students’ prior knowledge, in this excerpt Jamie is focused on building relationships with her students as indicated by her focus on the word “interpersonal”. On a side note, Jamie settles on the word intrapersonal, but she is actually talking about interpersonal relationships – relationships between people. These two terms are used in the LA seminar to describe two of the eight multiple intelligences (Armstrong, 2000) discussed in class. It was common for LAs to mix up these two similar words during class discussions, so it is not unexpected that she continues to struggle with the terms during the interview.

According to the generalized model, the reason that it is important for teachers to be seen as approachable by their students is because ultimately this helps them learn. Jamie references this idea during her mid-semester reflection,

I want to improve on helping all the students. Sometimes I worry that I just help the ones that ask more questions or the ones who I'm more familiar with, but often times I realize it's the ones that don't talk that are having the most trouble. I want them to be comfortable with asking for help and make sure they understand the material (Jamie, wk08, 1).
Jamie explains that she is working on being able to help all students learn instead of only those who approach her. To solve this problem Jamie’s focus is on “wanting them to be comfortable” so that they will talk to her and so that she will be able to help them. For Jamie, the first step in students being able to learn is for them to be comfortable. Jamie explains that when students are comfortable they will be willing to ask for help.

Andy also emphasizes the importance of teachers caring about students,

You need to show that you care that the students understand. And be friendly. You need to show that you're willing to help, not just that you're there to help just because it’s your job. Just because, you know, it's Thursday morning and I don't want to be here to help but I'm here. You show that, you have a desire to help them. And want them to do well and then you're interested in how they're doing (Andy, post, 301 – 306).

In this excerpt, Andy uses the words “friendly”, “willing to help”, and “a desire to help” to describe teachers being approachable. He also emphasizes the importance of teachers showing that they care to students. It is not enough for a teacher to care for students if the students are unaware of how the teacher feels about them. For Andy, a teacher needs to go beyond being in class because it is a job to being in class because they have a genuine desire to see students understand the material.

While previous excerpts have demonstrated the basic premise of the generalized model and have touched on various aspects, the LAs also talk very specifically about the entire generalized model and its mechanisms,

I mean I got to know lots of students, lots of great kids and, yeah became good friends with them as well as helping them. And I think that's really important - getting to know them and not just being. . . not just lecturing them or thinking about they’re just some person sitting there, just trying to learn. I mean you need to try to get to know them and try to help them the best you can and make them comfortable, so if they're not really comfortable with you they're not going to admit, you know, if they're having trouble or anything or they're not going to ask for your help (Jamie, post, 3 – 10).

Jamie begins this excerpt by describing her students as her good friends. Her description makes it clear that she cares about them, that she knows what was going on with them, and that she feels invested in their situations. It also indicates that she feels the caring was at least somewhat mutual. Jamie emphasizes the generalized model’s focus on “getting to know students’ when she states that it is important to not just think of students as “some person sitting there, just trying to learn”. Jamie is referring to the idea that teachers should not just see the people in their class as disembodied or disconnected students who exist only in their class and are outside of any other influence. Instead teachers need to recognize their students as whole people who have lives outside of the classroom and who bring these lives into the classroom. Rather than viewing these lives as impinging on the classrooms, teachers should also consider how students’ lives can be leveraged in their learning. Jamie’s description of students as not “just some person” and her emphasis on “getting to know them” refers back to the generalized philosophy of formative assessment’s construct of the individuality of students. Jamie is emphasizing that students are unique and should not be considered what Leah earlier referred to as “identical learning units”. 

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In this excerpt Jamie goes on to explain, as she has done before, that it is the teacher’s responsibility to make students comfortable and that if students are not comfortable then they won’t ask questions or admit if they are struggling. Based on Jamie’s description here, she expects the teacher to take the initiative to create a classroom climate that make students comfortable but she expects the students to recognize when they have questions or don’t understand a concept. This somewhat contradicts the generalized philosophy on formative assessment that expects the teacher to elicit students’ ideas so that she can diagnose and then address students’ understanding.

Andy describes a slightly different mechanism,

The aspect of caring that encompasses listening, understanding, and knowing students, are all important attributes of a good teacher. When a teacher listens to students, a bond of understanding is formed. This leads to mutual trust which in turn leads to improved communication that is not limited to the subject at hand. In this way the teacher knows what different students are feeling and are going through. (Andy, AR2, 22 – 27).

For Andy, when a teacher listens to his students, the student and the teacher come to understand each other and to trust each other. When students and teachers trust each other they are able to talk about both the content and things beyond the content. Several weeks earlier Andy explained why it is important for him to know his students beyond their content knowledge,

My goal for this week was to incorporate other topics of discussion to facilitate learning physics. For example

me: " what are you doing for spring break?"

student: " I am going skiing"

me: " have you thought of the forces and actions pairs that occur when u are skiing?"

Some random topic can arouse interest in the topic of study for the day (Andy, wk11, 1).

By knowing his students’ interests or spring break plans, Andy hopes to incorporate this information into his interactions with students, thereby making physics more interesting and relevant to his students.

As mentioned previously the philosophy of formative assessment and the philosophy of student/teacher relationships are closely tied together in the LAs’ writings. An excerpt from Jamie’s final paper demonstrates this,

In my previous tutoring experience, I did not put much consideration into the student’s priorities. I didn’t pay attention to the types of problems that they were having trouble with. I had only focused on getting them to the right answer. Previously, I mostly helped
students with mathematics. In most cases I would just give the students a shortcut to the right answer and not allow them to think through the process themselves.

After my experience in this classroom I have learned how to actually care about the students and focus on what is causing the difficulty they seem to be having. I pay attention to the mental models they have developed about a subject and help them to adjust these preconceptions to bridge to what I want them to learn. (Jamie, final, 9 – 17).

In this excerpt Jamie compares her previous experience as a tutor in high school to her semester as an LA. According to Jamie as a tutor her focus was on “getting [students] to the right answer” and “just giv[ing] them shortcuts”. When Jamie was tutoring she was not focused on the “types of problems they were having trouble with,” by which she means she was not looking for patterns that would demonstrate students’ underlying mental models. As an LA Jamie now notices patterns in students answers and looks for evidence of their mental models. Jamie uses the information about students’ mental models to help them adjust and bridge their ideas. She also encourages them to “think through the process”, by which she means having students work on developing their problem solving and metacognitive skills. What Jamie is describing as her focus when tutoring is a focus on answer-making. While, this philosophy of learning is often contrasted with sense-making and is often described in the literature as treating school as a game instead of a learning opportunity (Jimenez-Aleixandre, Rodrigues, & Duschl, 2000), that is not necessarily what Jamie is doing here. Later, Jamie’s case study will describe her original philosophy of learning, which saw learning as collecting a pile of previously worked problems to be recalled as examples when facing new problems. Therefore, it is not that Jamie’s view toward school has changed, but her understanding of how people learn that has changed. The LA experience has changed Jamie’s understanding of how people learn to align with the generalized philosophy of formative assessment. This has changed her understanding of how she should teach. Therefore while she has always valued student/teacher relationships her understanding of the purpose of those relationships has changed. Jamie now recognizes, as described in the generalized philosophy of relationships, that the reason students need to be comfortable with their teachers is so that not only are they willing to admit when they have questions, but they are also willing to share their prior knowledge with their teacher so the teacher can build on and leverage this knowledge. Jamie describes this process as “learning how to actually care about the students”. She is not suggesting that her students were not important to her when she was tutoring. She is instead explaining that she now knows how to demonstrate and act on her caring in an effective manner.

While Jamie’s above explanation of the generalized philosophy of student/teacher relationships focus only on the approachability construct, Leah’s explanation demonstrates how the approachability construct can be intertwined with the authority construct of student/teacher relationships,

I think a good teacher is a teacher who is able to relate to students and understand sort of what their needs are and at the same time be able to control the class and be the teacher and the authority figure but also somebody who the students aren't afraid to ask questions to. Because I know I've had teachers like that who are just really dry and really strict and you really don't want to ask them questions because you're afraid to look stupid and I
think that that's kind of sad because how else are people gonna learn if they don't ask questions on what they don't understand. So I think that the best teachers are the ones who are approachable and yet still very knowledgeable and authorities but are able to relate to the students. (Leah, pre, 193 -213).

Here, Leah is describing a good teacher as having two jobs that she views as somewhat at odds with each other. First, a good teacher needs to relate to and understand students. She is implying the ability to help students open up and share their ideas and difficulties. Second, a good teacher needs to be able to control the class and be an authority. In this excerpt, Leah does not explain why it is important for teachers to maintain control over the class, though she goes on to link being an authority with having content knowledge. Leah’s description of “dry” and “strict” teachers indicates that approachability, which she describes as the opposite of bad teachers who are dry and strict, is created by being interesting to and understanding of students. What Leah is describing here is for a good teacher to be seen as a friend by students, which would explain why she pits this against the idea of being an authority figure. Leah goes on to explain that not being approachable makes students feel afraid and specifically a fear of looking stupid. It is, to use Leah’s word, particularly sad that according to Leah, students’ greatest fear is to be seen as not knowing something by the person whose job it is to teach them that something. The student feels the need to hide and protect a part of their identity from a person who is intended to help them. In other words, the student must be a knower instead of a learner. Leah goes on to recognize the need for students to not have this fear and to instead be willing to be vulnerable. She states that students need to be able to ask questions and admit what they do not know in order to be able to learn. Earlier Leah explains that to help struggling students, she needs to find out what they don’t know. Here, Leah is explaining that only a good teacher, who relates to students, would be able to find out this information from students.

A final part of the generalized model of approachability in student/teacher relationships is the view that LAs are uniquely able to relate to students. Jamie explained this when asked what her previous LAs had done that she found helpful,

... they arranged time to meet with us, if you needed it and they were also very approachable. I find that sometimes the TAs are threatening a little bit because they're all grad students, but the LAs, the cool thing about them is that they're undergraduates, just like you and they're right there and they can help you out. So, it's just more of a community I guess, like a learning community feels like with them. They kind of have a link to you that the TAs don't have (Jamie, pre, 25 -30).

To explain how LAs can better relate to students, Jamie creates a dichotomy in the above excerpt between TAs and LAs. She describes LAs as being “just like you” whereas TAs are described as “threatening”. Jamie uses phrases like “they’re right there” and “they have a link to you” to describe the special circumstances that allow LAs to naturally relate more to students. Jamie describes students and LAs as being on equal footing while TAs are described as intimidating because of their higher academic status. For Jamie, this equal status and shared experience means that students see the LAs as more approachable.

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authority: The second construct of the generalized philosophy of student/teacher relationships is the focus on authority. Jamie references this focus in her first interview when asked what concerns she has about being an LA,

I think it's going to be weird when I'm teaching upperclassman . . . it just seems like it would be a little weird and I'm wondering if they'll still respect my ideas even though I'm so young, because I already went through this and I know (Jamie, pre, 214 – 219).

In the excerpt, Jamie is worried about a lack of respect from students because she lacks the authority that teachers usually have with respect to students that comes from their age or higher academic standing. Without the authority of a higher status Jamie is concerned students will not respect her ideas. It is important to note that Jamie’s concern is with gaining respect for her ideas and not specifically for herself. This is because Jamie’s focus is not on being able to manage the class, but on the content area of authority discussed in the generalized philosophy. Jamie is concerned that her lack of authority will prevent her from being able to help students because the ideas that she presents will not carry any weight. Jamie chooses to frame this idea as something that she thinks is “going to be weird” and not as something that she is worried or concerned about. Not only does she not describe it as a concern but also she also further dismisses it as only “a little weird”. Jamie is not all that concerned, or more likely, she doesn’t think she should be all that concerned about it. Finally, in line with the generalized philosophy, Jamie is not concerned with whether she can actually help students but with whether she is perceived as knowledgeable by her students. Jamie knows that she has the experience and the content knowledge to be helpful.

Leah expresses similar concerns at the beginning of the semester as well, “I'm a little bit nervous about people listening to me and respecting me. Not making fun of me or anything. But, that will probably go away after the first day or two. I hope” (Leah, pre, 280 – 282). Just like Jamie, Leah is concerned that students will dismiss her because she is seen as lacking the authority to be helpful. She expresses this idea in the phrases “listening to me”, “respecting me”, and “not making fun of me”. Following her first week of teaching, Leah returns to this idea,

My main goal was to try to get myself comfortable with being an "authority figure"; for a class of students. I felt that I met this goal, because I was able to maintain a reasonable presence throughout the tutorials that I taught. I felt that I was a person that the students respected enough to listen to and to ask questions (Leah, wk03, 2).

Here, Leah describes how she attempted to address her concern with authority. In order to convince students that she should be listened to and respected, Leah worked to maintain an authoritative presence in the classroom so that students saw her as knowledgeable. This solution also requires Leah to address the dichotomy between being approachable and being an authority – the same dichotomy she described good teachers as having to wrestle with. Leah’s solution to
her concerns with respect is to create a presence or to put on a performance. This could be at odds with her focus on being approachable which involved being friends with students. Despite conflicts between Leah’s desire to be approachable and be an authority, her purpose for both desires is the same – to help students learn. As Leah explains she wants to be seen as an authority and respected by students so that they will ask her questions. This means that the philosophy of student/teacher relationships requires teachers to walk the fine line between being seen as approachable so that students will be willing to ask them questions but also being seen as knowledgeable and respected because otherwise students won’t bother to ask them questions.

Later in the semester Leah focuses on the second area of authority – managing the classroom,

There were definitely some times where the students were very off track and just very unwilling to start the tutorial. And that was pretty frustrating. I'm not a very confrontational person so it’s really hard for me to go up to somebody and say "hey, you need to start working now." So I would try and do it in a light hearted manner but that didn't always work so well, so I think in the future that is something I would definitely work on, was getting a better authoritative presence when students were not doing the tutorials at all and were completely off track, working on trying to help them get on track better. (Leah, post, 17–24).

Leah sets up the situation as a dichotomy between her and the students with her use of opposition words such as “unwilling”, “frustrating”, and “confrontational”. Leah’s concern here is that students are not doing their work. This concern is not about being seen as having the necessary knowledge, as with her previous concerns around authority, but about being seen as having the right or the status to tell students what to do. Once again though, Leah’s solution is to perform so that she presents a stage presence to students that demands this status. Gen presents a similar concern when he describes how LAs can help students learn, “Like LAs could make sure that everyone's on the right track and make sure that everyone is doing it correctly and understanding it. Like just not sitting there for the sake of the grade” (Gen, pre, 210–212). Gen’s focus is on LAs having the authority to manage the classroom. Gen isn’t looking for this authority simply so that he can have the power to tell students what to do. His focus is on making sure that students “understand” the material. His goal is for students to learn and he feels that authority in the classroom will be necessary for this goal. Gen returns to this idea later in the interview as he describes how he would address the problem of off-task students,

Maybe motivating the kids who sat in the corner and just didn’t do anything. I think that would be the only thing that would change. But I would try and incorporate everyone and makes sure that they're doing what they're supposed to be doing. Maybe, threatening them with a grade sanction would be a good thing too. Because they're showing up, they care about grades. If we threaten them they might think differently, like just change their thoughts. (Gen, pre, 268–274).
Gen uses the term motivation but he means it in a different sense than it is used in the
generalized philosophy of relationships. Gen is talking about using external motivation – grades
– to manage his classroom. Yet, in his description Gen sets up an oppositional environment by
talking in terms of “threatening” students. It is unlikely that Gen consciously means to do this.
Instead, Gen is simply looking for a way to help students focus. Unlike Leah who is looking for
authority through a stage presence, Gen is looking for it from systemic power, the control of
grades, which he actually doesn’t have as an LA.

Motivation: The final aspect of the generalized philosophy is motivation. While Gen used the term to
talk about gaining authority, this philosophy is focused on LAs creating internal motivation for
students. Jamie describes what successfully creating this looks like when she talks about her
favorite teacher,

He was really fun. And he was a huge inspiration to go into any type of science because
he was just so devoted to it himself, you know. Like, he loved it so much, and he was just
having so much fun in the class even if the students were just staring at him blankly, he
always had a smile on his face and he was just a really good teacher. I wouldn't mind
being like him (Jamie, pre, 158 – 162).

Jamie is describing how a teacher can inspire students and create motivation within them by
modeling a love of science. Jamie considers modeling this style in her own teaching. She talks
about why this motivation is important to her earlier in the interview,

I'd like to make sure that groups are focusing more. 'Cause as I said there were some
distracting groups and if there's any way that I can make them focus more or make the
students that don't want to get involved in this more excited about this I think that would
be good. Because, I mean, I really love physics and I just want everyone else to too. And,
I just, I don't know, I guess I can't stand it when I see kids not enjoying it. So I just want
to see them and I want to see them have fun with this. Even if it's not the same way that I
think about it. I want to find a way to make them enjoy learning, just like I do (Jamie,
pre, 143 – 150).

For Jamie, motivating students is a way to address off-task students, the same problem Leah and
Gen talked about addressing using authority. Also, for Jamie motivation is personal as she wants
students to feel the same way about physics that she does. Jamie returned to this topic several
times during the semester. She talked about helping students to become more motivated to work
on tutorials (Jamie, wk05, 4; Jamie, wk11, 1) and more excited about physics (Jamie, wk06, 3).
For Jamie, this was an important part of why she became an LA (Jamie, wk05, 4), what she
considered to be good teaching, and one of the main reasons she would consider a career in
teaching (Jamie, post, 355 – 274). For Jamie, motivation is an important aspect of her
relationship with students because she wants to teach students to not only know the physics content but also to love physics.

Ultimately, the LAs’ greatest concern is for students to learn the material. They consider the relationships between students and teachers to be critical to this learning. Therefore their philosophy of student/teacher relationships focuses on three constructs. First, they believe teachers should be approachable so that students are comfortable enough to ask questions. Second, they want students to recognize LAs as being authorities who have the content knowledge necessary to help them and who have the right to insist that they focus on their work. Finally, LAs are a source of motivation to students by inspiring them to enjoy physics and to want to learn the material.
Individual Case Study: Leah

Leah’s philosophy of teaching includes a model of formative assessment and the importance of approachability in student/teacher relationships. Of the four LAs, Leah begins the semester with a model of teaching that most closely resembles the generalized model of formative assessment since she talks about both the importance of having students construct their own understanding and of building on students’ prior experiences. Leah goes on to construct a complete model of formative assessment similar to the generalized model during the first half of the semester. Within her model, Leah is the only LA to talk about the important life skills that students develop by learning to construct their own understanding of physics concepts. In her writing Leah describes how tutorials help students learn to work in groups and to creatively problem solve.

Leah is the only LA to begin the semester with a philosophy of student/teacher relationships that includes a mechanism for how being approachable helps student to learn. Leah’s model is based on the idea that students cannot learn if they are not willing to ask questions of the teacher. Yet students are not willing to ask questions unless they feel the teacher is approachable. Leah mentions this idea several times during the beginning of the semester interview, she does not return to the importance of teachers being approachable during the rest of the semester. Though she doesn’t mention approachability again, Leah does talk about student/teacher relationships several times throughout the semester by mentioning her concerns with authority. Leah’s discussions of authority are unique, compared to the other LAs, because her discussions of authority are focused on presenting an “authoritative presence” to address the problem of off-task students. While Leah does mention issues around authority several times during the semester, these are not a focus of her writing; instead she is focused on issues around her model of formative assessment such as adapting her teaching to fit her students.

Leah is the oldest of the four LAs. She is a post-baccalaureate student who has returned to college to complete her medical school prerequisites after receiving her bachelors degree in political science from a university on the east coast. Leah’s previous experiences appear to have made her the most articulate of the four LAs especially in her article reports and final reports. Leah did not intend to pursue teaching as a career when she started the semester, and her opinion did not change following the LA experience. She is planning to attend medical school, though she hopes that her future career would involve some aspect of teaching. She has previously worked as an EMT during college and enjoyed the opportunities to teach fellow EMTs and high school students.

Student/Teacher Relationships
Leah began the semester acknowledging the importance student/teacher relationships. Of the four LAs, she is the only one to describe the mechanisms of the approachability model at the beginning of the semester. Leah explained this mechanism when she was asked what makes a good teacher,

I think a good teacher is a teacher who is able to relate to students and understand sort of what they're needs are and at the same time be able to control the class and be the teacher and the authority figure but also somebody who the students aren't afraid to ask questions to. Because I know I've had teachers like that who are just really dry and really strict and you really don't want to ask them questions because you're afraid to look stupid and I think that that's kind of sad because how else are people gonna learn if they don't ask questions on what they don't understand. So I think that the best teachers are the ones who are approachable and yet still very knowledgable and authorities but are able to relate to the students.(Leah, pre, 204 – 213).
Leah explains that approachability is important in student/teacher interactions so that students feel comfortable asking questions and do not feel the need to protect themselves from appearing stupid. Leah’s model of learning is shown in Figure 4 and is shown in negative terms, how to prevent learning, since this is how Leah originally explained the idea.

Leah’s above description of good teaching is focused on the teacher being approachable, but it also mentions the importance of teachers being an authority figure. Leah does not heavily focus on issues of authority but she mentions the topic throughout the semester. In her description of good teaching Leah sets up a tension between being able to control the class and being seen as approachable by students. She considers both aspects of teaching to be important for creating an environment where students can learn. Leah returned to the issue of authority in the pre-semester interview, when asked what she was worried about, she responded that she was concerned that students would not listen and respect her – “I'm a little bit nervous about people listening to me, and respecting me. Not making fun of me or anything. But, that will probably go away after the first day or two. I hope” (Leah, pre, 280 -282). Leah again returned to the issue of authority in her weekly reflection following the first tutorial in which the LAs actually helped teach the class,

My main goal was to try to get myself comfortable with being an "authority figure"; for a class of students. I felt that I met this goal, because I was able to maintain a reasonable presence throughout the tutorials that I taught. I felt that I was a person that the students respected enough to listen to and to ask questions (Leah, wk03, 2).

Leah was concerned that if students did not see her as an authority they would not be comfortable asking her questions. This is the first area of authority as explained in the generalized philosophy of student/teacher relationships – being seen as a content authority. Leah did not mention the authority aspect of her relationship with students again until her week 12 reflection when she writes that her hope for the week was to encourage students to concentrate on and finish the tutorials since the semester was winding down (Leah, wk12, 3). Leah mentioned this issue again at the end of the semester when asked what didn’t go well in her experience as an LA,

There were definitely some times where the students were very off track and just very unwilling to start the tutorial. And that was pretty frustrating. I'm not a very confrontational person so it's really hard for me to go up to somebody and say "hey, you need to start working now." So I would try and do it in a light hearted manner but that didn't always work so well, so I think in the future that is something I would definitely work on, was getting a better authoritative presence when students were not doing the tutorials at all and were completely off track, working on trying to help them get on track better. (Leah, post, 17 – 24).
Toward the end of the semester Leah began to describe her concerns that students were not focusing on finishing their tutorials. She attempted to encourage them to get back on track but found that they didn’t listen. She blamed this on her lack of an “authoritative presence”. Now Leah is talking about the second area of authority. For Leah this authority came from the way she presented herself and was something that she could cultivate in the future.

Formative Assessment

Table 3. Summary of the Development of Leah’s Philosophy of Formative Assessment.

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<td>Construction</td>
<td>Don’t give answers</td>
<td>Students learn important skills through the process of learning</td>
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<td>Prior Knowledge</td>
<td>Innate understanding</td>
<td>Intuition &amp; learning preferences</td>
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<td>Individuality</td>
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<td>Different methods work for different students</td>
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<td>Adaptability</td>
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<td>Adaptability key to teaching</td>
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The development of Leah’s philosophy of formative assessment is shown in Table 3. Leah’s philosophy developed in two stages. First she began the semester already recognizing the importance of having students develop their own ideas rather than simply giving them the answers. Leah also recognized that students had ideas from their prior experiences that could be relevant to their study of physics. Leah’s ideas about these two constructs remain fairly constant throughout the semester. About half way through the semester, Leah began talking about a fully developed model of formative assessment that included recognizing that students responded to questions and other teaching strategies in different ways and therefore teachers needed to adapt their teaching to fit the needs of each particular student.

Construction

Leah entered the LA program recognizing the importance of students’ creating their own understanding. When asked what the role of LAs is, she responded,
. . .they're there to help you learn and so that I think to me sums it up. It’s that the LAs weren't really teaching you but like sort of pushing you to understand the concepts better. It was really helpful that none of the LAs that I had have ever given me the answers or anything which a lot of people want. And I know a lot of times I've wanted them too. So, yeah, just sort of there as the guide to help you figure out what's the best way for you to learn and help you understand the concepts (Leah, pre, 109 – 115).

Prior to the beginning of the semester, Leah recognized that LAs were in the tutorials to help students figure out the physics concepts for themselves. This is the construction element of the formative assessment philosophy. Based on her interactions with her previous LAs, she recognized the value in LAs not giving students the answers. Leah returns to the importance of having students construct their own understanding in her reflections from weeks five and six. She first explains that she wants “to work harder to get my students to understand and work through the ideas by themselves, and to minimize any ‘hints’ that I gave towards the right answer” (Leah, wk05, 2). The next week she states that she wants “to work again on ways to coax students into understanding the concepts with questions and dialogue” (Leah, wk06, 3). It is important to Leah that her students work through these ideas on their own and that her job is to provide minimal help when necessary to coax students to the answer. She is working to use questions and dialogue instead of hints to help students reach an understanding. Leah, reiterated her view of the job of the LAs in final reflection of the semester,

My job as an LA is not to teach students new concepts, but to help them go through the process of understanding concepts that have already been introduced. I consider myself an aide to comprehension rather than a teacher, because it is my job to encourage students to understand material on their own. I can clarify concepts that may be fuzzy, but it is not my role to tell a student what an answer to a problem or question is. Rather, my role as an LA is to act as a guide so that students can get some help figuring out good ways to go about tackling a problem. (Leah, wk14, 5).

Leah’s descriptions of the job of a successful LA are based on LAs offering minimal assistance to students so they can develop their own understanding. She considers her job as one of guiding, coaxing and clarifying instead of teaching. She defines teaching as giving information to students. In the end of semester interview, Leah explains why she feels it is important for students to develop their own understanding. When asked why she used questioning a lot when teaching, Leah explained,

“. . . directed questions and carefully constructed questions can really help the students come to their own understanding of the concept which is going to be a lot more lasting and a lot more solid than just hearing an answer from somebody else” (Leah, post, 106 – 108).
Therefore, Leah views the type of teaching she uses as an LA to be helpful because the understanding that students develop is more robust and more lasting than if students were told answers.

Leah’s responses in the beginning of the semester interview and in her final reflection hint at another reason Leah feels that it is important for students to develop their own understanding with the guidance of the LA. In both responses Leah explains that LAs can help students to figure out “the best way for [them] to learn” or to “figure out good ways to go about tackling a problem”. Leah recognizes that LAs are helping students to learn more than just the physics concepts. Instead, LAs are also helping students to learn about themselves and their own learning preferences and to learn problem-solving skills. In the second part of the semester, these problem-solving skills become very important to Leah. During her mid-semester reflection she states,

I have noticed that the more I teach and learn about teaching, the more I have realized the importance of allowing the student to reach his or her own answer. A student learns much better through thinking, and that process is much more important than the answer itself (Leah, wk08, 1).

Later, when asked why it isn’t helpful to just give students the answer, Leah explains why the problem-solving process is so helpful for students,

Lectures and answer-giving will not advance an understanding of the nature of science because students need to be able to produce their own creative ideas and thoughts regarding a specific problem. It is not simply scientific knowledge that students must learn, but scientific skills. These problem-solving skills can be applied to all subject areas but are particularly important in science. The scientific knowledge that students learn will be much more lasting and useful if students have a deep understanding of how someone arrived at those concepts, and how to understand specific topics in relation to other topics in science (Leah, wk13, 2).

Leah’s final paper returns to the importance of problem-solving as Leah describes how her views on small-group discussions have changed.

I no longer see discussion as an exchange of information between student and teacher. Instead, I increasingly believe that the value of discussion lies not in the information itself, but in the way that students learn to generate ideas and understanding within a small group. Creativity increases significantly when students combine and develop their individual ideas as a group. Not only does discussion enhance problem-solving skills and
allow students to contribute their own strengths to a group, but it is a necessary skill that nearly all students will need to use in the future (Leah, final, 81 – 87).

As the semester goes on Leah begins to talk about the importance of what was happening in tutorials. She recognizes that students are not just learning about physics instead they are also learning how they best learn, how to problem solve, and how to work within groups. None of these other important lessons would be possible in an environment that did not stress the construction of learning. Leah is the only one of the LAs to talk about the life skills that students develop in tutorials beyond learning the content and problem solving skills.

**Prior Knowledge**

Throughout the semester Leah talks about eliciting students’ prior knowledge, the second construct in the generalized model of formative assessment. At the beginning of the semester Leah explained that she would start helping a group of students by first finding out what they understood and where they were struggling.

First, I would probably try to figure out exactly what they were having a problem with. Like if there were certain parts to the problem that they understood and certain parts that they didn't. Then maybe try to figure out why they didn't understand, what they weren't getting (Leah pre, 149 - 152).

At the end of the semester she described a similar process.

Well, I think that at first I would ask them to sort of clarify to me what their understanding of the situation is, what their understanding of the problem is and how they would or have gone about solving it. Because I think sometimes when students verbalize what they mean to somebody else it kind of helps them clarify what they mean and maybe even see some contradictions or something they didn't see before. (Leah, post, 85 – 90).

While Leah’s answer at the end of the semester shows her continued commitment to base her interactions with students on their current understanding, it also shows an evolution in her understanding of problem solving. At the beginning of the semester, Leah’s questions are based entirely around finding out where students are stuck in the solution process. This suggests that she is assuming that there is a single linear path to solve the problem and the students are stuck somewhere along this known path. At the end of the semester, Leah is focused first, not on simply finding out where they are stuck along the path, but on finding out what path they are on.

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She begins the conversation by attempting to understand what students think the situation is in the problem and what they think the problem is asking. In other words, she is attempting to understand the terrain from the students’ perspective. Then, she asks them how they have tried to solve the problem. Leah also references eliciting students’ current understanding in the reflections when asked why she uses questions, “I tried to ask questions in a dialogic manner, so that I could see what the students were thinking and see what they had trouble with” (Leah, wk04, 2). The reason Leah is beginning the interaction with questions is so that she can see how the students are thinking about the problem.

When Leah describes helping students with specific problems in her weekly reflections, she does not usually describe how she elicited students’ current understanding. This is because she chooses to focus her response on her intervention and begins her narrative once she understands where students are struggling. This is supported by the fact that she begins these descriptions by stating the student difficulty - “Most of the students at first thought about the problem in terms of energy, which is how I also first looked at the problem, and arrived at an incorrect response” (Leah, wk12, 1). On the other hand, when describing in the interviews how she would assist a hypothetical group of students, this step is included. This suggests that Leah is aware of this step but is using her reflections to think about her own teaching strategies rather than reporting on what happened in the classroom or documenting student ideas.

Throughout the semester, Leah references a variety of types of prior knowledge that students can access in their physics classes. At the beginning of the semester, Leah references students’ everyday knowledge of physics, “Because especially in physics, everybody kind of has an innate understanding of physics, it’s just its hard to get there from just dry lecture or reading the book and stuff” (Leah pre, 154 - 156). Here, Leah describes the everyday resources or experience-based knowledge that students can use to learn physics. She also points out the difficulty that students can have connecting their experience-based knowledge with the academic knowledge of physics given the way it is presented in lectures and textbooks. Later in the semester, when she is asked to explain her theory of learning, Leah includes an expanded list of the types of resources that students have, “Students have a particular way of learning already in their heads, coupled with information that they may have already been told and their intuition” (Leah, wk06, 4). Besides students’ intuition or experience-based knowledge, Leah also now includes students’ prior academic knowledge – information they’ve already been told - and their learning styles – a particular way of learning.

While Leah talks about various resources that students have, she does not consistently talk in terms of a traditional resources model. When asked what she is struggling to understand about formative assessment, Leah responds,

What I did not understand were some of the distinctions between good ideas that students have and ideas that need some “fixing”. It is difficult to distinguish between a preconception that a teacher can build on and one that actually is wrong (Leah, wk05, 1). Here, Leah distinguished between ideas that students have that are just wrong and those that can be useful to build on. Leah returns to this point several weeks later “It’s very rewarding when a student reasons their way to a thorough understanding of a concept on their own, but sometimes students’ intuitions are plan incorrect” (Leah, wk09, 2). By the middle of the semester, Leah struggles to reconcile her understanding of theories of learning that instruct teachers to find
student’s current understanding and then shape that understanding with her experiences of student ideas that she can’t reconcile with her understanding of the topic.

**Individuality**

Leah began talking about the individuality of each student, the third element of the formative assessment philosophy, partway through the semester following the introduction of learning theories in the LA seminar. For the rest of the semester Leah talked about the importance of teachers’ noticing the differences between students and paid special attention to the differences in students’ learning styles or preferences. Leah also implicitly noted differences in student ideas when she reflected on students’ ideas and how she helped students.

Leah chose to focus both of her article reports and her final paper on students’ individuality. Her first article report contrasted Redish’s article on mental models (Redish, 1994) with Knuth and Peresini’s article on discourse styles (Knuth, Peressini, Teaching, & Jan, 2001). She talks about how teachers can use different questioning styles to elicit each student’s unique mental model. She goes on to describe individuality as one of the two main goals of teaching. In her second article report, Leah analyzes Lederman’s (Lederman, 1998) call for science standards that include the nature of science in light of Armstrong’s (Armstrong, 2000) call for teachers to recognize students’ varying mental intelligences. Leah argues that Armstrong’s argument can be expanded to a call for an increased focus on the individuality of student learning. In her final paper Leah comments,

> It is all too easy for a teacher to view students as identical “learning units” that must be filled with a particular subject. Analyzing these two articles at the beginning of the semester helped me to understand that students necessarily learn in distinct ways. A particular form of discussion may enhance one student’s understanding of a concept, but could do absolutely nothing for another student (Leah, final, 29 – 33).

Leah first mentioned differences in her students during her week six reflection. When asked to evaluate her teaching for the week, she began by stating that “different teach methods worked much better for different students” (Leah, wk06, 2). Leah demonstrates in her response this week that she recognizes that students do not learn using the same methods and therefore respond to various teaching methods differently. Leah’s references to differences between students tend to focus not on conceptual differences but on learning styles. This could be because Leah found working with different learning preferences to be challenging while building on different student ideas to be relatively easy. Therefore she focused her writing on the aspect with which she struggled. Another possibility is that Leah tended to use a teaching strategy that did not build on students’ ideas but had students start over from first principles. In this case she would not notice differences in students’ prior ideas because she would always point them to the same starting point and therefore the only difference between students would be how they responded to her various prompts.
Leah continues talking about the individuality of students in the post semester interview, when she explains one of biggest things she feels she has learned about asking good questions is that “the same question is not going to have the same effect on every student so you have to get to know your students, maybe how your student learns and how your student thinks in order to ask good questions to them” (Leah, post, 113 – 116). Leah’s papers show that she values the unique ideas and styles of each student and the influence this has on effective teaching.

Leah’s awareness of differences between students is also evident from her descriptions of students’ difficulties or her strategies for helping students with particular problems. Leah begins her descriptions by describing a problem most or many students had – “Most understand that force always acts at the center of mass” (Leah, wk12, 2) and “a particular group of students thought that the vectors pointed in the same direction” (Leah, wk14, 6). She then describes an intervention that usually worked – “Generally what worked for most students was when I went through each force . . .” (Leah, wk06, 2). In other words, Leah is recognizing that while there were common issues with which many students struggled and that there were common strategies that helped these students, these were not universal and other students had other ideas. Throughout the latter part of the semester Leah demonstrates the value she places on recognizing the individuality of her students and the influence this has on her teaching.

Adaptability

Of all the LAs, Leah talks the most extensively about adapting her teaching to her students - the fourth element of the formative assessment philosophy. Leah began talking about this during her first article report –

While both articles present the learning experience in a different manner, they each emphasize the necessity of adaptability of teaching style. Certain students and situations will require the teacher to guide the learning process differently. I support the general argument of both articles—a successful teacher must be able to alter lessons or concept explanation based on the individual situation and student (Leah, AR1, 19 – 23).

Leah explains that in order for a teacher to be successful they must alter both the general lesson and the specific explanation to the situation and the student. Leah’s description suggests that the teacher must make overall adjustments to the lesson as well as moment by moment adjustments to the explanation she is using. Leah’s description also suggests that while teachers need to adjust their teaching to individual students, the same adjustment won’t always work for the same student so the teacher has to also respond to the specific situation. At the end of the semester, Leah relates the concept of adaptive teaching directly to the job of an LA,

I found that one of the most important roles of the learning assistant was to identify the ways in which these students struggled and to try to find alternative ways of
understanding the material that did not rely so heavily on logical and mathematical intelligence (Leah, final, 60 – 63).

For Leah, the job of the LA is to understand where students are struggling and to then adapt her teaching strategies to these students’ needs. Leah talks specifically in terms of multiple intelligences since this was how she often categorizes student differences. In the final interview Leah does not talk in terms of adaptability in teaching as she did in her article report, but she explains the same idea in terms of flexibility in teaching,

I think flexibility is maybe the biggest thing that makes a good teacher. Because students are all so different. They're all coming from such different places and they all have such different experiences in the classroom, even with the same teacher and the same material. And so I think the best teachers are the ones that can recognize when what they're doing for a particular student or for a particular class is not working and be able to be open to changing that. I know that I have experiences with a lot of teachers who think that their way is the right way of doing it and that works for some people but it doesn't work for others. And so for the students who really are getting that method of teaching, they're just sort of left in the dust. So, I think that the best teachers are able to look at their individual students' needs and be able to change their teaching method accordingly (Leah, post, 201 – 211).

Leah pulls on her previous experience with teachers who only use one type of teaching strategy to reach all students to explain what she considers to be good teaching. For Leah, a good teacher is not wedded to a single teaching strategy or concept explanation. Instead a good teacher makes instructional decisions based on what the student needs.

Leah begins the semester already recognizing the importance of students constructing their own understanding and of the value of students’ prior knowledge in learning. She talks about the first idea based on her experiences with her own LAs. Leah values student’s prior knowledge because she recognizes that everyone has intuitions that are valuable in learning physics. Leah begins talking about recognizing students’ individuality and the importance of adaptive teaching in week six and especially in her first article report. Leah then continues talking about these ideas throughout the semester. Leah’s progression to the complete model of formative assessment is shown in Figure 5. The first time Leah mentions each factor is indicated.
Leah begins the semester talking about aspects of both philosophies of learning. But as the semester continues she focuses solely on the formative assessment philosophy. As the semester develops, Leah’s philosophy of learning comes to very closely resemble the generalized philosophy of formative assessment.
Individual Case Study: Andy

Andy begins the semester with a commitment to students constructing their own understanding. At first he talks about this only in terms the importance of having students talk about their ideas so that they can think more clearly. As the semester progressed Andy began to talk about using questions to help students construct their understandings and eventually using both questions and explanations to help students. As the semester progressed Andy’s philosophy of teaching and learning also expanded to include the other constructs found in the generalized model such as prior knowledge, individuality, and adaptive teaching. While Andy mentions prior knowledge and individuality, his focus remains throughout the semester on having students construct their own understanding. He only mentions adapting his teaching to help students process their understanding at the end of the semester.

Andy’s views on student/teacher relationships evolve over the semester. At the beginning of the semester, he recognized the role his relationship with his previous LAs and teachers played in his own learning. Yet he did not talk about trying to build similar relationships with his own students. As the semester progressed, Andy began to talk about the impact of student/teacher relationships on his own students’ learning and he begins to talk more explicitly about how to build these relationships. When talking about his own students, Andy’s focus is on learning about their everyday life so that he can draw on their experiences in his teaching. Andy is unique in the practical way he talks about improving his relationship with students and his focus on strengthening these relationships. While the other LAs talked about wanting to build relationships with students, they did not mention practical steps about how they would build these relationships like Andy did. Andy’s focus on relationships in the second half of the semester is somewhat surprising since he never mentioned wanting to build relationships with students in the pre-semester interview or the early weekly reflections.

Andy is a sophomore mechanical engineering major. While Andy had not made any career decisions by the end of the semester, he is the only one of the four LAs to eventually pursue a teaching certification. Andy’s interviews were unique in the emphasis he placed on his previous LA and TA. At the beginning of the semester Andy talks about his positive experience with his LA in PHYS 1110 the previous semester. Andy pulls on this experience to describe the job of an LA and how he thinks teachers can help students learn. Several times during the semester Andy also mentions his TA from PHYS 1110 who is now one of the TAs he works with as an LA. He had a good experience with her as a student and continues to like how she works with students throughout his semester as an LA. These two people had a very strong influence on Andy’s understanding of how people learn and the role of an LA.
Table 4. Summary of Andy's development of his philosophy of formative assessment.

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<tbody>
<tr>
<td>Construction</td>
<td>Students need to talk about their ideas</td>
<td>Questions help students learn</td>
<td>Both Questions and Explanations can help students</td>
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<tr>
<td>Prior Knowledge</td>
<td>Important to elicit student ideas</td>
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<td>Important to understand the problem from the students’ perspective</td>
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<td>Individuality</td>
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<td>Every student is different</td>
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<td>Different strategies help different students</td>
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<td>Adaptive Teaching</td>
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<td>It’s a puzzle to figure out what methods will help which students.</td>
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**Construction**

Andy’s valuing of the construction of knowledge, the first construct of the general model of formative assessment, remains fairly constant throughout the semester. While his focus remains constant, Andy’s understanding of how to help students construct knowledge changes over the semester. At the beginning of the semester Andy believes that the best way for students to construct their own understanding was for them to talk about their ideas aloud. As the semester progressed Andy began talking about using questions to help students talk about their ideas and to construct their understanding. By the middle of the semester Andy recognized that explanations could be equally effective for students in certain situations.

Andy’s views on the construction of knowledge are first apparent in how he describes the role of the LA. He began the semester with a clear idea of what he thought the job of an LA was, how he thought they should help students, and why this method was effective –
you understand it a lot better than when the teacher works it out. So if the students are able to understand the material pretty much on their own then they really have learned it a lot better than otherwise. So an LA's job is to help them learn on their own (Andy, pre, 80–87).

Andy explains this point again during the first reflection when he states that, “I think that my job will be to help students learn. I am not there to provide answers, but to facilitate the students understanding of the material” (Andy, wk02, 1). Andy’s beginning philosophy of teaching places a very strong emphasis on the construction element of the formative assessment model. Andy’s use of the phrases “facilitate learning, “teach themselves”, and “help them learn on their own” refer to the philosophy that it is important for students to create their own knowledge rather than passively absorbing information from the instructor. Under this philosophy the instructor must step back and take a secondary role to the student in the learning process. The instructor is a facilitator or an assistant. As an LA, Andy wants to make sure that students do most of the work and teach themselves. Therefore the LA should only offers hints so that students can continue figuring out the problem on their own. Andy reiterates this technique of giving only hints so that students can develop their own understanding in his second article report,

In the recitation sessions that we have, the environment is set up such that we are supposed to help but not always tell the answer. Even though some students are uncomfortable with this approach, I have found that it is a good method to help students understand physics. (Andy, AR2, 49–51).

By the end of the semester, Andy has noticed that students are not always comfortable with how he wants to help them. Instead, the students want him to give them the answer to the problems. Despite students’ discomfort with this technique, Andy remains committed to it because he views it as one of the best methods for helping students learn since people learn better when they work the material out on their own.

For Andy, a key way that students construct their own understanding is by talking aloud about their ideas. Andy places a uniquely strong emphasis on this idea compared to the other LAs. He explains this idea when he comments on why group work is important,

They use groups because when you discuss topics with other people, you understand them a lot better. If you try to figure it out in your head, I know from experience that a lot of times it won't make sense or you think you had it but then when you talk to somebody it will make a lot more sense. So when you say, 'this is what I think', somebody else says 'this is what I think' and they explain. It, it's almost like, it's like you're teaching each other the material, which is very helpful (Andy, pre, 41–49).

Based on this excerpt, Andy is drawing heavily on his personal experience in tutorials the
previous semester. His learning strategy is based on several elements. First, working problems 
out in one’s head can be misleading since logical jumps or inconsistencies can be glossed over. 
Second, his strategy is not simply about talking aloud. What he values is actually the dialogue 
that occurs between students as they share their ideas. Finally, Andy equates these dialogues to 
teaching. In this statement he is referencing a previous comment he made when he stated that a 
person learns the material best when they teach it. Andy demonstrates how he would use this 
strategy when he describes how he would help a group of struggling students,

Well, from what I've seen, what I think, and what I've seen this semester. What I would 
do is just kind of go over it. Talk over what they already did. A lot of times when 
someone, when you talk over it, and say well do you think this is correct, students get an 
idea that oh maybe I did something wrong. So they start thinking. I don't know, for me a 
lot of times when the LA would speak what our answer was and just kind of point out 
what we had done, “so this what you're meaning, this, this, and this”, suddenly it would 
come to me that “oh of course I was wrong. It has to be that”. And then if not, as the LA I 
would, if they still didn't get it I would prompt a little bit. Say, “well,” or I would give a 
counter example if there was one. To show a counter example and say, “well then what 
would be right.” Counter examples help a lot to show that for some case it may work. For 
all cases it may not, though, for all of things. (Andy, pre, 102 – 113).

In this excerpt Andy gives several teaching strategies that he would use as an LA. All of these 
strategies are intended to encourage students to use the learning strategy, talking aloud about 
their ideas, that he describes above. First, he would encourage students to continue thinking 
about their ideas further. Second, he would restate students’ answers, putting them in slightly 
different words. This rephrasing is done to highlight the implications of the students’ idea. 
Finally, if neither of the above strategies are effective then Andy offers a prompt such as a 
counter example to provide more information for the students to consider. The counter example 
is intended to work very similarly to the second strategy in that it encourages students to evaluate 
their answer based on its implications. Andy describes these strategies in order of increasing 
interference from the LA. This is in keeping with his previously discussed emphasis on having 
the student do most of the mental work while the LA only provides guidance when necessary.

Andy remains committed to having students talk about their ideas as a way for them to 
learn throughout the semester. Yet, his ideas on how to facilitate this talk evolve. At the 
beginning of the semester Andy’s strategies for helping students only include restating the 
student’s response and offering a counter example. By the week four reflection, Andy begins 
talking about using questions to guide students’ thinking when they do not recognize holes in 
their own argument. He demonstrates this technique in a vignette he included in his reflection 
based on his many interactions with students that week over a difficult part of the tutorial. In this 
problem students had been asked to draw the acceleration vector of a particle traveling at a 
constant velocity around an oval track.
I: "why do you think that the acceleration is way that you drew it?" (the angle between the velocity and acceleration was greater that 90)
Student: "well acceleration points towards the center of the oval".
I: "does it?" (Sometimes that was enough for them to see their mistake)
Student: "yes when an object moves in circular motion, the acceleration points towards the center of the circle"
I: "is the track a circle?"
Student: "no." (often they would get a puzzled look)
I: "how does radial acceleration work? how is it related to velocity?"
Student: "acceleration is change in velocity over time"
I: "is the velocity changing here?"
Student: "there is constant speed, but the direction changes"
I: " so the object is not speeding up or slowing down, right?"
Student: "yes"
I: "how do u think acceleration would have to act on the object to make it turn but remain at a constant speed?"
Student: " oh. it would have to be 90 degrees?"
I: "do you think it would?"
Student: "yes, because if it was not then the object would either speed up or slow down.
this makes sense now. thank you"
This one kind of conversation I had with students. (Andy, wk04, 2).

In his final paper Andy explains his thinking about the types of questions he often uses when working with students.

I try to use indirect questions when I am discussing concepts with students. Indirect questions give the students an opportunity to develop the concept by themselves and that makes the learning process exciting and also more effective. For example, “What do you think about this diagram?”, “Why have you answered the question like that?” and so on (Andy, final, 49 – 53).

Throughout the semester Andy tends to use vague questions with students – “do you think this is correct”, “does it”, or “what do you think about this diagram” – or brief questions that encourage students to reconsider a specific part of their solution or the problem – “well then would that be right”, “is the track a circle”, “how is [radial acceleration] related to velocity”. These two types of questions are intended to encourage the student to continue thinking about their understanding. This technique of asking brief questions is very closely tied to his preference for having the student do most of the work while the LA only provides hints to help students when they get stuck so that students are able to develop a deeper understanding of the material. Andy takes the most extreme view of construction among the four LAs.

While Andy prefers to use questions to help students develop their understanding, as the semester progresses he finds that brief explanations are sometimes necessary and very effective. In his final paper, Andy describes these two techniques,
There are two ways that I normally help the students. I either ask a question or explain the concept. I try to find ways to ask questions, as a question gives more room for thought generation than an explanation and can lead to a discussion. However, a simple explanation can do wonders at times. (Andy, final, 25 – 28).

Andy also explains why he uses these two techniques in his week seven reflection,

I found that the combination of questions and explanations did the trick. But when I only asked questions, some of the students did not seem to know where to start. When this happened I would give some hint or read the question again (Andy, wk07, 2).

While Andy prefers to use questions to help students develop their understanding because it requires students to take a create role in their learning, he recognizes the value of explanations. Andy’s use of the word “simple” to describe his explanations indicates that he is not talking about describing for the students derivations, example problems, or mini-lectures. Instead in his later excerpt, he equates explanations with “giving a hint” or “rereading the question”. Even when Andy is talking about explaining things to students, his focus is on providing only enough information to give students the push they need to continue thinking through the problem on their own. In the end of the semester interview, Andy goes into depth about these two techniques that he commonly used to help students,

Sometimes I'd ask them, “so what did you do here” and they'd think about it and talk about it. I'd say, “You sure that's right?” Kind of look at me like “well, maybe it isn't right” so they'd look at it and say, “Well, if this was right could this happen?” I'd ask a question, and then they'd say “Oh, maybe not,” and then they'd say, “well is it wrong?” And I'd say, “I don't know what do you think?” They'd go, “Well, if that couldn't happen then, maybe it is wrong, so then this would have to be right. Is this right?” “Well, does that coincide with everything else you've talked about?” And they'd say, "Humm, yeah.” I'd say, “well then.” (Andy, post, 40 - 47).

He uses vague questions, “are you sure that’s right” and “what do you think” and brief explanations that serve as counter examples, such as “if this was right could this happen,” that are intended to spur students’ thinking. In this excerpt Andy is demonstrating several teaching strategies he has already discussed. First, he is encouraging the students to continue thinking or rethinking about their answer. If that is not effective, then he revoices their answer to emphasize the implications of their answer. Andy also references a new teaching strategy or value – he refuses to validate students’ answers. Instead he asks them to place their trust in their own logic.
Andy feels it is incredibly important for students to develop their own understanding of the physics content, and for them to create their answers on their own. As a way to facilitate this, he feels it is important for students to talk about their ideas aloud; not just to help those in their group, but to mostly help themselves. In order to help students develop their ideas, Andy tends to use very vague questions to encourage students to develop their thinking. When necessary, he is willing to use brief explanations to help them continue their concept development. Throughout the semester Andy wants the LA to take a facilitation role in students learning rather than being the one who develops the answer for the students. His teaching techniques are all intended to facilitate student thinking as much as possible. While the way he talks about these techniques becomes more explicit as the semester continues, the way he wants to teach remains fairly constant during the semester.

Prior Knowledge

Andy does not begin talking about the second construct of the generalized model of formative assessment – student’s prior ideas until several weeks into the semester. Andy recognizes the need to use questions to elicit students ideas and tends to use a resources perspective when talking about the value of students ideas. Andy is unique among the LAs in the emphasis he places at the end of the semester on understanding students’ ideas. Andy attempts to see both the problem and the students’ explanation from their perspective. It is not enough for him to simply be aware of the students’ ideas, but he wants to fully understand how the student is thinking about the problem and how they are attempting to solve the problem.

The first time Andy mentions the importance of recognizing students’ prior ideas is in his week five reflection when he states that, “my goals for next week are to build off of students’ misconceptions. I plan to do this by asking broader questions or more open questions” (Andy, wk05, 3). While Andy uses the word “misconceptions” he is actually using a resources perspective. In a misconceptions perspective an LA would talk about identifying, confronting, and fixing students misconceptions. While in a resources perspective an LA would talk about identifying students’ resources and helping students use them to build up the physics concepts. Using the language of one perspective to express the ideas of another perspective can be a sign of learning as an LA struggles to reconcile an old perspective based on experiences with a new perspective. In this situation, though, the confusion of vocabulary and perspectives does not indicate that Andy is struggling with the two perspectives. Instead, he is emulating a common language convention used in the LA seminar. The instructors both taught and used a resources perspective but tended to fall back on the older language of misconceptions. Also, Redish’s (Redish, 1994) article used the misconceptions perspective and the instructors and LAs discussed the differences in the two perspectives acknowledging the usefulness of the word misconceptions while addressing the problems of the perspective. Therefore the vocabulary used cannot be considered indicative of Andy’s views on students’ ideas.

Andy continues talking about the importance of students’ ideas in his course papers. He focuses his first article report on students’ prior knowledge by comparing questioning strategies with Redish’s representations of mental models (Redish, 1994). In this paper, Andy talks about using questioning strategies to help students “develop, change and build off of previously
existing or new mental models” (Andy, AR1, 19). He also talks about the difficulties students have when trying to learn a physics concept that is very different from their current mental model. Andy suggests that questioning strategies can make this learning easier. In his final paper, Andy explains how he uses questions to elicit students’ prior ideas,

I have found direct questions to be useful when I am trying to find out exactly what the students understand or don’t understand. For example, “What does this do?”, “What is the value of x?”, “Where did this come from?” I have found this type of question very helpful in understanding what the student’s perspective is and what they know. (Andy, Final, 40 – 43).

Andy is describing how he diagnoses students’ understanding by asking them very specific questions about their answers. By this point Andy is not simply talking about the importance of recognizing students’ ideas but goes beyond this to discuss the importance of recognizing students’ understanding of the problem itself,

When students don’t understand a problem, I have to be able to see the problem from their perspective. I read the question with them and try to understand what they are thinking. Sometimes I am able to see where they went wrong. But lots of the time it is not so black and white. I have found that analyzing the question based on the student’s answers is a very useful technique for understanding their thought processes (Andy, Final, 19 – 23).

By the end of the semester, Andy recognizes the importance of understanding both students understanding of the physics concepts and their understanding of the problem. Andy is seeking to understand students from their own perspective instead of just comparing students’ responses to the correct response and finding where they diverge. Andy recognizes that his job is not that easy. Often there is not a clear point where students made an error like an addition error. Instead Andy recognizes that he often has to go back to the beginning and understand what students think they were being asked to do before he can understand what they did.

**Individuality**

Andy does not spend much time writing about the individuality of his students, the third element of the formative assessment model. He only talks or writes explicitly about the differences in his students in his first article report and later during the end of semester interview. Andy implicitly mentions this idea in the previously discussed excerpt from his final paper. He recognizes that students may think about the problem differently than he does and that he needs to spend the time to understand their perspective. It can also be assumed from his comments that Andy recognizes that students are thinking about the problems differently from each other and
that it is not enough to simply understand one student’s view. Andy focused his first article report on Redish’s mental models perspective (Redish, 1994) and Trowbridge’s description of questioning (Trowbridge, Bybee, & Powell, 2000). While he talks mostly about the importance the mental model perspective places on recognizing students’ prior ideas, he also states that this perspective stresses the individuality of students. As he explains, “The most important point that both authors make is that every student is different and unique. It is vital to keep this important point in mind when asking students questions” (Andy, AR1, 42 – 44). While Andy is talking about the articles in this comment, he does state that recognizing the individuality of students is not just something that is important to these authors’ points. He states that the individuality of students is something that all teachers need to remember when they are working with students and particularly when they are asking questions. In his end of the semester interview Andy twice referenced students individuality and its effect on teaching as one of the main reasons he enjoyed teaching. When asked what aspects of his LA experience went well, he responded,

I mean I enjoyed working with students and it was always interesting to see the concept from their perspective, ’cause I tried to do that. So I would be able to explain it to them. And it was cool seeing what different kinds of questions could do. Like, in order for me to get information about what or how they’re doing or in order for them to build on it, talk about it more. To discuss with them and some points, it was a challenge because I’d have to sit there and then everybody’s different so some people would get the concept if I explained it one way, but other’s wouldn't so I would have to think of a new way to explain it that I hadn't done before if I had tried the techniques. (Andy, post, 10 – 19).

In this excerpt Andy now explicitly states that students have their own unique understanding of the content and the problem and that he needs to understand each students’ perspective. Andy also finds that students differed in how they respond to questions. He doesn’t just mean that students gave different answers to his questions but that the questions triggered them to think about different things and led them down different paths. While Andy does not talk about student differences in his reflections, his comments in his end of the semester interview suggest that his model of formative assessment does include this third element of the generalized model. Andy recognizes that students have different understandings of the content and the problems and that these differences need to be understood.

Adaptive Teaching

While Andy talks extensively about wanting students to construct their own explanations and he describes the importance of recognizing students’ prior experiences, he does not talk about how these ideas influence his teaching for much of the semester. It isn’t until the end of the semester that Andy talks explicitly about adapting his questions to specific students – the fourth construct in the generalized model. Andy mentions this first in the excerpt described above when he mentions how he would have to find different explanations for different students based on
their unique ways of understanding the problem. Andy mentions this idea again when he describes how he improved his questioning over the course of the semester,

But what really helped was going to recitation and questioning because I'd see that kind of question helped 'em get the answer, that kind of question didn't help them get to the answer. What was interesting is, as the semester went on I kind of found which students, which recitation, which students, what kind of worked for each kind of students (Andy, post, 223–227).

Andy found that the most effective way for him to learn to teach was to work with students and to notice what helped certain students and what wasn’t effective for certain students. As the semester continued, Andy came to recognize which techniques were effective for which students and how he could more effectively help other students. At the end of the interview Andy indicates just how ingrained adaptive teaching is to his teaching style even though he does not talk explicitly about it frequently. When asked whether he was considering teaching as a career Andy explained how he saw teaching physics,

. . . teaching something like physics is definitely challenging, because you have to, it's not just you understanding, you get other people to understand and a lot of times they don't see it the same way you see it. So, it's, sometimes it's like a puzzle, you're like ha after you get them to understand and how do I get them to understand. I tried that, I tried that it didn't work, so now I'll try this (Andy, post, 322–326).

For Andy, teaching is ultimately like solving a puzzle. He is constantly trying to figure out how to adjust his teaching to meet the needs of his students and checking in with his students to see if they understand the material yet.
Figure 6 shows the first time Andy explicitly mentions each of the four elements of the model of formative assessment thereby showing his development of this model. Andy began the semester with a heavy emphasis on students’ constructing their own understanding of physics. As the semester continued he began talking about the importance of understanding students’ prior knowledge and of recognizing the individuality of each students’ ideas and experiences. While it appeared to permeate his teaching for much of the semester, Andy did not talk explicitly about adapting his teaching to his students until the end of the semester.

Student/Teacher Relationships

At the beginning of the semester Andy only talks about the role of student/teacher relationships in teaching when he mentions his previous LA and when he describes what makes a bad teacher. He does not talk about student/teacher relationships when he describes the job of an LA or when he explains how he plans to help students. By the end of the semester, does talk about the role relationships play in the job of an LA and how they can help his students learn. For Andy, having a relationship with his students helps to create a bond of trust that allows them to communicate. Not only does Andy talk about relationships in his interviews and writings, but he places an emphasis on these relationships in his weekly reflections. He is the only LA to provide specific examples of how he plans to strengthen his relationship with students.

At the beginning of the semester Andy mentions student/teacher relationships when talking about his own previous LA and good teachers in general. When talking about his own LA from the previous semester, Andy begins by describing him as friendly, “I thought my LA was good. He was friendly. He helped us with everything” (Andy, pre, 36 -37). While Andy does not explain why he thinks it was relevant to his learning that his LA was friendly, he does go into more detail when talking about what makes a bad teacher. Andy described a bad teacher as “giv[ing] off a cold feeling that you don't want to help anybody, that you don't want questions” (Andy, pre, 157 – 158). Here Andy is implying that good teachers are friendly which helps students to feel comfortable asking questions. This is a key aspect of the student/teacher relationship philosophy. As the semester continues Andy constructs more explicit explanations for why student/teacher relationships are important for student learning. At the end of the semester, Andy described a good teacher in very similar, if more detailed, terms to his explanation at the beginning of the semester,

You need to show that you care that the students understand. And be friendly. You need to show that you're willing to help, not just that you're there to help just because it’s your job. Just because, you know, it's Thursday morning and I don't want to be here to help but I'm here. You show that, you have a desire to help them. And want them to do well and then you're interested in how they're doing (Andy, post, 301 – 306).
During both interviews Andy explains that a good teacher needs to demonstrate to students that he is willing and eager to answer students and that he cares about his students. In his second article report Andy lays out how this caring leads students to be willing to ask questions –

The aspect of caring that encompasses listening, understanding, and knowing students, are all important attributes of a good teacher. When a teacher listens to students, a bond of understanding is formed. This leads to mutual trust which in turn leads to improved communication that is not limited to the subject at hand. In this way the teacher knows what different students are feeling and are going through (Andy, AR2, 22 – 27).

In this excerpt Andy lays out a mechanistic model for the importance of student/teacher relationships. His model is similar to the generalized model of approachability, but differs in some key points. A diagram of Andy’s model is shown in Figure 7. As with the generalized model, Andy begins with the teacher acting. For Andy, the key process is for the teacher to listen to students. He considers this to be the most relevant aspect of caring. His model then diverges from the generalized model to describe mutual states that are created by the student and the teacher. Where the generalized model has the teacher acting and the students responding, Andy’s model has both the teacher and the students responding. When the teacher listens to the student they both come to trust each other and they create a bond based on understanding that comes from this shared trust. When the students and the teacher trust each other and understand each other they are able to communicate. Andy does not state it but it can be implied from his other statements, that the level of communication that is achieved allows students to learn.

Andy tends to talk about teacher/student relationships in two ways. When talking more generally about good teaching, as in the excerpts discussed above, Andy describes the importance of teachers caring for their students so that a bond of understanding is formed. When talking in specifics about his teaching, Andy focuses on engaging students so that he can tie their everyday lives into the physics content being studied. This type of engagement is separate from
the generalized model, though it does not contradict the model. It is closely linked with the second element of the formative assessment model which values students’ prior knowledge including their everyday experiences. Several weeks into the semester Andy began focusing on building his relationships with his students. In his week five reflection he stated,

My goal for the week was trying to interact more with the students rather than just help them . . . I think that giving a random comment about anything helps break the ice. It seemed to me that the students were more comfortable asking me questions this week. So I think that I met these goals. (Andy, w05, 2).

Andy had a similar goal several weeks later,

My goal for this week was to incorporate other topics of discussion to facilitate learning physics. For example

Me: " what are you doing for spring break?"

Student: " I am going skiing"

Me: " have you thought of the forces and actions pairs that occur when u are skiing?"

Some random topic can arouse interest in the topic of study for the day. (Andy, wk11, 1).

Andy worked to get to know his students and their plans so that he could draw on their experiences when talking about physics. In his end of semester interview Andy explained that drawing on students’ everyday experiences when he was explaining things made physics more fun for students (Andy, post, 157 – 172). For Andy, relating to his students had a very specific purpose of being able to pull them into the physics topic. At the beginning of the semester, Andy did not talk about this aspect of student/teacher relationships, but as the semester went on he began to write of this as being an important part of his job. At the beginning of the semester, Andy was aware of the role that student/teacher relationships played in his general interactions with teachers, as indicated by his description of bad teachers as being cold and therefore apparently not open to student questions. Yet, Andy did not talk about the role relationships would play in his interactions with students or in his descriptions of the job of LAs. As the semester continued Andy still recognized the role that relationships played in general and was able to construct a detailed explanation of why they were important. He also began to recognize the importance of relationships in his own interactions with students. Therefore building relationships with his students became a significant aspect of his teaching that he attempted to improve.
References


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Appendix 1: Pre Interview Protocol

Purpose: Interview to be conducted with first time physics LAs at the beginning of the semester.

1. Icebreaker questions:
   a. How was your break?
   b. Are you going to have a busy semester?
   c. What classes are you taking?
   d. What’s your major?
   e. How many more semesters do you have left?

2. Why did you decide to apply to the LA program?

3. What has been your experience with LAs?
   a. Can you describe how they helped you learn?
   b. What are some of the things they did that you liked?
   c. What are some of the things they did that you didn’t liked?

4. Why do you think group work is used in the tutorials?
   a. How do you think group work is helpful to students?
   b. Do you think group work is helpful for all students? Why?

5. What has been your experience with tutorials?
   a. What did you like about tutorials?
   b. What did you not like?
   c. Can you describe what you found helpful?
   d. Can you describe what you found unhelpful?
   e. What do other people think about tutorials?
   f. I have heard that other people think that tutorials are repetitive. What do you think?

6. How would you describe the job of an LA?
   a. How do LAs help students learn?
   b. How does this compare to the job of the TA?
7. Let’s say you have a group of students who are struggling with a particular problem—describe how you would assist these students.

8. How are you expecting the tutorials to be organized/run?
   a. What do you want to see happen?
   b. How much control do you expect to have over how tutorials are run?

9. Who was your favorite teacher (K-16)? Why? What did they do that helped you or that you liked?
   a. What makes a good teacher?
   b. What makes a bad teacher?

10. What is your interest in teaching?
    a. Are you considering teaching at the K-12 level?
    b. Are you considering teaching at a university/college level?
    c. Are you considering teaching as a second career or a fall back plan?

11. What do you think about this quote from Parker Palmer? “Good teaching does not come from technique. It comes from the identity and integrity of the teacher.” [LA is given a hard copy of the quote.]
    a. Do you agree? Would you change anything about the quote to make it more accurate?
Appendix 2: Post Interview Protocol

**Purpose:** Interview to be conducted with all physics LAs at the end of their semester.

12. Icebreaker questions:

13. Tell me about your LA experience this semester?
   a. What went well?
   b. What didn’t go well?
   c. What surprised you?
   d. What did you learn?
   e. How have you changed?

14. How do your sections usually begin?
   a. Walk me through a typical class.

15. Tell me about your experience with the LA seminar?
   a. What did you like?
   b. What did you dislike?
   c. What was helpful? What wasn’t?
   d. What would you change?
   e. What did you learn?

16. How would you describe the job of an LA?
   a. How do LAs help students learn?
   b. How does this compare to the job of the TA?
   c. What makes a good LA? What about a bad LA?

17. Let’s say you have a group of students who are struggling with a particular problem—describe how you would assist these students.

18. Why do you question students?
   a. Did you do this a lot?
   b. When did you find this helpful? When wasn’t it?
   c. How did your students respond to your questions?
   d. How did your questions change over the semester?
   e. Do you think you’re good at asking questions?
   f. What did you learn about asking questions?
   g. What about asking questions are you still working on?
   h. Do you think the LA seminar helped you improve your questioning...
i. What more could have been done in the LA seminar to help you with this?

19. What does the concept of Formative Assessment mean to you?
   a. (If not familiar) What about the bridge analogy?
   b. How would you define this idea?
   c. (If still confused) Do you remember the 3 questions, Where are you at, Where are you going, and How are you going to get there?
   d. Do you think this is a helpful idea?
   e. How did you apply this idea to your teaching?
   f. How did your ideas about Formative Assessment change over the semester?

20. What makes a good teacher? What makes a bad teacher?

21. Are you planning to return to the LA program next semester or in future semesters?
   a. What prompted this decision?

22. Would you recommend being an LA to a friend?
   a. Under what circumstances?

23. What is your interest in teaching?
   a. Are you considering teaching at the K-12 level?
   b. Are you considering teaching at a university/college level?
   c. Are you considering teaching as a second career or a fall back plan?

24. What do you think about this quote from Parker Palmer? “Good teaching does not come from technique. It comes from the identity and integrity of the teacher.” [LA is given a hard copy of the quote.]
   a. Do you agree? Would you change anything about the quote to make it more accurate?
## Appendix 3: Weekly Reflection Questions

The actual wording of the reflection questions is listed below in alphabetical order of the question title.

<table>
<thead>
<tr>
<th>Question</th>
<th>Question</th>
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<tbody>
<tr>
<td>Changes Based on Feedback</td>
<td>What changes (if any) have you made to your teaching in the past weeks due to the feedback you received from your student FCQs and the LA who observed you? Did the changes work as you expected/hoped? What changes do you still need to make?</td>
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<tr>
<td>Conceptual</td>
<td>What types of alternative ideas did you notice among the students you worked with? Regardless of what is right or wrong, what were they thinking, that is, what <em>do</em> they get rather than &quot;do they get it or not.&quot;</td>
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<tr>
<td>Conceptual Topics</td>
<td>What types of alternative ideas or resources did you notice among the students you worked with? Regardless of what is right or wrong, what were they thinking, that is, what <em>do</em> they get rather than &quot;do they get it or not.&quot;</td>
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<tr>
<td>Describe an LA</td>
<td>Given what you know so far, describe what it means to be an LA. What is your job? What do you hope to accomplish? What does it mean to teach?</td>
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<tr>
<td>Evaluation of Group Interactions</td>
<td>Did all the students appear to be participating? Any good discussion? Any problems with the group, and if so how do you plan on addressing that problem in the future?</td>
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<tr>
<td>Evaluation of Your Teaching</td>
<td>What seemed to work for you (or for the students)? What did not seem to work? Why do you think this is the case?</td>
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<tr>
<td>Goal</td>
<td>What was your main teaching goal(s) for this week? These can be conceptual, motivational, metacognitive, etc. Do you feel you met this goal(s)? Why or why not?</td>
</tr>
<tr>
<td>Job Descriptions</td>
<td>Given what you know now and your experiences so far, describe your job as an LA.</td>
</tr>
<tr>
<td>Just Tell Me the Answer</td>
<td>No doubt you have heard (and said), &quot;won't you just tell me the answer!&quot; In light of what you read this week, why do you think it is important to not always just tell students the answer. Do your best to explain what you mean.</td>
</tr>
<tr>
<td>LA Job Description</td>
<td>In what course are you working? What is your main responsibility (Do you help with clicker questions during lecture; run a co-seminar, help with tutorials, labs, or recitations; work in the helproom; etc?)? Are students required to participate in the part of the course in which you are working? Are you working with a TA or fellow LA? Do you have grading responsibilities?</td>
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<tr>
<td><strong>Metacognition and Argumentation</strong></td>
<td>Describe an example of metacognition or argumentation that you observed in your interactions with students. What did you do in your teaching this week to encourage metacognition or argumentation in your classroom?</td>
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<td><strong>Mid-semester Reflection</strong></td>
<td>We are about halfway through the semester. Think back over your teaching so far and discuss how you have noticed your teaching and thinking changing. What have you learned? What do you do differently than you did the first several weeks? We also still have a lot of the semester left so discuss what you want to do with that remaining time. What do you want to work on? What areas are you trying to improve? What do you want to learn?</td>
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<tr>
<td><strong>Multiple Intelligence</strong></td>
<td>How were you able to draw on the strengths of different types of intelligences in your teaching this week? What examples of different types of intelligence did you notice? If you felt most of your lesson was focused on only one or two types of intelligence how would you have liked to change the activities to draw on other types of intelligence?</td>
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<td><strong>Nature of Science</strong></td>
<td>The atom or magnetism activity (which you were given at the end of class on Wednesday) specifically addresses Nature of Science. What do you think this activity accomplishes? Why? In what ways and for what populations do you think this would be useful? Why?</td>
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<td><strong>Next Goals</strong></td>
<td>Based on how things went this week, what are your goals for next week? Why is this what you want to focus on? How are you planning to meet this goal?</td>
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<tr>
<td><strong>Notes About Observation</strong></td>
<td>What were some of the good things that the LA you observed did? What were some of the things the LA you observed needs to work on? What are some of the suggestions you had for the LA observed?</td>
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<td><strong>Notes About the Observation Debriefing</strong></td>
<td>What was some of the helpful feedback that you got from the LA who observed you? What was not helpful about the observation and observation debriefing session?</td>
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<td><strong>Observed</strong></td>
<td>Who did you observe?</td>
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<td><strong>Observer</strong></td>
<td>Who observed you for the classroom observation?</td>
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<td><strong>Other</strong></td>
<td>What other things (if any) would you like to share?</td>
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<td><strong>Reflection</strong></td>
<td>What do you think about this week. For example, I am really glad that I... Why didn't I... Next time I am going to... My biggest problem during session was... I wish I was more...</td>
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</table>
**Appendix 4: Weekly Reflection Schedule**

The following table lists the titles of the questions asked during each reflection. The wording of the questions can be found in the previous appendix. The numbers in the cells represent the order of the questions for that week’s reflection.

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<th>Question Title</th>
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