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Enhancing Content Knowledge in Graduate Teaching Assistants through Lesson Study

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In the United States, graduate teaching assistants (GTAs) deliver a large percentage of instruction in the sciences, often having more contact with undergraduate students than the lecture instructor (Baumgartner, 2007). Thus, GTAs represent an important population of teachers when considering reform of undergraduate instruction (Dotger, 2011; Herrington & Nakhleh, 2003). The lack of development of knowledge for teaching among GTAs, however, has served as a barrier to reform (Wright & Sunal, 2004). Many GTAs do not have any prior teaching experience, so they rely on models of how they were taught, as well as on the training with which they are provided. Typical training opportunities range from one day workshops intended for a wide range of disciplines, to full-semester discipline specific training (Kurdziel & Lumbarkin, 2005).
As Luft, Kurdziel, Roehrig, and Turner (2004) point out, GTAs often assume their roles as classroom instructors early in their graduate careers, often right after they have completed their Bachelor’s degree. In this position, GTAs are expected to be knowledgeable both in their content area and in the appropriate ways to teach this content to their students. But, GTAs’ lack of pedagogical knowledge has been well documented, which is not surprising considering their lack of formal training in how to teach (Dotger, 2011; Golde & Dore, 2001; Luft et al, 2004). When GTAs lack the appropriate content knowledge in their subject area, it can be shocking to both GTA supervisors and their students because GTAs have documented their academic knowledge by obtaining a Bachelor’s degree. Additionally, some graduate programs also require subject specific entrance exams, such as the Graduate Records Examination in Biology or Physics. It would seem that students who have been admitted to graduate school based in part on these exam results would have the necessary knowledge for teaching introductory courses.

There are challenges inherent in assuming adequate content knowledge among GTAs. Bodner (1991) demonstrated that many entering graduate students in Chemistry hold misconceptions related to basic chemical concepts. His analysis focused on three years of data collected from entering graduate students (N=132) at Purdue University, who were given a conceptual knowledge exam. Although the majority of students supplied correct answers and an explanation to the questions presented, such as What makes up the bubbles in boiling water?, or, Does adding heat to an object always raise the temperature?, Bodner suggests that the misconceptions held by as many as 40% of graduate students on certain questions could stem from a variety of sources, including the instructor. Instructor driven misconceptions can arise when information is simplified for the benefit of explanation, information obvious to the instructor is not presented explicitly to the students, and when the limits of assumptions are not adequately explained. Considering the important role GTAs play in undergraduate science instruction, it is essential to also consider methods of preparation for GTAs that allow them to explore their misconceptions of science concepts in order to mitigate the effects of instructor driven misconceptions on their students’ learning.

Many STEM departments utilize weekly planning meetings to ensure that GTAs are prepared to teach each week. During these meetings, GTAs are briefed on the laboratory set-up, safety issues, and areas of the procedure that may cause confusion for students. Harrington and Nakla (2003) identified this procedural knowledge as important to whether or not GTAs are perceived as effective laboratory instructors by their students. Given their procedural focus, however, these preparatory meetings may neglect important areas related to science content, the relationship to the content in the lecture portion of the course, or the appropriate pedagogical content knowledge (PCK) needed to facilitate student learning (Luft, et al., 2004).

Several challenges for GTAs were recognized by Dotger (2010) in addition to a lack of formal training in teaching, including that they often lead students through laboratory activities, discussions, and assessments which they did not help design or develop. These challenges make it difficult for GTAs to develop pedagogical content knowledge (PCK) in the context of their normal teaching duties. Pedagogical content knowledge is knowledge of the "...the most powerful analogies, illustrations, examples, explanations, and demonstrations - in a word, the ways of representing and formulating the subject that make it comprehensible to others" (Shulman, 1986, p. 9). It is recognized as one of three essential forms of knowledge for teaching
by educational researchers who study teaching across disciplines in a variety of contexts, including post-secondary ones. The two other significant forms of knowledge are knowledge of subject matter and knowledge of curriculum (Luft, et. al, 2004; Shulman, 1986).

Alvine, Judson, Scheine, and Yoshida (2007) suggest that lesson study is particularly advantageous for graduate students and novice faculty members to develop their teaching skills, including PCK. Lesson study involves a group of teachers working collaboratively to plan, implement, observe, and refine a "research lesson" (Lewis, Perry & Murata, 2006). Teachers study representations of content in curriculum documents and instructional materials (see Fernandez & Yoshida, 2004). They then design, modify, or use already existing materials that they believe will help students meet previously specified learning goals for the lesson. In order to collect data to evaluate the research lesson, they must design instruction such that students' thinking during the lesson is evident. Thus, instruction needs to provide opportunities for students to talk, problem-solve, or write using processes that the observers can see and hear. Student work is collected and evaluated in conjunction with observation notes and observers' impressions immediately after the research lesson.

The purpose of this study was to compare the types of talk that GTAs engage in during a lesson study cycle to the types of talk they engage in during typical weekly planning meetings. We hypothesized that peer-to-peer interaction during these two modes of preparation for teaching would vary with the meeting focus. Lesson study was used as a model of professional development with GTAs in order to develop their content knowledge and PCK (Cerbin & Kopp, 2006). It also provided an opportunity for GTAs to participate in the development of lessons taught in the undergraduate science laboratory setting. Procedural knowledge is a focus of weekly preparatory meetings in addition to content and pedagogical content knowledge, each of which are crucial for GTAs who need an opportunity to develop these essential forms of knowledge for teaching (Harrington & Nakla, 2003; Luft, et. al, 2004; Shulman, 1986). Thus, we designed a comparative study to investigate similarities and differences present in GTA interactions within a lesson study cycle and weekly preparatory meetings. Comparing these two types of preparatory experiences for GTAs allows us to more fully understand the implications for using lesson study as a model of GTA training.

Methodology

Research Context

The current study was conducted at a large, private, northeastern, doctoral granting university, with approximately 14,000 undergraduate and 5,000 graduate students. The GTAs for the introductory level biology course make up approximately half of all GTAs in the department, and all graduate students are required to act as a teaching assistant for a minimum of one year as part of the Ph.D. program requirement. All of the department’s GTAs are assigned to teach this introductory course prior to teaching any higher-level courses. The Introductory Biology course enrolls 720 undergraduate students each semester, making up a total of 30 laboratory sections taught by the laboratory manager and GTAs.

This research investigation was conducted in two phases, during two distinct semesters, with two groups of GTAs assigned to teach the laboratory associated with Introductory Biology. The
lesson study portion of this research was conducted during the fall semester of 2008. Participant observations of weekly preparatory meetings were conducted by the first author during the fall semester of 2010.

Participants

A total of 10 GTAs are utilized to teach the laboratory sections of the Introductory Biology course each semester. Of these 10 GTAs, six participated in the lesson study. The lecture course professor and the second author also participated in the lesson study. Two GTAs participated in both phases of the study. Phase 2 of the study involved the observation of 10 GTAs as they participated in their weekly preparation to teach Introductory Biology laboratories.

Theoretical Framework

Throughout their preparation to teach undergraduate laboratories, GTAs build relationships with one another, and tend to rely on each other for advice concerning their students and navigating the doctoral education process (Gardner, 2007; Luft et al, 2004). These interactions between GTAs occur through conversations, probably in many contexts. As we are interested in how conversations between GTAs vary as a function of their context, we selected Gee’s (2005) language-in-use theory of discourse analysis to frame this study. This perspective values verbal interaction in the creation of a social language that can be analyzed in a situational context to understand participant identity roles as well as what is significant within those contexts. In the context of the current study, the social language of GTAs is analyzed as an indication of their role identity as teachers of undergraduate laboratories, including the development of knowledge specific to that role identity and their perception of students.

Data Collection

The lesson study group met five times during the fall semester of 2008 to plan and debrief their research lesson, following the lesson study process outlined below. Participation in the lesson study was voluntary, and not for course credit. These planning meetings, lasting approximately 1 ½ hours each, were videotaped and led by the second author to guide the group through the lesson study process. During the planning sessions, the researchers’ primary role was to take notes, ask clarifying questions, and provide brief explanations concerning the lesson study process. Although all GTAs who participated in the lesson study process taught the research lesson to their assigned laboratory sections, only one section was designated as the observed research lesson. Time constraints of the lesson study group, as well as whether or not GTAs volunteered to be observed teaching, were considered in choosing a laboratory section to observe. This analysis focuses primarily on the planning meetings, with the videotaped meetings serving as the source of that data.

Participant observation of weekly preparatory meetings for the entire population of Introductory Biology GTAs (N= 10) was conducted during the fall semester of 2010. These meetings lasted approximately 2 hours. The preparatory meetings were directed by the course instructor, laboratory manager, and course administrative assistant. The course instructor briefed GTAs on the topics covered during lecture and prepared GTAs to lead recitation. The laboratory manager
taught two laboratory sections in addition to preparing each week’s written laboratory and materials. The course administrator assisted in grade reporting and course related administrative tasks such as ordering supplies for the laboratory.

The researcher’s role during these meetings was to take notes, and participate in a small group setting with GTAs as they worked through the weekly recitation questions. During this time, the researcher would ask occasional clarifying questions, but primarily observed the interactions between GTAs. Throughout the semester, the small groups varied depending upon where GTAs happened to sit each week, but purposefully included a mixture of experienced and first-time GTAs. The researcher attempted to join different groups of GTAs each week. The topic of laboratory and recitation changed weekly, with brief discussion of the previous weeks’ experience. Field notes from these preparatory meetings, as well as the weekly laboratory exercise and recitation questions serve as additional data for this study.

The Lesson Study Process

Lesson study was used as a framework for the GTA participants to develop their research lesson. The context of the present study, however, necessitated several changes to the way that lesson study is practiced in other contexts, such as the elementary classroom. During lesson study, teachers begin by identifying long-term goals of education that may span through time relative to grade levels, but also across disciplines (Fernandez et al., 2003; Lewis, 2002). In the present study, the teachers are graduate teaching assistants who are tasked with leading weekly laboratory and recitation sections. This lesson study process, therefore, began with an analysis of the general goals for the laboratory, developed collaboratively by the GTAs and course instructor.

Generally, the lesson study process progresses from the designation of lesson goals, to the development of a carefully crafted research lesson. The research lesson can be developed or modified from existing curriculum materials, but importantly, it is done in a collaborative manner by all of the members of the lesson study team. The research lesson developed during this study focused on the concept of Hardy Weinberg Equilibrium, and was modified from two existing laboratories that GTAs located on the internet. The GTAs combined different sections of these existing laboratory exercises in order to reach their instructional goals of providing concrete examples of each of the factors that can disrupt the Hardy-Weinberg equilibrium, such as non-random mating and migration.

As lesson study is practiced in the elementary school setting, teachers observe how students respond to the lesson exercises by attending to their interactions, discussions, learning engagement, and treatment of each other (Lewis, Perry, & Murata, 2007). Similarly, the lesson study group in the present study designed a research lesson with observable student interactions. The lesson study group, made up of several GTAs, the course instructor, and a professor in Science Education attended the research lesson and observed small groups of students working through the laboratory, making careful notes of their actions and conversations. In a school setting, teachers meet following the research lesson to discuss their observations of student thinking and possible revisions to the lesson to improve student understanding. Following this model, the GTAs met after the research lesson was taught to discuss student learning and any changes needed to the lesson format.
Given the lecture/recitation format common to undergraduate science teaching, laboratory exercises are often "stand-alone". For example, the laboratory curriculum in place during the present study spanned 14 distinct topics in 14 weeks. Each week, the laboratory addressed a different topic, such as cells one week followed by biological molecules the next. This differs significantly from the context in which lesson study is used in the Kindergarten-12 classroom, where teachers can study a lesson within the context of a larger, more integrated, unit.

Another challenge of conducting lesson study in the context of the undergraduate laboratory was that during the laboratory meeting, some students already had an introduction to the topic in lecture, and others did not. The basic format of large lecture-laboratory courses, where labs are scheduled during various days of the week, is common to undergraduate science. Because students come to class at varied levels of preparedness depending simply on the day of the week, however, the GTAs thought the issue deserved attention. This challenge was confronted by designing a lesson including a pre-laboratory exercise intended to introduce students to salient concepts.

Analysis

The lesson study planning meetings were videotaped and coded using StudioCode® qualitative analysis software with a constant comparative methodology (Glaser, 1965). The videos were coded inductively as they were watched, and then all videos were recoded once the complete coding scheme was established. Data collected from the preparatory meetings also were analyzed using a constant comparative methodology and coded inductively as they were collected. A separate coding scheme was developed for this meeting format. Following a similar protocol, the data collected from preparatory meetings, including field observations, laboratory exercises, and recitation questions were recoded using the complete coding scheme developed from the preparatory meetings. The codes from both the lesson study planning meetings and the preparatory meetings were collapsed into categories and compared across the two meeting formats. These comparisons are discussed as themes, presented in italicized text with supporting evidence drawn directly from the data.

Findings

Analysis of the data revealed several themes related to the development of GTA pedagogical content knowledge, conceptions of students and student learning, and their understanding of the content they teach each week. For the purposes of this paper, we focus on the comparison between these two types of teaching preparation for GTAs.

Theme 1: Lesson study provided a context for GTAs to explore uncertainties related to the content they were required to teach.

The lesson study experience provided a forum in which the GTAs could explore their knowledge of the content within one particular area. The research lesson focused on the concept of Hardy-Weinberg equilibrium. The development of the lesson plan provided an opportunity for the GTAs to explore their knowledge of this content area in relation to how they planned to teach the
concept. During these planning meetings, GTAs regularly and repeatedly asked for content clarification of the material included in the lab from other GTAs and the course instructor. The same type of content clarification, however, did not occur during the normal preparatory meetings. For example, this exchange occurred between one GTA and the course instructor during a lesson study planning meeting:

**GTA**- So you said something that was confusing to me conceptually. 2pq is the heterozygote, so that’s big p and little p and q. Which is the same as…, so big p and little q, so it’s showing up twice?

**Course Instructor**- So let’s think about any old trait. We’ll just say that rolling your tongue is dominant. Big R. Little r is recessive, and if you have two of those you can’t roll your tongue. We can do the same thing with P and Q. It’s just different location. So if we were doing a punnet square and I had a heterozygote that was Rr, we can do a punnet square really easy. There are two ways of getting Rr, you can use this big R or this one. We can do the same thing with the p and q. Different notation, same traits. My punnet square would come out to look like this. You’ve all taken algebra, so we can just write it this way. So if we are talking about the p’s and q’s, we want [the students] to be aware that they are the exact same things that we used last week with the letters.”

**GTA**- But why p’s and q’s?

**Course Instructor**- That is just what they used. For this population equilibrium model, it’s not important that one of them is dominant and the other is recessive. But, when we are teaching about it, that is how we simplify the concept of genetics. But for so many of these traits that we look at, there are more than just two alleles.”

This exchange that occurred between one of the GTAs and the course instructor demonstrates a lack of conceptual clarity on the part of the GTA. This type of conversation, related to clarifying the content of the laboratory, happened frequently throughout the lesson study planning meetings. It should be noted that the format of the lesson study experience allowed for several planning meetings to be spent on one topic. This extended time period, and careful discussion of the wording and activities to be completed by students during the laboratory experience, allowed GTAs to explore their own understanding of the Hardy-Weinberg equilibrium, and may have prompted them to ask for clarification both in appropriate ways to present the material and in the content.

Clarification of content also occurred between GTAs when trying to construct the laboratory handout for students. The following conversation between three GTAs presents an example of how GTAs worked together to refine the laboratory:

**GTA 1**- Why are the last two sentences relevant?
GTA 2 - Because you still want to figure out the frequency of alleles in the offspring.

GTA 1 - So, like what do you mean?

GTA 2 - So, this is what we have so far. The offspring, (draws a table on the chalk board) we’ve got three possibilities, and they will tally them up like we did before.

GTA 3 - So, could we call that offspring genotype? That would make more sense to me. If you had the genotype and then the total number next to it.

GTA 2 - The genotype frequency is how often this Bb shows up in the population, which is this column divided by the total, but we still want them to be able to calculate the frequency of each allele so we would still need to include that question, or the last two sentences.

This exchange demonstrates that, within the lesson study format, GTAs talked with each other publicly about the content and to clarify their ideas of how to present this content to their students. This is significant for several reasons. First, although there were “experts” present, i.e. the course instructor and a professor in Science Education, the GTAs worked amongst themselves to clarify information for their peers as well as make changes to the format of the laboratory handout. Second, this exchange happened publicly in terms of the lesson study meeting, and was not reserved for one-to-one peer interactions. Instead, these GTAs felt confident in expressing their confusion about the content and the presentation of the content to both their peers and the course instructor.

Within the preparatory meetings, GTAs were most confident regarding content knowledge directly related to their field of research, and less certain of the content in other areas of Biology. Interactions surrounding content knowledge, however, were reserved for one-to-one interactions between GTAs, and never occurred in front of the full meeting. When the content of the laboratory differed from a GTA’s research area, he or she relied on other graduate students who conduct research in that field to answer content related questions. This exchange, for example, occurred between two GTAs, one who focuses his research in ecology and the other who focuses her research in sexual selection:

GTA 4 - There are different ways to define success. I give examples to my students: numbers, individuals, range.

GTA 5 - But, you are an ecology person, and those are ecology answers.

In another example, while GTAs were working in a group of 4 to discuss the weekly recitation questions related to current taxonomic relationships, two GTAs who focus their research in ecology, provided explanations to two GTAs who focus their research in molecular Biology. One GTA continued to ask a number of content related questions of the ecology students, finally stating “I’ll take your word for it, I don’t know this stuff” (Field Notes, 1 November 2010). Luft, et al. (2004) also found that GTAs tend to rely on each other, instead of faculty members, for support related to teaching.
In the lesson study planning meetings, GTAs directed questions to each other as well as to the course instructor. These GTAs still displayed the behavior of deferring questions to those they perceived as experts either in the content or the laboratory exercise. Within this setting, two GTAs took the lead in terms of answering content and laboratory related questions. After this precedent was established, the remainder of the GTAs continued to ask questions directed at these two GTAs in addition to the course instructor. As mentioned earlier, within the preparatory meetings, GTAs deferred their content related questions to those students who conducted research in that field. It is possible that students who conduct research in a particular area of Biology were perceived as experts in their field.

In contrast to the discussions during lesson study, during the preparatory meetings, GTAs primarily discussed procedural issues with the laboratory, needed materials, and “house-keeping” issues such as posting student grades to the course management system. During one preparatory meeting, for example, only three GTAs addressed the group during the meeting. These questions were related to the functionality of the microscope, the solutions to be used during specific parts of the exercise, and to provide an example of a “tricky situation” that occurred with students the previous year (Field notes, 9 September 2010). This type of discourse related to where students had “problems” understanding the laboratory was relatively common during this meeting format, during which one of three of the experienced GTAs provided example areas of the lab that needed clarification. During the preparatory meetings, however, this type of lab refinement only occurred between a GTA and the laboratory manager. There were no instances where other GTAs provided suggestions for refining laboratory exercises.

**Theme 2: Weekly preparatory meetings provide a model of how to deliver laboratory instruction**

In addition to clarifying procedural issues, the weekly preparatory meetings served to provide explicit models of how to teach the material each week. The laboratory manager, who also teaches two laboratory sections, provided these examples for the graduate students, stating what she was going to do in her sections. For example, she stated:

> You need to do a demo for your students like I am doing now. Again, you’ll have to show them how the pipettes work because they probably won’t know….make sure you show them a good example of how this works. Set it up for them so they can see (Field notes, 20 September 2010).

> They will spend the rest of the lab on the genetics problems. I’ll probably do the first few as a lesson. Do it on the board to show them. Some will get it and some won’t. Even if they get how to do a simple cross, that’s progress (Field notes, 18 October 2010).

This type of instruction related to how to deliver the laboratory occurred during each preparatory meeting. During this aspect of the preparatory meeting, GTAs generally made a few notes in their laboratory handouts as reminders of “things to say or do” while they were teaching (Field notes, 1 November 2010).
When the point in the semester came to teach the Hardy-Weinberg lab that was developed in phase one of the study, the preparatory meeting for the Hardy-Weinberg lab was led by the GTAs who designed the exercise, rather than the laboratory manager. As not all GTAs in phase two of the study participated in lesson development during phase one, this preparatory meeting was necessary and appropriate. The GTAs who led the Hardy-Weinberg preparatory meeting in phase two utilized the meeting time to provide a demonstration of the lab exercise they developed, but they also provided their peers with a rationale for their lesson choices. This type of explanation related to why the lab is ordered the way that it is, and what the lesson designer hopes students will “get out” of the experience. These characteristics were absent from the other preparatory meetings observed in phase two. This small addition to conversation related to the laboratory exercise demonstrates that these GTAs believed this information was relevant and important to the presentation of their lesson to other GTAs who will be teaching it. This suggests that the GTAs who participated in lesson study learned not only what to teach students about Hardy-Weinberg equilibrium, but also why teaching these ideas in this particular way was important. These articulations of the reasons for teaching a lesson are often absent from descriptions of lesson activities, which frequently focus on a prescription for action (Morris & Stigler, 2011).

**Theme 3: GTA talk reveals their low expectations of student ability**

One similarity spanning both the lesson study planning meetings and the preparatory meetings was that GTA talk concerning their students was generally negative, revealing their low expectations of student ability. This finding supports that of Luft, et al. (2004) that GTAs were generally frustrated by the lack of motivation and skills exhibited by undergraduate students. Throughout both meeting formats, when GTAs spoke about their students, they did so to present an example of a “stupid kid moment of the week” (Field notes, 25 October 2010). Although the intention was to be humorous in most cases, the prominent type of discourse concerning undergraduate students characterized them as “a little dingy and a little slow” or “babies who don’t understand anything”.

Several other GTAs also made comments complaining about a lack of student learning among students in the laboratory such as “but they really won’t remember anything, if you ask them what something means, they just flounder” or “I think this is a tall order for our students. I would be surprised if they could make that connection”. These types of comments, lamenting the perception that students would rather memorize facts than learn deep conceptual ideas, were also common to both meeting formats. These comments show limited confidence in the ability of students to learn as a result of the laboratory experience. Interestingly, when these conversations occurred, there was no discussion of what could be changed to increase student learning in either meeting format. Instead, these anecdotes were affirmed by other GTAs, who often responded with examples from their own teaching of what their students had done or said that was similar.

**Discussion**

While it is often assumed that GTAs have the depth and breadth of content knowledge to be adequately prepared to teach introductory level courses, this study revealed that providing a
forum such as lesson study in which GTAs can explore their ideas for specific content allows them to clarify their understanding. In comparison, when participating in weekly preparatory meetings, GTAs focused primarily on procedural knowledge, and only asked questions to clarify the science content of the laboratory of their peers who do research in that specific field. These content questions were asked with reduced frequency compared with those asked in the lesson study context, and were limited to one-on-one interactions with peers instead of the larger group context.

The context of the lesson study planning meetings also allowed GTAs to develop their PCK related to teaching about the Hardy-Weinberg equilibrium in populations. When compared with weekly scheduled preparatory meetings, the lesson study planning meetings included a greater amount of discussion of the rationale behind certain teaching decisions. As Dotger (2011) points out, the use of lesson study with GTAs supports the exploration of the “why and how” behind instructional decisions in addition to providing an avenue for GTAs to test their ideas in the classroom (p. 166). As GTAs explored why they believed it was important to include or reword certain aspects of the laboratory, they also developed the ability to discuss their pedagogical decisions. This type of discourse was absent from the other format of teaching preparation, which instead focused on providing a model of how to deliver information, a limitation of most lesson plans (Morris & Hiebert, 2011). This development of teaching knowledge has the potential to transfer to other teaching situations, generally increasing GTAs pedagogical knowledge (Luft, et al., 2004). The increase in pedagogical, content, and pedagogical content knowledge developed within the lesson study context, also can work to increase GTAs self-efficacy, which may have positive influences on student achievement.

Teachers’ expectations of students are related to student achievement (Lumsden, 1997). In their review of the literature related to the effects of teacher expectations on student outcomes, Jussim and Harber (2005) report that these expectations become self-fulfilling prophecies. In other words, students will perform to the level of expectations held by the teacher, either high or low. Although it may happen subconsciously, teachers tend to act differently towards those students they perceive to be high achievers in comparison to those perceived as low achievers. These students may receive more attention from their instructor, including more stimulating questions, and a greater amount of feedback on their work (Lumsden). The majority of GTAs in this study revealed low expectations for their students’ ability in learning the content. Although student achievement was not investigated in this study, GTA attitudes toward student ability may be impacting their interactions with students and ultimately their students’ achievement. The talk among GTAs concerning their low expectations of student ability dominated all talk concerning students in this study. There was, however, some discussion of student learning of Biology within the lesson study preparatory meeting format, although it did not directly follow negative anecdotes recounting student actions. Lesson study’s focus on student learning may help to shift the discourse about students away from simply stating negative anecdotes to promoting solutions to student learning challenges (Dotger, 2011).

As most GTAs begin their teaching careers in introductory courses designed to provide a broad overview of many topics within a discipline, it is important that GTAs have the opportunity to explore their own misconceptions or lack of content knowledge in this breadth of topical areas. Lesson study provides a method for graduate students to develop the three recognized forms of
knowledge necessary for teaching; content, pedagogical, and pedagogical content knowledge (Shulman, 1986). The high frequency of content related questions in the lesson study meeting format, in addition to the tendency of GTAs to defer questions to perceived experts in certain topical areas of Biology, indicates that GTAs may not have adequate levels of the content knowledge required to effectively teach undergraduate courses. However, providing a forum to allow GTAs to explore their own conceptual understanding, as well as developing appropriate ways to teach content through lesson study, may help alleviate this issue.

Conclusions and Implications

As many recent reform documents have called for increased training in teaching for doctoral students, much remains unknown concerning the development of instructional knowledge in this population (Austin, 2010; DeChenne, 2010; Luo, Grady & Bellows, 2001). This study, however, provides an example of one model of professional development with the potential to encourage the development of key types of instructional knowledge in GTAs. Participation in lesson study provided a novel experience for GTAs to assist them in the design or development of laboratory curriculum materials (Dotger, 2010). Participation in this type of professional development may help break the ongoing cycle of new science professors beginning their careers with limited knowledge of effective teaching methodologies, and encourage GTAs to participate in ongoing professional development related to their teaching (Luft, et al., 2004).

References


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