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ABSTRACT

This article describes a strategy for instructing graduate teaching assistants and presents results on how the program influenced their conceptions of teaching science. The discipline-specific seminar was designed to help teaching assistants learn how to effectively communicate biology content to undergraduate students, and aimed at increasing teaching assistants' awareness of discipline-specific teaching strategies. Topics included the current state of undergraduate teaching and learning, alternative strategies, students' conceptions, specific teaching strategies related to biology topics, and innovative approaches. An open-ended questionnaire was used to explore how graduate students define the teaching of science. Results indicated that after the seminar graduate teaching assistants changed their conceptions of good science teaching to include knowing pedagogical strategies. Results also indicate that as a result of the seminar the teaching assistants recognized that (1) conceptual understanding is the basis of learning, (2) learning is more of constructing individual understanding and their role should be to facilitate, (3) planning is much more than reviewing the material, it is necessary to understand pedagogical strategies to help students understand the material, and (4) learning is an active process of constructing knowledge. (JRH)

Biology Graduate Teaching Assistant's Conceptions about the Nature of Teaching

by
Penny L. Hammrich, Ph.D.

Biology Graduate Teaching Assistant's Conceptions About the Nature of Teaching

INTRODUCTION

By the time graduate students in science become teaching assistants, they have been exposed to a substantial amount of science content. Generally, less attention will have been paid to the nature of teaching science itself -- how scientific knowledge is communicated, how scientific knowledge is constructed, how teachers facilitated instruction for understanding. Yet, understanding the substance of science content without understanding how to communicate scientific knowledge and its understanding must be considered.

How well do graduate teaching assistants understand the nature of teaching science? This is not an idle question nor is it a new one. For over two decades university administrators and others outside the university have been questioning graduate teaching assistants preparation to teach science (Carroll, 1980). The America 2000 program and the 1983 report A Nation at Risk have brought educational concerns to the forefront of public opinion (Anderson, 1992). As a result many academic administrators are rethinking how they prepare graduate students to teach undergraduate courses. Researchers have also responded to these situational factors by focusing more attention on teaching assistant instructional programs.

Instruction for teaching assistants does exist in most departments and at most Universities, however, it is usually little more than a review of course materials and procedures. If teaching assistants follow typical patterns, they will teach as they were taught and continue without the benefit of understanding current research and theories about teaching strategies that help students construct knowledge. If the instruction provided by teaching assistants is to improve, they will need to learn the basics of pedagogical theory. More specifically, research on teaching indicates that they must

learn pedagogical theory that is directly related to the subject matter they will teach (Shulman, 1986,1987). The research also suggests that together with the broad information and assistance provided to teaching assistants through the university-wide program, teaching assistants need to have the kind of discipline-specific instruction that can only be provided at the departmental level. As Carroll (1980) argues, although there is plenty of information on how to instruct teaching assistants, there is very little research concerning how well these methods actually work. This article will present a discipline specific seminar along with presenting results on how the program influenced graduate teaching assistant's conceptions of teaching science.

The Discipline Specific Seminar

With these concerns enumerated, a seminar was designed to help graduate teaching assistants learn how to more effectively communicate biology content to undergraduate students. The aim of the seminar was to increase biology graduate teaching assistants' awareness of discipline specific teaching strategies designed to increase undergraduate students' understanding of biology content. Participants in the seminar were twenty-five graduates students who teach the undergraduate non-majors biology course. The seminar took place during second summer session, 1993, and involved a total of 16 hours of instruction. During the academic year the graduate students met three hours a week for further instruction. Graduate teaching assistants were identified as the audience for the seminar due to the major role they play in teaching the undergraduate biology laboratories thus having an influence on the scientific literacy of their students.

In planning the discipline specific seminar there was considerable effort to review the literature on effective teaching in science including measurement of teacher effectiveness, strategies for increasing teacher effectiveness, effectiveness of higher education science teachers using different approaches, and instructional programs for graduate teaching assistants. In the review of

this literature, the following findings were made: Educators and researchers agree that there are discipline-specific strategies that are necessary for effective teaching. Integrating these findings resulted in the following lists of strategies that are necessary for beginning science teaching assistants:

1. An understanding of learner misconceptions in biology;
2. An understanding of how pedagogy relates to subject matter knowledge;
3. An introduction to alternative learning and teaching strategies in biology;
    A. Cognitive Change Learning/Teaching
    B. Inquiry Learning/Teaching
    C. Cooperative Group Learning/Teaching
    D. Discovery Learning/Teaching
4. Discussion and practice on the use of multimedia presentations used in science education;
5. An introduction and modeling of laboratory activities.

The seminar was systematically designed to incorporate these features. The seminar also examined the current state of undergraduate biology teaching and learning, explored new and innovative ways to structure laboratory instruction to better teach such topics as evolutionary relationships and hypothesis testing, variation and inheritance, mechanisms of evolution, population ecology, etc., and modeled teaching approaches that graduate students may adopt in their future biology teaching.

The topics that were highlighted in the seminar include: (a) current state of undergraduate teaching and learning; (b) alternative learning and teaching strategies; (c) student's conceptions of biology topics; (d) specific teaching

strategies related to biology topics; (d) innovative approaches to designing new biology laboratories.

Instructional materials included handouts given to each graduate teaching assistant that contained an outline, objectives and activity pages to follow during the seminar. Pertinent readings on student misconceptions, teaching strategies, and teacher effectiveness were also included. Each graduate student actively participated in discussing their teaching preferences, writing objectives, constructing test questions, preparing lessons, and redesigning laboratories that incorporated alternative teaching strategies to more effectively communicate the content of biology to their undergraduate students.

Method

In order to measure patterns and trends in how graduate students define the teaching of science an open-ended qualitative questionnaire was developed and administered to the graduate students prior to and after the completion of the seminar. The questionnaire consisted of 11 items selected from research studies on teaching (Clark and Peterson, 1986; Borko and Livingston, 1989). The 11 questions were divided into four areas: overall conception of teaching, planning, assessment of student understanding, and reflection of the effectiveness of instruction. The responses were analyzed by content analysis measuring patterns and trends on how graduate students define the teaching of science. Both the author and another science educator analyzed the responses. The author analyzed the responses twice for an agreement of 80.4% (intra-rater reliability). The agreement between the author's and the independent science educator's analysis was 79.2% (inter-rater reliability).

Results

More than 100 different graduate teaching assistants conceptions were identified. In the interest of space, commentary has been restricted to conceptions expressed by 20% or more of the sample. Results are presented under four main headings, namely overall conception of teaching, planning, assessment of student understanding, and reflection of the effectiveness of instruction.

Overall Conception of Teaching Science. Under this heading, the following questions were asked: What are elements of good teaching in science? What are characteristics of a good science teacher? Besides knowing your content, what else do you need to know to be a successful science teacher?

Before the seminar, results revealed that graduate teaching assistants held similar conceptions of teaching science. While reflecting upon their conceptions, graduate teaching assistants noted that it was difficult for them to "figure out why" they held such conceptions. In general when asked to think about how they obtained or why they held alternative conceptions, graduate teaching assistants attributed their conceptions to the teaching practices of science teachers when they were students in K-12 and college science classrooms. A typical response was, "I think good science teaching is knowing your subject area ... and being prepared to follow the lab manual."

Teaching was seen primarily as knowing your subject matter and having good organizational skills. Listening to the questions students ask and handling the lab as an inquiry was hardly mentioned, which suggests that teaching science is seen as an activity of being prepared to follow the lab directions and communicate the steps of the lab.

In response to the question, Besides knowing your content, what else do you need to know to be a successful teacher?, the idea of knowing pedagogy

strategies was ignored. Although graduate teaching assistants avoided referring to pedagogical strategies, what they described was nevertheless a representation of the all too typical school cookbook approach.

After the seminar, results revealed that graduate teaching assistants changed their conceptions of good science teaching to include knowing pedagogical strategies. A typical response was, "I have realized that knowing your subject matter is not enough...it is important to understand how to help students understand the material." Graduate teaching assistants became more aware of the importance of using pedagogical strategies when teaching their subject matter.

In response to the last question, graduate teaching assistants typically responded by saying, "understanding the learner and helping the learner understand difficult concepts." Although graduate teaching assistants mentioned that knowing pedagogical strategies was important, the overwhelming response was that knowing subject matter is more important than knowing how to communicate the subject matter.

Planning. Under this heading, the following questions were asked: What techniques do you use to plan? How do you determine what is important to teach? At the beginning of the course, what information about students and how they learn is important to you?

Before the seminar, the overwhelming response to the first question was, " the technique I use to plan for a lesson is to review the lab material for the week." A typical response was that, " to plan I prepare by making an outline of the material."

Few graduate teaching assistants could give examples of how they determine what is important to teach. Approximately one-half of the subjects expressed a conception that, in light of the prepared quizzes and tests, I determine what is important by the questions on the quizzes and tests. Four graduate teaching assistants were less

sure of the importance of questions on quizzes and tests and qualified their response with the suggestion that they determine what is important to teach by what they think is important. Three graduate teaching assistants stated that they determined what was important to teach by the students needs.

An overall conclusion with respect to information about students and how they learn is that the graduate teaching assistants were interested in why students were taking the course, if they speak English, and their names. Five of the graduate teaching assistants mentioned that they are interested in the students backgrounds and learning styles.

After the seminar, many of the graduate teaching assistants still said that they plan for a lesson by reviewing the material. A typical response was, "I review the material to make sure I know the concepts of the lab." Few graduate teaching assistants mentioned that they try to foresee difficult concepts that students may have trouble with and develop strategies to help the students.

Many of the graduate teaching assistants mentioned that they rely on objectives and goals in determining what is important to teach. Approximately one-half of the graduate teaching assistants expressed a conception that they determine what is important to teach based on what the students already know. A typical response was, "goals and objectives are important but I also rely on the student's needs in deciding what to teach." Overall graduate teaching assistants concluded that they are interested in the students background in science and how they learn.

Assessment of Student Understanding. Under this heading, the following questions were asked: How do you assess whether or not a student understands a science concept? What are the most common reasons students have trouble understanding science concepts? If a student doesn't understand, what do you do?

Before the seminar, assessment was generally considered to be how students perform on quizzes and tests. For example, a common conceptions was, "... if students do well on tests I know that they understand the material presented in lab."

Overwhelmingly, graduate teaching assistants assigned the responsibility of students troubled understanding of science concepts as the result of students not studying for quizzes or tests. In other words, they saw student understanding as an automatic transmission or absorption of scientific knowledge. There was no mention that learning is an active process of interpreting information and constructing understanding. It is not surprising, then, that many graduate students attributed students troubled understanding of scientific concepts as a lack of transmission of knowledge.

Appropriately, graduate teaching assistants, when pressed, could give few examples of what they do when a student doesn't understand. Two graduate teaching assistants mentioned that they tend to review the material that the students had trouble with during the next class period. However, the review was seen as merely rereading the material. Graduate teaching assistants ignored learning as an active process of conceptual understanding.

After the seminar, graduate teaching assistants said that they assess if a student understands a science concept by how well the student can apply the concept in class. Still, many graduate teaching assistants said they rely on how well students do on the quizzes and tests to determine student understanding.

Overwhelming, graduate teaching assistants assigned students lack of understanding to their troubled construction of knowledge. A typical response was, "if a student has trouble understanding a concept, apparently they have had trouble interpreting information and constructing the new information with what they already know...in this case I try to find ways to help the students construct understanding, perhaps presenting the information in a different way." Graduate teaching assistants

came to realize that learning is an active process of interpreting and constructing knowledge and that it is important to use various strategies to help students understand the information.

Reflection of the Effectiveness of Instruction. Under this heading, the following questions were asked: What are elements of effective instruction? How do you evaluate the effectiveness of your instruction?

Before the seminar, not surprisingly, in light of the previous discussion, responses indicated student success on quizzes and tests indicated graduate teaching assistants effectiveness of instruction. Conceptual understanding was never mentioned. Success on quizzes or tests were represented as proof of effectiveness of instruction. For example, " How effective my instruction is depends on the number of students who pass the quizzes or tests."

Other comments included, "... effectiveness of instruction is measured on the clarity of information presented and the success students encountered in the course." Typically, graduate teaching assistants did not mention students conceptual understanding of concepts as a measure of effective instruction.

Finally, as indicated earlier, the essential difference seen between effective and ineffective instruction rested on students achievement in the course. Some of the graduate teaching assistants mentioned that they measured the effectiveness of their instruction based on the students evaluations of the course; although, they mentioned that this was secondary to how well students performed in the course.

After the seminar, an overwhelming number of graduate teaching assistants still assigned their effectiveness of instruction by how students perform on quizzes and tests. Five graduate teaching assistants comments included, "... if students are able to apply the knew information then I feel that they have learned and therefore my instruction has been effective." Finally, many of the graduate teaching assistants

mentioned that they know whether their instruction has been effective by the questions the students ask.

CONCLUSION

The study suggested some promising conclusions:

1. Before the seminar, three-fourths of the graduate teaching assistants did not understand that conceptual understanding is the basis of learning and the role of the teacher is to facilitate learning. After the seminar over one-half of the graduate teaching assistants responded by saying that teaching for conceptual understanding should be the role of the teacher;

2. Before the seminar, graduate teaching assistants saw teaching science as a process of transmitting knowledge. After the seminar many of the graduate teaching assistants recognized that learning is more of constructing individual understanding and that their role should be to facilitate;

3. Before the seminar, planning for instruction was believed to be little more than reviewing the lab manual. There did not seem to be an awareness that students background or prior knowledge of science concepts is a necessity in planning instruction. After the seminar, planning was see as much more than reviewing the material. Graduate teaching assistants mentioned that students prior knowledge should be considered when planning for a lesson;

4. Before the seminar, teaching is seen as knowing your content while pedagogical knowledge is rarely mentioned as a sign of a good teacher. After the seminar, graduate teaching assistants recognized the necessity of understanding pedagogical strategies to help students understand the material;

5. Before the seminar, graduate teaching assistants did not generally recognize that pedagogical knowledge is a necessary element to instruction, let alone that students conceptually understand scientific knowledge. Rather, graduate teaching assistants tend to link good teaching and understanding as a transmission of scientific

knowledge, although, transmission is not seen as facilitating students understanding but as transmitting knowledge. After the seminar, overwhelmingly graduate teaching assistants recognized that learning is an active process of constructing knowledge and that their role is to facilitate learning.

Discussion

Understanding the substance of science content without understanding how to communicate scientific knowledge is an issue that plagues many graduate teaching assistants. For years graduate teaching assistants have been learning the substance of their content area without learning how to facilitate understanding of the content itself. Graduate teaching assistants are placed in the unenviable position of communicating their content knowledge to undergraduate students without the benefit of understanding the nature of teaching their content area. Like many graduate teaching assistants before them, they fall into the same pattern of teaching as they were taught.

University administrators are recognizing the need to better prepare graduate teaching assistants to teach. This recognition has come from outside the university itself. The National Science Foundation is sponsoring a number of programs that focus on the teaching of science at the college level. This article not only discusses a discipline specific seminar designed to promote graduate teaching assistants understanding of the nature of teaching but also provides insight into graduate teaching assistants conceptions of teaching science. While it can be argued that one seminar is not enough to make permanent changes in graduate teaching assistants conceptions of teaching; nonetheless, conceptions graduate teaching assistants hold concerning the teaching of science must be illuminated and challenged.

Finally, while some might argue that developing an understanding of the nature of teaching science may be of practical significance only to those who will eventually take up careers directly concerned with the of teaching science, this argument is not

tenable in a world that has seen its students becoming more scientifically illiterate. Today's students lean more than ever on the influence of science in their world. It is not possible for today's students to evaluate and apply science without understanding the science content that they are taught. Hopefully, the insights from this article will enhance university administrator's understanding of the role graduate teaching assistants play in promoting scientific literacy.

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