Summary of Breakout Session on TA Training
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The discussion leader was Dr. Ken Heller from the University of Minnesota. He started by suggesting that TA Education would be a more appropriate term for this activity, and that it should be part of every physics graduate program because graduate students cannot be expected to be skilled teachers when they arrive. Furthermore, his research has shown that many TAs do not have a sufficient understanding of introductory physics. The problem is compounded by the fact that the students whom the TAs are teaching are not skilled learners; they need guidance and support in learning physics concepts.

Dr. Heller then posed a series of questions for the audience:

- Is the TA experience a useful part of graduate education?
- What do we want TAs to do?
- Is it is possible to achieve those goals?
- How much support should we give to the TAs?
- What can TAs successfully do?

He said that at the University of Minnesota they conduct a one-week orientation (49 classroom hours total) for all new students prior to the beginning of the term. Following that the new TAs have a 1-hr/week class session during the term in which teaching techniques and findings (from physics education research) about common student difficulties are discussed. Each new TA is also assigned an experienced TA whose function is to mentor the new TA in a non-threatening way.

The department of physics at the University of Minnesota conducted a survey in which they asked the departments for which they teach service courses in physics what they expected their students to learn in the physics courses. The survey results indicated that the bio-sciences departments whose students typically enroll in the pre-med physics courses wanted their students to learn problem solving skills. In order to help undergraduate students develop these skills, Dr. Heller and his colleagues have developed context rich problems for the introductory courses. During recitations students work on these problems in groups, with the TA serving as coach in case they get stuck. They have found that three students are the optimal group size

and a TA can coach up to five groups at a time. At Minnesota the introductory courses have one such discussion section and one lab per week. Each TA teaches two discussion sections and two labs per week. Surveys have shown that their TAs prefer to have a mix of discussion sections and labs. This also assures good synchronization between the lectures and the labs. This pattern is followed in all of their introductory courses.

TAs at Minnesota do all the grading, but homework in the introductory physics course is not graded. Control studies have shown that there is no difference in the students' performance on examinations whether the homework is graded or not. The laboratory courses are writing intensive and the TAs have to grade the students' work in those courses. In fact, in the lab courses students have to make predictions about the outcome of each experiment before they collect any data. Then they perform the lab and describe their findings and discuss differences between what they predicted and what they found. Both their prediction sheet and the notebook with the actual experimental data are graded for each lab. In the recitations, there is a quiz once every three weeks; otherwise all the recitation time is spent in group problem solving. The department expects TAs to work 16 hours/week.

TAs are also used in upper-level courses, if requested by the faculty member teaching the course. If a faculty member teaching an upper-level course (or a graduate course) requests an extra hour per week added to the schedule for discussion, the department always provides a TA. In response to a question how they can afford it financially, Dr. Heller explained that they try to make optimal use of the fixed amount of total resources available. He noted that each faculty member with assigned TAs is expected to meet with them weekly to coordinate the TAs' activities. Dr. Charlie Holbrow, who is a visiting faculty member at MIT, commented that they recently conducted a workshop for TAs in the Boston area in which the TAs noted that they really would appreciate it if the faculty took the time to meet with them each week to discuss the progress of the class.

Graduate students at Minnesota receive a total of three credits for teaching. Like many other universities, the Minnesota physics department also uses undergraduate students as teaching assistants. Students who completed the introductory physics course in the top 20% of their class are invited to be teaching assistants in the following years. All of the TA education materials and supplementary material related to group learning is available at the website of the physics department at the University of Minnesota.

In response to a question why a group size of three is optimal, Dr. Heller responded that two students in a group is too small because they may not have enough expertise between them and because there is no way to resolve differences of opinions between them; on the other hand, four students are too many because slackers can hide or the group may break up spontaneously into two groups of two. In a group of three, one student can assume the role of critic. At Minnesota, students are assigned to groups and rotated if needed. Students are also assigned rotating roles of leader, note taker, and critic. They have also found that it is better to put at least two women in a group of three because one woman with two men may not be able to get her point across even if she is very good. In TA education sessions they pay attention to alert students to special challenges they may face if they are women TAs, soft spoken, or short. Creating a culture of teaching among the TAs also helps.

Online homework systems are not used by faculty in the physics department at the University of Minnesota. They collectively decided not to use them because they felt that such systems place excessive emphasis on getting the correct answer rather than on the process of solving problems. They felt that they wanted students to learn the importance of effective problem solving strategies rather than focus on a numerical final answer.