

Summary of the breakout session “Does the Undergraduate Curriculum Prepare for graduate education?”

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This session addressed aspects of undergraduate education that can be improved or strengthened to better prepare students for success in graduate school.

The session leader, Dr. Charlie Holbrow of Colgate University argued that preparation for graduate school is not the most important task of most undergraduate physics programs. That said, however, he asserted that an undergraduate program is deficient if it cannot prepare for graduate work in physics those students who wish to go on.

He presented data showing that roughly 50 % of students entering physics PhD programs leave without getting their degrees. He asked: What aspects of undergraduate preparation foster success in graduate school? What changes in undergraduate preparation might reduce the large attrition?

In the group’s discussion the following points were made

- Incompetence and inability to do graduate work are not the main factors leading to attrition (anecdotal evidence supported this view).
- Undergraduate research experiences attract students to go on to graduate work and help them succeed at it.
- There was mixed agreement as to whether more extensive and rigorous coursework in physics would help. Dr. Holbrow suggested that assessment goals for the adequacy of undergraduate programs should be objective. He gave two examples of goals for the depth and breadth of its content and scope :
 - A reasonably capable student must rank in the 25th percentile or better in physics GRE scores. Dr. Holbrow pointed out that although this target may seem unsatisfactorily low, it is realistic in terms of the amount of physics preparation most American students are likely to acquire in the American educational system.
 - After a year of physics courses, a student must be able to read and explain physics related material in the sections of *Nature*, *Science*, or *Physics Today* that explain advances in physics related research.
- Some participants pointed out that the unifying themes and overall structure of physics are often not perceived by students. Unlike in some other science disciplines, the coherence of physics as a discipline is often not transparent in undergraduate courses, and students fail to develop a comprehensive sense of the field. This can limit their ability to function in a varied grad school environment as well as their ability to identify opportunities and contribute their full potential as physicists in our rapidly changing technological society. Several participants pointed out that students graduating from liberal arts type institutions that emphasize breadth seem to succeed better in graduate school compared to their counter parts from undergrad programs in research intensive schools although the latter often has the advantage of more depth of content.

- There was general agreement that physics education emphasizing only specialized knowledge and skills is deficient. Physics education needs to give equal emphasis to both skills and context so that students get glimpses of the bigger picture early in their undergraduate experience.
- Several participants emphasized the positive role of undergraduate research in preparing undergraduates for graduate school. Involving a student in a specialization as early as the freshman or sophomore years is effective in areas of physics that are amenable to hands-on involvement of undergraduates in research. Even if the research is beyond the scope of undergraduates, some participants recommended involving them in mundane activities associated with the project while helping them to see progressively larger views of the bigger picture.
- Absence of a physics accreditation agency and its possible impact on undergrad physics curricula and programs was discussed. It was pointed out that physics undergrad programs have maintained a large degree of uniformity without an accreditation agency. However, many physics departments face institutional pressures to limit or reduce the required number of credit hours, while chemistry and biology departments with larger number of credit hours are spared such restrictions because they are meeting mandates of accreditation agencies.

Summary of Group Recommendations

After the core presentation and discussions, participants formed smaller discussion groups. These groups identified the following as key components of undergraduate preparation for success in graduate school and beyond. Highest priority was generally assigned to the first three items.

- Oral and written communication skills developed by writing research reports, delivering talks, and by teaching, e.g. in outreach to K-12 students.
- Critical thinking and analysis of scientific information.
- Mastery of mathematics : focus on concepts as distinct from just algorithmic skills (develop a physicist's perspective of mathematics)
- Training in problem solving skills with focus on the process.
- Undergraduate research experience/senior thesis/capstone research and /or components in advanced courses that give students a head start on the transition from dependence to independence.
- Adequate instruction in intermediate level core physics courses.
- Configure some parts of the 'distribution' or 'general education' curriculum to provide courses that are meaningful in a physicist's context: for example, courses that emphasize skills of scientific and technical writing, presentation, and communication in place of general writing or communication courses.