Teaching Tips

Innovations in Undergraduate Science Instruction

Edited by Marvin Druger, Eleanor D. Siebert, and Linda W. Crow

A publication of the Society for College Science Teachers, an affiliate of the National Science Teachers Association

NSTApress®
NATIONAL SCIENCE TEACHERS ASSOCIATION

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06 05 04 4 3 2 1

Library of Congress Cataloging-in-Publication Data

Teaching tips : innovations in undergraduate science instruction / edited by Marvin Druger, Eleanor D. Siebert, and Linda W. Crow.
p. cm.
ISBN 0-87355-245-8
1. Science—Study and teaching—United States. I. Druger, Marvin. II. Siebert, Eleanor Dantzler. III. Crow, Linda W.
Q183.3.A1T44 2004
507'.1'1073—dc22
2004002044

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About the Society for College Science Teachers

History

The need for such an organization was identified by a group of concerned individuals within the National Science Teachers Association (NSTA). Significant to their concerns was a lack of a forum through which college science teachers could interact in an interdisciplinary manner with their colleagues from other institutions. The Society for College Science Teachers (SCST) was established on March 24, 1979 in Atlanta, Georgia, during the NSTA meeting by participants attending a National Science Foundation–sponsored program on undergraduate education.

In April 1981, SCST became an official affiliate of NSTA. The merger provides increased services for college science teachers by assisting them to reach their personal objectives as well as those of the profession. SCST also affiliated with the American Association for the Advancement of Science's Section Q in 1991.

Goals of SCST

- Improvement in the teaching of college science courses via interdisciplinary interactions among teachers of college science.
- Provision of a profession-wide identity for teachers of college science.
- Promotion of a societal and cultural awareness of the significance of science to the modern world.
- Sponsorship of appropriate projects such as local and regional conferences and workshops.
- Promotion of collective self-interests.

SCST-Sponsored Awards and Grants

The Society sponsors, with the support of Kendall/Hunt Publishing Company, the Outstanding Undergraduate Science Teacher Award. SCST also provides mini-grants to members for small projects consistent with the goals of SCST. These grants are limited to a maximum of $1000.

SCST Monographs

The Society has published the following monographs:

- *Innovations in College Science Teaching* (1988)
- *Enhancing Critical Thinking in the Sciences* (1989)
- *Successful Approaches to Teaching Introductory Science Courses* (1992)
- *Science Discoveries and Science Teaching: The Link* (1994)
- *From Traditional Approaches Toward Innovation* (1997)

Preface

This book is presented as a celebration of the 25th anniversary of the Society for College Science Teachers (SCST). We asked SCST members and others to describe for us specific ideas or activities that they use in their teaching. This book is a compilation of those brief descriptions of innovative and effective ideas, tips, and approaches in undergraduate science teaching.

Teaching Tips: Innovations in Undergraduate Science Instruction is organized into three parts. Part I contains articles that deal with the practice of teaching and learning; articles in Part II explore assessment techniques; and Part III contains descriptions of effective ways that teachers have found to promote learning of traditionally challenging concepts. Each part begins with a description of general principles of successful learning found in the National Science Education Standards. You will find that while each article is generally linked to a specific course in a specific discipline, the tips can almost always be applied across the sciences.

Because these tips are limited to 500–700 words each, each contributor has generously provided contact information. If you would like to know more about a particular article, please contact the authors directly.

SCST joins with other professional societies and projects in working for the improvement of undergraduate science education. It provides a forum for interdisciplinary contact and, through its association with the National Science Teachers Association, promotes interaction with preK–12 teachers of science. We invite you to join us in this exciting work!

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Part I

Pedagogical Practices

Successful learning is more apt to occur when students are engaged in discovering and building their own frameworks of knowledge. To meet this standard, teachers must design work that actively involves students in asking questions and finding answers. Teamwork in exploring relevant and important science is encouraged.

Collaboration in the Science Classroom

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Course: Topics in Biology (Honors), a General Studies course (four-semester hours) for non-majors with lecture and laboratory components in which the general principles of biology are explored.

In this era of collaborative learning, creating a classroom environment conducive to collaboration is imperative. Through collaboration students gain confidence and expertise in logical thinking, in working with others, and in communicating ideas. These skills are highly valued in today's competitive employment marketplace.

For the first day of class in a non-majors biology course, strategies that promote student involvement and set the stage for collaboration can be coupled with a view of the characteristics of science. The activity presented below engages the students in thinking about science and initiates student interaction. You will need to provide an index card or sheet of paper for each student. Facilitator instructions and comments below are in bold print:

- **If you can name at least one person in this classroom, raise your hand.**
- **If that person is yourself, lower your hand.**
- **If that person is your instructor, lower your hand.**
- **If you knew that person before you entered the classroom, lower your hand.**
- **Those of you remaining with your hands up, introduce that person to the class.**
- **Each of you introduce yourself to at least three other people in the classroom.**

On the back of your card, complete the following:

Science is……… Label this definition #1. This may be the only time this semester that all of you "get the right answer." The right answer is your view of what science is.

(As students begin to slow or stop writing, announce that they have one minute to complete their writing. After one minute, continue.)

Now pair up with one other student to continue this exercise. Each of you read your definition to your partner. The two of you discuss the definitions and develop a definition that reflects your collaboration. Write this definition as #2 on your sheet.

(As discussion and writing slows, give a one-minute alert. After one minute, continue.)

Form a new group with two to three other students. Your group should not include your pair partner. Read and discuss definitions and write a definition of science based on this collaboration.

(As discussion and writing slows, give a one-minute alert. After one minute, continue.)

A reporter for each group will now be selected. Determine who in your group arose at

the earliest time this morning. If you are the earliest riser in your group, raise your hand. In your group the student to the right of the one with the raised hand is the reporter for your group.

Ask the reporter for each group to read the group's definition. Allowing continued input from students, write key words from each definition on the board, discuss the definitions, point out commonalities among the groups' definitions, and develop a class definition based on contributions from groups. At this point the instructor may contribute to the definition. To follow up, engage students in discussion of the benefits of collaboration in the development of their definitions of science. Relate these benefits to the importance of collaboration in scientific research and advancements in science.

This strategy has been implemented in classes of small enrollment (20 students); however, with minor adjustments (e.g., group size) it can be used in larger classes.

Effectiveness:

No scientific study has been conducted to assess the effectiveness of this strategy. Based on my informal observations and experience, this activity serves as an excellent "icebreaker." General student interaction is enhanced by implementing this collaborative experience early in the course. In combining a collaborative experience with a simple task, the students are likely to be successful and have a positive attitude toward collaboration in general. Students become engaged with science and involved in collaboration. This facilitates the use of additional collaborative work throughout the course.

The Learning Cycle

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Course: Can be used in a variety of science courses.

The "Learning Cycle" is a methodology grounded in Piaget's theory of cognitive development that provides students with concrete experiences prior to or in place of terminology (Odom and Kelly 1998). In a sense it is a method that reverses the usual lecture-then-laboratory sequence. It has had more widespread use in school science with limited use at the college level. I have used this approach in both small education methods classes, as well as in large (200+) Invertebrate Biology classes.

While there have been a number of modifications of the approach since its introduction the most basic model is composed of just three phases (Barman 1989), namely,

Exploration Phase

Data gathering or an activity on which to build knowledge involving observing, touching, and manipulating materials.

Concept Development Phase

Students share information in their own words. Concepts are applied to the experiences in the exploration phase to develop student vocabulary.

Concept Application Phase

Students apply the concepts to a new situation, or design ways to answer the question.

The best way to explain this method is by using an example. I conduct biological research into the phylum Tardigrada (water bears) and teach about this phylum in a number of classes. Rather than use the traditional approach to teach about the characteristics of this group I use this more active learning method, which fully involves the students in their own learning.

In the first phase, the exploration phase, I give each group of three students a number of drawings of six or more "typical" tardigrades and ask each group to make a list of the characteristics of the phylum based only on the drawings. Each group is then given about five minutes to perform this exercise. .

In the second phase, concept development, I then ask each group in turn for one such characteristic and I write each on the board. Once each group has given one characteristic I ask the groups for any others that they might have to add to the list. I then ask the groups if they would agree with all the "characteristics" that have been listed on the board. This often leads to spirited discussions of some of the suggested characteristics.

I then go through the list of characteristics giving the correct nomenclature for each characteristic (i.e., macroplacoid, microplacoid, pharyngeal apparatus, and so forth). These terms replace the terms the students used previously to describe various characteristics.

In the final phase each group of students is given drawings of two further organisms, which may or not be tardigrades, and are asked to decide whether or not each is a tardigrade, with reasons. Each group is once again given up to five minutes to complete this part of the exercise. I then put up an overhead of each drawing and ask the group evaluating that organism to give their answer, again with reasons. I then ask the rest of the class whether they would agree with these assessments and again spirited discussion can occur over the true identities of the specimens.

This particular approach is not only a very student-oriented activity, but it also provides opportunities for students to interact with each other, to speak up in class, and even debate with their peers. While I have no data to support the contention that students learn better using this approach, informally I have been told by students time and time again that they will always remember tardigrades while they will probably forget many of the other lesser phyla. In fact I have even given similar presentations at higher education conferences and had participants at my sessions mention to me several years later that they still remembered tardigrades, and this from non-scientists!

References:

Barman, C. R. 1989. A procedure for helping prospective elementary teachers integrate the learning cycle into science textbooks. *Journal of Science Teacher Education* 1 (Summer): 21–26.

Odom, L., and P. V. Kelly. 1998. Making learning meaningful. *The Science Teacher* 65(4): 33–37.