

# **SCIENTISTS AND SCIENCE EDUCATORS: COLLABORATING TO DEVELOP CONCEPTUAL CHANGE TEACHING STRATEGIES**

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Research in science education has identified conceptual change teaching strategies that may enhance pre-service teachers' understanding of scientific concepts and processes. These strategies, supported by constructivist learning theory in the social and cognitive sciences, include the use of discrepant events to engage students' prior knowledge, the learning cycle, and collaborative learning. Science educators have used these strategies to challenge alternative conceptions of pre-service K-8 teachers in methods courses in an effort to facilitate learning scientific concepts. Pre-service K-8 teachers, motivated to explore scientific phenomena and clarify their own understandings, gain confidence in their ability to learn science and are better prepared to use similar strategies with children. In redesigning innovative courses for pre-service teachers in university science departments, scientists and science educators would benefit from a mutual collaboration to develop instructional strategies informed by constructivist learning theory. In this partnership, scientists, experts in content and scientific research, would work with science educators to develop curriculum in both science and science methods courses that challenges pre-service teachers' existing knowledge and facilitates more authentic understandings of science. A more seamless transition would thus be possible between science courses and science methods courses.

Research in science education has identified teaching strategies that use a conceptual change approach to enhance pre-service teachers' understanding of scientific concepts and processes [1, 2, 3]. These strategies, supported by constructivist learning theory in the social and cognitive sciences, are designed to challenge students' existing conceptions of scientific phenomena while helping students develop more acceptable scientific understandings. In this paper, we will discuss various teaching strategies designed to promote conceptual change, including discrepant events, the learning cycle, and collaborative learning. We will also suggest that scientists and science educators collaborate as they develop innovative science and science methods courses that promote conceptual change teaching and learning.

## **CONCEPTUAL CHANGE TEACHING**

Inquiry teaching strategies, recommended in science education reform documents, involve students in active learning, examination of evidence, and interpretation of scientific phe-

nomena [4]. Students' learning and understanding of science, however, is influenced by the prior knowledge that they bring to science classes:

The concepts of the world that students bring to school will shape the way they engage in science investigations, and serve as filters for their explanations of scientific phenomena [5].

According to research into how children learn, students come to science classes with common sense ideas or alternative conceptions about scientific phenomena [6]. For example, in a study of ninth graders [7], it was found that most of them believed that there is no gravity on the moon as only 28.9 % of the students thought a wrench (dropped by an astronaut) would fall toward the moon's surface. Further, teachers were not aware of students' alternative conceptions of gravity, as 73.5 % of the teachers predicted that students would choose the scientifically acceptable response. Similar research has documented students' alternative science conceptions on numerous science topics in grades K-12 and college, including mechanics, electricity, heat, optics, particulate nature of matter, energy, conceptions of life, genetics, and evolution [8]. These alternative conceptions of students are known to influence learning and are very resistant to change.

The job of the science teacher is to help students connect their prior knowledge with current understandings of scientific phenomena. Often this requires students to change their existing viewpoints and conceptions to accommodate more scientifically acceptable explanations. This task is difficult because many teachers, particularly those learning to teach in elementary schools, do not have an extensive science background. According to Wandersee [8], elementary teachers often have the same alternative science conceptions as their students.

Discrepant Events. In response to helping students experience meaningful learning and develop their scientific understandings, innovative approaches have been developed to challenge students' prior knowledge. Based on Piagetian learning theory, discrepant events (investigations of scientific phenomena with surprising or unexpected results) are used to challenge students' existing conceptions by promoting cognitive disequilibrium [9]. For example, students may investigate the refraction of light by placing a coin under a beaker and then pouring water into a beaker. Confronted with surprising results (the image of the coin

from the side of the beaker apparently disappears from view), students are motivated to find the reason for this discrepant observation. Similarly, in the history of science, anomalies have traditionally spurred new scientific understandings and theoretical thought [10]. According to Piaget, when students' prior knowledge is challenged, students will reorganize or accommodate their existing prior knowledge by making new connections with observed phenomena.

Learning Cycle. Another instructional strategy designed to promote conceptual change is the three-phase learning cycle instructional sequence [11, 12]. Unlike the traditional lecture-lab format, the first phase of the learning cycle engages students in exploration and inquiry investigations before presenting scientific information. Student explorations through discrepant events, dialogue, or other investigations encourage students to access their prior knowledge and in the process, they become motivated to learn and find out more information.

During the second phase of the learning cycle, teachers may introduce concepts or assign reading and research to help students clarify their understandings. During this time, traditional lectures may be more appropriate because students would be motivated to learn more about scientific information and explanations related to their explorations. Students could further clarify their understandings and establish connections with existing knowledge by creating conceptual or schematic maps of their ideas [13]. The third phase involves students in further investigative activity as they apply or elaborate on their existing knowledge. In the process of teaching through the learning cycle, students have opportunities to change their existing understandings of science.

Collaborative Learning. Inquiry and conceptual change teaching is also enhanced by involving students in collaborative learning. During collaborative learning, student thinking is stimulated when students share ideas and discuss strategies for investigating scientific phenomena. According to Lev Vygotsky, teachers should create an environment which challenges students to learn more in a group than they could learn individually [14]. Just as scientists collaborate in their research, scientists and science educators should be promoting collaboration and dialogue among pre-service teachers. Pre-service teachers, motivated to explore scientific phenomena and clarify their own understandings with their peers, gain confidence in their ability to learn science and are better prepared to use similar strategies with

children.

## COLLABORATION: SCIENTISTS AND SCIENCE EDUCATORS

In many undergraduate science courses that pre-service teachers enroll, students' prior knowledge about science is not challenged by traditional lecture teaching methods in which students take notes and memorize information to pass a test. In fact, students may compartmentalize their own prior knowledge and answer test questions correctly without meaningfully connecting their existing knowledge to scientific knowledge [8].

In redesigning innovative courses for pre-service teachers in university science departments, scientists and science educators would benefit from a mutual collaboration to develop instructional strategies informed by constructivist learning theory and research on students' alternative science conceptions. In this partnership, scientists, experts in content and scientific research, would work with science educators to redesign introductory science courses and laboratory activities to be more inquiry-based and discrepant in nature. Teams of science and science education professors would collaborate to develop conceptual change teaching strategies that challenge pre-service teachers' existing knowledge. Science professors, for example, could experiment with innovative strategies such as the learning cycle to break from the traditional lecture-lab format.

Investigative non-traditional laboratory activities have been successful in engaging students in problem solving in undergraduate biology classes [15]. In this study, students departed from "cookbook" laboratory exercises and designed their own experiments to investigate the respiration of yeast. Students formulated their own hypothesis and tested their ideas to investigate the alcohol content of naturally aged wine. This pilot project was the result of collaboration between science professors and science educators.

Alternately, science educators would benefit from collaboration with scientists to redesign the science methods curriculum. Science professors would be invaluable as a resource for discussing current scientific research and explanations of discrepant events or other investigations that take place in the methods classes. Scientists would suggest contemporary research methodologies that may enhance inquiry activities of pre-service teachers. Collaboration between science and science methods professors would promote a more

seamless transition between science content courses and methods courses for pre-service K-8 teachers. Learning from scientists and science educators as role models, pre-service K-8 teachers would be better prepared to engage children in conceptual change teaching and learning. ■

## References

- [1] G. Posner, K. Strike, P. Hewson, and W. Gertzog, "Accommodation of a scientific conception: Towards a theory of conceptual change," *Science Education* 66(2) (1982) 211-228.
- [2] P. A. Basili, and J. P. Sanford, J.P. "Conceptual change strategies and cooperative group work in chemistry," *Journal of Research in Science Teaching* 28(4) (1991) 293-304.
- [3] R. N. Thorley, and R. T. Stofflett, "Representation of the conceptual change model in science teacher education," *Science Education* 80(5) (1996) 317-339.
- [4] American Association for the Advancement of Science, *Benchmarks for science literacy: Project 2061*, Oxford University Press, New York, 1993.
- [5] National Research Council, *National science education standards*, National Academy Press, Washington, DC, 1996.
- [6] R. Osborne, and P. Freyberg, *Learning in science: The implications of children's science*, Heinemann, Portsmouth, NH, 1985.
- [7] T. Berg and W. Brouwer, "Teacher awareness of student alternate conceptions about rotational motion and gravity," *Journal of Research in Science Teaching* 28(1) (1991) 3-18.
- [8] J. H. Wandersee, J. J. Mintzes, and J. D. Novak, "Research on alternative conceptions in science," in D.L. Gabel (ed.), *Handbook of research on science teaching*, Merrill/Prentice Hall, Upper Saddle River, NJ, 1994.
- [9] C. L. Thompson, "Discrepant events: What happens to those who watch?" *School Science and Mathematics* 89(1) (1989) 26-29.
- [10] T. S. Kuhn, *The structure of scientific revolutions*, The University of Chicago Press, Chicago, 1970.
- [11] A. E. Lawson, M. R. Abraham, and J. W. Renner, *A theory of instruction: Using the learning cycle to teaching science concepts and thinking skills* (Monograph of the National Association for Research in Science Teaching (NARST), No. 1) Cincinnati, OH, (1989).
- [12] G. E. Glasson and R. V. Lalik, "Reinterpreting the learning cycle from a social constructivist perspective: A qualitative study of teachers' beliefs and practices," *Journal of Research in Science Teaching* 30(2) (1993) 187-207.
- [13] J. Novak, "Concept mapping: A strategy for organizing knowledge," in S. M. Glynn and R. Duit (ed.), *Learning science in schools*, Erlbaum, Mahwah, NJ, 1995.
- [14] L. S. Vygotsky, *Mind in society: The development of higher psychological processes* (M. Cole et al ed), Harvard University Press, Cambridge, MA, 1978.
- [15] G. E. Glasson, and W. L. McKenzie, "Investigative learning in undergraduate freshman biology laboratories," *Journal of College Science Teaching* 27(3) (1998) 189-193.