Towns Research Group Literature Review

Division of Chemical Education
Department of Chemistry
Purdue University

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This is the inaugural edition of a publication of the Towns Research Group, Division of Chemical Education, Department of Chemistry, Purdue University. The purpose of the literature review is to review and share relevant chemical education research literature with fellow group members, university colleagues, and the chemical education research community at large. Please fell free to direct questions about this publication to Dr. Marcy H. Towns (mtowns@purdue.edu).

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AMERICAN JOURNAL OF PHYSICS

Zacharia, Z. C., & Constantinou, C. P. (2008). Comparing the influence of physical and virtual manipulatives in the context of the physics by inquiry curriculum: The case of undergraduate students' conceptual understanding of heat and temperature. *American Journal of Physics, 76*(4), 425-430.

This study compares the effect of a computer-based lab and traditional hands-on lab on student understanding of heat and temperature. Participants were undergraduate elementary education majors enrolled in an introductory physics course and had received no prior physics instruction. The course was taught using a guided inquiry approach, and the study was done during the first module of the course, which covered concepts of heat and temperature. The class met in lab sessions once a week for 90 minutes for two months, during which time they worked in small groups (of three students when possible) and carried out experiments to explore concepts of room temperature, thermal interaction and thermal equilibrium. Students were randomly assigned to the experimental or control group. Both groups used the same lab space and instructional method, time spent on activities, course resources and curricular materials were equivalent.

The control group manipulated thermometers, objects (such as beakers and Styrofoam cups), and materials (like wood and water) while the students in the virtual lab group used the Thermolab software. The software enabled students to manipulate virtual images of the same instruments and materials used in the experimental group. Feedback for both groups included information such as time, temperatures, volumes, and indications of phenomena such as boiling.

Students' conceptual understanding of heat and temperature were tested before and after laboratory instruction. They responded to a written test with open-ended questions which asked for an explanation of reasoning when solving problems. Responses were scored for correctness and also analyzed using a phenomenographic methodology in which answers were coded for instances of scientific and non-scientific conceptions. Analysis pre-post scores showed that both conditions resulted in an improvement of students' understanding of temperature. Phenomenographic analysis showed that both groups shifted towards a greater degree of scientifically accepted explanations after the lab.

The results of this study challenge the idea that hands on experiments with manipulation of physical variables are an essential part of introductory science courses. Software-based labs may be an equally effective means of developing student understanding of scientific concepts and may be a more manageable and efficient means of conducting labs. However, course objectives must also be examined when deciding to use virtual labs; virtual labs used in courses intended for science majors may fail to address objectives such as teaching laboratory technique and manipulative skills that would be needed in future coursework.

BIOCHEMISTRY AND MOLECULAR BIOLOGY

Cardosos, F. S., Dumpel, R., Gomes da Silva, L. B., Rodrigues, C. R., Santos, D. O., Cabral, L. M., & Castro, H. C. (2008). Just working with the cellular machine: A high school game for teaching molecular biology. *Biochemistry and Molecular Biology Education, 36*(2), 120-124.

The authors of this article created an interactive board game to help high school students enhance their understanding of molecular biology topics such as DNA replication, transcription, and translation. The board game is set up like a puzzle. There are areas of the board already filled in, and it's the student's job to fill in the missing pieces by answering questions that they draw from a question bank. As the students are filling in the puzzle pieces, they are able to visualize the molecular biology process at hand.

CHEMISTRY EDUCATION RESEARCH AND PRACTICE

Overton, T., & Potter, N. (2008). Solving open-ended problems, and the influence of cognitive factors on student success. *Chemistry Education Research and Practice, 9*, 65-69.

As stated by the authors, "many problem solving activities encountered on undergraduate programmes are algorithmic, and require lower order cognitive skills to be applied in order to reach a solution" (p. 65). This statement has often been made when arguing for more complex problem types and more emphasis on developing problem solving skills in the science classroom. Overton and Potter discussed the development of "open-ended problems that use real life context and require the applications of higher order cognitive skills" (p. 65). A key component of their research was a problem solving attitudes questionnaire given pre and post participation in problem solving session. Only a selection of the questions were included in the article. This instrument was built on a five point Likert scale with two opposing statements on either end; a 'neutral' choice was thus available. Description of the results from this questionnaire was limited only to say that the questionnaires "revealed a more positive attitude towards questions [problems] having a real-life or work-related context after the problem solving sessions" (p. 68). As with other surveys that appear in the literature, the authors did not include information about the generation of the survey either by literature review or personal anecdotes. Little is know about the validity and reliability of the survey and yet it is used as a key result in promoting the cause of open-ended problems in problem solving instruction. While the method of instruction may be useful, further exploration must be made into the instruments used to measure the success of this and other problem solving instruction.

JOURNAL OF RESEARCH IN SCIENCE TEACHING

Ibrahim, B., Buffler, A., Lubben, F. (2007, November 5). Profiles of freshman physics students' views on the nature of science. *Journal of Research in Science Teaching*. Retrieved April 11, 2008, from http://www3.interscience.wiley.com/cgi-bin/abstract/116838565/ABSTRACT

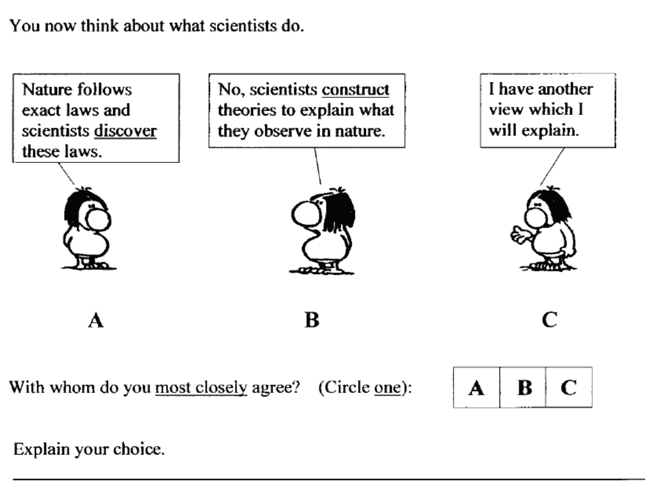

Figure 1. Example of a NOS probe from the VASM questionnaire.

In this article, the researchers used open response questions of 64 “mainstream” first year science students and 115 “foundation” first year science students in a South African university. The differences in the educational history of the students determined what group they were considered to be part of (mainstream students had more formal school and science training than did the foundation students, who tended to be of lower socioeconomic and educational backgrounds). The researchers used a tool called the VASM (Views About Scientific measurement) questionnaire to get these responses. The VASM included questions such as the one featured in Figure 1, where a student was asked to make a choice about the nature of science and explain their answer.

Their analysis was based in grounded theory. The authors did open coding on the responses, looking for trends. They then compiled their codes, using multiple coders to establish inter-rater reliability (82%). These open responses and codes were then used to construct the four profiles of students based on their nature of science beliefs: modelers, experimenters, examiners, and discovers. (See Table 7 in the article for further details). These four profiles were comprehensive enough to describe the general viewpoints of 86% of the study’s participants. Statistical tests were also conducted between the two groups to determine if any statistical differences between the students being “mainstream” or “foundation” and the NOS profile that they aligned to. A two-tailed t-test showed that a significantly larger number of mainstream students fell into the “modelers” profile than their foundation counterparts (z=-2.24, p=0.025, statistically significant at the 95% confidence level).

SCIENCE EDUCATION

Slater, M. H. (2008). How to justify teaching false science. *Science Education, 92*(3), 526-542.

This article indirectly addressed the nature of science and the ways that school science represents real science. For instance, Slater used Newtonion mechanics as an example of “false science” that is taught in the science classroom, arguing that, even though Newtonion physics is no longer accepted as the most accurate model of motion, it is still taught as if it is. Slater wrote, “I believe many science education researchers have long held: that a central goal of science education is providing students with a realistic understanding of science, of the ‘nature and development of scientific knowledge’… How specifically we should approach this challenge as teachers and scholars remains to my mind an open question. But it is a question that more philosophers and historians of science ought to take seriously. Teachers and scholars alike need to think seriously and carefully about how the historical and philosophical study of science might be integrated into classroom science, even at an early level” (p. 527). Slater discussed issues related to teaching in science classrooms and possible solutions. What should students need to know to be successful in science? Slater discussed theory in science, scientific inquiry, and other issues within science education, such as teaching students a “dumbed-down” version of science content, with the hope that students will learn a more accurate version of it in later courses when students are more ready for it. “The important point, however, is that its impossibility (in whatever sense) does not compel teaching false science as a prelude to our bust science unless it is clear that other preludes would not do just as well (or better). As long as we are teaching what is false, why not teach other false theories if they would make for more compelling learning?” (p. 533). Overall, this article provides a great discussion on issues in science, and is a good introduction and reference for those interested in learning about the ways that science is portrayed in the classroom. Slater’s paper challenged the way science is taught, and raises good points for all science educators.