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ABSTRACT

This paper describes the results of implementing a team-project approach to a methods course for preservice physical science teachers. The course is meant to give future teachers realistic experiences in the pursuit of solutions to problems where no answers are provided by the textbook or the instructor. Each lesson introduces a problem, offers demonstrations of key concepts, asks students for applications from their own experiences, and ends with a quest for new solutions. (WRM)

Team Projects: A Taste of Real Science in Our Content/Methods Course

by

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TEAM PROJECTS: A TASTE OF REAL SCIENCE IN OUR CONTENT/METHODS COURSE

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We have designed a hybrid content/methods course for preparing physical science teachers. This 3-credit-hour physics course is jointly taught by two professors - one from engineering and one from secondary science education. The objectives include giving future teachers realistic experiences in the pursuit of solutions to problems where no answers are provided by the textbook or instructor. Using the course theme of energy in the home and automobile, we discuss heat transfer, home energy consumption, battery storage, solar photovoltaic arrays, and other basic energy concepts. Each lesson introduces a problem, offers demonstrations of key concepts, asks students for applications from their own experiences, and ends with a quest for new solutions.

At the mid-point of the course we divide students into teams of three and assign them a project that requires synthesis and analysis of course content. Examples of these projects include (a) testing and scale-up of a solar photovoltaic array panel, (b) construction and energy audit of a scale model house to minimize heat losses, (c) exploration of several methods of heating water in search of the most effective, (d) efficiency and durability of residential sources of light, and (e) a quest for the most effective way to cool a six-pack of carbonated drinks. In each case, the team is given the following instructions:

> The final project is designed to challenge you to apply some of the science and engineering principles we have studied in this class. You will work with two others to study a problem and reach a conclusion supported by your own data. The descriptions below are intended to "draw a circle around the problem", not to fully delineate all the details. Thus, you must examine the problem statement carefully, consult with your partner, seek clarification where it is needed, and ask for any equipment you cannot locate yourselves. Of the 100 possible points for each problem, 60 will be awarded for simply doing what is specified in the written description below. The remaining 40 percent will be awarded for "creative sciencing", defined as applying your best means of solving the problem using ingenuity and common sense. There are no right answers in the back of the book. We do not even know the answers. But there are good answers! Your job is to find them, test them, and document them in your report. Your grade will be based on both the written report and the oral presentation {@ 50 points each}. All team members must take part in the entire process of library research, construction,

testing, and graphing results. All team members must sign the cover sheet of the report stating that you either have contributed equally to the final product or declaring your actual contribution. Project reports are due on ______. Your team would be wise to begin work at once and allow plenty of time for the natural frustrations that are an inevitable part of applied science.

This video/paper presentation (see Appendix A for video outline excerpt; see Appendix B for index to entire video) will describe the results of our team project approach to preparing better science teachers, noting that many of them do not otherwise get a real taste of the frustrations and joys of authentic science projects (Linn & Clark, 1997). We feel this is a good way of helping teachers meet the National Research Council standards with their own students. We seek to prepare science teachers who will engineer learning environments in their own classrooms that avoid "looking for the same answer as the one in the back of the teacher's manual." Project approaches in the classroom can help achieve this.

Our future plans for the course include CD-ROM and web page development to go with printed materials for distribution to other institutions. We are working on export of several course modules for use in our state-wide "Science in Motion" mobile van outreach program.

Figures 1 through 3 provide example project descriptions as given to student teams for this 5-week effort:

Figure 1

How many ways can I heat water?

Project managers : <<names of team members>>

You are to compare two methods of heating water – electric resistance coil and a second, non-electric method. Use a simple, 120-volt immersion coil heater to heat 1000 cu. cm. of water from 20 deg. Celsius to 50 deg. Celsius. Calculate the efficiency of this operation. Do this three times and take the average of your efficiency calculations to be more sure of your answer. Now repeat the heating of 1000 cu.cm. of water through a similar temperature change, but your only source of heat must be non-electric. Again calculate the overall efficiency. You may use any second method of heating, but you must explain where heat is going, and account for differences in measured efficiencies. Repeat this process three times and take the average of your efficiency results. Compare both the energy input and output to produce the specified temperature changes using each energy source.

Your final report must contain all collected data for all trials. Display this in tables and graphs, and show all efficiency calculations. Explain how you controlled for error of heat losses. Recommend in your report the "better" way to heat water for your bathroom based on (a) economy, (b) availability, and (c) wise use of resources. Do some reading and use common sense. Explain your recommendations.

Figure 2

Solar photo voltaic array panel

Project managers : <<names of team members>>

Monitor a photo-voltaic panel over three 24-hour cycles. You are to determine using a light meter how much solar radiant energy strikes the panel. You will simultaneously monitor the energy and power output from the solar array. Produce graphs that link the energy input and energy output. Calculate the overall efficiency of the panel for producing electricity. Correlate power output with local conditions over each 24-hour cycle. Recommend uses for this energy conversion device. What are its limitations?

Your final report must provide graphical evidence for the potential uses you recommend for solar energy conversion to electricity. Why is this the preferred choice for energy conversion in deep space probes? Using the data from his monthly statements, how large would this type of panel need to be to supply the electrical needs of Bill Baird's house in Auburn? Your report must also include information about solar photo-voltaic energy conversions that come from your own group's library investigation of this topic.

Figure 3

Keep the heat

Project managers : <<names of team members>>

Build a house with a single room of 3,500 sq. cm. floor space or less. Wall space must be about 7,200 sq. cm., with 15% of this used for windows. Wall thickness must be less than or equal to 2.0 cm. Use shingles for roof covering. Use a single type of wall insulation. Use plastic wrap for windows. Heat your house with a single 40-watt heat source, placed in the center of the house and not contacting any wall or floor. Monitor the inside and outside air temperatures over two 24-hour day-cycles, and calculate heat loss through the walls, windows, and ceiling (attic). Your house must occupy a foundation in Haley 2462 during the "winter" season, but the object is to keep the maximum amount of heat inside the living space. Temperature difference between inside and outside should be equal to or greater than 10 deg. Celsius. Building materials should be cardboard, fiberglass, plastic wrap, and fiberglass shingles.

Your final report must describe the building construction, energy input and loss, three cycles of 24 hour temperatures, and recommendations for next design based on your findings. Include information on home energy conservation of space heating. Include at least eight infrared photos taken of your building with the internal heat source "on" but all room lights off. [We can provide camera and infrared film.] Where was heat escaping most rapidly? What are some design changes that you recommend for reducing heat losses?

Note

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Reference

Linn, Marcia C. & Clark, Helen C. (1997). When are science projects learning opportunities? *Research Matters to the Science Teacher*, No. 9704. Available at http://science.coe.uwf.edu/narst/research/projects.htm.

Appendix A

Video outline

The 10-minute video provides a short collection of scenes selected from the Spring 1998 edition of our course.

1. Faculty from the sciences and engineering can collaborate with faculty from education in preparing and teaching quality content courses for teachers. The central theme of our course is "energy in our personal lives", especially the home and car. We apply current technology and recent physics developments to develop the ideas of our course.

Scenes of Baird & Zee teaching the course, beginning w/ calc. of body surface area. Mutual concern for improved science classroom instruction led to course design. Zee with electric car, solar photovoltaic array, steam power from home pressure cooker. Baird with electric pickle.

2. Such team-taught courses have the advantage of providing multiple perspectives on content and pedagogy for teachers. We try to demonstrate the learning cycle in each class meeting of our course.

Scenes showing how instructors demonstrate good teaching style. Frequent questions, hands-on approach, etc.

3. The preparation of science teachers should include classroom experiences and assignments that follow the (1995) NSES standards:

* concrete experiences should precede abstract concepts;
* frequent, hands-on encounters with science enhance conceptual learning;
* seek connections with science-technology-society themes in the classroom;
* promote collaborative student learning through peer teaching;

* questioning strategies promote inquiry and encourage life-long learning;

* fewer concepts presented in greater depth lead to better mastery of content.

Selected scenes that show the above. Zee reasons out an equation with help from class.

4. Physics content in our course is selected to connect with the theme of "energy in our personal lives."

Baird with cross-section of wall from home. Inquiry about heat transfer through roof into attic.

5. Use of the learning cycle in each lesson facilitates content learning while demonstrating good teaching style.

Engage -
Explore -
Explain -
Elaborate -
Evaluate -

6. We try to use current technology to deliver our message in class.

Representative of Science in Motion brings equipment to collect data on solar flux.

Student shows how to handle a spreadsheet on his laptop computer.

7. Small class size and continuous interactivity help produce active learners, who go on to become student-centered teachers.

Ralph carries the power supply out to show students how hot the resister is.
Baird reasoning about thermostat setting and resulting costs of home heating.

8. Each student is expected to play an active role in each class.

Students working problems on board.

9. Learners construct meaning from personal experiences with new knowledge, and must fit this into meaningful understanding of the subject. Students solve problems on the board, demonstrate spreadsheets on laptop computers, assist in each demonstration, and present their final projects to the assembled class and instructors. In these ways they construct meaning from their experiences, and fit this meaning into pre-existing understanding of physics concepts.

Male student working problem on board.
Students explaining their final projects to the class.

10. In their final projects, teams of three students explore a problem, collect essential data, make sense of their results, and present their conclusions to other teams. The assigned questions are

open-ended; even the instructors do not have a "correct" answer. For some students, this is the first time they have tackled a problem of this type and produced a final report of their own research. These projects apply physics concepts to everyday problems as students cooperate to study an open-ended question and produce an engineering report.

More scenes of final project presentations, especially solar panel and heating water.

Following this short segment is a longer collection of scenes (one hour and 28 min.) taken from each week of the ten-week course. A printed index is provided below.

Appendix B

The rest of this tape is a selection of scenes from the course in Spring 1998. In the following outline of these scenes, remember that Dr. Zee is Engineering professor and Dr. Baird is the Education professor. Approximate start times are given in hours:minutes:seconds.

Start Time	Scene
0:00:00	Dr. Zee makes a "tin man" of himself for estimating surface area
0:02:35	-as above with a student helping measure Dr. Zee's arm
0:04:12	An experiment testing efficiency of an immersion coil heater
0:05:05	-ongoing experiment
0:05:49	-ongoing experiment
0:06:45	Dr. Baird teaching
0:07:22	Description of efficiency
0:08:10	Dr. Zee describes why kilowatt hours are used by utilities
0:09:46	A student demonstrates computer spreadsheet use
0:10:47	Dr. Zee "kills himself" with an electrical outlet
0:13:52	Dr. Zee makes steam in a heating efficiency experiment
0:14:56	-further discussion of the efficiency
0:17:00	Dr. Baird discusses boiling temperature with the class
0:17:57	Dr. Zee and a student measure kinetic energy in water from faucet
0:18:27	-that water power is used to lift a weight
0:19:18	Dr. Zee discusses with students
0:19:58	A student working an assigned problem on the board
0:20:11	Dr. Zee discusses Ohm's law
0:20:59	-continued discussion, with an experiment to measure resistance
0:22:22	-continued work on resistance with a heated resistor
0:26:33	-more on resistance
0:27:45	Heater wire as an example of a metal with a different resistivity
0:28:08	-more with heater wire
0:31:14	A student working an assigned problem on the board
0:31:31	Dr. Zee and the class create a formula relating resistance to temperature
0:33:52	Dr. Zee and the class devise a way to measure the length of coiled wire
0:35:46	Review of some concepts and problems presented to this point
0:36:14	A student working an assigned problem on the board
0:36:51	Dr. Baird introduces the electric pickle lesson
0:37:15	-light flux from a candle is measured
0:37:52	-light flux from a lightbulb is measured

0:38:30	-students help set up the electric pickle
0:39:12	-the electric pickle glows
0:39:58	-the electric pickle smokes
0:40:28	A student working an assigned problem on the board
0:40:54	Dr. Zee describes how mass cancels to simplify a waterfall problem
0:41:43	Dr. Zee describes an electric vehicle that is actually on the market
0:42:22	-calculating range and power for the electric vehicle
0:43:08	Solar cells are introduced
0:44:06	Light flux from a lightbulb is measured again
0:44:36	Dr. Zee and the class discuss an experiment where they heat water
0:45:26	-Dr. Zee and a guest use probes and a computer for the heating exp.
0:46:29	-the experiment in progress
0:47:05	Dr. Baird leads a discussion on energy costs
0:49:55	Dr. Zee describes methods of concentrating natural gas
0:52:28	Introduction of thermal energy transfer topics
0:52:55	Students and Dr. Zee test some materials as thermal conductors
0:53:38	A wall model is presented that will be used for a heat transfer experiment
0:54:59	Dr. Zee diagrams heat conduction and questions students
0:56:22	Dr. Zee works a heat resistance problem
0:57:56	An experiment on heat transfer through the wall model
1:01:02	Dr. Baird discusses thermostat settings and national standards
1:01:49	A student working an assigned problem on the board
1:02:38	Dr. Baird and the class work on figuring out what emissivity implies
1:03:52	Dr. Baird describes interaction of roof and sunlight for heat transfer
1:05:28	Dr. Baird describes double-pane glass
1:06:54	Student project -- heat retention in a house
1:08:57	-house project continued
1:09:16	Student project -- comparing ways to heat water -- sterno
1:13:32	-heat water continued -- propane
1:18:05	-heat water continued -- electricity
1:23:23	Student project -- using a solar panel
1:25:06	-solar panel continued

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