

INTERNATIONAL PROGRAM PROMOTES CREATIVE THINKING IN SCIENCE

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Abstract: An International Program in Creative Education is successfully being carried out by educators in the United States and Japan. Its main goals are to turn students of all ages onto science and engineering and to prepare them to be critical thinkers and creative problem solvers. A brief description of this national award winning program is presented. Also the authors' definition of creativity and standards-based lesson ideas are provided.

Introduction

An international program, that promotes creative thinking in science, is being successfully carried out by educators and researchers in the United States and in Japan. The overall program received a National Award (Certificate of Excellence in Public Relations) from the American Chemical Society in 2007. This unique project (with sponsorship from the Northern New York Section of the American Chemical Society), includes the preparation and use of innovative teaching techniques and tools. It also involves a variety of workshops that are presented to college students, their instructors, high school students and other groups. Major program goals are to turn students of all ages onto science and engineering and to prepare them (our future leaders and scientists) to be critical thinkers and creative problem solvers.

To provide a better understanding of their program, the authors define creativity and describe the instructors' role in creative education. Creativity is the ability to produce original work and ideas. It includes the combining of existing work and objects to create new items such as a motor bike, composed of a motor and a bike. The creative process starts with a creative person (ex. chemist) and results in a creative product (ex. new medicine or herbicide). It includes the thinking and acts that take place to produce an original item.

Instructors are encouraged to promote creative thinking in the classroom. They need to be open-minded, value originality, and seek imaginative solutions to problems. Also they

should allow students to express innovative ideas (ex. hold class discussions and debates on various topics such as global warming and green chemistry).

Creative Education Program

The creative education program is being carried out using innovative teaching techniques developed by the authors. Each technique serves as a program component. These components include the Multisensory Teaching Approach, the Science Fair Project Teaching Approach, the Reading and Solving a Mystery Teaching Approach, the Space Science Teaching Approach, and the Creative Engineering Design Teaching Approach. These methods are currently being incorporated into science lessons and laboratory activities of existing college, high school, and middle school course curriculums. A chemistry course at Clarkson University uses the multisensory teaching approach in the lessons and lab work of a unit on Acids and Bases.

MULTISENSORY TEACHING APPROACH

The multisensory teaching approach, known as the Chemical Sensation Project, takes advantage of students' senses. Some students learn by listening. Others learn by seeing, writing, or performing laboratory activities. This method is designed to meet individual student needs and requires instructors to incorporate visual, writing, listening, and laboratory activities (utilizing the senses of smell, touch, etc. where appropriate) into their science lessons.

The authors' creative Chemical Sensation Project received a National Award of Excellence (ChemLuminary Award) from the American Chemical Society in 2004. The program was carried out at colleges and high schools in the United States and Japan. Materials used in this project were prepared by Barry and translated into Japanese by Kanematsu. They include a music CD of science songs, overhead transparencies, pictures to serve as visual aids, hands-on science experiments, science questions, and evaluation forms. Students begin each multisensory lesson by viewing the activity picture and words to the selected science song, while listening to the song. Next they perform an exciting hands-on activity that complements the song. Finally they answer science activity questions and complete the evaluation forms.

Project participants include Clarkson University, Edwards-Knox High School, and Canton High School in the United States and Suzuka National College of Technology, Takada High School, and Kanbe High School in Japan. They rated the workshops as being very useful, challenging, and fun. Survey results show that 96 % of the U.S. student participants and 93 % of the Japanese students had a neutral to very positive reaction to the exciting science activities. Also 84 % of them had a neutral to very positive reaction to the creative songs. In addition, 96 % of the U.S. participants answered all of the science questions correctly.



Clarkson University's science students carryout a multisensory lesson to learn about acids and bases.

Chemistry Professor Barry Lavine's class at Clarkson University used the multisensory approach to learn about acids and bases. For one lesson, they listened to the song "Acid Verses Base" and then determined the physical and chemical properties of various fruits, drinks, and cleaning solutions. His students used magnifying glasses to closely examine the reaction of baking soda with lemons and other fruit.

National Science Standards requirement addressed: (Standard 4: Science – Physical Setting: Key Idea 3: Matter is made up of particles with properties that determine the observing characteristics of matter and its reactivity.)

Multisensory workshops were also used to prepare instructors to turn students onto science, to emphasize the importance and relevance of science to daily life, and to promote creative thinking. One major workshop was carried out in New York State (2006) for instructors. They performed several multisensory activities about chemicals, which addressed required areas of the National Science Standards.

(Standard 4: Science – Physical Setting: Key Idea 3: Matter is made up of particles with properties that determine the observing characteristics of matter and its reactivity. Physical Setting Process Skills based on Standard 4: Determine the density of regular and irregular-shaped solids - number ten. Determine the volume of regular and irregular-shaped solids, using water displacement – number eleven.)

One lesson began with the viewing of pictures and models of chemicals (including sodium chloride), while listening to a song titled “Chemicals.” Then they analyzed and determined the physical properties (including density and volume) of a variety of apples, oranges, and potatoes and other items. They used tape measures, graduated cylinders, magnifiers, digital balances, and the water displacement technique. Participants recorded, organized, and shared data. They also filled out evaluation forms and prepared multisensory lessons for use in their science courses.

This instructor workshop was very successful and very well received. Survey results show that 100 % of the participants enjoyed the workshop, felt it enhanced their creative thinking, believed it motivated them to prepare and use more science activities in the future, and that the workshop was very meaningful for science education.

SCIENCE FAIR PROJECT TEACHING APPROACH

This method gives students an opportunity to select an interesting problem to solve for their science fair project.

National Science Standards requirement addressed: (Standard 1, Scientific Inquiry.)

They develop problem-solving and critical thinking skills by performing mental exercises in collecting, analyzing, and interpreting data to draw conclusions about the outcome of their exciting investigations. In addition, they are encouraged to use their imagination and talents to prepare creative displays of their work.

This teaching technique is a relatively new concept in Japan. Therefore Barry and Kanematsu prepared a special book, *Science Fair Fun in Japan* published by Gendai Tosho, Japan in 2005, for the Japanese students. The authors used it to lead four major science fairs in Japan. Highlights of these very exciting and successful events appeared in prominent Japanese newspapers and on the TV news in Tsu City, Japan. In addition, the Nissan Foundation donated money in 2006 to continue /expand the Science Fair activity throughout the Country. Questionnaires completed by student participants show that more than 90 % of them were turned onto science and thoroughly enjoyed the event.

The main Science Fair took place at Suzuka National College of Technology. Students had many interesting and diverse projects to share. One was the mixing of a variety of vegetables in a blender to prepare the best tasting juice. Another was the adding of various items to soap, to find out each additive’s effect on bubble size. Also the students prepared creative poster displays of their work.



Students at Suzuka National College of Technology in Japan measure the size of their newly created soap bubble.

Newest Program Components

Three important and recent additions to the International Program in Creative Education are the Reading and Solving a Mystery Teaching Approach, the Space Science Teaching Approach and the Creative Engineering Design Teaching Approach.

READING AND SOLVING A MYSTERY TEACHING APPROACH

This innovative method provides students with an opportunity to develop critical thinking and creative problem-solving skills by reading stories and solving a mystery. The authors published creative science books to complement this teaching approach. Their new book *Develop Critical Thinking Skills, Solve a Mystery, Learn Science*, published by Tate in 2007, is available in both paperback and audio versions. It can be found at www.amazon.com. Also a Japanese edition was published by Pleiades of Japan in 2007. These books target middle / high school and college students. They include a problem-solving model, experiments for students to do, two short stories, and a detailed science education component. Students master the steps of a problem-solving model by acting as detectives to analyze each short story and solve its crime (problem). They also carry out

story related activities that make use of science process skills and cover all levels of Bloom's Taxonomy. This teaching approach has been introduced to instructors and students in the United States, Japan, and Malaysia.

National Science Standards requirements addressed: (Standard 1, Scientific Inquiry. Standard 1, S2.1b - Conduct an experiment designed by others. Standard 1.1c – clarify questions so that they are subject to scientific investigation.)

A short Mystery Workshop activity was carried out by instructors and students in the United States. Workshop participants read the first four parts of Mail Mystery, a short story included in the authors' new creative science book. While referring to the book's problem-solving model, they wrote possible problem (s) to solve, an educated guess to answer the problem (s) and data / information from the reading to back up their hypothesis (hypotheses). This activity resulted in very interesting / thought-provoking discussions of the numerous and diverse problems to solve in the story.

SPACE SCIENCE TEACHING APPROACH

Barry had the honor and pleasure of organizing three World First Space Missions with support from Space Explorers Inc. and the National and Aeronautics Space Administration (NASA). Her World First MarsLink Space Mission Program received a National Award from the American Chemical Society in 2004, for its creative approach to teaching science. Also the names of her MarsLink team members are on a disk aboard the Mars Exploration Rover.

Using space related activities is a great and exciting way to learn science. College and middle / high school students in the United States, Malaysia, and Japan are actively participating in this exciting portion of the Creative Education Program. They are learning about space exploration, the planets, mission positions and duties, instrumentation, and a teamwork approach to solving problems. Program activities include planet and star gazing, planetarium shows, space-art painting contests, rocket launching, data analysis, and space missions. The students are preparing to participate in a Mars Explorer Simulation.

National Science Standards requirements addressed: (Standard 1, Scientific Inquiry. Standard 4, The Physical Setting: Key Idea 1: The Earth and celestial objects, phenomena, etc. can be described by principles of relative motion, perspective, etc.)

CREATIVE ENGINEERING DESIGN TEACHING APPROACH

The combining of creative science and engineering design is very important and necessary to meet the needs and challenges of the future. Our leaders and scientists must be creative problem solvers, so that the global society can have an opportunity to adjust and live in our ever changing world.

A few activities are provided for this new program component.

College students in a Materials Science / Engineering Design class as well as middle / high school students study the properties of various materials and metals (elements). Then they creatively use aluminum foil to design and build boats to carry a cargo of pennies while floating in a small plastic tub filled with water. They test their boats, modify, and retest them to create the best type for carrying cargo. Later they are encouraged to creatively design boats using other materials. This will allow them to determine the best material and the best boat design.

National Science Standards requirements addressed: (Standard 1, Scientific Inquiry. Standard 1, Engineering Design. Key Idea 1: Engineering design is an iterative process involving modeling and optimization (finding the best solution within given constraints); this process is used to develop technological solutions to problems within given constraints.)

Students study the Solar System in a Physics or Astronomy course. After obtaining information about the moons, the chemical makeup, etc. of the planets, they are asked to create imaginary planets of their own. For example:

One instructor started a lesson with a general discussion about our planet Earth, which included land, water, plants, animals, and people (who breathe oxygen to stay alive). Then some photos were displayed of our planet and of other planets in the Solar System like Mars (a cold planet with two moons and an atmosphere that is composed of about 95% carbon dioxide gas). Finally the students were asked to brainstorm and create a new planet of their own. They were told to name, draw, and color a picture of their planet. Also they had to provide a written description with information such as planet size, life forms, and the presence of gases, minerals, water, and moons.

National Science Standards requirements addressed: (Standard 1, Scientific Inquiry. Standard 4, The Physical Setting: Key Idea 1: The Earth and celestial objects, phenomena, etc. can be described by principles of relative motion, perspective, etc.)

Also students studying the topic of Mars and its exploration, participate in a Mars Explorer Simulation that is sponsored by Space Explorers, Inc. and NASA. They operate and control a Mars Rover and then have an opportunity to modify it or to creatively design one of their own.

National Science Standards requirements addressed: (Standard 1, Scientific Inquiry. Standard 7, Interdisciplinary Problem Solving; Key Idea 1: The knowledge and skills of mathematics, science, and technology are used together to make informed decisions and solve problems, especially those relating to issues of science/technology/society, consumer decision making, design, and inquiry into phenomena.)

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