# INTERNATIONAL PROGRAM TO PROMOTE CREATIVE THINKING IN CHEMISTRY AND SCIENCE

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**Abstract**

An international program to promote creative thinking in chemistry and science has been initiated by educators / researchers in the United States and Japan. This paper provides a short description of the program and its components. Also the topics of creativity and creative thinking are briefly discussed.

## Introduction

A new program, which promotes creative thinking in chemistry and science, has been initiated by educators and researchers in the United States and in Japan. This unique project (with sponsorship from the Northern New York Section of the American Chemical Society and Suzuka National College of Technology in Japan) includes the preparation and use of innovative teaching techniques and tools. Its main goals are to turn children onto chemistry and engineering, and to prepare them (our future leaders and scientists) to creatively solve problems and to adapt in our ever changing world.

This program in creative education actually serves as an umbrella to several innovative teaching techniques (developed by the authors) for science instruction in grades K- 12. Each technique (the multisensory teaching approach, science fairs, and the use of mystery stories) includes its own creative tools and activities. The multisensory teaching approach (referred to as the Chemical Sensation Project) is the only program component that has been carried out extensively. Details of this national award winning project are published in journals of various countries. Some include *The Chemist* (2003) in the United States, *Science Education Review* (2003) in Australia, and Tokai Kagaku Kougyoukai (2003) in Japan. The other components of this international effort are in the preliminary stages, so data is still being collected for them.

## Creativity and Creative Thinking

A brief discussion of creativity and creative thinking is presented to give a better understanding of the program. Creativity, which has been important since the beginning of time, is the ability to produce original work or ideas. It is also the ability to take existing objects and ideas and combine them in different ways for new purposes. An excellent and very useful example is the wheelchair, which is composed of wheels and a chair. Three important components of creativity (Barry, 2005) are the creative person, the creative product, and the creative process. A creative person is usually energetic and full of ideas. The creative product is one that never existed before. It may be a new book, movie, toy, song, or invention. The creative process starts with the creative person (examples: artist, musician, scientist) and results in the creative product. It includes the thinking and the acts that take place to produce an original item.

Creative thinking stimulates curiosity and includes the skills of originality, fluency, flexibility, and elaboration. It is exploratory, looks for relationships, and develops many original and diverse ideas. These new ideas are then evaluated by critical thinking, which involves logic, reasoning, and science process skills (of comparison, classification, evaluation, etc.).

Creative thinking is part of our thinking process, which is explained in a simple way by Ebert's Cognitive Spiral Model (Ebert, 1994). This model includes five modes of thought (Perceptual Thought, Creative Thought, Inventive Thought, Metacognitive Thought, and Performance Thought) which occur in sequence along a spiraling path. They recur over and over again, but do not return to the exact spot from which they began. In Perceptual Thought the brain detects stimuli (such as flower fragrances) and translates them into neuro-chemical impulses. The next step of the model is called Creative Thought. This is defined as the search for patterns and relationships between a perception and the individual's knowledge. A person's long term memory is searched for prior experiences that are similar to the new one. If the sound of a ringing bell is perceived, then Creative Thought comes up with possible sources for the sound such as a telephone, doorbell, or alarm clock. During Inventive Thought, the information provided by Creative Thought is assembled into a product (such as a ringing telephone). Then Metacognitive Thought (popularly referred to as critical thinking) evaluates the product. If this product is found to be an acceptable solution, then it is expressed (in the model's final mode) through a performance like speaking or writing. However if it is not acceptable, then the process starts again (but at a new starting point).

The teachers' important role in creative education is to promote creative thinking and encourage students to express innovative ideas. Educators must prepare the younger generation to think for themselves so they can solve new and challenging problems and adapt to our ever changing world. To be successful, individuals must be able to understand, process, and synthesize information into unique ideas, purposes, and products. Teachers (in a creative education program) should be open-minded, seek imaginative solutions to problems, and encourage students to do their own thinking. They should also value originality, mention that several solutions may exist for any given problem, and engage the class in meaningful activities that incorporate individuals' abilities, interests, and backgrounds.

The international effort to promote creative thinking in science began in November of 2005 when Barry served as a Visiting Professor for Suzuka

National College of Technology, Japan. She gave teacher training seminars for Creative Education to teachers and instructors in Japan and led four science fairs throughout the Country. She is in the process of providing similar workshops for K-12 instructors in the United States. (These workshops define creative thinking and its importance, describe the teachers' role in creative education, and provide sample activities to develop children's creative thinking skills.)

## Components of the Creative Education Program

This section describes the program's innovative teaching techniques and tools to develop creative thinking and problem- solving skills in students of all ages.

### *1. Multisensory Teaching Approach*

This method, known as the Chemical Sensation Project (Barry & Kanematsu, 2003), takes advantage of students' senses. Some students learn by listening. Others learn by seeing, writing, or performing laboratory activities. The multisensory approach (Barry & Others, 2003) is designed to meet individual student needs and requires teachers to incorporate visual, writing, listening, and laboratory activities (utilizing the senses of smell and touch, where appropriate) into their science lessons. One example is a lesson about the element carbon and its various forms. While three-dimensional models or pictures are used to visually represent the diamond and graphite forms of carbon, students listen to information about them (e.g. in a song or audible presentation). Then they perform a laboratory activity to determine and compare the physical properties of various forms of carbon (e.g. diamond, graphite, charcoal). Finally the students write a short report about their results.

Teachers may imitate this approach by incorporating available multisensory materials into their lessons. Creative materials (tools) used in the Chemical Sensation Project include a music CD (Barry, 1996) of original chemistry songs with diverse music styles and words, overhead transparencies, pictures to serve as visual aids, and chemical experiments, to complement existing high school / college chemistry curriculums.

The authors successfully carried out the Chemical Sensation Project (which received a ChemLuminary National Award of Excellence from the American Chemical Society in 2004) at colleges and high schools in the United States and Japan. They traveled to these organizations, and provided teacher training sessions and assistance for carrying out and evaluating the project. A variety of evaluation forms were used to rate the program. Project participants include Suzuka National College of Technology, Takada High School, and Kanbe High School in Japan and Clarkson University, Edwards-Knox High School, and Canton High School in the United States.

## 2. *Science Fairs*

This method gives students an opportunity to select an interesting problem to solve for their science project. They brainstorm about many topics to come up with an exciting idea for their investigation. Then they prepare a list of possible materials and a creative procedure for carrying out their experiment. This method helps students 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 science projects. In addition, science fair participants are encouraged to use their imagination and talents to prepare exciting, multisensory displays of their work.

Creative materials (tools) used in this project may include any books about science fairs and science projects. The authors prepared special books written in English and Japanese for this purpose.

Both books include a problem-solving model and the necessary skills, information, and activities to prepare students to successfully identify and creatively solve problems. In November 2005, the authors used their Japanese book to lead four major science fairs at Katada Elementary School, Kitarissei Elementary School, and Suzuka National College of Technology in Japan. Highlights of these very successful events appeared in prominent Japanese newspapers and on the TV news in Tsu City, Japan.

***Figure 1.*** Japanese elementary school students prepare data sheets for their science fair display. (The books on the table are written in Japanese and have the English title: *Science Fair Fun in Japan*.)

***3. Reading Stories and Solving a Mystery***

This innovative method provides students with an opportunity to develop critical thinking and problem-solving skills by reading stories and solving a mystery. This technique can be used in any classroom. Students are assigned to read a mystery and to treat it as a research project. They define the problem (the crime in the story), obtain data, carry out the steps of a problem- solving model, and solve the crime. One example is to have the class read Agatha Christie's book titled *The Mirror Crack'd*. In this mystery a film star throws a large party, at which a guest sips a poisoned cocktail and falls dead. The students must identify and solve the problem (crime). They gather and record data (evidence) about the contents of the poisoned drink and about the possible suspects and attendees of the party. Then they organize and analyze the data to draw conclusions and solve the problem (crime).

The creative materials (tools) prepared by the authors for use in this project are two special books (one written in English and to be published in the United States and a Japanese version of the book to be published in Japan). The books target upper middle school / senior high school students (ages 13 – 18 years old) and their teachers. They include two short stories ("Mail Mystery" and "Mind Games Plus") 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). The books also include a special foreword (to the mysteries) by Hollywood actor Eric Barry, who performed the science education rap song "Chemicals" featured in the national award winning Chemical Sensation Project.

4. ***Other***

There are numerous ways to promote creative thinking in science for students of all ages. Barry teaches the course "Using Hands-on Activities to Creatively Stimulate Your Mind" for SOAR (a program of stimulating opportunities after retirement). One of her activities is called "Creative Art Using Chemicals." Participants prepare unique paintings using fruits and vegetables. Each person is given 10 cotton swabs, a paper cup full of water, paper towels, 2 large sheets of white construction paper, and a variety of fruits and vegetables. Cooked peas (containing the chemical chlorophyll) provide a green color. Cooked beets (containing chemicals classified as flavonoids) provide a red color, while blueberries (also containing flavonoids) provide a blue color. Also a piece of charcoal (containing carbon) can be used for black.

**Summary**

This ambitious program in creative education is an international effort to promote creative thinking in science and chemistry. Chemistry is very important to our global society. People eat, drink, breathe, wear, and use chemicals everyday. Chemistry teachers should provide students with enjoyable and meaningful experiences in science. They should encourage creativity in the laboratory ( use some open-ended research activities) and also inform their classes of the importance and many uses of chemicals in their daily lives such as in medicine, cosmetics, clothes, paints, homes, food, drinks, cars, etc. In addition to teachers, chemists should also take the role of turning students onto science. They can serve as judges at science fairs and share the excitement and discoveries of chemistry as volunteers in the classroom.

This program in creative education includes the preparation and use of innovative teaching techniques and tools. Its main goals are to turn children onto chemistry and science, and to develop their creative problem-solving skills. The relatively new program continues to grow and to attract schools and students in various countries. Also the authors are in the process of preparing additional activities and materials to stimulate and promote creative thinking in students of all ages.

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*Develop Critical Thinking Skills, Solve a Mystery, Learn Science* (two books: one to be published in the U.S. and a Japanese version to be published in Japan).

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