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A Formulations Laboratory Project

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Recent public awareness and concern about energy, environmental and consumer issues has emphasized the limitations and short-comings of science. While knowledge of these limitations is important to the understanding of the serious technological problems facing society, they inherently deal with the negative side of chemistry. For a more positive approach, a formulations laboratory project has been tried in which students attempt to prepare a common household product from laboratory chemicals. Although students are trying to solve consumer, economic, and environmental problems, they do so from the positive posture of making a product rather than battling against an existing chemical or chemical process.

A formulation which depends only upon the physical properties of the chemicals involved provides a medium for high school students to do chemical research and development analogous to that being done in industry. By eliminating chemical reactions, the task is made simple enough that the student can grasp the problems involved and tackle the assignment with a minimum of direction from the teacher. The chemistry involved in relating properties of solubility, abrasiveness, and corrosiveness to other considerations such as cost, consumer safety, convenience, and availability of the chemical still provide the student with the opportunity to discover that only optimum solutions are available.

Students play the role of research companies and perform the tasks associated with bringing the product to the market place, beginning with a library search and proceeding all the way to making commercials for their finished products. Students concern themselves with issues such as product quality, product safety, shelf-life expectancy, and truth-in-advertising, but from the perspective of the manufacturer rather than the consumer. In addition, the skills utilized by the students approximate those used by scientists in industry: conducting a library search, keeping a research notebook, writing progress reports, and performing both exploratory and developmental research. The interface between the industrial researcher and the management of the company he works for is explored as the exact type of product is chosen, the price is established, a label is prepared and an advertisement is written.

The entire simulation-project is spaced over a period of about six weeks with the initial library research and the advertisement preparation done as outside assignments. Good, usable products have been made in four 90-min periods.

The Mechanics of the Assignment

The class is divided into companies of no more than four students each and product types are assigned so that at least three companies compete to make the best product of each type. Paint removers, fuel tablets, flame retardants, water-prooers, glue or paste, and floor cleaners and waxes have been prepared successfully. The specific product choice is left

to the student. For the glue/paste category, the companies can choose among an all-purpose glue, a paste for paper, or a glue for ceramics. After each company has a product to make, they are given one week to do a library search outside of class and to write a preliminary proposal listing the type of product they will try to make and the recipes they will test.

There are several formularies ((1)-(5)) which can be used by the students as sources of recipes. In addition, reference books such as the "CRC Handbook of Chemistry and Physics" and technical dictionaries are useful in helping the student decipher chemical synonyms, check on properties, and provide the background information for making substitutions of chemicals or modifications in procedure.

A detailed proposal is written after the student companies have been in the laboratory for one period and understand the difficulties they will face in formulating their product. The proposal states the specific product to be made, specifies the initial problems encountered and how they plan to overcome these problems, and lists special chemicals or equipment desired.

A standard price list using scientific catalogs is provided so that students can determine the cost of materials used on a common basis. The price assigned to the product reflects only the cost of raw materials with no research, labor, advertising, or distribution cost included. The resultant low cost dramatically illustrates the relatively minor role the cost of materials plays in the price of a consumer product.

During the laboratory periods, the companies make decisions concerning changes in procedure and substitutions of ingredients. Procedural modifications are usually aimed at improving the appearance of the product or trying to make the product compatible with a convenient type of packaging by changing the solubility, making the product softer or harder, or adding food coloring. Substitutions of reagents are often made mandatory because the required chemical is unavailable or is too expensive. Alternatives are also sought to decrease flammability, eliminate obnoxious smelling or toxic chemicals, or to improve the stability of emulsions.

A research notebook is kept by each student during each laboratory period using a format as close as possible to that used in industry. For example, bound notebooks of blank pages are used. A new page is started for each experiment, the observations are written in ink in an essay format, and the notebooks are dated and witnessed by a lab partner. These are reviewed by the teacher each week to monitor the companies' progress. To eliminate frivolous questions and to maximize the independence of the research companies, the teacher plays the role of a consultant whose fee must be included in the price of the product.

The last laboratory period is spent making the batch to be tested, preparing a label, packaging the product, and video-

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taping a thirty-second advertisement. The labels must state the percentages of ingredients, directions for use, and any safety precautions. A great deal of pride is generated in the products as illustrated by some of the titles of the paint removers: "Quicker Stripper," "Removo Paint Remover," and "Strip T Ease Paint Remover." There is also an unusual amount of imagination and effort put into the preparation and video-taping of the commercials. At the same time the products are turned in for evaluation, a formal paper is also submitted. This report follows the format of a research paper written for publication in a journal with "abstract," "results and discussion," and "experimental" sections. The products of each type are displayed together in a Product Fair. The video-taped ads are viewed by the classes and bonus points are assigned to the ad voted best by the students. The products are then evaluated against their competition, the claims made by their ad and label, and the price.

Summary

At a time when attitudes toward science are critical, it is important to present a realistic but favorable picture of the applications of chemistry to the largest possible number of chemistry students. A formulations project is more convincing than a discussion of the role of chemistry in society. It allows the student to experience the limitations and strengths of science and technology from the viewpoint of science. Students discover that relatively simple mixtures make up the majority of commercial home products. By doing the project as a role-playing exercise, students gain insight into the processes and problems that industry faces; a need for confidentiality in research, scarcity of materials, price versus quality decisions, and consumer safety considerations. Finally, the skills utilized by industrial scientists are practiced by the students. The student learns firsthand the importance of teamwork, library skills, and effective communication for the success of an industrial research project.