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Reflections

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Publisher of ***Introductory Physical Science*** *(IPS)* and ***Force, Motion, and Energy*** *(FM&E)*
Thoughtful Curricula Developing Thinking Students

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IPS: The Why and How of Its Beginning

Uri Haber-Schaim

The basic objective of the *Introductory Physical Science* (IPS) course, now in its Ninth Edition, remains: to provide all students with the basic knowledge of physical science and the ways such knowledge is acquired. Improvements were made over the years. Topics were added and deleted. Authors changed. But the biggest effort was the completion of the First (commercial) Edition in 1967.

The acknowledgements from the preface of the First Edition, to be found at the end of the textbook in every edition, provide an idea of the magnitude of the four-year effort to produce the first commercial edition. The list of names include a core group of five college professors and eight high school teachers plus about twenty part-time staffers, many of them pilot teachers working during the summers. All these people worked efficiently because they had the strong support of technical staff, including editorial, art, photography, secretarial, and shop.

The purpose of this article is to describe in some detail why the project was started and what led to some of the basic decisions that were made.

BACKGROUND

The second half of the nineteen-fifties was the beginning of an unprecedented period of innovation in science education in the United States. One of the early projects was the high-school physics project known as the Physical Science Study Committee (PSSC). The project was led by two MIT professors, Jerrold Zacharias and Francis Friedman. I was a member of the development team.

The approach of the committee was revolutionary. Adding or deleting topics was not the starting point of the process, but the result. What was first discussed were the basic goals of teaching physics in the senior high school. The results of these discussions determined

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Looking for courses to take this summer?

Science Curriculum Inc. will offer IPS teacher workshops for 2-semester hours credit each at Colorado School of Mines (Golden, Colorado) in July. For more information, click here, or scan the code at the right.

the choice of content as well as the learning aids: text, lab, and films. In the new course students replaced the memorization of vocabulary and formulas with investigating nature first hand and understanding how generalizations are made.

In 1960, after three years of field-testing, *Physics* by the Physical Science Study Committee saw its first commercial edition. Its use in the schools rose rapidly, backed by a variety of in-service workshops for teachers. The monitoring of the use of the course in schools showed that the goals of the project were met. However, there was one problem that could not be fixed within the one-year course: the vast majority of students who took the PSSC course in physics (or the new chemistry and biology courses) had really no prior experience in science. As a result, too much time had to be spent on teaching the incoming students basic skills, such as collecting data and drawing graphs. What was needed was a "junior high school project" in physical science to address this problem by having students do science in the same spirit as in the PSSC *Physics* course but at a more elementary level. Sure, all students had a general science course at some grade or another. But in those courses students developed neither basic lab skills nor the evidence for the many authoritative statements found in their textbooks.

GEARING UP FOR IPS

In 1963 I formed a sub-group of staff members of the Physical Science Study Committee that took upon itself to produce a full-year course. The purpose and style of the proposed course were clearly stated at the outset in the preface to the first three chapters of the Pilot Edition, the first version to be tried in a small number of schools:

> **Preface**
>
> This booklet contains the first three chapters of a full-year course in introductory physical science, intended to lay a solid foundation for later courses in biology, chemistry, and physics. The theme is the development of the evidence for an atomic model of matter, based upon experimentation performed by the students themselves. The laboratory experiments are contained in the body of the text and are therefore relied upon for proper development of the story. In several cases, a substantial amount of experimental evidence is collected during one class period by having different students perform the same experiment on different materials.
>
> The planning stage of this project was financed by Educational Services Incorporated. It is now supported by a grant from the National Science Foundation.

How did such a succinct statement define the overall structure of the entire course? At the risk of oversimplifying the content of many group-discussions, mostly in front of a large blackboard, I would describe the process in the following way. The role of a model in science is to create order in known areas and extend these areas by making testable predictions. This means that before students learn about the atomic model of matter, they must know quite a bit about matter. For example, students have to know how elements combine to make compounds. But this in turn requires the ability to distinguish between elements and compounds.

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WHY AND HOW (from page 2)

Although ninth-grade students are familiar with objects such as chairs and hammers, and substances such as wood and iron, they may still say that " iron is heavier than wood." So we had to start at the beginning and make sure that students understood the difference between the properties of an object and the properties of the substance of which it is made.

Some ideas that we intended to use came from Part 1 of PSSC *Physics*. However, we had to show first that they could be adapted to students in ninth grade. Therefore, we used the planning stage mentioned in the preface not only to state the goals of the course but also to make sure that they were attainable under a set of conditions that we assumed existed in most schools. Specifically:

- **Prerequisites:** No prior knowledge of science was assumed, only general familiarity with our technological world, including the ability to read a linear scale on a ruler and thermometer. General reading and arithmetic skills were assumed, but no algebra.
- **Classrooms:** The minimum requirements for an IPS class were a flat table for each pair of students and at least one sink per class, and minimal storage facility. (A well-equipped lab that was available only at pre-set times was useless because the lab had to be accessible at all times.)
- **Equipment:** For reasons of safety, cost, and the length of a class period, experiments had to be performed on a semi-micro scale. There were no suitable balances and heat sources available from suppliers. We developed them ourselves. Ring-stands were available but were expensive and hard to store. We came up with the pegboard. All the experiments for the course were developed and tested directly with the equipment that the students were going to use, without first working with fancier tools. Figure 1 shows the setup for the original curtain raiser, The Distillation of Wood. The alcohol burners were made from empty 35 mm film containers. (A year later they were replaced by small glass containers, in which one could see the amount of fuel present.) Figure 2 shows an early version of the IPS balance with beads serving as standard masses.

Figure 1

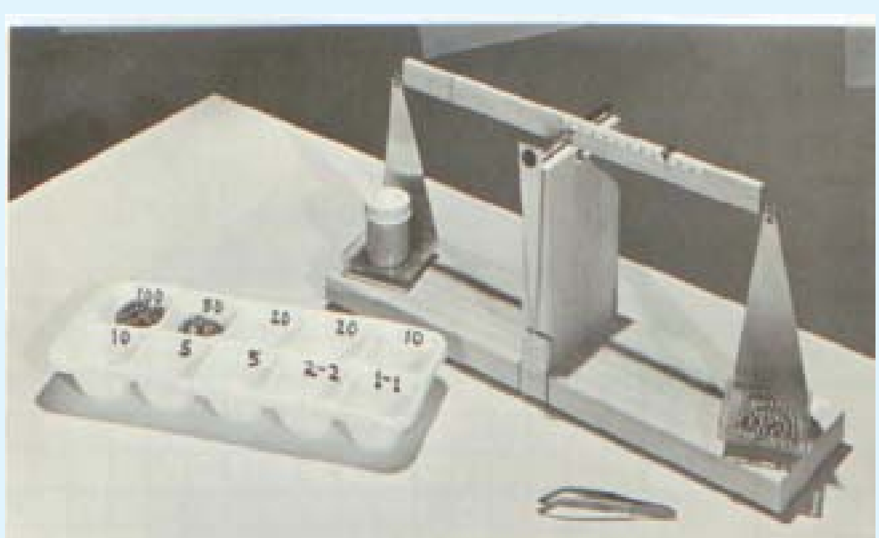

Figure 2

See WHY AND HOW on page 4

2014 Summer Workshops

Join us for the 2014 IPS Summer Workshops at Colorado School of Mines in Golden, Colorado. Earn college credit as you enhance your teaching skills in a beautiful setting at the base of the Rocky Mountains.

Properties of Matter – July 13-18, 2014

~~**Atoms and Molecules** – July 20-25, 2014~~ CANCELLED

Energy and Forces – July 20-25, 2014

A workshop application is provided at the end of this newsletter.

WHY AND HOW (from page 3)

THE PROCESS OF DEVELOPMENT

Drafts of the outline of the course had the appearance of an annotated table of contents. In addition to the titles of sections there was a brief statement of their content and the description of any needed photographs. (My experience with PSSC taught me not to rely on the use of a photograph in the text before I have it in front of me, and it indeed shows what I expected it to show.) The construction of the outline was an evolving process that usually took place in a group session so that many ideas could be discussed, especially for experiments, before individuals were given specific assignments.

The outline led to the development of resource papers. For experiments these papers contained not only a detailed description of the set up, all the raw data, and final results, but also comments about possible pitfalls and a comparison with other ways of reaching the same goal. For reading sections the resource papers contained the logical structure of the section and the necessary graphics to support it.

I like to remind the younger readers that in 1963 we had no personal computers and no copiers. Much of our resource papers were typed by our secretary on "speedy sets" of three or five carbon copies. The writing of the student text was done mostly by Judson Cross, an experienced author and a distinguished physics teacher at the Phillip Exeter Academy in New Hampshire, and by me.

All experiments were tested by a staff member other than the one who did the resource paper. This procedure led to improvements in the text and gave useful suggestions for the Teacher's Guide and Resource Book.

FIELD-TESTING

Field-testing a new curriculum poses a dilemma for developers. On the one hand, the developer wants teachers with a deep understanding of the goals of the curriculum. This will guarantee that any problems encountered in the classroom are due to flaws in the material. On the other hand, one wants a broad spectrum of teachers to identify rough spots that can be cleared up by suggestions on how to handle the material.

In IPS we solved the dilemma by restricting the field-testing of the Pilot Edition to teachers who worked on the development of the course. We then extended the field-testing on the Preliminary Edition to almost 2,000 students of different abilities in both eighth and ninth grades. Our strategy paid off; the feedback from the field-testing of the Pilot Edition, at times devastating, was all to the point. It highlighted the successes and addressed shortcomings of the material.

The field-testing strongly supported the basic premises of the program: that learning can be based on the class results of collective experimentation. It also showed that simple equipment, which is carefully designed and well executed, will work in the hands of junior-high school students.

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A Look Back at the IPS Feedback Process

Harold Pratt

INTRODUCTION

Since I have been a part of the IPS feedback process from both sides, as someone submitting feedback from a school district and the IPS Feedback Coordinator, Uri asked me to describe the process and its significance as a brief companion to his article.

PROVIDING THE FEEDBACK

During the 1964-65 school year, as the science supervisor of the Jefferson County (Colorado) School District (Jeffco), I had the privilege of facilitating seven junior high teachers who were piloting the IPS Preliminary Edition. An important side note to that arrangement was that Frank Oppenheimer—brother of Robert Oppenheimer, the director of the Manhattan Project—had committed to weekly professional develop training of the pilot teachers. Frank, a research professor at the University of Colorado Boulder, had also been a physicist at the Manhattan Project.

One of my functions as the leader of the pilot center was to collect the feedback, add my comments, and forward it to Uri. Part of our weekly sessions with Frank involved listening to the experiences of the teachers, reviewing issues and questions with Frank, and developing suggestions for improvements for Uri and the writing team. I can still remember the challenges faced by the teachers in making the shift from a didactic textbook to the experimental approach of IPS and the excitement the team felt about making a significant contribution to the development of IPS. In addition to the weekly reports, Judson Cross (mentioned in Uri's article), visited the teachers and met with the team to listen directly to their feedback.

Although it wasn't immediately apparent because of the intensity of learning and teaching a radically different course of study, it soon became clear that the pilot experience, coupled with contact with Frank Oppenheimer and the responsibility for submitting constructive feedback, was one of the most effective professional development opportunities I have experienced or facilitated. In the years that followed, as we created a variety of instructional materials in Jeffco, we established a systematic feedback process patterned after the one used with IPS.

ORGANIZING AND USING THE FEEDBACK

My professional life and experience with the feedback process shifted the following school year when Uri asked me to move to the Boston area and assume the responsibilities of coordinating the feedback process from field test teachers across the country. Teachers were asked to write open-ended comments about their students' experiences with each section of the book and mail them to me on a regular basis. For each section, I took a teacher's submission and physically cut out the comments, compiling them with the comments from other teachers regarding that section. These compilations of feedback comments were copied and circulated among the members of the writing team. The writers reviewed, discussed, often debated but never ignored those reports as decisions were made about modifications for the next edition. The Field Test Edition was published in modules of two or three chapters as the feedback from the Pilot Edition were assimilated and used in the rewriting process. As that rewriting took place, I witnessed first-hand the value of the feedback that our Jeffco team and the other pilot teachers submitted the previous year.

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A LOOK BACK (from page 5)

SIGNIFICANCE OF THE FEEDBACK PROCESS

Prior to the development of PSSC *Physics*, and later IPS, the piloting process and the use of feedback from teachers were unheard of. Authors wrote books and book companies published them. And often the consumer wondered why many of the experiments, if there were any, didn't seem to produce the expected results.

Even after the initial NSF funding came to an end and after IPS became commercially published—first by Prentice-Hall and more recently (since 1992) by Science Curriculum Inc.—we have piloted the new sections and experiments in every new edition. The process has been a part of every edition of IPS since the beginning!

The advent of NSF-funded projects such as IPS brought with them the major innovation of testing instructional materials before their final commercial publication. A number of new projects in biology, chemistry, earth science, and elementary science soon followed PSSC using a similar process for writing, piloting, and field testing. The quality of these funded instructional materials was significantly increased by two factors: (1) the writers were teams of highly qualified academicians working with experienced classroom teachers, and (2) the material was extensively piloted and field tested. A careful examination of these materials today compared to others publications reveals a marked contrast in the format, learning expectations of students, and the general quality of the materials.

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- **developing collaborative and analytic skills;**
- **scaffolding science reading skills with Comprehension Guide Questions (CGQs).**

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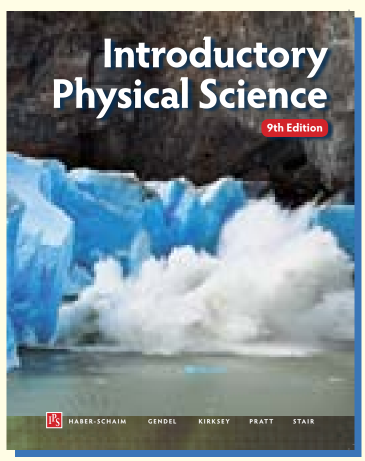
or visit sci-ips.com/links.htm



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For information about our physical science workshops at Colorado School of Mines, scan this code or visit sci-ips.com/e_workshops.htm

WHY AND HOW (from page 4)

THE FIRST REVISION: THE PRELIMINARY EDITION

It is interesting to compare the first three chapters of the Pilot and Preliminary editions. (My copies of the later chapters of the Pilot Edition disappeared over the years.) The message was clear: Cut the number of topics and give students the time they need to develop skills and understanding.

Here are two examples. First, we thought that junior-high students had a clear idea of volume. Therefore, in the Pilot Edition we dismissed the idea that volume can serve as suitable measure for the quantity of matter by making two brief statements. The volume of a sample of liquid increases when the liquid is heated, but the amount of matter has not increased. On the other hand, when the tire of a bicycle is pumped up, the quantity of air in the tire increases while the volume stays practically the same. The feedback proved otherwise. Many students thought that only objects of regular shape have a volume, which is given by a simple formula. They had no idea that a formula was only a shortcut for counting units of volume.

As a result of this feedback, the Preliminary Edition added three sections devoted to volume. The first section discussed the concept and ways of measurement. The second section was an experiment: the measurement of volume by displacement of water. Only in the third section did we address the shortcoming of volume as a measure for the quantity of matter. With some further improvements, these sections appear in the Ninth Edition as Sections 1.2, 1.4, and 1.5.

The second example has to do with the experiments providing the motivation for the Law of Conservation of Mass. In the Pilot Edition, a single reading section on the Equal-Arm Balance was followed by two experiments: The Mass of Ice and Water and The Mass of Copper and Sulfur. With these three sections, students were expected to master the use of the balance to produce reliable results leading to the idea of the conservation of mass. It did not work. The class results were far from convincing because the students lacked the basic skill of using the balance.

To remedy this shortcoming in the Preliminary Edition, a reading section on mass was added, followed by two experiments devoted entirely to practicing the use of the balance and examining its precision. Only then did the students examine the change of mass in five different reactions: the two that were in the Pilot Edition and three more: The Mass of Dissolved Salt, The Mass of Mixed Solutions (a great experiment, which we reluctantly eliminated later because it required a solution of lead nitrate.), and The Mass of a Gas.

One of the original aims of the chapter on mass was to show the wide range of masses in nature and how to measure such masses. This material was deleted in favor of concentrating on the measurement of mass in the range used in the course. All in all, about half the material in the first three chapters of the Pilot Edition was moved to the "Circular File," i.e. the trashcan.

The field testing of the Preliminary Edition showed that the drastic changes accomplished their goal: IPS students gained a deep understanding of the law of conservation of mass and laws of nature in general. They developed lab skills that served them well in later science courses.

Beyond contributing to further improvements in the students' textbook, the comprehensive field-testing of the Preliminary Edition made essential contributions to the Teacher's Guide and Resource Book. A unique insight into this phase of the field-testing is provided by the accompanying article by Harold Pratt.

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To register, print and complete this registration form.
Mail it with your deposit check to the address given at the bottom of the second page of the form.

Registration for the Science Curriculum Inc.

*Introductory Physical Science (*IPS*) National Workshops*

Colorado School of Mines

July, 2015

Course selection - please check the appropriate workshop(s):

___ ***IPS* Part 1 – Properties of Matter July 12–17, 2015**
___ ***IPS* Part 2 – Atoms and Molecules July 19–24, 2015**
___ ***IPS* Part 3 – Energy and Forces July 19–24, 2015**

Tuition cost: The tuition cost is $380 for each one-week workshop.

For maximum benefit, it is <u>highly</u> recommended that the* IPS Part 1 *workshop be taken <u>prior to</u> the* Part 2 *and/or* Part 3 *workshop.

NOTE: Since* IPS Parts 2 *and* 3 *meet concurrently, it is not possible to enroll in both.

NAME ____

GENDER *(for lodging purposes only - please circle one)* M F E-MAIL ____________________________

HOME ADDRESS ____

HOME PHONE ___________________________

SCHOOL NAME ______________________________ PHONE __________________________

SCHOOL ADDRESS ____

SCHOOL DISTRICT NAME ____

In what area of science teaching do you teach the most classes? (please check one)

Physical Science ____ General Science ____ Earth Science ____ Other (please specify) ______________

What was your major in college? ____________________ Graduate concentration, if any ______________________

Have you attended a previous *IPS* or *Force, Motion, & Energy* (*FM&E*) workshop or summer program? Yes No

Have you previously taught *IPS* or *FM&E*? Yes No

If yes, which program and for how many years? ______________ At what grade level(s)? ____________

Credit: Credit is awarded by Colorado School of Mines as graduate-level semester hours in continuing education. Each one-week workshop can be taken for 2 semester hours credit.

I do ___ do not ___ plan to take the workshop for credit.

NOTE: The tuition amount is the same with or without credit, and all registrants are expected to complete and submit all assignments.

LODGING AND MEALS *(Please complete this section even if you will not be staying on campus.)*

Lodging preference: ***(All accommodations are single bedroom in 2-4 bedroom suites.)****

___ I will be staying off-campus and will not need on-campus accommodations.

___ One week: $258.00 (6 nights: check-in Sunday; check out Saturday)

___ Two weeks: $559.00 (13 nights-includes weekend between workshops: check-in Sunday; check out Saturday)

Meals:* ***(It is recommended that participants have lunch together to facilitate the informal exchange of ideas.)***
Commuters – please complete the lunch line even if arranging for your own lunch.

Breakfast (Monday-Friday)	____One week ($43)	____Two weeks ($86)	____ I will arrange for my own breakfas
Lunch (Monday-Friday)	____One week ($53)	____ Two weeks ($106)	____ I will arrange for my own lunch.**
Dinner (Monday-**Thursday**)	____One week ($48)	____ Two weeks ($96)	____ I will arrange for my own dinner.

* The prices quoted for lodging and meals include 7.5% tax.

** Please be aware that workshop participants who bring their own lunch are not admitted to the dining hall.

PARKING (Prices are set by Colorado School of Mines at $4 per day.)

Like many universities, Colorado School of Mines now charges for parking anywhere on campus, including streets. Wheth you will be commuting or staying on campus, if you bring a vehicle with you, you will need a parking permit. Please sel one of the following:

___ I will not have a vehicle on campus and will not need a parking permit.

___ I'll be commuting or staying on campus and will need a parking permit for one Monday–Friday workshop.

___ I'll be commuting and will need a parking permit for two Monday–Friday workshops.

___ I will be staying on campus for two weeks. I need a parking permit for two weeks, including the intervening wee end.

DEPOSIT AND FINAL PAYMENT

A non-refundable deposit of $100 (payable to Science Curriculum Inc.) must accompany this application.

Please mail both to:

Coordinator of School Services
Science Curriculum Inc.
13701 W. Jewell Ave., Suite 204
Lakewood, CO 80228

A confirmation of your registration and deposit will be sent to you, along with an invoice for the remaining balance.

Due to planning and commitment deadlines at Colorado School of Mines, *all outstanding balances will be due and must be paid in full* ***by May 25, 2015.***

Signature ____ **Date** ____________________

If you have any questions, please contact us at 303-988-5041 (toll-free 888-501-0957) or email workshops@sci-ips.com .