NEWSLETTER

ONTARIO ASSOCIATION OF PHYSICS TEACHERS
(an affiliate of the American Association of Physics Teachers)
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From the President

by David Marshall
Trent University, Peterborough

Your OAPT membership allows you to provide the executive with valuable input. Any suggestions, questions on current OAPT practices, constructive criticism, etc., are always welcome. As we all tell our students: "If you have a thought, odds are a couple of others have the same thought and everyone will benefit from hearing it."

There is also another avenue for supplying input to the OAPT and that is to take a position on the executive. Geographical separation is not a factor when communication is largely done via phone, fax and mail. The time commitment is not a great one. No one has extra time they need to fill up, but setting aside a few hours a month is a worthy sacrifice if you are serious about sharing physics education ideas.

You can also do a presentation (short or long) at the annual conference, you can write to Paul at the newsletter or submit articles on demonstrations to Ernie at the Demonstration Corner. We want to hear from you. As you may have heard me say during the OAPT Conference at Trent University: "This is your association, help us give you what you want."

I look forward to seeing you all in Ottawa next June.

WHY WAIT UNTIL IT'S TOO LATE?

The date on your address label is the expiry date for your membership. You may use the coupon below (or a facsimile) to renew it, or to indicate a change of address (or both) by checking the appropriate box. And, hey, what the heck, why not renew it for two (or more!) years; it will save you the hassle of renewing over and over again.

Membership Application
Renewal ☐ Change of Address ☐

Name ______________________

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$8.00 / year x ____ years = $ _______, payable to the OAPT
Send to: Ernie McFarland, Department of Physics, University of Guelph, Guelph, Ontario N1G 2W1

EDITORIAL:
You Are What You Teach
Like Teacher, like Student, like Teacher...

I had the pleasure of attending a talk given by Lillian McDermott at the University of Western Ontario's faculty of education at which she posed the following problem: given several circuits with identical batteries and bulbs (see figure 1), rank the relative brightness of the bulbs. She has used this question in a study of the understanding of physics concepts.[1]

Originally, McDermott asked for the question to be placed on a university physics test, but the professors teaching the course felt it was too simple. After giving the test to over 500 people (including physics professors) only 15% answered correctly (try it yourself; the answer's at the end of the editorial[2]).

Many people try to apply Ohm's Law to the problem, but the formulaic solution is complex, and is usually completed incorrectly. One typical error gives the brightness of bulb B as brighter than bulb C, indicating that the person believes current is used up; another common belief is that the battery always produced the same current.

McDermott then described how you might use batteries and bulbs to model the concepts necessary to understand the question , and, after spending only a few minutes on it asked some of the non-physicists in the room to rank the brightness of another

(see EDITORIAL, p. 3)

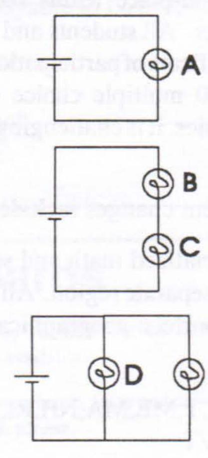

Figure 1

OAPT Technology Conference

Make Plans for the **1994 OAPT Conference.**

This year's conference will be held at Carleton University in Ottawa, Thursday, June 23 to Saturday, June 25.

The tentative schedule of events will be as follows.

Thursday and Friday evening: Workshops on electronics in your physics class, fractals in the classroom, and using telecommunications.

Friday day: Tours are being planned of the Bell Northern Integrated Circuit Fabrication Lab, and the National Research Council Acoustical Engineering lab, Wind Tunnel, and Biophysical Engineering Lab.

Saturday day: Contributed papers.

AAPT News

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PHYSICS BOWL

The 1994 AAPT/Metrologic PHYSICS BOWL Contest will be held Thursday, April 21. Entry forms will appear in winter editions of *The Physics Teacher and The Announcer* or can be obtained by writing PHYSICS BOWL, AAPT, P.O. Box 989, College Park, MD 20741-0989. Entry forms must be received at the national office by March 21, 1994. First and second year physics students compete in separate divisions. A school's score in a division is the sum of the four highest student scores. The thirty first place schools receive a laser donated by Metrologic. First and second-place teams receive PHYSICS BOWL T-shirts. All students and teachers who enter receive a certificate of participation. The contest exam consists of 40 multiple choice questions from all areas of physics. It is challenging, with an average score about 50.

Recent changes include:

Specialized math and science high schools compete in a separate region. All other schools compete in one of fourteen geographical regions. The regions are:

02	CT,ME,MA,NH,RI, VT	10	MN,ND,SD,WI
		11	AR,LA,MS,TN
03	NY, Maritime Prov., ONT, QUE	12	CO,KS,M0,NE,OK, WY
04	NJ, PA	13	AZ,NM,TX,UT
05	DE,DC,MD,NC,VA	14	CA,HI,NV,Am Samoa, Guam
06	AL,FL,GA,SC,PR,VI		
07	KY,OH,WV	15	AK,ID,MT,OR,WA, AB,BC, MAN, SAS
08	IN,MI		
09	IL,IA	20	Math & Science Sch.

First and second year physics students compete in Divisions I and II, respectively, without regard to AP status.

You may request a list of the top scoring schools and/or students in your region. This could be used to award section prizes or certificates. Last year the South Dakota Section, in conjunction with the South Dakota Academy of Science, used the results of PHYSICS BOWL for a regional physics contest. This year the Southern California Section plans to use PHYSICS BOWL results to award scholarships to top scoring students. Or, present the physics teacher of your top scoring team with a certificate at your section meeting.

I would be happy to discuss using PHYSICS BOWL results for a local contest.

1994 AAPT INTRODUCTORY PHYSICS EXAM

The 1994 Introductory Physics Exam will be available this spring. Ads will appear in The *Physics Teacher and The Announcer* or write 1994 Introductory Physics Exam, AAPT, P.O. Box 989, College Park, MD 20741-0989. The Introductory Physics Examination is designed to be a test of basic physics concepts. It consists of seven sections:

Mechanics	24 multiple choice questions	25 minutes
Waves, Optics, Sound	16 multiple choice questions	20 minutes
Heat and Kinetic Theory	8 multiple choice questions	10 minutes
Electricity and Magnetism	20 multiple choice questions	25 minutes
Modern Physics	12 multiple choice questions	15 minutes
Mechanics	Do 2 of the 3 problems	25 minutes
Electricity and Magnetism	Do 2 of the 3 problems	25 minutes

A teacher may use all or some of the sections. Recent changes include:

- ☐ Easier and more conceptual than previous editions,
- ☐ Physics formulas are provided on a separate sheet for use with the exam.
- ☐ In addition to the five multiple choice sections, there are two new free-response sections (Mechanics and Electricity & Magnetism). Scoring standards will be provided for these problems,

If you have questions, please contact me by mail, phone, FAX, or email. The Examinations Editorial Board meets at the winter and summer national meetings, see the Announcer for the time and place. These meetings are open to all and I strongly encourage anyone who is interested to attend.

...EDITORIAL (from page 1)

circuit (see figure 2)[3]. She suggested that this type of modeling/reasoning should precede a study of Ohm's Law, and stressed that teaching these concepts was not something to be completed in a day

McDermott stated that a facility in solving standard quantitative problems does not mean that the student has an understanding of physics concepts. According to McDermott how we teach does not match how students learn.

Does this mean we need to produce a new elementary/high school physics curriculum and arm the new physics teachers with it? The problem with most of these existing programs is that they are either not developed with the teacher's background in mind (elementary school) or are incongruent with the average student's ability. This leads to a disillusionment and degeneration in the adoption of the new curriculum.

McDermott believes that it is the university physics department that determines how we teach, not the faculty of education. Those students who eventually become teachers find it difficult to teach differently from how they learned. For the most part this style of science learning has been through fast paced top-down lectures which stress theory and formalism instead of scientific reasoning. Curriculum development has, therefore, been based on the curriculum author's present understanding of the subject matter, and their perception of the student (which is based on personal recollection). This leads to an emphasis on the physicist, not the student. The student ends up seeing the physicist as a collection of facts and formulas, and fails to recognize the critical role of reasoning in physics.

This brings us back to the original problem: how do you introduce curriculum change that is useful and long-lasting? McDermott believes that university departments should be more responsible for helping teachers gain knowledge on how to teach the material that they do, through practical in-service for teachers and by changing the methods of undergraduate education. With this in mind, the University of Washington physics department, where McDermott teaches, offers an education option to students in their graduate programs.

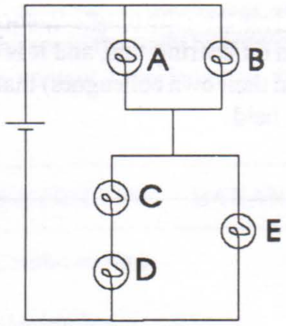
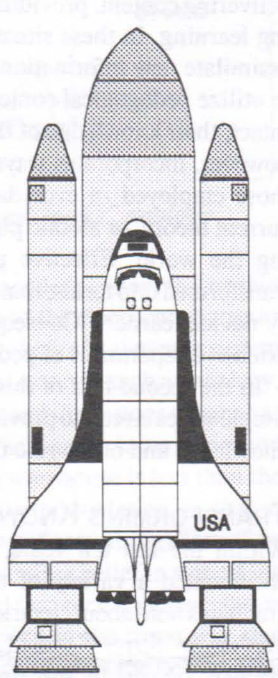


Figure 2

There is a lot of inertia to overcome before any changes of this magnitude would be possible, but I think that, as individual teachers, it is always a good idea to have a critical look at our own courses and to consider what exactly our students are taking away with them when the year is over—a life-long understanding of the physics of nature, or a head full of equations that evaporate as soon as the final exam is written.

Notes:

1. McDermott, Lillian C. and Shaffer, Peter S. (1992). *Reasearch as a Guide for Curriculum Development.* American Journal of Physics, 60(11), 994-1013.
2. E=D=A>B=C
3. E>A=B>C=D



Building a Professional Memory: Articulating Knowledge About Teaching Physics

by Art Geddis
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In many ways teaching is a profession without a memory. Unlike professions such as architecture and engineering, there are few detailed records of what teachers do and how they do it. Architects leave behind drawings, specifications, models, contracts, and the buildings themselves. Such artifacts provide a record of the problems that were faced, the solutions tried, and the product produced. Teachers, however, leave few records of their struggles with this year's destreamed nine, or last year's Applied Physics, and the records that are left do little to capture the complexity of their pedagogy.

An integral part of the education of doctors, lawyers, and business students, is the study of "cases" that record the history of their profession. Presently there is no comparable body of literature to which beginning and practising teachers can turn to discover the wisdom of their predecessors. Interestingly, there is a substantial literature devoted to demonstrations and experiments. Irwin Talesnick's Idea Bank, Tik Liem's Invitations to Science Inquiry, and Ernie McFarland's Demonstration Corner are just a few that come immediately to mind. This literature, however, focuses primarily on the presentation of phenomena and captures only a portion of the complex pedagogy involved in classroom teaching.

A useful focus for articulating more of the complexities of subject matter pedagogy is provided by Lee Shulman's view that effective teachers **transform** knowledge of subject matter into forms accessible to their students. The ability to perform such transformations is based on knowledge particular to subject matter teachers; Shulman (1987) calls this knowledge **pedagogical content knowledge.** Pedagogical content knowledge is an amalgam of subject matter and pedagogical knowledge. It arises from deliberation about how to teach particular content to particular students in particular contexts, and consists (among other things) of: **misconceptions** students typically bring to instruction, alternative **ways of representing** subject matter, and effective **teaching strategies** for changing misconceptions. To a significant degree, it is the acquisition of the relevant pedagogical content knowledge that distinguishes effective physics teachers from fresh physics graduates.

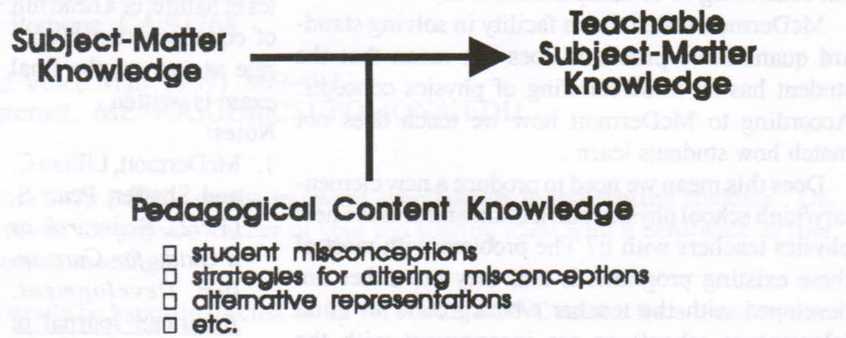

Figure 1. Transforming Subject Matter Knowledge

When learning primarily involves acquiring information, instruction can proceed in a **transmission mode**. This typically involves motivating students, delivering content, providing opportunities for students to practice, and evaluating learning. In these situations, students employ familiar ways of thinking to assimilate new information presented by the teacher. Teachers have little need to utilize pedagogical content knowledge because they can **transmit**, relatively intact, their knowledge of the subject matter to their students. Much of physics, however, incorporates ways of thinking that are fundamentally different from those employed in everyday life. Learning Newtonian mechanics, electrical current theory, or atomic physics involves mastering new ways of conceptualizing the world. Effective physics teaching demands that subject matter be transformed into forms, that while still valid physics, can be learned meaningfully by novice learners. Consequently, physics teachers find themselves in need of extensive repertoires of pedagogical content knowledge.

In the second half of this article I will use the flow of electrical current in a simple series circuit to provide an example of the need to transform subject matter knowledge and of the role that teachers' pedagogical content knowledge plays.

Transforming Knowledge: Electrical Current Flow

Within the last ten years, researchers (e.g., Osborne & Tasker 1985) have documented a variety of misconceptions that even some university physics graduates hold about electrical current flow. One common misconceptions is that the "return current" must be less than the outgoing current. Beginning physics teachers are usually surprised on hearing this, and it is only after questioning a variety of school students (and their own colleagues) that they are convinced that this misconception is widely held.

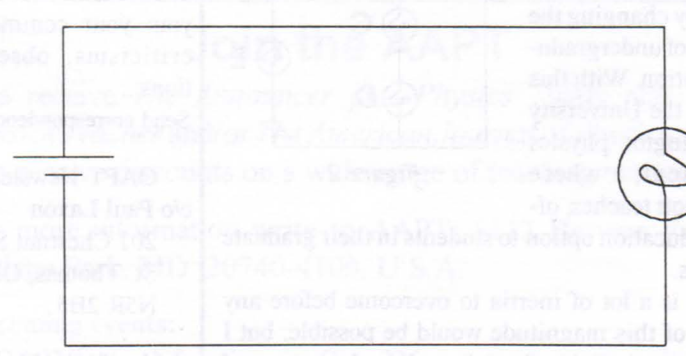

Figure 2. A Simple Series Circuit

Knowledge of this misconception is important pedagogical content knowledge, but in itself it is not enough to enable teachers to transform their subject matter knowledge about electrical current into forms that are meaningfully understandable by novice physics students.

Generally, widely held misconceptions about scientific knowledge are not simply naive mistakes, but conceptions held for good reason in that they serve everyday situations quite adequately. It is quite evident to any novice student that the bulb in figure 2 is giving off light. Consequently it is not unreasonable to think that something is being "used up" (transformed) in the bulb. (This is an especially reasonable position for the student who is aware of the Law of Conservation of Energy.) Why then should the student believe that the "rate of flow of electricity" is the same returning as going out? Here the root of the problem can be seen to lie in the everyday use of the term "electricity" to refer to both electrical **charge** and electrical **energy**. While the return rate of flow of electrical energy is indeed less, the return rate of flow of electrical charge is the same. Electrical energy is being "used up" in the bulb but electrical charge is not!

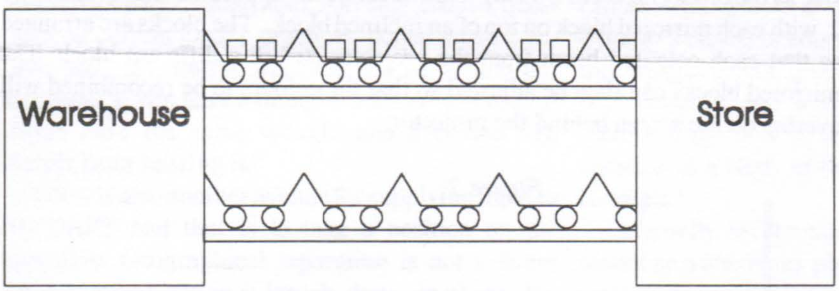

Figure 3. The "banana cartons on the conveyor trucks" analogy

One way for teachers to transform their scientific knowledge about the current around a series circuit is by devising a representation of the electrical charge as a "carrier" of electrical energy--perhaps by using an analogy of a conveyor system moving cartons of bananas from a warehouse to a retail store. In such an analogy, the conveyor trucks correspond to the electrical charge and the cartons of bananas to electrical energy, so that while the rate of flow of trucks is the same all around the circuit the rate of flow of cartons returning to the warehouse is less than the rate of flow going out. The advantage of such a representation is that it incorporates students' knowledge that the return flow (of something) "must" be less. Consequently it does not strain credulity by demanding belief in something that appears to be patently wrong. It might be objected that such a representation is "incorrect"--i.e., that electrical energy is not carried in the same way that bananas are. While in one sense this may be correct, it ignores the pedagogical imperative to transform content knowledge to make it accessible to novice students.

	ELECTRICITY	BANANA CARTON ANALOGY
CURRENT	coulombs/second	trucks/second
VOLTAGE	joules/coulomb	cartons/truck
POWER	joules/second	cartons/second
P=VxI	J/s=J/C x C/s	cartons/s=cartons/truck x trucks/s

Table 1. A banana carton analogy for electrical current

I do not want to claim that these ideas incorporate the "best" way of teaching electrical current flow, but they do provide a basis for transforming subject matter for learners. Certainly teachers who are aware of a **misconception**, cognizant of the **origin** of the misconception, and are in possession of one or more **representations** that deal with the misconception, have the pedagogical content knowledge to engage the problem of knowledge transformation in instruction. Seldom, however, is this sort of knowledge shared in any systematic manner with colleagues. If each generation of teachers is to be spared having to discover the relevant pedagogical content knowledge on their own, it is important that we begin the task of recording what present teachers know about teaching their subject matter.

References

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Tasker, R. and Osborne, R. (1985). Science teaching and science learning. In R. Osborne and P. Freyberg (Eds.), Learning in science: The implications of children's science (pp. 15-27). Auckland, New Zealand: Heineman.

Art Geddis spent 22 years as a secondary science teacher before moving to the Faculty of Education at the University of Western Ontario in 1989. At Althouse he teaches physics and chemistry methods courses to pre-service students, curriculum and science education courses to graduate students, and also conducts research into various aspects of learning about teaching.

THE DEMONSTRATION CORNER

COLOUR MIXING THE ECONOMICAL WAY

by

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I am sure that, in the schools of Ontario, the range of equipment presently in place to demonstrate colour mixing varies all the way from ray boxes with colour filters to expensive projectors specifically designed for that topic. Many of these may be effective but frequently one finds that the resulting colour is not exactly what theory predicts. For example, a blue light, a green light, and a red light projected onto the same area of a white screen may produce a "yellow" white or a "greyish" white. The demonstration described below gives excellent results and, in keeping with current budget constraints, is very economical. To carry it out, proceed as follows.

First cut two squares of cardboard from a box (such as a discarded cereal box or shoe box) that are the same size as a 35 mm slide. Now use a paper punch to punch 3 holes in these squares as shown in Fig. 1. (The holes should coincide when the squares are placed back to back.) Now cut a narrow strip from a red filter gel, a green filter gel, and a blue filter gel. These gels should be sandwiched between the pieces of cardboard so that the blue filter gel is in the middle and the green and red are on opposite sides.

This slide, when inserted into a 35 mm projector, will produce the three beams of light that are required, namely, red, blue and green.

To enable colour mixing to occur, these beams must be recombined. Have the carpentry shop in your school create three wooden blocks with top surfaces that are inclined slightly to the horizontal. An additional set of three blocks is required measuring roughly 5 cm x 5 cm x 5 cm. Onto each of this second set of blocks glue a plane mirror that is about the same size as the block (i.e. 5 cm x 5 cm). Now arrange the apparatus as shown in Fig. 2, with each mirrored block on top of an inclined block. The blocks are arranged so that each coloured beam from the projector strikes a different block. The mirrored blocks can then be adjusted so that the colours to be recombined will overlap on the screen behind the projector.

Figure 1

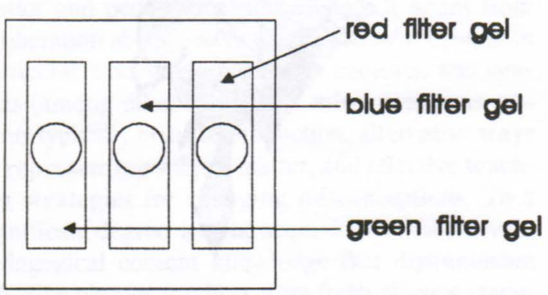
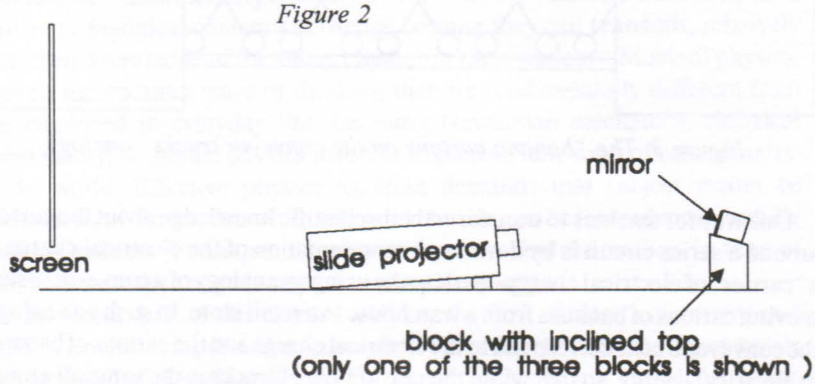


Figure 2



The demonstration works very well. I want to give credit for it to Lorraine Maynard who presented it at the winter meeting in Orlando, Florida, in January of 1992. Lorraine explained that the white resulting from the recombination of the three primary colours is very white because the three colours being recombined all come from the same source and therefore have the correct relative intensity. In many demonstrations where different light sources are used for the three primary colours, the intensity of the sources is not the same, and so the recombined colours do not always live up to expectations.

A second critical factor is to have good quality filter gels in the first place. A good source for these is theatrical supply companies. You may wish to check with your theatre arts teacher. I found an outlet about 2 km away from my school and I am sure that such filters are available in most large towns and small cities. When I tracked down the source, I made an additional discovery. For each of the many filters available, a transmission graph is available. This graph shows percent transmission as a function of wavelength in nanometres. This is a great combination of physics and art, the potential of which I have not yet fully exploited with my classes.

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Submissions describing demonstrations will be gladly received by the column editor.