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THE SCIENCE EDUCATION REVIEW

Ideas for enhancing primary and high school science education

Did you Know?

In 350 BC, people believed that our intelligence was held in the heart, not the brain. In other ancient times, people believed that you could learn what another person knew by eating that person's brain. For this reason, warriors sometimes ate the brains of enemies they had defeated.

Science Story

The stories in this regular section of *SER* may be used to enrich lessons and make them more interesting.

Flatus: Beware!

Flatus is the gas generated in, or expelled from, the digestive tract, especially the stomach and intestines. More than 99% of human flatus comprises nitrogen, oxygen, hydrogen (hydrogen-consuming bacteria in the digestive tract may consume some of this to produce methane and other gases), carbon dioxide, and methane.

During World War II, US fighter pilots flew at increasing altitudes. The associated reduction in the (external) atmospheric pressure allowed the digestive gases trapped in their intestines to expand (Boyle's law), causing very painful cramps. Foods known for their ability to produce flatus--dried beans and peas, vegetables of the cabbage family, carbonated drinks, and beer--were therefore removed from pilots' menus.

Methane is a combustible gas (e.g., a good fuel for Bunsen burners), although it is produced by only about one-third of people in the Western world. In the early days of the space race, there was concern that the methane emitted by astronauts, if accidentally ignited, could cause an explosion within the spacecraft. No such incidents have occurred to date. However, exploding flatus has caused the accidental death of at least one surgical patient. An electrode touched to the patient's colon ignited the hydrogen and methane it contained, also causing the surgeon to be blown back to the wall of the room.

In Their own Words: What Girls say About Their Science Education Experiences

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Abstract

The purpose of this phenomenological study was to identify and describe the essential components of the current science education experience as constructed by female high school physics and advanced chemistry students. The participants identified five major factors as salient components of the science education experience: (a) mathematics, (b) interest in science, (c) previous experiences, (d) instructional strategies, and (e) the teacher. Unfortunately, participants recalled very few school-related elementary experiences. As a result, out-of-school experiences emerged as crucial to interest development. Further, students related teacher attributes closely to course attributes. In addition, instructional strategy preference varied widely. Mathematics (i.e., the quantitative nature of science) was described as a key factor in the determination of future science participation. Apparently, in high school, as the quantitative nature of science emerges, students must adjust their personal perceptions of science. This adjustment may determine the likelihood, and type, of future science participation.

To read the full text of this article (16 pages), please **click here**.

Demonstration

While the activities in this section of *SER* have been designated demonstrations, some might easily be structured as hands-on student learning experiences. Although some sample lesson sequences may be included, the notes provided both here and in the following *Student Experiments* section are meant to act primarily as stimuli for classroom activities and to provide teachers with background information, so please modify any sample pedagogy as you see fit.

Balloon in the Flask

Needed. Flask, water, tripod stand, Bunsen burner or lamp, tongs, and balloon.

Pre-lesson preparation. Add a little water to the flask, place the flask on the stand, and heat it until plenty of steam is coming from the opening. Remove the flask from the stand and rest it on the bench. Stretch the opening of a balloon over the opening of the flash, and allow the apparatus to cool. As it cools, the balloon will first move inside the flask, and then inflate there. The balloon will remain inflated for more than a day, so the apparatus may be prepared well ahead of class, and even used for multiple classes.

Invitation. Have the flask, containing the inflated balloon, on display when students arrive. Tell them that their task is to work out how the balloon inflated inside the flask.

Exploration. Invite students to ask yes/no questions only, helping them to restructure their questions in this form, and providing hints, where necessary. Then, ask students to hypothesize about how the balloon came to be inflated inside (i.e., to propose a possible procedure, and explain the science principles involved).

Concept introduction. Perform the demonstration for the class. As the water inside the flask is heated, some forms steam. There is not enough room for both the original air and the steam inside the flask, so some air is forced to leave the flask. With the balloon then on the flask and the apparatus cooling, steam condenses back to liquid water on the bottom of the flask. This leaves less air particles inside the flask than were there initially, and fewer particles in the same space means less pressure. The greater (atmospheric) pressure outside the balloon therefore pushes the balloon inside the flask, causing it to inflate inwards.

Since air pushes, but not pulls, on things, address any student misconceptions about the balloon being "sucked" inside. As we say, there is no such word as *suck* in science.

This can also be an excellent first-day-of-school activity. It will engage students, motivate them towards learning science, and allow the teacher to get a "feel" for the science backgrounds of students in the class.

Student Experiment

Reminder: Appropriate risk assessment, supervision, and guidance are necessary.

The Dissolving Money

Needed. Paper money notes (bills) made using water-soluble paper, beaker, water, and stirring rod. There are various sources for the paper money. Mole Dollar bills may be purchased from Flinn Scientific (2004). They are printed on Dissolvo (Dissolvo, 2004), a water soluble, non-toxic, biodegradable, and recyclable paper composed of 20% wood pulp and 80% carboxylmethyl cellulose (a semisythetic, water-soluble polymer). Alternatively, blank sheets and rolls of Dissolvo can be purchased from Flinn Scientific, *Gilbreth* (n.d.), or some magic shops, and a money note may be designed and photocopied onto the paper.

Invitation. Tell the class that attending science classes can certainly pay, and hand each student, or each group of students, a paper note. Following their expressions of doubt, suspicion, amazement, or whatever, invite them to describe the note (e.g., colour, texture, smell). Then ask them to place the note in water, stir, and observe. The note dissolves. Easy come, easy go!

Exploration. Invite students to ask questions about the paper, and about what they have observed--questions that might be subsequently investigated. For example: "Would the temperature of the water affect the rate at which it dissolves?" From what is the paper made?" How well does the paper dissolve in different liquids, such as methylated spirits (mainly ethanol) or a detergent?"

Have students design experiments, or other research procedures, to answer their questions (a homework possibility). Group students according to the question they are asking, have them refine their design, and provide any materials required for inquiry in a subsequent lesson. Note that some questions require library, rather than hands-on, investigation.

Concept introduction. Summarise the class findings. Ask students to research present-day uses for Dissolvo.

Concept application. Invite students to devise new uses for Dissolvo (e.g., as the paper used for ticker parades, to save on clean-up costs).

References

Dissolvo. (2004). *Dissolvo*. Retrieved November 15, 2004, from http://www.dissolvo.com .
Flinn Scientific. (2004). *Flinn Scientific*. Retrieved November 15, 2004, from http://www.flinnsci.com .
Gilbreth. (n.d.). Retrieved November 15, 2004, from http://www.gilbrethusa.com .

Adapted from: Shubin, J. (2004). It pays to go to school. *Science Scope*, *28*(1), 57.

Critical Incident

An Invitation

Readers are invited to send, to the Editor at editor@ScienceEducationReview.com , a summary of a critical incident in which you have been involved. A critical incident is an event or situation that marks a significant turning point or change for a teacher. The majority of critical incidents are not dramatic or obvious, but are rendered critical through the analysis of the teacher (see Volume 3, p. 13 for further detail). You might describe the educational context and the incident (please use pseudonyms), analyse the incident (e.g., provide reasons to explain your observations), and reflect on the impact the incident made on your views about the learning and teaching process. Upon request, authors may remain anonymous.

We have undoubtedly all done things about which we were very pleased, and perhaps done other things about which we did not feel so pleased, and we all need to remain reflexive of our practice. While teachers will view an incident through the lenses of their own professional experiences, and may therefore explain it differently, this does not detract from the potential benefits to be gained from our willingness to share our experiences and thus better inform the practice of other teachers.

When Teachers Give up on Students

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“Peter? Oh him, I just ignore him now. He’s a waste of space, so I just let him do his own thing these days. As long as he doesn’t stop me teaching the others in the class, I just leave him alone”.

It was my first day at the school. Being a student teacher, I was nervous, but excited all the same. I could not wait to get in the classroom. Before I was to be allowed the privilege of teaching my own class of students, I was set to observe more experienced teachers, at least for a couple of days. I was looking forward to learning some “tricks of the trade,” and also to obtaining a better idea on some of the students at the school. The responsibility of teaching science to a large class of middle year students seemed a bit overwhelming, so having the chance to watch others in action seemed like a great idea to me.

The class I had just observed was 9C General Science, and the teacher I was speaking with had just finished teaching a lesson on how to balance chemical equations. With Period 2 on Tuesday over, she seemed a little relieved and was looking forward to a good strong coffee. As we wandered back to the school's staff room, I was interrogated about "why on Earth" I was considering that I might also want to be a teacher. I realised straight away that she personally had little interest in teaching--to her it was just a job to be done with the minimal effort.

Prior to the lesson, I had been told of the class's reputation, and was interested to see how the teacher handled them. During the lesson, I noticed that she had totally ignored one male student, and vice versa. I asked her about him, and why he appeared to be doing no work during the lesson. At first, she brushed the question off as if everything was normal with the situation. Eventually, I got the response: "Peter? Oh him, I just ignore him now. He's a waste of space, so I just let him do his own thing these days. As long as he doesn't stop me teaching the others in the class, I just leave him alone". She freely admitted that she had given up on him. Her strategy was simply that Peter understood, if he did not annoy her, she would not annoy him.

I felt sure that there must be more to it than simply the student being disruptive. I wondered why he had obviously been difficult to deal with in past lessons. What was the real problem? Were there learning problems of some kind here, or were the topics uninteresting? Was Peter's home situation causing problems for him, or were there hidden problems such as vision impairment or deafness? His teacher had no answers for me.

Next lesson, I deliberately sat as close to Peter as possible without being obvious. I was interested to see what he did all lesson, and to have a chat with him if I could so that I could learn more about why he did not appear to want to be involved in the normal class activities. The rest of the class was going on with the planned worksheet activity, yet Peter was doing his own thing and hadn't even bothered to pick up one of the sheets as they were handed around the room. His science teacher continued to treat him as if he was not there.

With most of the other students busy on the set task, and my curiosity aroused, I decided to have a quick word with him. He was eager to talk, and so we quietly talked about anything that seemed distant to Year 9 Science. I felt bad that I was seemingly at odds with the existing teacher's philosophy on leaving him alone, but I couldn't resist. Eventually, I asked him what he thought about Science and the topic they were discussing at present. Typically, his first response was "boring." I pulled a worksheet across so it lay between us. After asking him some simple questions, I found that he actually understood the basic concepts quite well. There was a problem there somewhere, but I still couldn't quite work it out.

My offer of working through the sheet with him grew a series of grunts, but surprisingly he actually seemed interested, in a non-committing manner. I don't think he could quite believe that someone was actually willing to take an interest in him beyond simply telling him off. He was obviously stuck in a cycle of failure, meaning that others expected little of him and thus he expected little of himself.

We started through the equations, with Peter doing about 5% of the work and I the rest. Gradually, he was gaining confidence and the balance of work was changing. It took a long time for me to realize, but I had discovered that it was not the science that was confusing but the mathematics that were involved. Peter could hardly do basic maths problems on paper, let alone in his head like the rest of the class. It was obvious that it was something that he did not like others to see him struggling with. He was using disruptive behaviour to hide his difficulties with doing any form of maths. But with a lot of patience, and no acts of surprise on my behalf (e.g., when he couldn't do simple additions or multiplications), he was slowly working his way through the chemistry equation sheet. As he went along, his confidence appeared to be growing.

Finally, the lunchtime bell went and he still had one question to go. Instead of running out the door and trying to disappear first as he had the last lesson, he actually stayed where he was and kept going. Two minutes later and it was all over. He signed his name on the top and handed it in to the startled teacher. He was just heading out the door when he turned around towards me and said "thanks." His teacher just looked at me in shock, as if: "Wow, you somehow managed to get through to him."

Even though I knew it was probably not a life-changing incident for Peter, for me, I felt like I had made a small difference. Perhaps this was the start for Peter, a chance to be a part of the class again and for him to try to start learning again. I resolved to never again give up on a student. Making a difference was what first got me interested in teaching, and it is something that I will endeavour to remind myself of constantly. Obviously, students like Peter are going to require a huge amount of commitment from both teachers and schools.

One question that intrigued me at the time was why Peter's science teacher never made the connection to one of the main reasons as to why he was misbehaving in her class. Was it perhaps the large number of students in the class? A lack of time? Or, perhaps, was it the teacher's general lack of enthusiasm for teaching? Other questions that arose were: Was Peter's lack of mathematical skills a symptom of his schooling, or was it a sign of something deeper? What initially had led Peter along this path of misbehaviour that seems to spiral ever downwards?

Whilst I cannot answer these questions, I hope that I have learnt some valuable lessons from this critical incident that will assist me in my role as a teacher. The first was to learn that there is always a deeper reason as to why a student is misbehaving. As a new teacher, I will need to be extremely vigilant and proactive about trying to work out what the real issues are. This will seemingly take time, and effort, as I can see that the only way of achieving this is through getting to know your students really well. Having the chance to teach a particular student over a number of semesters or years would seem to be a key tool in achieving this.

The thing to be wary of here, though, is in making assumptions too quickly. I know from my personal experiences as a student, that one of the things I hated most was when a teacher put you in a box straight away. Some teachers presumed to know all about you, and your problems, from simply looking at you or talking to you once, or from having previously taught your brother or sister. My aim as a teacher is to resolve to try and never be guilty of this myself--a very hard task to achieve.

The second valuable lesson for me was the realisation that teachers need to really care if they want to make any difference. Given the pressures on teachers these days, it is easy to see how students can become lost within the school system. The only way of assisting these students is by teachers showing a real passion, and commitment, towards assisting each and every individual, and not simply teaching to the general average student. My rounds taught me that this is not an easy thing, as the pressure of trying to get through a crowded curriculum with a broad range of student abilities can be extremely difficult. Realistically, to make a big difference, it is going to take a lot of time. Fortunately, it may only take a few minutes initially to start the ball rolling.

How will I, as a new teacher, seek to assist students such as Peter through such difficulties? For me, questions arise as to how can I not make the same mistake? And how will I be able to make a difference for all the other students in a similar situation to Peter, students who are disengaged because they don’t have sufficient skills to deal with their schoolwork? Many teachers suggest that, by teaching through a wide variety of methods, there is more scope for students at either end of the spectrum to learn, and that students’ different strengths and weaknesses will also become more apparent. This may also make it more likely that one student will be less disadvantaged by methods that may not suit his/her learning style. Similarly, having a broad range of teachers, each with a unique style, appears to me to be a good idea, as different teachers will connect with students in different ways.

My turn to start teaching was about to begin. It was going to be interesting to see if I could stick to my convictions, as I was quickly learning that there were a lot of “Peters” out there . . . .

Science Poetry

Reading and/or listening to poems that have been composed by other children their own age can inspire and reassure students as to their ability to understand and write poetry, and the science poems in this regular section of *SER* may be used for this purpose. Please find information about the *International Science Poetry Competition* at http://www.ScienceEducationReview.com/poetcomp.html .

Poetry and Science

Very diverse are poetry and science
They will never make a good alliance
May be it's a myth I'm in doubt
Let's see what it's all about

Poetry has many beautiful lines
Science many chemicals combine
They both offer an educational tour
In symbols, imagery and disease cure

'Cos of science we went to the moon
We'll visit all other planets soon
'Cos of poetry I express my thoughts in word
I love writing poems . . . but I'm not a nerd

Science kills disease and happiness brings
Whether it is to beggars or kings
Poetry can soothe our souls so well
Make our hearts with emotions swell

Science can open hearts and do transplants
"Organ donors are great," I chant
Poetry can open hearts to love
And symbolize peace with a lovely dove

Who said science and poetry are far apart?
One saves us from physically falling apart
The other certainly appeals to our senses
And makes us view life with different lenses.

Chamara Seneviratne, 14 years
Australia

The Enlightening Periodic Table

Hydrogen, helium, lithium, beryllium
What a lot to say!
The first four elements in periodic order
Will help you in a chemical way!

But this IS too easy . . . let's start again
And re-mix the order here,
So across from lithium beryllium sits
While below magnesium appears.

Jump up to the right and nitrogen is next,
Then step down a row and see,
One of the elements that makes sand
Can you guess?
It's Si you see!

Recycling is fun it starts along this line
Aluminium is waiting to be found,
Diagonally gives zinc, Sn is short for tin
What wonders come from the ground!

To rise above all elements is 79,
Au stands preciously there,
Gold shines while silver stands on gold
Au + Ag make a royal pair!

Don't fret your tongue will need to twist . . .
As you say your very long elemental list,
Molybdenum, neodymium and lead,
Will make you wish you learned Latin instead!

If you're superman you'll need krypton,
Or human, for potassium find K,
K + Na will keep your muscles strongly ahead
Helium will raise you up all the way!

If you're posh you can find platinum,
Even warlords will find the table cool,
As they look and find atomic number 92,
Uranium gives their weapons fuel.

Elements are for everyone,
So grab that table now . . .
There are 257 chemical reasons to explore,
. . . They'll make you noble, wise and proud!

Luke Shakespeare, 11 years
Australia

Students' Alternative Conceptions

Students' alternative conceptions have been variously called misconceptions, prior conceptions, preconceptions, preinstructional beliefs, alternative frameworks, naive theories, intuitive ideas, untutored beliefs, and children's science. The tasks in this regular section of *SER* are based on the literature and may be used at the beginning of a constructivist learning segment to arouse the curiosity of students and to motivate them, while simultaneously eliciting their ideas or beliefs. They are designed to address areas about which students are likely to have an opinion, based on personal experiences and/or social interactions, prior to a specialist learning sequence, or areas that might be considered important for the development of scientific literacy.

1. Draw a diagram of a screw-type torch bulb on the board, showing glass envelope, base (comprising screw thread and pointed section at the bottom), and spiral filament (but with the wires that connect the filament to the base omitted). Invite students to complete the diagram by drawing wires to show how the filament is connected to the base of the bulb.

Comment: One end of the filament should be connected to the pointed base, and the other end to the screw thread. Don't be surprised if even many older students, including those who have studied physics, draw both these wires to the pointed bottom.

Source: Engelhardt, P. V., Gray, K. E., & Rebello, N. S. (2004). How many students does it take before we see the light? *The Physics Teacher*, *42*, 216-221.

2. Consider the following scenario: A remote area is inhabited by a large number of deer, which run at an average speed of 32 km/h. A mated pair of cheetahs, capable of running up to 96 km/h, are introduced to the area. Ten years later, scientists find that the deer in the area are now running much faster--64 km/h.

The best explanation for this result is:

A. Evolution always works in such a way as to produce a better organism, and faster deer are better deer.
B. The deer have a need to run faster, so they do.
C. The environment makes the deer run faster.
D. The deer want to run faster, so they do.
E. By exercising their legs, the deer develop better leg muscles, and these acquired characteristics are passed on to the next generation.
F. I have a better idea. (Please explain.)

Comment: None of the alternatives A-E are appropriate. The Lamarckian Option E is likely to be popular, with students being only too ready to employ the law of use and disuse. Rather, faster deer are more likely to escape the cheetahs, survive, and reproduce. These individuals will have more offspring displaying this same trait in the next generation (i.e., natural selection at work).

Source: Crow, L. (2004). Lamarck is sitting in the front row. *Journal of College Science Teaching, 34*(1), 64-66.

Please send to *SER* any suggestions you may have, based on your own experience or the literature, for adding to or otherwise modifying the items in this task.

Teaching Techniques

This regular section of *SER* describes thinking, cooperative learning, and other teaching techniques.

The* Class Points *Game

To help motivate students, Peters (2004) has her four classes compete in a Class Points game. At the end of each lesson, a score from the range -4 to +4 is awarded to each class. Initially, the points are awarded for class behaviour, but as time progresses, other aspects such as punctuality and homework are added. The classes' points are displayed on a bulletin board, and the class with the highest cumulative score at the end of each quarter is rewarded with a lunch-time pizza party.

To provide substitute teachers with added authority, they are asked to award points from the -8 to +8 range. The points awarded for each lesson are discussed with the class at the end of the lesson, although substitute teachers usually record the marks for the regular teacher to announce upon return. The teacher may listen to, and take account of, special circumstances impacting the class score, such as fatigue due to participation in some other school activity.

Class Points provides closure to a lesson, and the opportunity for students to reflect. It can also facilitate desirable peer pressure, whereby students are keen to avoid disappointing others by behaving poorly or not completing homework.

Reference

Peters, E. (2004). Maximize student time on task. *Science Scope*, *28*(1), 38-39.

Show of Fingers

To ensure all students in a class respond to yes/no questions (e.g., “Can cold water evaporate?”), ask them to show one finger for *yes*, and two fingers for *no*. Student interest may then be maintained by asking for a show of hands by students who think they have good reasoning to support their answer. Elicit such reasoning, using further questioning to guide the discussion towards evidence-based answers, a process that may even lead to the need to design an enquiry activity. Multiple-choice questions can also be answered by a show of fingers.

National Flag and Anthem

When the contribution of a scientist is introduced in class, make it even more memorable by adding a touch of drama--“raise” a replica flag of his/her country, play the music of that country’s national anthem (*National Anthems of the World*, n.d.), and display the words of the anthem (*World Anthem Database*, n.d.).

References

National Anthems of the World. (n.d.). Retrieved November 7, 2004, from http://www.geocities.com/TheTropics/8106/anthems/ .
World Anthem Database. (n.d.). Retrieved November 7, 2004, from http://www.geocities.com/olusegunyayi/ .

More Mnemonics

To identify poison ivy, “Leaves of three, let it be; berries white, take flight.”
To distinguish between the nonvenomous scarlet king snake and the venomous coral snake, “Red next to black is a friend of jack; red next to yellow will kill a fellow.”

Source: Glynn, S., Koballa, T., & Coleman, D. (2004). Mnemonic methods. *The Science Teacher*, *70*(9), 52-55.

To remember the six metric prefixes most commonly used in a middle school (kilo, hecto, deka, deci, centi, and milli), ***K***ing ***H***enry ***D***anced ***O***nce ***D***rinking ***C***hocolate ***M***ilk. ***O***nce is included to remind students that the base unit of quantities have the value of ***O***ne.

Source: Rose, R., & McNeal, K. (2004). Scruples and hogsheads. *Science Scope*, *28*(2), 43-44.

For elements in the second row, ***Li***ttle ***Be***tty ***B***ought ***C***hest***N***uts ***O***n ***F***riday.

Editor

Processing Pictures From Digital Cameras

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Introduction

The relatively cheap availability of digital cameras makes it easy to obtain digital pictures, and lots of them. Pictures can be used in teaching Science in many and varied ways. For example, they can record students' work, illustrate key ideas, and show an experimental setup. I have also used a digital camera to photograph notes on a whiteboard after a lesson, and to record the placement of rocks in their container to guide students how to put them back correctly (Figure 1).

However, most pictures need some form of processing to improve them, or adapt them, for various purposes, such as insertion into a Word or PowerPoint document or a web page. The software that comes bundled with cameras and scanners is usually able to perform basic image editing functions such as adjusting colour, brightness, and contrast. Most allow you to crop and rotate the image, add text, and change the picture size and resolution. I use a resolution of 72 pixels (dots)/inch for web pictures and 150-200 pixels/inch for pictures that will be printed.

Figure 1. Rock Box layout.

Photoshop is a professional image editor that can do far more. A reduced version called Photoshop Elements (also bundled with some cameras) has become available and sells cheaply, especially when purchased at an academic price. Another plus is that both PC and Apple versions are on the same CD. This version has been designed to simplify a whole range of extra features in processing pictures. For example, you can *fill flash* the foreground if the background is too bright or, conversely, darken the background if it is washed out. Photoshop Elements also has powerful tools to remove unwanted detail, heal blemishes, and brighten, darken, colour, sharpen, or soften selected parts of a picture. The list of features goes on and on. Using Photoshop Elements, you can even make up a strobe picture by superimposing time-lapse or multiple images. Also, several photos can be joined together to make a panorama--as when visually recording a transect line on a field trip.

An Example of Image Processing and Addition of Detail

This example shows some basic image processing, and then explains how a detailed area of an image can be inset into the original.

Figure 2. The original image.

The original picture (Figure 2) was taken using a 2.0 megapixel digital camera with the flash turned off. The image produced was 221 kB in JPEG format and had dimensions 1800 × 1200 pixels.

To begin, the picture was cropped. The *Rectangular Marquee* tool was selected from the *Tools* box on the left-hand side of the screen in Figure 3a, and used to select the desired area. Once the area was selected, the *Crop* action was chosen on the *Image* menu. The resulting cropped image is shown in screenshot Figure 3a.

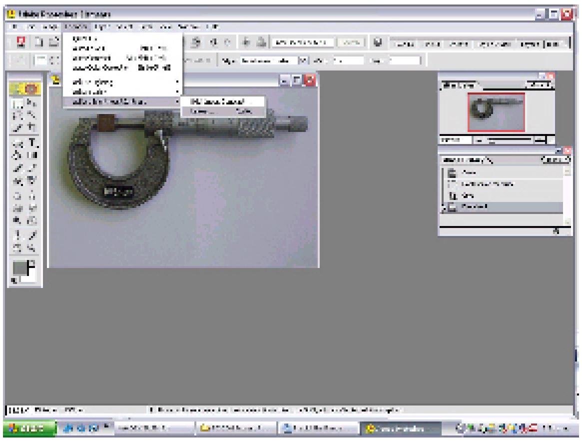

Figure 3a. Choosing *Levels* (Ctrl+L).

The next step was to adjust for brightness and contrast. Photoshop Elements does have an automatic brightness/contrast tool, but choosing *Levels* from the choices given on the *Adjust Brightness/Contrast* option, which in turn is on the *Enhance* menu (Figure 3a), brings up a more powerful tool shown in screenshot Figure 3b. The three triangles below the histogram in the *Levels* adjustment box can be clicked and dragged to change both brightness and contrast. In Figure 3b, the empty triangle has been dragged from the right-hand end of the histogram to the right-hand end of the histogram data. This adjusts the maximum *White Level*, and has the effect of brightening the whole image without

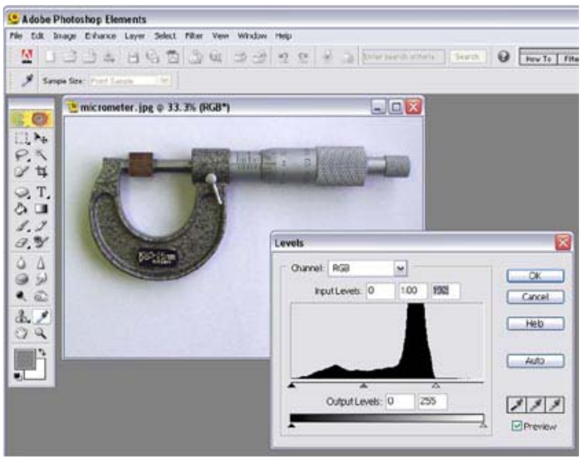

Figure 3b. Adjusting the white level.

any loss of detail. To see the result, compare the micrometer images in Figures 3b and 3a.

In a similar way, the centre shaded triangle can be dragged to adjust the mid-tones and so change the contrast. Moving the triangle to the left lightens the image, and to the right darkens it. The maximum *Dark Level* is set using the solid dark triangle at the left-hand end of the histogram. This adjustment was not made in this case, because there was no gap between the left-hand end of the data and the left-hand end of the histogram. Any adjustment here would darken the picture and cause detail in the dark sections of the image to be lost.

Two more actions are shown in Figure 4. The *Rectangular Marquee* tool has been used to select a part of the micrometer that will be shown, as an inset, in enlarged detail. This selection was first copied to the clipboard (*Ctrl+C*) but, before pasting it back onto the image, the marquee region was outlined using the *Stroke* tool from the *Edit* menu. Figure 4 shows the stroke dialogue box and the settings used (dark grey, 4 pixels wide). Once stroked, the marquee rectangle was *Deselected* (in the *Select* menu). The copied area was then pasted (*Ctrl+V*) onto the original image and dragged using the *Move* tool (from the *Tools* box) to the bottom right corner of the image, as seen in Figure 5.

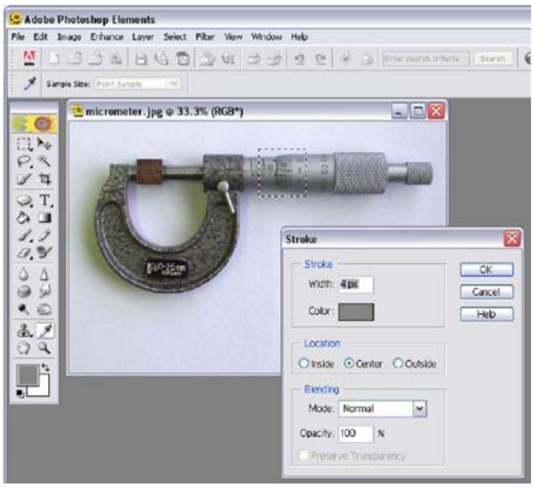

Figure 4. Stroking a selected area.

In Figure 5, the pasted detail of the micrometer has been enlarged. This was done using the *Move* tool again, to select the detailed area, by clicking on it once with the mouse. Handles appeared around the selection, and dragging one corner handle diagonally with the mouse while pressing the shift key enlarged the selection. (Pressing the shift key ensured that the enlargement action kept the original proportion.) The enlarged detail was then *stroked* using the same method and settings as earlier.

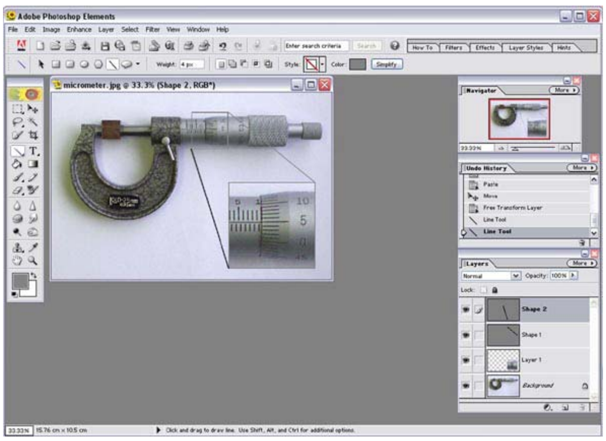

Figure 5. Modifying the detail.

Finally, Figure 5 shows two connecting lines added between the original and enlarged regions. This was done using the *Line* tool from the *Tools* box, again using the same shade of grey, and width settings, as the stroke actions. Those settings are displayed in the bar immediately above the main micrometer image. The *Layers* box at the bottom right of the screenshot in Figure 5 shows that the image now consists of four layers--the original micrometer image (called the *background*), the pasted detail, and a layer for each of the connecting lines. (Choose *Layers* from the *Window* menu, to display the *Layers* box, if it is not visible when using Photoshop Elements.) Having layers like this allows parts of the image to be modified without affecting the rest of the image. This is a real advantage that Photoshop Elements has over less powerful image editors.

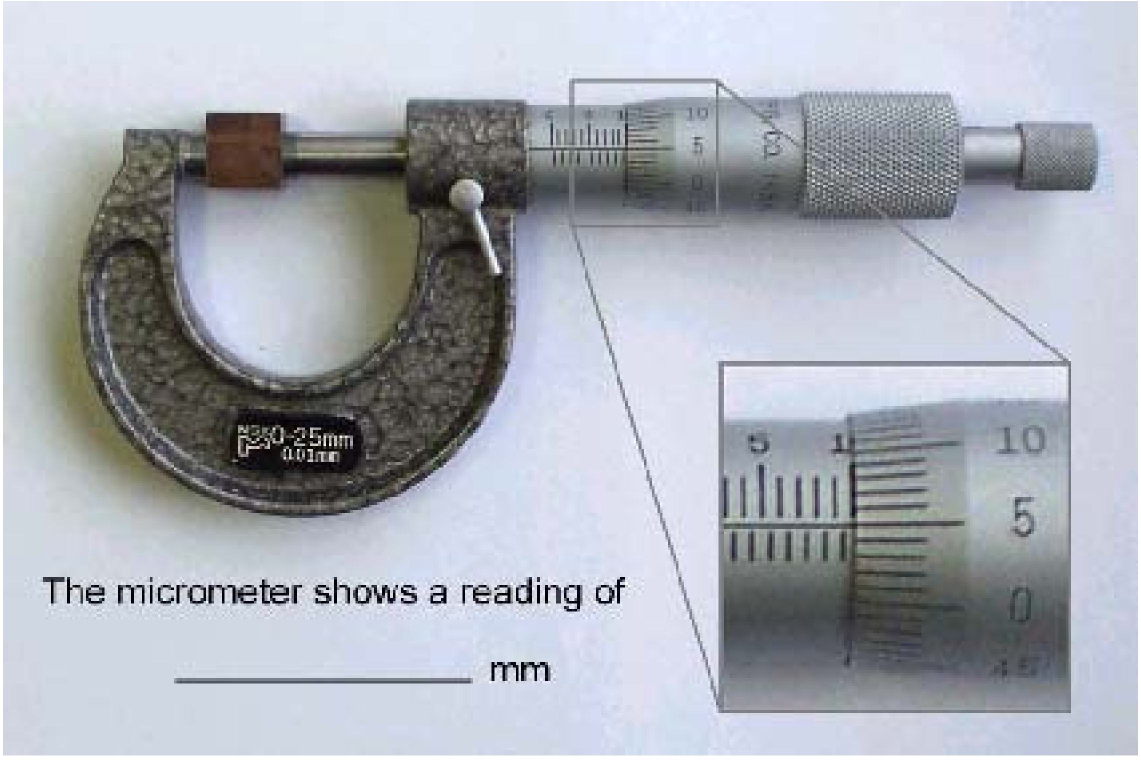

Figure 6. The finished picture.

The finished picture is shown full scale in Figure 6. A fifth text layer was automatically added when using the *Text* tool to write the text shown, and a sixth layer was formed when the *Line* tool was used again to draw a horizontal line next to the “mm” text. When finished, it is a good idea to save the image in Photoshop format (.psd), because the layer structure is saved with the image and it is easier to rework parts of the image if desired at a later date.

Two further actions were performed to produce the picture shown in Figure 6. The image was resized to 15 cm × 10 cm, and the resolution changed to 150 pixels/inch. These settings were entered into a dialogue box that appeared when *Image Size* was chosen from the *Resize* option on the *Image* menu. After resizing, the layers were *flattened* to one layer using *Flatten Image* on the *Layer* menu. The picture could then be saved in JPEG format, allowing it to be inserted into a wide range of documents (e.g., a Word document) or displayed as part of a web page. So, the final action was to choose *Save As* on the *File* menu and select *JPEG* as the format. After clicking *Save*, a *JPEG Options* box appeared in which I chose *6* as the image quality and then clicked *OK*. When saving in JPEG format, there is some loss of detail, and 6 was chosen as a compromise between a decent image and small memory size of the saved image file. The finished image now had a memory size of 82.2 kB and dimensions 886 × 591 pixels.

The above explanation is at times fairly detailed. I have found, though, that it is very easy to miss a step that can completely halt progress, especially while becoming familiar with new software. I'm therefore happy to correspond with anyone who finds the steps need further explanation.

As a further example of this layering technique, Figure 7 shows a biological image with a more detailed inset. In this case, though, the added detail was cropped from a different image and rotated to match the orientation of the mosquito larva. Both images were taken using a Proscope computer microscope (*The Proscope: Digital USB Microscope*, 2004) set to different magnifications.

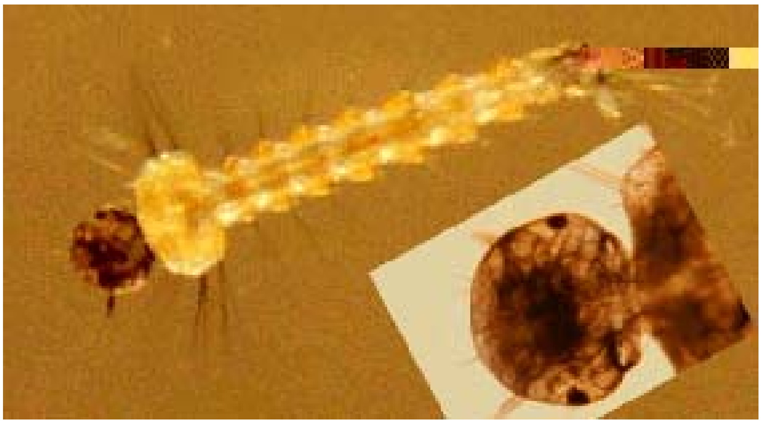

Figure 7. Mosquito larva with detail of head.

This article has only touched on a small part of how Photoshop Elements can be used to make images in science more useful for helping students learn. Scanned images can be similarly processed, especially if the initial scanning is done at a fairly high resolution. The software is very flexible and should allow you to perform almost any kind of image editing.

Taking it Further

There are a wealth of internet resources and discussion groups to assist with using Photoshop Elements. For example, Adobe Systems (2004) and About (2004) have many tutorials, and an active discussion forum may be found at Yahoo! (2004).

Even though Photoshop is the industry standard, you may be interested in using free digital imaging software. One such program is The Gimp Team (2004). According to the description on the website, "the GIMP is the GNU Image Manipulation Program.

It is a freely distributed piece of software for such tasks as photo retouching, image composition and image authoring. It works on many operating systems, in many languages." Microsoft also sells a coordinated set of programs for digital imaging called Microsoft Digital Image Suite 10 (Microsoft Corporation, 2004). Happy image editing!

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Ideas in Brief

Summaries of ideas from key articles in reviewed publications.

A Fair Classroom Setting

Hand (2004) thought his classroom was a fair one, yet feedback from students indicated that some did not perceive it to be so. He used the following techniques to address this need, and found that they also impacted positively on student engagement.

Seating plan. Prior to the first day, students' files are perused and students are grouped, as well as can be judged from the files, into heterogeneous (on the basis of sex, first language, etc.) groups of 4. Each desk position in the room is numbered and, when students arrive, they sit in accord with the list of student names and corresponding desk numbers displayed on a transparency. (The transparency is displayed at the beginning of the first few lessons.) This procedure overcomes the uncertainty, and associated scramble, associated with students trying to seat themselves with a friend(s).

Should a better balance be needed, students are reassigned to a different group. Students may also submit a written request for a change of group for some good reason, such as difficulty with vision. The groups are also usually rearranged each quarter.

Choosing students. Groups are distinguished by allocating each a different letter. Also, the numbers on the desks, at each group of 4, are in a different colour: red, blue, green, and yellow. When it becomes necessary to assign a task (e.g., each group needs to get a certain resource), ask that it be carried out by a student with a particular coloured (red, say) number.

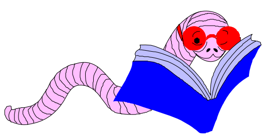
When asking questions, have groups discuss, and then invite students with a particular coloured number to respond on behalf of the group. Use a spinner, divided to represent the four colours, to choose the colour. Some spinners are clear and can be displayed on an overhead projector. A second spinner, with a section for the letter representing each group, can then be used to select the green-numbered, say, students in the class who respond. This process ensures that class discussions are not dominated by a few students only.

Show of fingers. Please find this technique, used to involve all students in responding to yes/no questions, explained in the *Teaching Techniques* section of this issue.

Selecting lab partners (pairs). A table, listing pairs of student desk numbers, is displayed. Each column is headed with a letter, designating a particular lab station at which a pair of students will work. Each row comprises a set of paired numbers, and row 1 is used for the first pairing, row 2 for the second, and so forth. The table contains all possible number pairs, so as time progresses, each student can partner every other student in the class.

Reference

Hand, R. (2004). Creating a fair classroom environment. *Science Scope, 28*(1), 54-55.



Research in Brief

Summaries of research findings from key articles in reviewed publications.

Using Constructivist Environments to Change Students' Enjoyment of Science Lessons

While the decline in students' attitudes to learning science, during the compulsory years of schooling, has been an enduring problem, we do have evidence (in the form of correlations) suggesting that the development of a constructivist learning environment might counter this trend (Aldridge, Fraser, Taylor, & Chen, 2000;

Fisher & Kim, 1999; Hand, Treagust, & Vance, 1997). In a constructivist approach, students working in an authentic environment are actively engaged in their own enquiries into problems relevant to them. Communication and collaboration with peers and teacher are stressed.

Oh and Yager (2004) used data from two action research projects to investigate the relationship between the development of constructivist classrooms over time and corresponding changes in student enjoyment of the science lessons. The projects, which monitored two 11th-grade Earth Science classrooms in a Korean high school each year during 2 consecutive years (each year was regarded as a separate project), used a modified Group Investigation (GI) model to create the constructivist classrooms. This comprised collaborative learning in small research groups in which students enquired into topics that arose from their own questions. During the second project (the second year), peer assessment was also employed.

To measure students' perceptions of their classrooms, a Korean-translated version of the Constructivist Learning Environment Survey (CLES) (Taylor, Fraser, & Fisher, 1997) was used. Their enjoyment of science lessons was measured using the 10-item Enjoyment of Science Lessons Scale (ESLS) of the Test of Science-Related Attitudes (TOSRA) (Fraser, 1981), which was also translated into Korean. Each survey was repeated three times during each project: at the beginning, middle, and end of the year.

Statistical analysis of the data showed that, during both yearly projects, the science classrooms became progressively more constructivist, and that student enjoyment of science lessons increased. Of the five elements of a constructivist learning environment measured by the CLES, personal relevancy (PR)--which determines the degree to which school science connects with students' out-of-school lives--was the most important in explaining the positive change in student attitude.

Oh and Yager (2004) identify Problem-Based Learning (PBL) and Project-Based Science (PBS), both of which can use everyday student experiences as a context for learning in science, as approaches that can promote the relevance of learning in science. The differences between them are subtle (Esch, 1998), and although they have been used mostly at elementary and post-secondary levels, both are also appropriate for high school. There are two possible ways to determine a problem or topic for study: it may either be solicited from the learners, or the teacher might present a problem or topic in such a way that students readily adopt it as their own.

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Taylor, P. C., Fraser, B. J., & Fisher, D. L. (1997). Monitoring constructivist classroom learning environments. *International Journal of Educational Research*, *27*, 293-302.

? ? ? ? ? Your Questions Answered ? ? ? ? ?

This section of *SER* responds to readers' queries, so please submit your question to The Editor at editor@ScienceEducationReview.com . Have that long-standing query resolved; hopefully!

I recently placed a bottle of soft drink in the freezer. When I removed it, the drink was still a liquid. However, after removing the top, it began to freeze from the top down. What is happening here, please?

Editor: This question has prompted much deliberation, and has sent students in at least two classrooms in the world into enquiry mode. The situation appears to be much more complicated than a first glance might suggest.

A carbonated beverage contains carbon dioxide dissolved in the water, under pressure. The effects of the pressure have a small, but insignificant effect, on the freezing point of the liquid. More importantly, the dissolved carbon dioxide acts as an anti-freeze, lowering the freezing point of the solution. When one opens the bottle, two things occur:

1. The dissolved carbon dioxide escapes from the liquid, raising its freezing point.
2. Evaporation and expansion are both endothermic, and quickly lower the temperature of the liquid.

The effect starts at the top, and works its way down, because of how the carbon dioxide is released, and also because the liquid has greater density than the ice. As in many things in life, several actions are going on at once.

Charles Bedard, Maryland, USA

In my opinion, the most important factor in causing the soft drink to freeze is the nucleation centers created as the pressure is released when you open the bottle. Clearly, the liquid in the freezer is below its normal freezing point, or it wouldn't freeze when the bottle is opened. Therefore, you can consider it to be supercooled (cooled below it’s normal freezing point without becoming solid). Under normal circumstances, dirt in the water and scratches on the sides of the container act as nucleation centers (where ice first starts to form) and prevent supercooling. However, a soft drink is made of very clean water, and today's drinks are delivered in pristine, single-use plastic containers. Even with care, you'll have trouble freezing water more than a few degrees Celsius below zero. Scientists have cooled very pure water in special containers more than 10ºC below zero.

Another factor that helps create the situation you see is freezing point depression. Whenever something is dissolved in water, the freezing point is lowered. Thus, people put salt on their steps in winter to melt ice. More dissolved solids mean lower freezing points. Soft drinks have lots of sugar in them and so get a substantial freezing point depression. There's also a bit of carbon dioxide (CO_2) dissolved that makes the soft drink fizz. Altogether, the dissolved substances could drop the freezing point by a few degrees Celsius.

The decrease in freezing point has significance because the temperature in a freezer is typically around 15ºC below zero. Without freezing point depression, your drink would probably freeze at this temperature and do so rather quickly. With a freezer that isn't set to such a low temperature, the actual supercooling may amount to only a few degrees below the reduced freezing point.

The wild card in this scenario is the CO_2. When water freezes, most of the dissolved gases come out of solution. Ice is a poor solvent. Also, as ice freezes, unlike most liquids, it expands. As the soft drink cools, it must get larger and put out a lot of CO_2 into a volume that is almost fixed. Thus, the freezing is retarded. I cannot estimate the amount with any precision, but suspect that it may be a degree or two. Therefore, it may be that the liquid is not supercooled, or only slightly supercooled, until the cap is removed and the liquid is open to atmospheric pressure.

In any event, the liquid definitely is at a temperature below freezing once the bottle is opened. The carbon dioxide bubbles that form create nucleation centers for ice to form, and the freezing begins. Freezing generates heat energy, which slows the freezing action and prevents every last molecule of water from becoming ice. The final contents of the bottle are likely to be liquid and solid interspersed and appearing to be solid ice.

Harry Keller, USA

Why do stars twinkle, yet planets do not?

The atmosphere continuously moves (air flow) due to the interplay of cold and warm air. This creates moving air lenses (grandpa wears fixed glass lenses), which change the direction in which light moves through the air. When we see stars from the distance they are at, they are point-like. So, when starlight passes through the air, you see stars shaken a bit (we call it *twinkling*). On the other hand, planets are much closer and therefore broader. There is movement with them too, but the tiny shake is not noticed.

Magan Savant, Hong Kong

Stars (except for the Sun) are so distant that they act as point light sources, and our view of them is readily affected by variations in refractive index of the air as thermal differences in the air move due to winds. Planets often are larger sources of reflected light that are not so dramatically affected.

The twinkling is the same effect, as observed near the surface of a hot road, that causes distant objects to waver. For a point source, this wavering makes it disappear and reappear quickly (i.e., to twinkle). A larger source, like a planet, may move a bit, but will not usually disappear completely.

Harry Keller, USA

What changes might be made to teacher education programs to better prepare teachers for the science classroom?

The three areas that beginning teachers, and experienced teachers, have the most problems with are classroom activities, motivation, and discipline. I've always felt that as someone being prepared to teach science, which by its very nature requires I be able to implement multiple activities and experiments in a student-centered curriculum, that I should have walked out of college with a couple dozen labs that I could walk into a classroom and implement. Additionally, while teachers can't give students motivation, or force motivation on them, we can do things to positively impact the motivation of students, such as connecting interpersonally with them every day, showing interest in the things that interest them, and when the class gets excited about a topic, learning how to go with the interest and alter the curriculum accordingly while still teaching the standards.

About the only thing I learned about discipline was proximity control. It is true that if a teacher stands by an offending student, the behavior tends to cease because the kids really don't want to hang with us. However, while a new teacher may be successful at curbing the behavior in that one student during the time that he or she stands by the student, in the long run that will do little to modify the behavior--and in the mean time, the rest of the class may be engaging in offending behaviors while taking advantage of the distraction. I should have participated in discussions and role plays on how to respond during certain difficult disciplinary situations, such as when 2 students begin arguing or fighting, or when health and safety problems arise. I can't help but wonder if the reason that we lose so many of our new, talented educators during those first few years is that lack of preparation makes an already stressful career not worth the monetary compensation. Teaching awards are nice, but many of us will never get one. We therefore also need to learn how to self-motivate, because it is rare for someone to come into my room and tell me that a lesson was a great one.

Pamela Galus, Burke High Planetarium Director, Omaha Public Schools, USA

Aside from hand-to-hand combat training (☺), teachers should have more exposure to doing science like scientists do. Too many science teachers in the United States have no comprehension of what science is like, and how it functions. Many don't even understand basic science principles. A science teacher should embue students with the joy of doing science, and of understanding science writing. Richard Feynman pointed out that a scientist looking at a beautiful sunset sees much more, and thus has a stronger and better experience, than a non-scientist, even though both appreciate the basic beauty. Seeing more is deeply fulfilling. If the teacher sees more, then that teacher can pass this concept on to students. If not, the science class loses a great deal.

Harry Keller, USA

I think the competition principle should be introduced into the teacher education program. For example, teachers could get a competency, or honor, through the program and this would increase his/her salary, or something like that. As individual teachers, we should try to increase our skills voluntarily. But the problem of keeping quality in the work of teachers belongs to school administration, and should be solved not only from a spiritual viewpoint, but also from a materialistic one.

Hideyuki Kanematsu, Institute of National Colleges of Technology, Japan

I think that student teachers should be guided to learn as they are supposed to guide their pupils to learn. Essential to me appears to be students' attitude to study based on interest and curiosity, and a key skill for teachers is that they can arrange the climate so that learners develop that attitude. Bewilderment, fascination, imagination, experimenting, formulation, formalization, logical thinking, reflection, and many more are the ingredients of the learning attitude. Teacher education should be like an atelier (workshop), where student teachers can experiment with how to guide/coach others to learn and to experience what it is like to participate in these various learning/teaching scenarios.

Piet Kommers, University of Twente, The Netherlands

Is it still appropriate to teach students in year levels, or should we set classes up in a vertical way?

Was it ever appropriate to teach students by chronological age? I doubt it. The mechanistic, industrial view of schooling has arisen to meet the needs of our industrialised world. Therefore, it is more efficient to deal with all children at a given age level as the same. However, teachers know this is not the case, and indigenous cultures around the world all have some form of education as learning when ready. So, by treating your students as unique individuals, you can learn to meet the diverse needs of the children within your classes.

For vertical groupings to work more effectively, the school system as a whole needs to see the need to change in this manner. This would allow gifted students to move through more rapidly, and students with learning difficulties to be supported through a slower-paced program to ensure that they could function fully in their society. Individual schools have attempted this in Victoria (Australia), but with limited success. The limitations are due to systemic restrictions that allow the procedures of power within the social matrix of a school system to militate against innovation. That is, a school must fit into the state educational system, and with the tertiary education and community expectations that exist for schools. A Foucaldian analysis of the power relations involved would suggest that it will always be so. There is a thesis, or three, in the answer to this question.

Gary Simpson, Australia

All plans have positives and negatives. There can be no winner--you need to decide what path you will prefer.

Jim Butler, Australia

I have a serious problem with the concept of vertical timetabling, the way it is usually done in high schools. The problem is that the structure is often, or mostly, used to avoid the difficulties of individualised teaching. There is a mistaken belief that students can be organised in ability groups, and that you can therefore teach common work to the group. Apart from the basic misconception that previous performance in one strand, or curriculum area, transfers to other strands or curriculum areas, there is a paradigm shift between teaching each student in your class to move through the levels in their own way and time, and teaching a class of students an outcome at a (supposed) particular level. By teaching each student as an individual, you reinforce your role as helping the student to move through the levels. As soon as you teach a class a common outcome, however, there is an underlying message that some will “pass” the outcome and some will “fail.” This is absolutely not in keeping with an outcomes approach, nor with Glasser beliefs.

Mark Gould, Australia

In the United States, there is a trend to implement standards-driven classrooms. This approach allows a teacher to differentiate instruction, based on the skill level of the student. Since the standards are product-based, instead of knowledge-based, the teacher can create different performance-based assessments that can challenge students at different levels. Even if students are progressing through school on a year-by-year basis, they can still be attaining greater levels of knowledge if they are able. Vertical classes are great on paper, but they are in violation of many guidelines that are in place, and would be next to impossible to change to on a wide scale.

Nicole Harvey, USA

Further Useful Resources

Tsunami Textbooks

http://www.prh.noaa.gov/itic/library/pubs/textbooks/tsunami_textbooks.html

A set of textbooks, each with a Teacher's Guidebook, spanning pre-elementary to high school levels. There are no copyrights to these textbooks, and readers are invited to make as many copies as required. Also available in Spanish.

Effective Teaching http://www.teachers.net/wong

A collection of classroom management strategies and approaches, including *A First Day of School Script*, *The First 5 Minutes are Critical*, *The Problem is not Discipline*, and *Dispensing Material in 15 Seconds*.

A Home Science Program Called MOS

http://www.mswiz.net/for_teachers.htm

Enrich and individualise experiences in science with the My Own Science (MOS) program. Possibilities include labs, demos, reading an article, visiting a science center, star gazing, interviewing a scientist, watching a science TV program, and working on a thought puzzle.

The Naked Scientists Guestfile

http://www.thenakedscientists.com/HTML/Guestfile/guestlist.htm

Listen to scientist interviews on-line.

NASA Solar System Simulator http://space.jpl.nasa.gov/

Constructs images of the Solar system, and the components of it, from various positions both inside and outside it.

Virtual Fishtank.com http://www.virtualfishtank.com/fishtank/fishtank.html

Build your own fish, specifying a certain appetite, fears, and other traits. Release it into a virtual tank and observe how it interacts with the environment. Modify the fish to ensure its survival.

Bucket Buddies http://www.k12science.org/curriculum/bucketproj/index.html

Elementary students around the world collect samples from local ponds to answer the question: "Are the organisms found in pond water the same all over the world?" Participants identify organisms in a water sample, compare their findings with other participating classes, determine which, if any, of the organisms are the same in other, more distant water sources, and look for relationships and trends in the data collected by all project participants.

Earth Science Classroom Activities

http://www.uky.edu/KGS/education/activities.html

Activities to foster an interest in the earth sciences. Includes a Geological Time Scale.

Science and Nature: Prehistoric Life http://www.bbc.co.uk/dinosaurs/

A variety of information about dinosaurs, plus quizzes and games.

Dinosaur Clip Art http://www.kidsdomain.com/brain/dino/clip1.html

Free dinosaur clip art.

Chemical of the Week http://scifun.chem.wisc.edu/chemweek/chemweek.html

Fact sheets about chemicals and chemistry-related topics, to increase students' knowledge about chemicals, their production, cost, and uses.

Chemistry Diagrams

http://www.btinternet.com/~chemistry.diagrams/index.htm

Diagrams, which are easily copied and pasted into Word, that may save time preparing learning materials or test papers. Headings comprise *Gas Preparations*, *Industrial Processes*, *Organic Preparations*, *Electrolysis*, *Molecular Diagrams*, *Organic Mechanisms*, and *Miscellaneous*.

The Physics of Cycling

Analytic Cycling http://www.analyticcycling.com
Exploratorium Sport Science http://www.exploratorium.edu/sports/index.html
Bicycle Helmet Safety Institute http://www.helmets.org/henderso.htm
Aerodynamics of Bicycles
http://www.princeton.edu/~asmits/Bicycle_web/bicycle_aero.html
Project Links: Mechanics, Linear Algebra and the Bicycle
http://links.math.rpi.edu/devmodules/bicycle/index.html

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The Science Education Review (*SER*) is an international, peer-reviewed periodical aiming to provide primary and high school teachers with the latest, and best, ideas in science education from around the world. *SER* also publishes original articles, including research articles, and much more.

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