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THE SCIENCE EDUCATION REVIEW

Ideas for enhancing primary and high school science education

Did you Know?

Clinical Trial of TGN_{1412}

While clinical trials are essential for developing new and improved treatments, they can present researchers with an impossible dilemma. On the one hand, researchers need to be concerned for the safety of their subjects. At the same time, though, a decision not to proceed with a trial could stifle innovation. Determining if the risk is worth taking can be a very subjective process.

On March 13, 2006 at Northwick Park hospital in London, 8 young men who had each been paid £2330 were injected with the experimental drug TGN_{1412} that had shown promise in fighting multiple sclerosis, some cancers, and rheumatoid arthritis. Within minutes, 6 were in much trouble, tearing at their shirts to relieve the fever that had struck, vomiting, writhing in agony, fainting, and experiencing multiple organ failure. The swelling of their faces resulted in them being described in the press as elephant men. Weeks of hospitalization followed, with one needing to have toes amputated as a result of the onset of frostbite-like symptoms.

At the end of the year, the problems for these 6 subjects were continuing. For example, one developed dozens of potentially cancerous lumps all over his upper body. Even after another year, memory lapses, severe headaches, and stomach problems were reported, with one subject having developed lymphoma.

Source

Brooks, M. (2011). *Free radicals: The secret anarchy of science*. London: Profile Books.

Teaching Ideas

Techniques, demonstrations, activities, alternative conceptions, critical incidents, stories, and other ideas

Classroom Management Tips

Romano (2012a, 2012b) offers the following classroom management tips for particularly new teachers:

- Plan, prepare, and keep your students active.

- Move around the room while you teach, especially during lab work. Use wireless technology to change slides or whatever else might be displayed on the projector screen.
- Assign students to seats and lab groups, at least for the first couple of months. If desirable, change the seating of a student, giving your reason but without debate. Avoid making such changes too frequently, though, as this would impact negatively on students' perception of your ability to maintain control.
- Visit the classrooms of experienced teachers, have experienced teachers visit your classroom, and debrief afterwards. This will improve your ability to read student signals and provide new strategies for engaging students and dealing with problems.
- Teenagers typically want someone to care about them, so build positive relationships on the basis of mutual respect and concern for one another. Apply classroom expectations consistently. To avoid embarrassing a student, in the case of minor problems arrange to meet with the student after school rather than publically embarrassing him or her. During the meeting, try to turn an uncomfortable situation into a positive one by personalizing the incident, linking it to possible stressors in the student's life such as difficulties at home or academic struggles.
- Learn from your mistakes. Teaching involves making quick decisions, and all teachers make mistakes. Reflect on your classroom management with a view to avoiding the same problematic situation in the future.
- Be true to yourself. Certainly look to model successful classroom management techniques but, because teachers have different personalities, there is no common mold for all teachers. Aim to develop an approach compatible with your personal comfort zone.

Reference

Romano, M. (2012a). Mastering classroom management (Part 1). *The Science Teacher*, *79*(7), 14.
Romano, M. (2012b). Mastering classroom management (Part 2). *The Science Teacher*, *79*(8), 12.

Electronic Voting System to Mark Longer Questions

A longer question might be marked by assigning 1, 2, or 3 marks, say, but such an aggregate mark hides much detail. An alternative is to have students mark their answer but to report their results using an electronic voting response in which the options reflect the mark that a student has lost, which provides more detail about the weaknesses students have.

Source

Read, D. (2010). Happy zapping in the classroom: Enhancing teaching and learning with electronic voting systems. *School Science Review*, *91*(336), 107-111.

The Year I was Born

Cherif (2012) uses The Year I was Born assignment to engage students, help develop their historical and scientific literacy, and improve their attitude towards the learning of science. Students are given 3 weeks to research important scientific advances that occurred in the year they were born, rank the advances in order of importance, justify their rankings, and select two advances of particular interest and elaborate them, including linking the advances to related science that came before and after and highlighting the impact of these advances on technology and society. Each student delivers a 5-10 minute presentation to the class; 5 minutes for research and 5 minutes for questions and discussion. Each student is also asked to submit one or two critical-thinking questions, based on the two advances they elaborated, for the teacher to use in a quiz.

As an example, the teacher might present scientific discoveries from the year of his or her birth. A written paper could also be required of students. Since many students in a class will have the same birth year, this activity may be completed in groups with students in each group choosing different advances to elaborate. Or, to further reduce duplication, students could be asked to research scientific advances from any year of a student's choosing rather than their birth year.

Reference

Cherif, A. (2012). Scientific discoveries the year I was born. *The Science Teacher, 79*(7), 54-57.

Using Ethics Committees to Teach Bioethics

Goodwin, Kramer, and Cashmore (2012) recommend the use of ethics committees to allow students to practice the skills of critical thinking and ethical debate. A session, which might take about 1 hour, consists of the following four phases:

1. *Introduction to bioethics*. Exemplify some bioethical issues to the whole class, including any suggested by students, noting that the issues are topical, emotive, and controversial.
2. *The problem of convergence*. Emphasise that the aim of each group is to work towards convergence rather than agreement or consensus (a position that can be supported by all members of a group even though it may not be the first-choice position of each member). Students need to appreciate that the inability of a group to reach agreement does not represent failure and, since ethical arguments are based on principles as well as consequences, different student moralities based on secular or religious convictions are to be welcomed and not considered to be beyond challenge.
3. *The ethics committees*. Introduce three or four case studies to the class (e.g., a 62-year-old woman with three grown-up children has a new 60-year-old husband who does not have children but has always wanted "a child of his own." They want to use a donor egg and the husband's sperm to allow the woman to have a baby by in-vitro fertilization (IVF). Ethics committees, each comprising 4 or 5 students, are formed and each group is assigned one case study. The same case could be assigned to more than one committee.

   Each committee receives brief introductory material, in the form of a bullet list, for the case comprising the overview given to the class as a whole (as per the foregoing example about the 62-year-old woman) plus some suggestions for the committee to think about (e.g., do older parents make better parents?). Such introductory material for a selection of prepared case studies may be obtained from Mark Goodwin at majg1@le.ac.uk .

   The committees are then asked to discuss their cases and arrive at a collective yes/no decision (e.g., should the 62-year-old woman be given IVF treatment?), just as real-life ethics committees need to do. A number of techniques exist to help with the decision-making process. One approach could be for the committee to list three or four arguments for each of a *yes* and a *no* decision and debate their relative merits. At a more advanced level, Mepham's (2008) ethical matrix could be used, whereby the interests of stakeholders in the issue are tabulated under the headings of well-being (health and welfare), autonomy (freedom and choice), and justice (fairness). This table could then even form the basis of a decision-making matrix (2003).

4. *Results*. After 10-15 minutes, the class comes back together as a whole group and each case study is treated in the following way:

   - Refresh the case by outlining it again to the class.
   - Take a whole-class vote on the decision. This is preferably done anonymously (e.g., using an audience response system) and reflects the taking of a public vote in real life.
   - Share the decision of the committee(s) and contrast it with the previous public vote.
   - Discuss the factors considered by the ethics committee and possibly the processes involved in reaching the decision, including any obstacles.
   - In the event the case study is adapted from a real-life scenario, discuss the real-life decision. This may involve additional issues such as legislation.

Reference

Decision-making matrix. (2003). *The Science Education Review*, *2*, 86-88.

Goodwin, M., Kramer, C., & Cashmore, A. (2012). The ‘ethics committee’: A practical approach to introducing bioethics and ethical thinking. *Journal of Biological Education*, *46*, 188-192.

Mepham, B. (2008). A framework for ethical analysis. In B. Mepham (Ed.), *Bioethics: An introduction for the biosciences* (pp. 454-66). Oxford: Oxford University Press.

Science Poetry

Reading and/or listening to poems 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 .

The Emotionless Einstein/Computer

He walks like a professor with no need for a thesis,
A graduate from the University of La La Land,
Located beyond the Milky Way,
Taught by Mr “Physics for Dummies.”
His content is a frequency beyond a human’s receiver.
Where the students are assumed to have broken antennas,
He is a short wavelength in his physical size, but not his brain.
That hair gravitationally stationed on his head,
Has no distinction with a melon wearing a wig.
Is he really human, we ask?
Momentarily jotting and solving with a great mental acceleration,
From initial to final conclusion,
No error found!
Oh, what calculation can’t he solve?

Theory theory theory, thus he claims, such expectations are beyond ordinary,
Practical doesn’t exist within his dictionary.

“All content should be known!” he remarks, transcending the syllabus guidelines,
He is surely no friend of the Board of Studies.
Just like his youth days, when he was so called top of the class, back in France.
Certainly not in literature!

“Zis is not azzeptahle!” claims Mr Einstein,
Bang! Bang!
The electrodes fire neutrons at his head,
Ripping through his synthetic metal computer, covered with flesh and bone
Deteriorating his intelligence and ability, to which he is prone.
(Awoken Monday morning)
0h what a dream!

Period l - Physics
Next thing you know you are overtaken by a bolting jet of
Greater acceleration towards the lab, than any man can,
How can this be? He has negative physical potential energy
And has great kinetic energy when that hell rings.
Could it be a scientific contradiction, I had right wrong.
I ask myself
What wonderful women would withstand William’s weather?
His conversations are like a bolt of lightning containing greater charge,
Shocking all.
The pressure and temperature have been raised in class yet his knowledge particles have
No melting or boiling point.
Nor does cold affect him, as he has no critical temperature.
Can't believe it, this was the only experiment done all year,
Steven Hawking has more cheer.

The threat displaced the class’ ability, as if he was an ability amplifier,
Propagating and penetrating faster than light through every student.
“I will throw you out of the window!” where third place is a mortal failure in his dictionary!
He is saturated with a positive negative electric charge that keeps him neutral.
Zero decajoules needed to pull his protons (personal positivity)
0nly an infinite quantity of energy can extract his electrons (personal negativity)
Surprisingly, why is he not an anion, on the school’s status.

Who am I to argue with
Mr Computer, electrical and mechanical engineer, as he claims.
Can he be regarded as a human being or rather a high tech computer?
With an emotional resistance of one zillion!
“Scratch, squeak scribble!” problem solved.
0h, what calculation can’t he solve?

Are his capillaries linked to microchips that he can think so momentarily?
Criticizing the abilities of others. From University of La La Land
The question of his intelligence remains open.

George Manassa, Year 11
Australia

Plastic Facts

Polymers, monomers, atoms and many other elements
Make a synthetic substance, plastic!
A recyclable, multipurpose material
Which is quite fantastic!

Polymers ("poly" meaning a lot)
Are made of very large molecules (atoms joined by chemical bonds)
Of which many materials are not
And consist of many repeating units--monomers!

Monomers are made of many elements such as . . .
Oxygen, chlorine, hydrogen
And carbon is the main element that a monomer has
There are other contributing elements like fluorine and nitrogen

The structures of plastic are formed from a polymer chain
That contains chemical bonds that hold two monomers
And have only one unit (monomer) to gain

Co-polymers are substances made from two . . .
Different monomers that alternate
And create things such as nylon, something very new!

Plastics are produced in many different forms
Coloured, solid, bendy, you can see it transform!
However the structure and elements will always remain the same
For that's how plastic gets its name!

Samantha Harstedt, 15 years
Australia

Ideas in Brief

Ideas from key articles in reviewed publications

Treat Creationism as a Misconception

By: Colin Foster, University of Nottingham, Nottingham, UK c@foster77.co.uk

There are few areas in science education as controversial as the teaching of evolution. Even among those who find the scientific evidence for the theory of evolution completely overwhelming, there is room for much debate over what to do about the objections of highly vocal creationists. Should we, as many advocate, simply ban all talk of creationism from the science classroom? Can we legislate the problem away? In Foster (2012) I argue that students' understanding and acceptance of evolution may be supported, rather than hindered, by classroom discussion of creationism. I suggest that censorship can inadvertently raise the status of creationism in students' eyes, thus hindering its exposure as a falsity. Attempts at suppression can make it easier for opponents of evolution to portray themselves as an attacked minority and the theory of evolution as some kind of conspiracy. If creationism cannot be talked about in science lessons, then it will be discussed elsewhere instead--the playground, the canteen, the religious studies classroom, the home, the church--places where it is unlikely to be challenged as effectively as it might be by a scientist.

In Foster (2012) I categorise creationism as a misconception and compare its treatment in the classroom with that of other scientific misconceptions. I advocate the use of socio-cognitive conflict, where students' ways of thinking are deliberately confronted by experiences that do not fit in with their current understanding, as a more authentically scientific approach. A very strongly-supported scientific explanation does not win the day by attempting to deny its opponents a voice but by engaging them with evidence. Lessons along such lines seek to cultivate in students a disposition to think critically. I disagree with those who suggest that students are too inexperienced or lack the necessary knowledge to reason scientifically about evolution. I regard it as essential for young people to be given opportunities to examine the facts for themselves and to see how the evidence supports some explanations but not others. We cannot regard young people as scientifically literate simply because they know some important scientific facts; they need to be able to make evidence-based scientific judgments for themselves.

None of this is to elevate creationism to the status of an alternative competing theory. In the history of science it has always been necessary for scientists to challenge superstition and false, "common sense" arguments. Many science teachers see part of their role as debunking pseudoscience, for instance. Scientific observations and theories inevitably stand in opposition to alternatives, and it is just as necessary to teach the negatives as it is to teach the positives: students need to know what is not supported as well as what is. Teaching about the errors of creationism can help students to understand the character of scientific inquiry better, both in and beyond the context of evolution. To expect students to suspend their critical faculties in school and become passive recipients of generally-accepted scientific wisdom would be the very antithesis of science!

Although a single conversation or lesson is unlikely to move a student from outright rejection of evolution to cheerful acceptance, stages such as uncertainty, peripheral belief change, and belief decrease may be viewed as educationally positive steps towards an eventual acceptance of the theory. To be in favour of discussing creationism in science lessons is not to be in favour of promoting it; on the contrary, creationism's demise will inevitably follow from its careful examination. Should the Holocaust "be taught" in history lessons? Should eugenics be taught in biology? To teach about these topics does not imply that they are good or correct! Many of the debates about whether creationism should be taught implicitly invoke a transmission model of teaching, in which the teacher is passing on facts to the students, who are accepting them on trust. So to "teach" something is to imply that it is valid. By contrast, a constructivist paradigm places the responsibility on the students to make sense of the evidence for themselves. From this perspective, presenting creationism as a case study can be seen as an opportunity for learning real science.

Reference

Foster, C. (2012). Creationism as a misconception: Socio-cognitive conflict in the teaching of evolution. *International Journal of Science Education*, *34*(14), 2171-2180.

Research in Brief

Research findings from key articles in reviewed publications

Improving Introductory Tertiary Lab Reports

By: William Morgan and Dean Fraga, College of Wooster, Wooster, OH, USA
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The best science courses teach students how to "do science," which includes clearly communicating one's findings in an efficient writing style and format. Given that introductory college/university students have little experience with scientific writing, it is not surprising that teaching this aspect of the scientific process can be especially challenging. A common teaching format is for students to submit a series of laboratory reports that are then reviewed and returned with extensive comments. However, students often exhibit little improvement from one assignment to the next. Furthermore, papers that reflect the least student effort typically require the most time by the instructor to critique. Morgan, Fraga, and Macauley (2011) describe a multipronged approach to help prepare and motivate students to write a scientific laboratory report.

The approach assesses student comprehension of the lab before report writing occurs, focuses instructor feedback on the most serious report-writing issues, and rewards early success. Given the difficulty of writing about something that one doesn't understand, students are first given feedback on their understanding of relevant material in the lab, based on their responses to short-answer "content" questions that are embedded within each lab (e.g., a question about the aim of the lab, asking students to analyze their results, asking what conclusion can be drawn). Students receive a numerical grade for their performance on these questions, as well as a color-coded classification as follows:

- *Green:* Proceed to writing your lab report.
- *Yellow:* Review the lab, possibly including discussion with an instructor, before writing your lab report.
- *Red:* Suggest you do not write a lab report.

The instructor then critiques the submitted laboratory reports using a prioritized feedback scheme that provides each student with feedback using the following sections in order: results, discussion, introduction, title, abstract, method, paragraph construction, sentence structure, grammar, language. The review of a lab report is terminated with the first unsatisfactory section and a prioritized review form is returned to the student with suggestions for improving this section. Rather than overwhelming students with a blizzard of critical comments, this approach seeks to improve student writing by addressing the most serious writing difficulties while allowing faculty to use their time efficiently.

Finally, an all-or-nothing grading scheme was developed to motivate students by rewarding their efforts. The first time a student submits an "A-quality" report he or she receives the full 5% credit for this part of the course and is excused from writing additional reports (although all students are still required to submit answers to the content questions for all labs). However, if a student never succeeds in preparing an A-quality report during the course, no credit is given for this part of the course.

The pilot study of biology students suggested that the simple change in course structure, combined with the all-or-nothing grading scheme, could improve the quality of lab-report writing and increase students' motivation to write effectively, at least as measured by the assigned grades. First, more students were able to write an A-quality report than students in courses using the traditional format. Second, an in-class survey suggested that students were more motivated to write their lab reports at an A-level. Faculty noted that while the class success rate was higher with this new approach, the faculty workload was reduced, since fewer lab reports needed to be evaluated and those students who attempted the report had better mastery of the relevant content. Finally, the instructors were able to give more directed feedback and assistance to those students who most needed help.

Reference

Morgan, W., Fraga, D., & Macauley, W. J., Jr. (2011). An integrated approach to improve the scientific writing of introductory biology students. *The American Biology Teacher*, *73*(3), 149-153.

Schoolchildren's use of Poetry and Paintings in Conveying Environmental Messages

By: Susan Gebbels, Newcastle University, Newcastle upon Tyne, UK susan.gebbels@ncl.ac.uk

There are several challenges that the natural world faces today; for example, climate change, energy security, marine pollution, and overfishing. Yet, despite much press and media coverage, the majority of people still only vaguely understand scientific problems. An explanation for this apparent lack of understanding is that science is frequently communicated using rather dry, uninteresting methods such as the scientific report, the academic conference, and the late-night debate. With technology and science evolving faster than ever before, it has never been more important to communicate new ideas and concepts to the public and young people in a meaningful yet lucid way.

Watts (2001) has argued that it is necessary to move beyond the customary curricular constraints within schools. He suggests that school science can be both a scientific and literary experience and highlights the power of poetry in stimulating observation, imagination, and emotion in school science. Kempton (2004) recommends the use of paintings and cartoons to teach ethics in science, and Francis (2007) found that drama-based science lessons have positive impacts on both attainment and attitudes in science lessons. In Gebbels, Hunter, Nunoo, Tagoe, and Evans (2012), we explored the possibility that young people have the talent and motivation to use art forms, in this case poems and paintings, to communicate views and information on the environment and biological world to wider audiences.

The project is based on a programme of environmental education, focussing on the effects of climate change on Ghana, in particular the coastal zone of that country. It was taught at the University of Ghana Primary and Junior High School. Pupils took part in a series of science-orientated workshops based on the topic, visited a range of coastal areas around Accra, and took part in a debate. The pupils had little knowledge about climate change, or the flora and fauna of their local coastal environments, prior to the start of the project. Each pupil was asked to compose a poem and make a painting as a means of expressing their feelings about the effects of climate change on the coastal environment.

Paintings and poems were used in the teaching programme because they were a means of communication that the students could relate to and they utilised skills that they already had. The finished paintings and poems were mounted and displayed on boards that were placed outside in the school grounds so the whole school, visitors, and parents could view the art. Members of the wider school community were invited to an outdoor assembly where the University of Ghana's Dean of Science was the guest speaker. Two children gave an overview of the teaching programme and several pupils read out their poems. The local media covered the story and articles appeared in two papers; one a national, publicly-owned newspaper and the other a popular, privately-owned newspaper. This coverage allowed the children's messages to reach an even larger audience.

When the researchers returned to the United Kingdom, all the poems and paintings were subjected to content analysis. Poems were scanned for the use of words that conveyed specific messages, referred to as descriptors. In the case of poems, descriptors were words of five different kinds:

- Positive descriptors, such as beauty or enjoyment.
- Negative descriptors, such as pollution or degradation.
- Descriptors with religious, national, or global meanings.
- Descriptors that attributed environmental responsibilities to particular groups of people.
- Descriptors that recommended particular actions with regards to the environment.

In the case of paintings, descriptors were images within the painting. Both positive (wildlife) and negative (agents causing pollution) descriptors (images) were identified. As with the poems, content analysis was based on the frequency with which descriptors appeared. Images were also used to convey uses of the seas (e.g., boating). Since use of colour was feasible, attention was given to the use of colours used for the sea, sand, clouds, sky, and sun. Analyses of both poems and paintings focussed on content, literary, or artistic merits were ignored.

The poems and paintings produced by the Ghanaian schoolchildren contained a range of different environmental messages. Content analysis of both revealed that particular themes or messages tended to recur in them. There were nevertheless differences in the ways in which these two art forms were used to convey messages. Both of them depicted the negative impacts of pollution and habitat degradation, which reflected the current state of the coastal area of Accra. Poems also used words to stress the national importance of the seas, their value as assets of God's creation, and the need for actions, such as everyone working together in order to manage them at sustainable levels. Paintings, on the other hand, used images to identify specific causes of pollution and to illustrate the uses of the seas. There was an unexpected emphasis on pollution, rather than climate change, in the paintings, probably because pupils had difficulties in creating images of climate change, which is an abstract concept.

Feedback from the school children, their parents, and the wider community was very positive. The researchers concluded that poems and songs are particularly powerful tools of communication to non-specialists because they can convey messages in forms that are far more palatable and persuasive to the general public than a scientific report or a media interview. There is no doubt that young people have the potential to influence environmental attitudes and the behaviour of adults in positive ways (Liu & Kaplan, 2006; Nunoo & Evans, 2007), and the creative arts provide one means by which they can do so. Studies by Ballantyne, Fien, and Packer (2001) and Vaughan, Gack, Soloranzano, and Ray (2003) found drama and art to be successful tools in raising paternal awareness of conservation issues. When science meets art and the two work together, the result can be extraordinarily productive, as gaps in our understanding are filled and new ways of expressing problems and communicating with people are established. The Arts can provide a different view point from which we can understand science, and it is a perspective that young people have the power and passion to show us.

References

Ballantyne, R., Fien, J., & Packer, J. (2001). School environmental education programme impacts upon student and family learning: A case study analysis. *Environmental Education Research*, *7*, 23-37.

Francis, M. (2007). The impact of drama on pupils' learning in science. *School Science Review*, *89*, 91-102.

Gebbels, S., Hunter, J., Nunoo, F. K. E., Tagoe, E., & Evans, S. M. (2012). *Journal of Biological Education*, *46*(2), 93-103.

Kempton, T. (2004). Using paintings and cartoons to teach ethics in science. *School Science Review*, *86*, 75-82.

Liu, S-T., & Kaplan, M. S. (2006). An intergenerational approach for enriching children's environmental attitudes and knowledge. *Applied Environmental Education and Communication*, *5*, 9-20.

Nunoo, F. K. E., & Evans, S. M. (2007). Citizenship in a Ghanaian school: Students' contribution to sustainable management of the coastal environment. *School Science Review*, *88*, 107-114.

Vaughan, C., Gack, J., Soloranzano, H., & Ray, R. (2003). The effect of environmental education on school children, their parents and community members: A study of intergenerational learning and intercommunity learning. *The Journal of Environmental Education, 34* (3), 12-21.

Watts, M. (2001). Science and poetry: Passion v. prescription in school science? *International Journal of Science Education*, *23*, 197-208.

Readers' Forum

Does "Hands-On" Indicate Real Reforms of Science Teaching?

Too often the reform of science for K-12 students is described as being "hands-on." Analyses of the hands-on ideas for classrooms seem to miss how and why hands-on actually do not define needed reforms adequately. Hands-on often become merely directions students are expected to follow! Teacher directions also often refer to specific information included in textbooks or those found in laboratory manuals. Students are left out in terms of why their hands are to be used! They are not expected to think; just to do what they are told.

Do students really need to be directed and/or encouraged to use their hands; and, for what purpose? Are "hands" basic for "doing" science? What about thinking and questioning?

It seems once again that teachers, administrators, parents, and even NSTA members are only looking for quick fixes and things to keep students involved with their muscles and hands. There seems to be no real concerns for student thinking and/or their use of the ideas suggested for responding to their own questions. Further, there is rarely any attempt to relate the hands-on ideas to the real nature of science itself.

Certainly not many scientists would indicate their work is related to their hands. Most need (and often develop) tools to test their ideas. But, they are not "directed" to do this! Hands-on misses vital ingredients of science envisioned by most current reforms!

Science starts with humans exploring the things encountered in nature. One uniqueness of humans is their interest in exploring the natural world. It is there to be explored! All humans, even when still in the mother's womb, react to the objects, conditions, and events that they encounter. The human mind cannot be stopped until death.

Most love to do things with their hands, but it often has nothing to do with exploring nature. Some parents encourage children to play with toys. Too often, though, they are not encouraged to explore more deeply and/or to formulate questions, express interests, or suggest evidence that can be used to support their ideas and explanations.

Why is it so hard to encourage teachers to ask students, and encourage them, to investigate, to offer ideas, and to interact with especially other students as well as with parents and local "experts" concerning their ideas?

If reforms are to be realized, we need to encourage more student ideas that are followed with questions about their validity and usefulness. These should also lead to a consideration of them in conjunction with ideas from others. Science is not like art in this respect! It requires collaboration!

Everyone, especially students in science classes, should be encouraged to question, to follow-up with evidence to support their ideas, to evaluate each idea for its validity, to consider other explanations, and to share all ideas with others. Hands-on may be needed to develop tools to investigate student ideas. They might be of use in terms of evidence that can be offered. Evaluating the differences of the ideas from other students is part of science itself. It is what scientists do! Often collecting evidence involves technology, not science!

Professional scientists start with questions--not playing with tools. They do not start with directions described and/or actions suggested by others. Most often, hands-on means doing what teachers, texts, and laboratory manuals suggest. The focus of science in classrooms is too often only words and explanations advocated by others. Teachers rarely encourage debate about questions or the collection of evidence to validate the answers offered. Learning of real science does not happen if teachers or instructional materials continue to push for more hands-on efforts on the assumption that such acts exemplify science; instead, there should be more attention to defining the actions needed and portraying what science actually is! In fact, hands-on directions may hinder the learning and practice of real science!

Robert E. Yager, University of Iowa, Iowa, USA

? ? ? ? ? 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!

Static Electric Discharge

Can you suggest an acceptable, reliable way to demonstrate the discharge of a static charge through a group of students in the classroom? I am looking to use this demonstration as part of a treatment of the effects of electricity on muscles and am thinking that an effect students can feel without being exposed to excessive pain and a group of students holding hands, say, would produce a touch of theatre! Some use the discharge from a Leyden jar that has skilfully been charged only a little, but this demonstration appears to be unacceptable in some educational jurisdictions.

The Van der Graaff generator gives a safe spark. You can test it by keeping the small dome between 5 and 10 mm away from the large dome that gets charged up. Once the static charge voltage is high enough the spark will discharge to the small dome. On humid days you may have to dry and warm the generator using a hair dryer.

Keep the small dome 10 mm away so that if the voltage gets too high it will discharge safely. Gradually bring your knuckle close to the large dome to receive the spark. Using a knuckle is preferable to using an out-stretched finger, which can be quite painful. Once everything is working, line the pupils in a row, making sure they are standing on plastic or that their shoes are good insulators. They hold hands (yuk!) and the last pupil places his/her hand on the base of the Van der Graaff machine. You hold the first pupil's hand and receive the spark with your free hand, via the knuckle. Voilà!

Keith Ross, France

(*Editor:* I see that Silicon Van de Graaff generator belts, which don't absorb atmospheric moisture, are now being advertised in Australia and should give better all-year-round performance. The teacher could be left out of the line by asking the first pupil to hold the wire on one end of a length of insulated wire and having the teacher, while holding the insulation, move the other end of the wire towards the dome. Finally, for even more drama, perhaps a leg of the last student could be earthed rather than a hand. While the short-lived current will pass through the upper bodies only of all but the last student, this last student will experience a current through both the upper and lower parts of his or her body, which may be a tad more uncomfortable!)

In the past, I have had brave students line up holding hands while standing on insulating 1" x 6" lumber. The first student places her hand on a 400 000-V Van de Graaff generator. The string of hands clasped together extended into the hallway where an unsuspecting passerby got an uplifting high five! This works well during winter when air is drier.

Chuck Fidler, Wheelock College, Boston, MA, USA

(*Editor:* Please find the warning about this student configuration in the next response.)

Sorry to put a downer on the idea, but advice we give to trainee teachers in the United Kingdom is not, under any circumstances, to charge up a group of students in the way that we used to do in a less safety-conscious era. The logic, as I understand it, is that a group of students can act like a human capacitor and any latecomer to the chain may get the full "benefit" of the charge accumulated.

John Twidle, Loughborough University, UK

(*Editor:* Interested readers may wish to research body capacitance, a concept with which science teachers do not appear to be typically aware.)

Newton's Third Law

What activity might I use, during the exploration phase of the learning cycle, to allow students to investigate Newton's Third Law?

A good way for students to explore Newton's third law is with a tug of war. Use fairly heavy-duty spring scales (20 N or more), have the students connect two, and then pull. One student should pull and then the other. Students should pull while walking as well as standing still. Various methods of attaching the two scales should be used; directly hooking the two together, string, rubber band, stiff spring.

However, my favorite version of this is to use computer-based, real-time measurement of the tug of war using force sensors (available from PASCO or Vernier). This requires that you have the equipment or the budget, but when done properly this clearly shows that point-by-point Newton's 3^{rd} always holds. A good lab experiment of this type has been written up in *RealTime Physics: Module 1* by Sokoloff, Thornton, and Laws (Wiley, ISBN 978-0-471-48770-8).

A less expensive demonstration would be to have the students compare the motion of a fan cart with sail (Arbor Scientific P4-1986, $19) with a clip from a Warner Brothers Road Runner Cartoon.

Joseph J. Calabrese, DeVry University, Columbus, OH, USA

Please see the article by Uri Haber-Schaim in the newsletter at http://www.sci-ips.com/pdf/reflections/Reflections_36.pdf .

Harold Pratt, Educational Consultants Inc., Littleton, CO, USA

Laboratory Safety Guidelines

This section presents a series of 40 laboratory safety guidelines kindly provided by Dr James A. Kaufman, President, The Laboratory Safety Institute (LSI), USA. Please visit http://www.labsafety.org for further information, products, services, and publications.

#18 of 40. *Forbid Smoking, Eating, and Drinking in the Laboratory*

The practice of forbidding smoking, eating, and drinking in laboratories is one of the basic good hygiene practices. Unfortunately, it is often one of the most frequently disregarded. Too many people seem to have a "good reason" for continuing these bad habits. None of these reasons are good enough.

These practices protect people in laboratories from ingesting toxic chemicals or infectious materials. The stuff that's on your hands ends up in your mouth. I've watched science department heads drink coffee while supervising the lab. I've seen teachers make stir-fried vegetables in a wok in the lab between classes for lunch. Don't do it. Set a good example yourself and enforce the rules.

Set up a separate area that can be used for taking breaks, making coffee, and consuming food. Don't allow it in the lab. And that includes applying cosmetics, too. It's not only a bad practice but it is also against the law. Two OSHA regulations speak specifically to this unfortunately widespread practice. One is the bloodborne pathogens standard, 29CFR1910.1030. The other is the sanitation standard, 29CFR1910.141(g)2/4.

There are many worthwhile experiments that involve eating something. For example, teaching colligative properties by making ice cream. Take your students to the cafeteria, use paper plates and plastic utensils, and teach your students about safe practices at the same time. Remember, safety is a teachable moment. Also remember that Pierce College in Tacoma, Washington, USA was sued for $2.5 million dollars following the death of a young woman. She drank a saline solution as part of an Anatomy and Physiology class. It contained sodium azide as a preservative. She died 4 days later.

Many laboratory have ice machines. They should be clearly labeled: "This Ice is Not for Human Consumption." A 35-page *Laboratory and Occupational Safety Bibliography* of health and safety references is available from LSI for $10.00.

Further Useful Resources

Modeling Earth's Climate (Available from http://concord.org/projects/high-adventure-science) Free software to allow students to explore how adjusting variables in a dynamic model affects the entire system.

TED-Ed: Lessons Worth Sharing (http://ed.ted.com/) Use prepared lessons, and/or create customized ones, around videos.

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Contributions are welcome, as are expressions of interest in joining the Editorial Review Board. The latter role requires the periodic review of submitted contributions, and is not onerous. Comments, questions, and article proposals may be sent to The Editor, Dr Peter H. Eastwell, at editor@ScienceEducationReview.com .

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