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ABSTRACT

One way of making scientific concepts more accessible to students is to use active approaches, such as drama, in the classroom. The study reported in this paper evaluates the use of three dramatic improvisations performed by second year undergraduate students to improve their understanding of the generation and supply of electricity. Student improvisations were videotaped, and follow-up questionnaires and interviews were used in the study. The pedagogical advantages of using active learning in the classroom and the wider issues of drama's contribution to cognitive development are also discussed. (Contains 20 references.) (WRM)

Using Drama to Improve Student Teachers' Understanding in the Physical Sciences

by
M.R. Braund

USING DRAMA TO IMPROVE STUDENT TEACHERS' UNDERSTANDING IN THE PHYSICAL SCIENCES

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ABSTRACT

Teacher trainers are under increasing pressure to improve students' understanding in the physical sciences. This pressure is associated with changes deriving from circular 4/98 (DfEE,1998) and in particular the imposition of a national curriculum for teacher training in science. Many entrants at undergraduate level, however, have previously experienced problems with their understanding of concepts in the physical sciences. This is particularly true for students entering teacher training courses from 'access' or other non -'A' level routes.

One way of making concepts more accessible to students, for whom more traditional methods of teaching have previously failed, is to use more active approaches such as drama. The study reported in this paper evaluates three improvisations used by second year BA (with QTS) students to improve their understanding of the generation and supply of electricity. Student improvisations were videotaped and evidence from this and follow-up questionnaires and interviews is used to promote the method used as a very effective learning tool. The pedagogical advantages in terms of using active learning in the classroom and the wider issues of drama's contribution to cognitive development are also discussed.

As part of the UK government's push to improve the standards of entrants to teaching, the Teacher Training Agency (TTA) has introduced a statutory national curriculum for trainees in the 'core' subjects (english, mathematics, science and ICT- information and communications technology). This curriculum defines the subject knowledge that trainees must demonstrate to gain Qualified Teacher Status (QTS). For science the level of knowledge and understanding required is at least equivalent to level 8, in national curriculum terms, and in many cases assumes detailed understanding of concepts beyond this. In addition it is expected that trainee teachers following a science specialist course, as part of their degree, will show a level of understanding in relation to the science contained within the national curriculum programmes of study 'at least equivalent to 'A'- level' (DfEE,1998).

Contructivist research over the last 20 years has shown that many students studying science (including those studying for the highest level qualifications) have major problems in coming to terms with concepts particularly in aspects of physics such as Newtonian principles of force and the ideas associated with current electricity (Driver *et. al.*,1994).

It has been shown that primary teachers feel less confident with their knowledge in science than in other subjects and this has been linked with the lack of educational background in science both at school and in training courses (Harlen *et. al.*, 1995). We might expect that the school experience of science for recruits to teacher training courses in recent years has improved since the introduction of 'balanced science for all' and the national curriculum – but experience shows otherwise. Many new entrants to BA(with QTS) and PGCE programmes still bring negative images of their secondary school science experience with them. A vital part of the trainer's job is to tackle these attitudes, allay fears and turn the study and practice of science into a positive learning experience. We must also bear in mind that an increasing number of students entering Initial Teacher Training (ITT) courses come through non-traditional, non - 'A' level routes. Many of these students are of an age (and gender) where their secondary schooling is less likely to have included any formal education in physical sciences after the age of 14. The proportion of these students entering BA(with QTS) courses with Environmental Science as a specialist subject at Bretton Hall in 1998 was 27%.

Putting all these points together makes the prospect for assuring the standard of students' knowledge and understanding in physical sciences demanded by the TTA, at first sight, seem bleak. Science educators, however, are drawn largely from the ranks of teachers and advisors who have practised and researched a wide variety of methods to put over the hard ideas of science. I would argue that the most successful methods rely heavily on a high degree of engagement and interaction by learners – in this sense they are strategies often referred to as 'active'. In this paper I shall concentrate on an approach that uses a form of drama. I shall show how the approach can be used to address student teachers' understanding of concepts associated with the generation and supply of electricity.

A JUSTIFICATION FOR THE USE OF ACTIVE LEARNING AND SPECIFICALLY DRAMA IN SCIENCE LEARNING

Science is often seen as hard to understand because many of its core ideas are abstract and more remote from the learner than in other areas of the curriculum. The tradition, over many years, has been to use practical work to make ideas more concrete; but the purposes and methods of laboratory work have been criticised for adding to the confusion (see for example Hodson, 1990).

During the late 1970s and 1980s a number of approaches to science learning loosely termed 'active learning' gained favour. A prominent review of science education (The Secondary Science Curriculum Review - SSCR) even suggested that active and self-directed learning methods should become the norm for science work (SSCR, 1987).

Another prominent group, compiling a set of resources demonstrating these methods, justified active learning in science thus:

> *'Active learning techniques frequently can enable students to attain a higher level of understanding in science than with traditional passive learning approaches. The key to this is a sense of ownership and personal involvement that active learning creates. Students see their work as important because they feel important and their ideas and findings are valued. Student satisfaction is enhanced and there is greater motivation'*
>
> (Harrison, Hudson, and Williams, 1992. P.6)

As for drama, the claim has been made that it helps learners to make their ideas explicit and in this sense has relevance as a method that teachers might use in almost any area of the curriculum (HMI, 1989; Arts Council, 1992). One of the great doyens of drama education, Dorothy Heathcote, went much further claiming that the challenges involved in creating drama stimulate left brain activity and hence scientific functioning (Wagner, 1979). Evidence from neurological research into brain function supports the view that creative (right hemispheral) activity contributes to general cognitive ability (Gazzaninga, 1989).

Specific ways in which drama might contribute to the learning of science began to filter into the literature accompanying the introduction of the National Curriculum as this quote from the non-statutory guidance for science issued to teachers in 1989 shows:

> *"When pupils act out incidents the experience can help them to remember and learn more effectively. It (drama) can also be useful for stimulating the different social conditions in which science ideas arose and motivate those pupils whose special talents are not usually employed in science lessons."*
>
> (NCC, 1989 Section C16, 9.3)

Most of the literature exemplifying cases where drama can help the learning of science refers to types of drama that allow pupils to explore science concepts and issues through acting in roles relating to stories, scenarios, or simulations of events. This type of drama is often referred to as 'role playing', although the use of terms in this area of education is notoriously confusing and contradictory (Jones, 1988).

The drama used by the student teachers in the study reported here is not of this type. It is really a case of r 'acting out'; a type of improvisation where the concepts and processes of science are explored, modelled and made explicit through acting, mime, dance and movement, sometimes aided by narration and use of costume and props.

THE METHODS USED

Background of students involved in the study

Thirty-seven second year environmental science students were involved in presentations using drama. They were studying for the BA (with qualified teacher status) degree at Bretton Hall College, Wakefield and were engaged in a module of their subject specialism course dealing with energy and energy resources. It should be noted that, whilst these students are termed 'specialists', in the sense that a major part of their degree course is science based, their entry qualifications do not often include any formal experience in the physical sciences. A quarter of the students involved had entered Higher Education through non-standard 'A' level routes (e.g. from Access, GNVQ and BTEC courses). These students (mainly females) were also classed as mature (aged over 24) and so, as stated previously, are unlikely to have had much teaching in the physical sciences after the age of 14.

The contexts

Three context domains for presentations were set up. These were related to aspects of circuit electricity, its generation and supply. Each domain was accompanied by a set of materials that could be used to support students' learning and aid discussion; guided practical work was included. Students were also given a set of concepts and key ideas to include in their presentations. An example of the materials used (for '*the generation game*') can be seen in appendix 1. It should be noted that the practical work associated with these tasks is largely derived from standard illustrative exercises described in Key Stage 4 and sixth form texts.

Students were also given a sheet describing a number of techniques commonly used to structure and support improvisations (appendix 2). Some discussion of these approaches took place before students embarked on practical work and preparation of their improvisations. After each presentation time was provided for reflection and for the tutor to talk through (debrief) improvisations. Students could also question other groups or ask them to 'replay' scenes from their presentations and explain their actions.

Methods of analysis

Nine groups gave presentations; three in each context domain. Each group's presentation was videotaped for further analysis. Following the presentations every student was given a questionnaire eliciting their views on the methods and materials used and perceptions of gains in their understanding of the concepts. Three in-depth interviews were also conducted after the questionnaire had been collected and these were also videotaped for further analysis.

Video evidence was used to analyse students' improvisations in terms of the range of techniques applied.

FINDINGS

Techniques used by students

All groups used a wide variety of techniques in their drama. Hand movements, small scale mime and movement or dance featured strongly in the presentations for *What is a Watt?* and *The Generation Game.* These techniques were generally applied very effectively. To demonstrate a battery charging electrons, for example, two students used pit-a-cake, pat-a-cake movements with their hands. Another group modelled the energy levels of transformed voltages using undulating movements of their arms as they 'danced' around the laboratory.

Props proved useful in nearly all improvisations. Bulbs, electrons, magnets, 'packets of charge' were all represented by various cut-outs, symbols and cards. One group showed transformed voltages in power lines using currants poured down different lengths of card tube and so were able to add a quantitative dimension to their explanation. Costume/dressing-up also featured strongly and in one case was used in the opposite sense, i.e. striptease! In this group students decided to show energy transferred and 'lost' to the system as heat for different wattage's of bulbs by progressively divesting themselves of various layers of clothing as they 'travelled' through the bulb's filament. Two groups included formal presentations of ideas using posters or overhead projector transparencies (OHTs).

One item in the questionnaire asked students to rate the value of practical work used to help understanding prior to preparation of the drama. Interestingly the groups that relied most heavily on presented information also admitted that they had problems with carrying out the practical work or rejected it altogether. A group using a wide variety of techniques and presenting one of the most competent and scientifically accurate explanations, claimed the practical work was especially helpful to them. It seems that, for some students, practical work may be generally beneficial in that it has helped to provide a concrete reference point for improvisation. This effect has been noted before in student role plays where the structure has been called a 'two-tier event' (Jones, *op.cit.*).

Students' perception of drama as a way of learning science

Five categories of response were available on the questionnaire for students to rate their own learning gains. The results are shown as table 1 below.

TABLE 1
STUDENTS' PERCEPTIONS OF LEARNING GAINS

The first figure shows the number of students (frequency). The second figure in brackets shows the percentage of students presenting drama in each context.

Total number of students involved = 37

	Category 1	Category 2	Category 3	Category 4	Category 5
	Major gains	Significant gains	Some gain	No gain/same	less understanding
CONTEXTS **What is a Watt?:** (N=13)	3 (23%)	5 (38%)	4 (31%)	1 (8%)	-
The Generation Game (N=12)	-	2 (17%)	9 (75%)	1 (8%)	-
Power to the People (N=12)	-	8 (67)	4 (33)	-	-
Total of all students (N=12)	3 (8%)	15 (40%)	17 (46%)	2 (6%)	-

Virtually all students (97%) felt their understanding of the science had been advanced and almost half (48%) said that gains were major or significant. The most positive views on gains, however, were not uniformly distributed across all three context domains. Students carrying out the *Generation Game* felt generally less positive about gains than in the other two areas. The reasons for this were not the same for all groups. In follow-up interviews some students claimed that the drama in this domain did not add to learning from practical work because it was too simplistic whilst on the other hand another group felt that ideas were too abstract to portray clearly. Nearly two thirds of students (65%) felt that the methods used were preferable to 'conventional' leaning (i.e. through lectures, IT and information based independent learning or laboratory practical work).

Students generally valued the chance to learn from other groups' dramas as well as from their own. As one of the students interviewed put it:

> *"You can understand a lot from other groups' presentations ... you can see what they have gone through to explain the ideas because you have been there yourself."*

DISCUSSION

For most of these students this method has been both popular and fruitful in terms of improving their understanding, though I have no test-based, empirical evidence to confirm their opinions! What these students have done, in effect, is to enact analogies or simulations that help them link abstract and 'difficult' ideas with familiar and understandable reality. Research on the use of analogies in understanding physics with secondary school pupils has shown that enactment of the analogies adds extra power to the learning (Van den Berg and Grosheide, 1997). It is even claimed that students remember the analogy ***and*** the science two years later! There is also some evidence of a gender effect; that girls prefer active learning strategies in learning physics (Ramsden, 1990). This has particular significance in primary ITT generally and in this cohort specifically as most recruits to courses are women.

We should also remember that learners too have preferred methods of understanding. Some recent research carried out with pupils across the secondary age range shows that whilst many pupils are well disposed to creative methods, these do not figure significantly in the diet of teaching offered to them (Taylor, 1997). This mismatch between teaching method and preferred learning style is probably one of the reasons why pupils (and maybe some of the students in this study) often see the physical sciences as too demanding, remote, irrelevant or unexciting (OFSTED, 1995).

It is not only a question of whether these methods helped students acquire and understand the science here (possibly for the first time).There are additional benefits for student teachers as learners and these are concerned with enhancing professional experience and pedagogical knowledge. Students on secondary PGCE courses have commented on the value to their own development as intending teachers of using active approaches on teaching practice (Williams, Murray and Poole, 1992). It is to be hoped that the values given to the methods and so clearly articulated by students will influence their classroom practice. Drama is just one of the many examples of ways in which the abstract ideas in science can be made accessible to pupils. As such it contributes to a student teacher's professional 'toolkit' of strategies. If students can see the advantages of using these methods in their own learning of science, then they are more likely to see the value for children and adopt similar techniques in their teaching.

CONCLUSION

Understanding the abstract nature of science and the many difficult ideas of physics demands considerable mental effort from students in teacher training as it does for all learners of science. If science education is largely about tackling the abstract and solving problems, then drama should have its place in every science teacher's 'toolkit' of approaches. As Frank Smith sees it, creativeness adds extra "explanatory brain power" (Smith, 1992).

Active approaches that engage the intellect but in enjoyable, non-threatening ways should play a much larger part in science education generally and so feature in higher education courses as well. The shortages of physical science students entering further and higher education and the problems of poor science background of primary teachers will not be resolved easily, yet they must be tackled if the nation's drive for improved standards are to be realised.

We must not allow the requirement for learning so much scientific knowledge in teacher education courses drive us into designing a curriculum based on the failed didactic and passive learning modes used in the past and experienced by many students entering teacher training courses. Attitudes of student teachers to their own science learning influence their teaching of science in the classroom (Bentley, 1996) and so it is important that student teachers see scientific study as one where a wide range of creative and active approaches to learning is valued.

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APPENDIX 1

SUPPORTING ACTIVITIES AND KEY CONCEPTS USED IN 'THE GENERATION GAME'

1. If a wire is moved through a magnetic field, electrons are induced to flow along the wire as a current. The current only flows as the wire is moving. The current can be measured using a galvanometer.

   Explore this effect using the equipment provided.

2. A current can also be induced in a coil of wire by moving a magnet and keeping the coil still. Explore factors that might affect the amount of current induced e.g. strength of the magnetic field, number of turns in the coil, the speed of movement.

   Try this using the equipment provided.

3. In a power station electricity is generated by spinning a magnet inside fixed coils of wire. The rate of spin must be kept constant to maintain a frequency of 50 Hertz (Hz). If the demand for electricity is increased, the turbine has to work harder to maintain this constant spin.

   Try turning the cycle dynamo provided with and without a bulb connected and with bulbs of different voltages. How does this affect the effort required to turn the handle?

Your Task:

Demonstrate how a flow of electrons is induced in a coil and the factors that affect output voltage from a generator.

OR ...

Explain why and how the power station must maintain the speed of spin of the rotor as demand for electricity changes.

The Generation Game - Key concepts:

You should aim to include in your drama as many of the key concepts/terms listed below as you can. Plan to help others in the group understand the ideas by relating them to tangible/visible objects, personalities or events or by using your own body movements. Refer to the drama techniques sheet (Appendix 2) to give you ideas for your presentation.

Magnet and coils	
Electrons	
Current:	the rate at which electrons move in a wire/coil;
Voltage:	the amount of energy or force/push given to electrons;
Rotor:	the magnet spinning inside a generator;
Stator:	the coils surrounding the rotor in which electrical current is induced;
Generator:	a combination of rotor and stator;
Supply and demand:	as more electricity is changed into other forms in homes the amount of energy changed in the power station also has to increase to maintain the spin of the rotors (i.e. more fuel has to be used)

APPENDIX 2

TECHNIQUES THAT CAN BE USED IN IMPROVISED SCIENCE DRAMA

These are some of the techniques that can be used to heighten the effect of your presentations. You are not engaged in the production of a polished piece of theatre, more in applying techniques that help you to explain the science. Simplicity and clarity are the key to powerful explanations.

Narrator:

A useful way to introduce characters, action and to move the story of the process along. The narrator can be used to link parts of the drama, fill in missing information or to move time and place; e.g. "meanwhile at the power station ..."; "Just a few milliseconds later ..."

Mime:

Useful in portraying actions or processes; e.g.the behaviour of electrons, movements of magnets, rotors etc. A 'voice over' can be effective to explain more obscure mimed actions.

Movement/dance:

'Actors' portraying action on a larger scale e.g. flow of electrons around circuits, along power lines etc. Use of props/costume:

Simple props e.g. paper, card, tennis balls, plastic cups are useful to help the audience visualise what is going on. Sound effects can be added to emphasise points in the drama. Props/costume can be over-used if they distract the audience and obscure the main points of the presentation.

Freeze frame:

This helps to stop the action at a particular point. This technique can be used with voice over or the audience can stop the action so that points in the process can be explored. The technique can also be used to start or conclude a drama as in a still photograph or tableau.

Flash-back or rewind:

Often used to remind the audience of steps in a process or the previous actions of players. 'Flash-forward' can also be used but could be confusing if used too much.

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