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ABSTRACT

Four papers to be used in conjunction with video-tapes developed by the Learning in Science Project are presented. Topic areas of the papers focus on: (1) animals; (2) electric current; (3) force; and (4) science activities. The first paper presents transcripts of class discussions focusing on the scientific meaning of the word animal. The second paper includes excerpts from three interviews where 11-year-old children were asked about their ideas regarding electric currents in a simple electrical circuit, summary of children's ideas about electrical currents, and a sample lesson taking into account their ideas. The third paper includes discussions of scientists'/children's ideas about force, excerpts from interviews with children on their ideas of force, and lessons designed to modify children's views of scientists' views. Presented in the fourth paper are: excerpts from interviews with children designed to provide insight into their views about what happens when a crystal is dissolved in water; an activity involving the dissolving of crystals in water (which makes unfounded assumptions about the ideas children bring with them to the lesson); and an alternative approach to the same lesson where an attempt is made to take the children's views into account. (JN)

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LEARNING IN SCIENCE PROJECT

VIDEO : ANIMALS

University of Waikato
Hamilton N. Z.

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WORKING PAPER No. 51

VIDEO: ANIMALS

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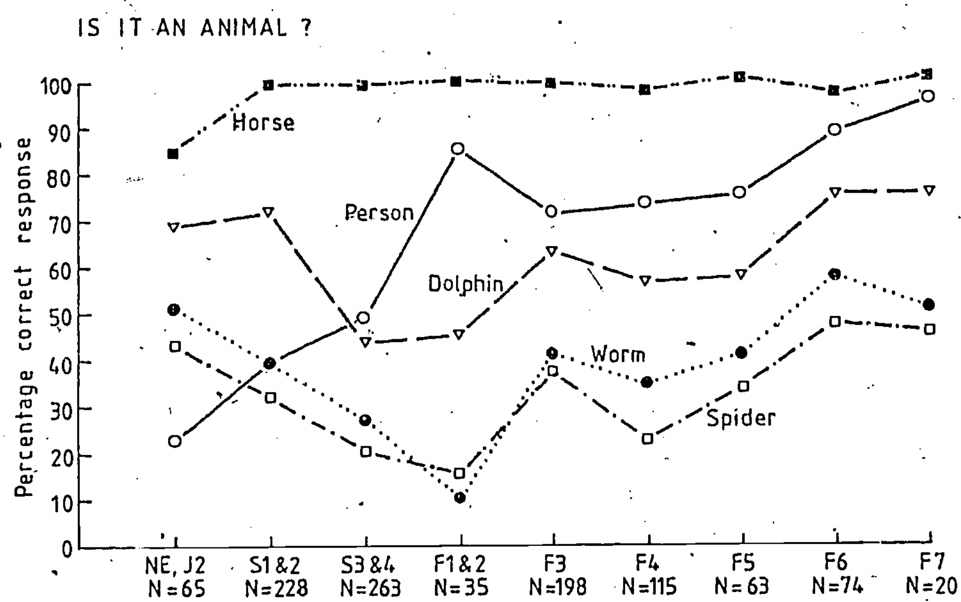
This paper is designed to be used in association with the video-tape "Animal" prepared by the author.

INTRODUCTION

In the last two years we have spoken to students about their meaning of the word 'animal'. Most students have a much narrower meaning of the word animal than a scientist. For example they consider cows, horses, dogs and cats to be animals, but not spiders, insects and worms. The reasons they use to classify something as an animal or not, are things like the number of legs, fur, where it lives and size. But we as adults, often use this narrower meaning in an everyday sense. For example, a shop sign "No animals allowed", cannot be interpreted in the scientific sense if we are wanting to enter and buy food. How widespread is this use of this narrower and everyday meaning of the word animal?



A survey was given to a cross-section of students aged from 5-17, that is new entrants to Form 6 and 7 biology students. They were required to classify a horse, person, a worm, a spider and a dolphin as an animal or not. To a biologist these are all animals. The graph indicates the percentage of students who also consider them to be animals. More students considered the horse to be an animal, but 50% or less considered the worm and spider to be animals, even at Form 6 and 7 level. One explanation might be that teachers have assumed that students use the scientific meaning of the word animal in classrooms, and therefore have not focused their teaching on the word animal. The Learning in Science Project has developed a set of teaching activities to focus on the scientific meaning of the word animal.

CLASS DISCUSSION

Teacher "First of all this afternoon we are going to concentrate on the word animal; animal, have you heard the word before? Can I have some examples from you of animals? What things are ... some of those things that we call animals?" ("Mammals ...") "Yes, any others ... some examples ... what's an animal to you?" ("People are animals.") "Okay, yes." ("Cow.") "Cow." ("Birds.") "Birds." ("Fish.") "Okay. Fine, well we have got an idea of the kind of thing that animals are about. Now what I want you to do now in your small groups, is I've got a set of cards here with a whole lot of different things on them, pictures.[1] What I would like you to do, is in your groups just sort them into two piles ... those things which are animals, and those things which are not animals. Into two piles ... animals and not animals. Now I don't want you to place a card in a pile until everyone in the group agrees with where it's going. You have got to get a group decision about whether to put each of these things on the animal or non-animal piles. Now if you don't agree with the rest of the group, then say so and you have got to sort it out between you, okay?"

GROUP 1:

P1. [Takes over leading the group and putting cards in two piles.] "That one is not. (Fish) That one, yes. (Lion) Tree. (It's a plant) Okay."

P. "We put it over there. Whale." (Yes)

P2. "It's a mammal."

P1/4 "Mammals are animals!"

P3 "Yes, okay then."

P1. "Seagull." (Yes)

P3. "I don't think birds are animals."

P4. "What else could they be?"

P3. "Birds."

P1. "But they have the same kind of cells as animals."

P2. (Going back) "I reckon fishes are. Do you reckon fishes are?"

P3. "No."

P1. "We agree that a tree is not. So put that one (the fish) over there." (Separate pile)

P4. "We'll discuss that (pile) later."

[They proceed to get three piles - those things they definitely consider are animals, those that they consider are not animals, and the ones that they are unsure about. We return to the discussion as they discuss the cards they have placed in the dubious pile.]

P1. "The rock cod."

P3. "A fish."

P2. "But fishes have got cells and that."

P1. "Yes, I think it is an animal."

P4. "But when you play the game animal, vegetable and mineral ..."

P1. "It would come under animal."

P3. "Possibly."

P1. "Agree?"

P3. "Yes."

P1. "Seagull ... I think birds are definitely animals."

P2. "So do I."

P3. "Yes."

P1. "Right and a spider ... I think that it is definitely an animal."

P3. "I still don't reckon it is an animal."

P2. "What a spider?"

P3. "Yes."

P4. "Insects are animals."

P3. "I have never thought of them as animals, or insects, they are pests."

P1. "Oh yes, but I just think it is a smaller animal."

P2. "Why do we think they are animals?"

P3. "All the things we have got for animals are living things as in moving, like plants, they are just living ... they have no say in their life but these have."

P1. "This (spider) has then hasn't it?"

P3. "Yes, but ..."

P1. "It should be an animal then."

P3. "Yes."

Teacher "Can you think of some reasons why you put these in one pile ... and these in another?"

P3. "Well these things (the animal pile) they have all got ..."

P1/P3 "A brain."

P3. "Like they (the non-animal pile) have got no say in how they live just depends on weather conditions."

P1. "They are dependent on being put there ... but these things (the animal pile) can think for themselves ... they can move ... but trees haven't really got a brain."

Teacher "What about something like barnacles? Would they be animals or not?"

P1. "I think they are animals."

P3. "I don't ... I don't know."

GROUP 2:

[We join this second group as they discuss the ones they cannot agree about - the spider and the worm - they have just finished with a worm and start discussing the spider.]

P1. "I don't think a spider is an animal."

P2. "No."

P3/P4 "I do."

P1. "Oh yes ... well animals have ..."

P2. "No ... (a spider is not an animal."

P4. "Why not?"

P2. "It's (spider) is type of an insect."

Others "But an insect is an animal."

P1. "Is a fly an animal? ... Insects are animals."

P2. "Okay then."

GROUP 3:

[We join Group 3 who have got a number of cards that they are unsure about to reconsider. However they have already classified a spider as not an animal.]

P3. "Who do you not think this bird is an animal?"

P4. "Well it's an animal but it is different ... it is a bird."

P3. "A whale is an animal but you don't just call it a fish do you?"

P2. "But it flies."

P3. "We fly!"

P4. "No, but is it (an animal)?"

P3. "I think it is."

P1. "Yes, I reckon it is an animal but it is just one of those different ones like mammals, reptiles and different branches."

P3. "What about a snake?"

P1. "Reptile."

P4. "I think a reptile is an animal."

P3. "So do I because it's got blood and bones."

P2. "So is a spider."

P4. "Yes, but that's an insect isn't it?"

P3. "It's not an insect ... it's another branch ... I have forgotten its name."

P3. "Do you think (the snake) is an animal?"

P1. "Yes."

P4. "Yes."

P3. "Good! Now a fish."

P4. "I don't reckon it is."

P1. "No I don't know ... put it down for a moment.

[They leave this and move on.]

P3. "A worm ... I think a worm is an animal."

P4. "I am not sure."

P1. "I don't know."

P2. "It's got legs."

P2. "So has a spider."

[They place it to one side ... go on to the final card, deal with that and then return to the worm later.]

P4. "I would say no (a worm is not an animal)."

P2. "It makes you think aye?"

P1. "Yes (it is an animal)."

P3/P4 "No."

P1. "It is sort of an in-between."

P2. (To P3) "Why don't you think this is an animal?"

P1. "No it's not an animal ... well it might be an animal but then ..."

P3. (To P4) "Is it an animal or isn't it?"

P4. "No, I don't think of it as an animal ... because it doesn't look like one."

P3. "It doesn't have eyes or anything!"

P4. "You think of something like a lion or an elephant ... cat, dog, but a worm ... it lives underground."

P2. "Yes and it eats dirt."

P1. "Trees eat dirt so!"

P3. "It's not the same thing."

P1. "Well what do you reckon ... put it on no animals?"

P2/P3/P4 "Yes."

P1. "Right!"

P3. "Rock cod."

P1. "When we were discussing it before someone said it was an animal."

P4. "I think it is in-between this one."

P3. "Is it a mammal that lays eggs?"

P1. "Cods ... do they?"

P3. "I think they do."

P1. "No ... worms they just part off ... they just grow longer ... and when they have babies they just break off."

P2. "Fish don't they hatch eggs?"

P2. "Yes, they have eggs."

P4. "I say no actually (a fish is not an animal)."

[They agree to put it on the no-animal pile ... but they then return to the spider originally classified into the non-animal pile.]

P2. "It's an insect ... it is not (an animal)."

P3. "But is contains blood and all that ... so ... it's got eyes and it's got a mouth."

P1. "Six legs."

P4. "It's an insect and an insect is not an animal."

[P3 is most unhappy about putting the spider in the no-animal pile.]

P1. "Do you agree (it is not an animal) or not?"

P3. "No, I don't agree."

P1. "We need a not sure file."

P3. "Okay, well you persuade me that it is'nt an animal then."

P4. "Well, it's an insect isn't it?"

P1. "You know in science and that they always class spiders as insects."

P3. "No they don't ... they have another name for them."

P1. "I have never heard them say that they are animals."

P4. "It seems too small to be an animal ... you think of an animal to be large."

P3. "I say you can get ultra small animals!"

P1. "Yes ... cause guinea pigs aren't all that big."

P3. "You can get big spiders!"

P4. "Not quite as big as guinea pigs."

[P3 finally decides the majority will have to rule. He asks each in turn if they consider the spider to be an animal. All others consider it is not, so P3 throws the spider card on the non-animal pile.]

Animals	Not Animals
elephant	spider
frog	fish
snake	worm
bird	grass
lion	tree
whale	
cow	
cat	
boy	

Fig. 2. Blackboard drawing.

Teacher "Right now that you've all had an opportunity in groups to decide which you consider to be animals and non-animals, I have put one group's results on the board - I want you to have a look at. I think most groups commonly agreed that these ones here are animals (frog, snake, bird, lion, whale, cow, cat, boy). I think most groups ... all three groups agreed that these two were not animals, (grass, tree), but there seemed to be a bit of confusion on those three there ... the spider, the fish and the worm. Which group put these in the non-animal pile? Would you like to tell the rest of the class the reason for putting them in there?"

P. "Well, the spider is an insect, and, um, the worm we generally thought would be a non-animal ... it is sort of too small and it eats dirt and that ... it just doesn't seem right to be an animal."

Teacher "How did the other groups go about it? How would you challenge that statement?"

P. "I ... we thought they were animals because they have all got cells and they are living and that sort of thing. It has to be an animal."

P. "We decided on the animals because of the brain ... they all have got brains and a mind of their own ... they do what they want ... and the ones that aren't animals ... which are the grass and the tree ... they don't have a brain ... they just go how nature intends them to go.

Teacher "That's a good idea ... what about the other group? Why did you put them in the animal pile?"

P. "Oh well I sort of didn't agree with our group but they persuaded me."

Teacher "Okay, well what were you thinking about?"

P. "Oh, just the same as Glen, that they are insects."

Teacher "They're insects. So we have got quite a few people in the class who consider these to be not animals? (Spider, fish, worm). Does anyone know how a scientist would group these? If a scientist came along and put them into two piles ... animals and non-animals ... does anyone know how a scientist would do that?"

P. "I think a scientist would be more 'inclined' ... I don't know he would put them in that animals and not-animals because the scientist would be more inclined to think of the spider, the fish, the worm and that in other categories all together."

Teacher "What sort of categories?"

P. "Well ... the spider is an insect ... but I don't really know because I am not a scientist."

Teacher "Any other views on what a scientist would do with those? I'm going to tell you what a scientist would do. A scientist looks at living things ... which all of these are ... (things that have been categorised). I think most of the groups used that term living things ..."

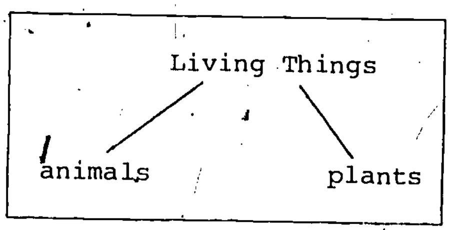


Fig. 3

Teacher "Very simply, living things can either be animals or plants. Animals or plants. That's how a scientist would divide them up. So, would someone be able to change these two groups here, to do is as a scientist would?" (Referring to Fig. 2).

P. "The grass and the tree would be the non-animals and the rest would be animals because (neither) the worm, the fish, or the spider is a plant."

Teacher "So these would come over here?"

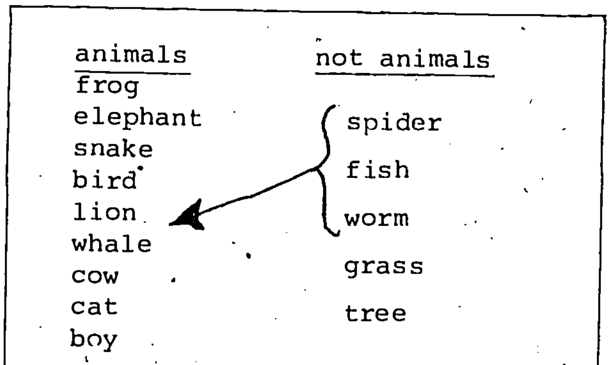


Fig. 4

Teacher "Does everyone agree with that? ("Yes.") "Does anyone disagree? Another way of looking at it ... we talk about a set of things called living things.

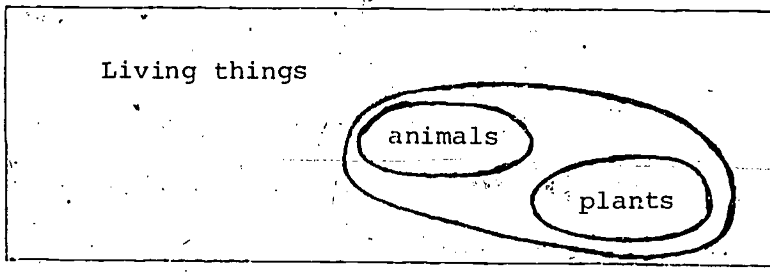


Fig. 5

Teacher "And there are two subsets ... the animals and the plants ... so, think of it in terms of sets and subsets, you can either ... like to do with maths or you can think of it in terms of it like that diagram there." (Fig. 3)

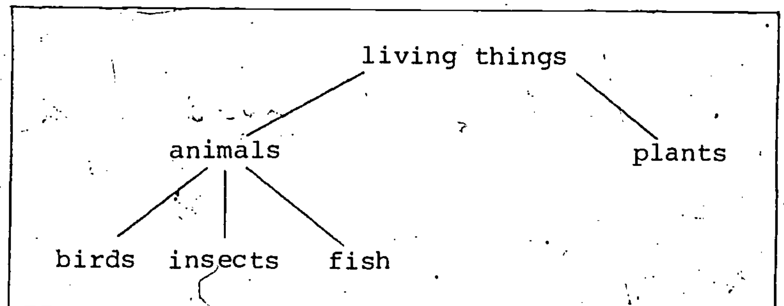


Fig. 6

Teacher "Now, a little bit of further information, this other diagram (Fig. 8) says you can take living things and divide them into two things ... animals and plants ... but scientists also take the group animals and divide it up again. So you have got different kinds of animals. Like birds, insects, fishes ... you've got your mammals ... like we are mammals, so we would be a separate group of animals. You can also represent this in sets and subsets like you do in maths."

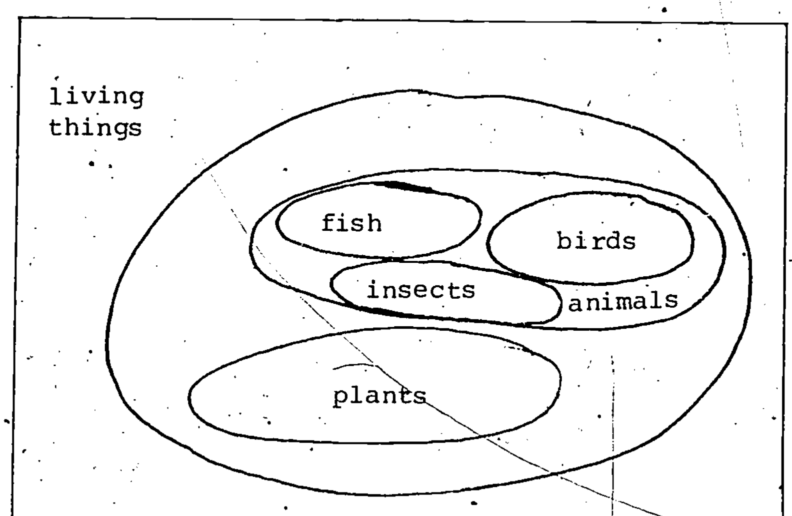
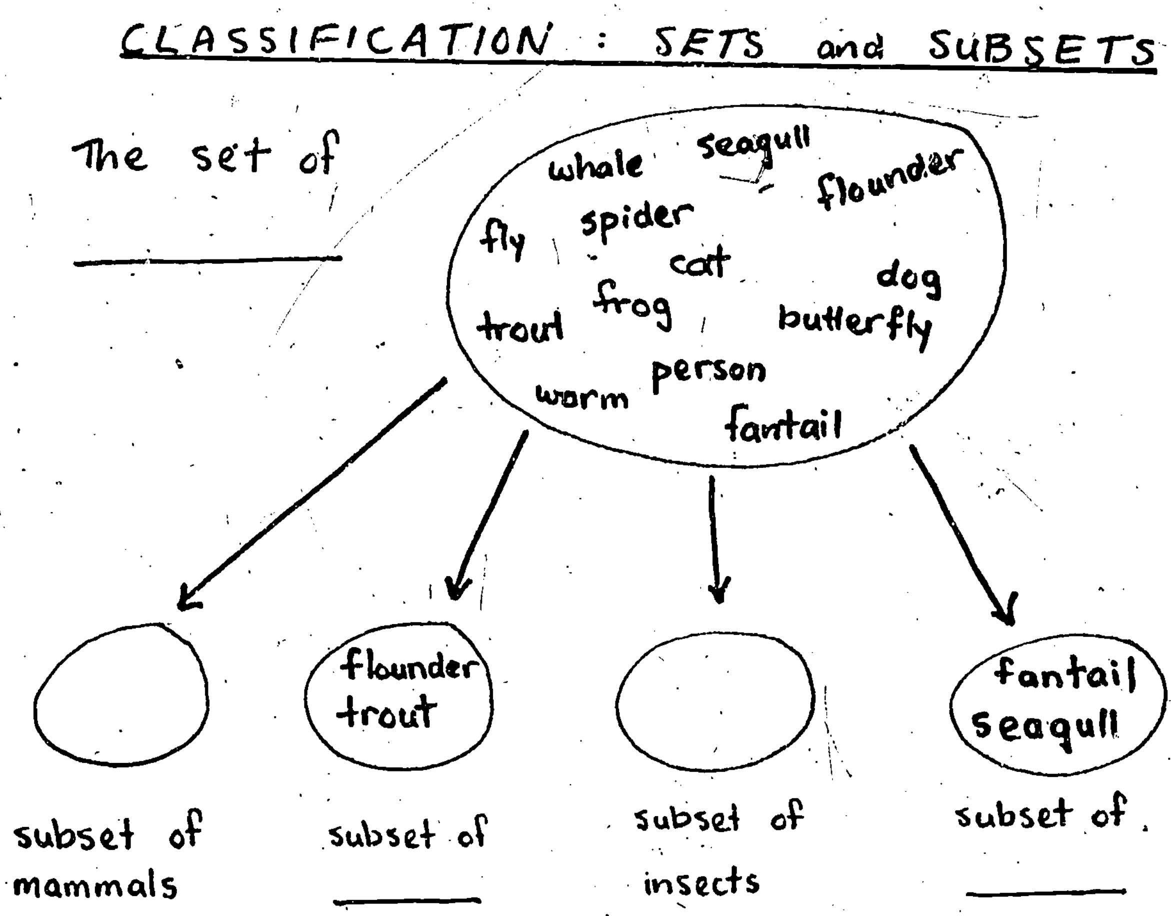


Fig. 7

Teacher "So we have got a whole set of living things, we can divide it into animals and plants, and we can further subdivide the animals into smaller groups, for example, I have just written a few up here, birds, insects, fishes, you could have mammals, does anyone know any other groups?" ("Reptiles.") "Reptiles, yes good." ("Amphibians.") "Amphibians, good ... any others? Fine, so that is the scientists' way of sorting things into groups, and most of you got very close to that when you were doing it in your groups. What I would like you now to do is this small exercise on the sheet here. I'll hand it out and you can share one between the two of you. And you can fill it in as well."



EVERYDAY AND SCIENTIFIC VIEWS

Teacher "Now one of the difficulties that I think you had when you were originally sorting things into animals or not animals, is that there are two meanings of the word animal. Two meanings. There's the scientists' meaning of animals, in other words animals and plants make up living things; and also what we call an everyday meaning of the word animals. An everyday meaning. And I think this is the meaning you were using when you were sorting them before. When you use animals in everyday language, you usually think of things like a cow, dog, sometimes people ... mainly four legged animals. How many people have seen that sign on the shop, "No animals allowed?" Yes, so in other words, animals aren't allowed in that shop ... do people go into that shop?" ("Yes.") "Are people animals?" ("Yes.") "So right, if you were to interpret that message as a scientist you wouldn't be able to go into the shop and buy things. But if you interpret it from an everyday meaning, meaning that we don't bring in cats and dogs and cows and horses, that leaves you to go in. So, there are these two meanings of the word animal. An everyday meaning, meaning just some of those four legged pets and farm animals, and then there's the scientific meaning of the word. So when we are in science classrooms we have to put on our thinking cap, or think in terms of the scientist; animals are all of those things that are living that aren't plants.

This lesson may be adapted for primary, intermediate and secondary school students so that they revisit these basic ideas.

For Further Information:

Refer Learning in Science Project, Working Papers:

Animals, Plants, and Living:

Notes for Teacher,

Working Paper No. 30.

Teaching about Animals, Plants and Living:

Suggested Teaching Activities,

Working Paper No. 31.

LEARNING IN SCIENCE PROJECT

VIDEO : ELECTRIC CURRENT

University of Waikato
Hamilton N. Z.

 WORKING PAPER No. 52

VIDEO: ELECTRIC CURRENT

Roger Osborne, Ross Tasker and Brendan Schollum,

Learning in Science Project,

University of Waikato,

Hamilton, New Zealand.

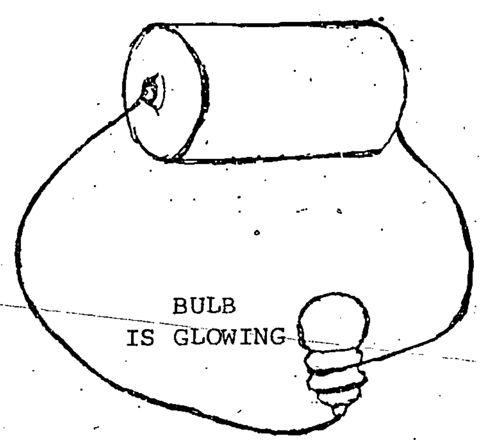
This paper is designed to be used in association with the video tape 'Electric current' prepared by the authors.

INTRODUCTION

During the last three years a group of us in Hamilton have been studying problems of children learning science. If you teach science you will know many children have difficulty understanding ideas about electrical circuits. We believe this may be because children come to science lessons with ideas about terms like electric current, but their views are often quite different to the scientists' view. Because of this children often interpret their learning experiences in quite a different way to that intended, and we as teachers make unfounded assumptions about children's learning and knowledge. In this session what we want to do is to show you the views that children hold about electric currents in simple circuits, and to explore a possible teaching strategy which builds on, rather than ignores, children's ideas. We'll begin by showing extracts from three interviews where 11 year old children were asked about their ideas regarding electric current in a simple electrical circuit. The circuit we have chosen is a very simple one, consisting of just a battery and a bulb.

THE INTERVIEWS

The situation under discussion.



INTERVIEW 1 - Ross Tasker with Wayne

R. "I have got a drawing here, where we've got a battery, alright?" ("Hmmm.") "And a wire connected to a bulb and another wire connected to the battery ... the other end of the battery. The bulb ... you have got to imagine the bulb is glowing." ("Mmmm.") "Now what I'm interested to know, in terms of how you think about something like that, is there an electric current in the battery?"

W. "Now?" ... ("Hmmm.") "Ah, yes."

R. "There would be. Can you tell me about that at all?"

W. "Well, there would have to be an electric current in there to get the bulb glowing."

R. "Oh, I see. Now, what about in the wire here?" [from top of battery to base of bulb] ("Yes.") "Would there be one there?" ("Yes.") "And what about the bulb itself?"

W. "Umm ... there would be."

R. "There would be on there too?" ("Hmmm.") "And what about this second wire?" [from the bulb to the base of the battery]

W. "That second wire ... um ... yes." ("So, there's an electric current ...") "Oh no, hang on ... there's not one in there."

R. "There's not one in this wire?" ("No.") "So, there's one in the battery, one in this wire and one in that bulb?" ("Mmm.") "Okay."

INTERVIEW 2 - Roger Osborne with Tracey

R. "Alright, now the way you think about it, is there an electric current in the bulb?" ("Yes.") "Why do you say that?"

T. "Because the current's flowing from the battery to the bulb."

R. "Because the current's flowing from the battery to the bulb ... okay, so what about this wire here going from the battery to the bulb, would there be a current in that wire do you think?" [from the top of the battery to the base of the bulb]

T. "Yes."

R. "And why do you think that?"

T. "Because the current has to go through the wire to get to the bulb."

R. "Because the current has to go through the wire to get to the bulb. Okay, that's fine. What about this other wire here. Would there be electric current in that wire ....in the way you think about it?" [from the bulb to the base of the battery]

T. "Yes?"

R. "Yes ... less sure about that one?"

T. "I'm not sure because that's negative and that's positive ... I don't know much about it."

R. "What's that about?"

T. "Well the top one's positive and the bottom one's negative."

R. "Oh yeah, where did you learn that?"

T. "I don't know." [laughs]

R. "You don't know ... you've just got a feeling about it? Okay, so you think there is a current in that wire or ...?"

T. "I think so."

R. "You think so, okay ... well if there is, how would it compare with the electric current in this wire?" [from the top of the battery to the base of the bulb]

T. "It would be the opposite."

R. "The opposite ... show me ... how do you mean the opposite?"

T. "Well positive is opposite to negative."

R. "What do you mean opposite in ... I mean, if electric current is going from here down to here, okay?" [from the top of the battery to the base of the bulb] "What would be in this wire?" [from the bulb to the base of the battery] "Would it be going from the battery to the bulb, the bulb to the battery ...?"

T. "It should be going from the bulb to the battery."

R. "Okay, how does the amount of electric current in this wire compare to the amount in this wire?"

T. "Should be the same." ("Should be the same.") "Um ... less, because the bulb uses some."

R. "Because the bulb uses some. So in the way you think about it there would be electric current going from the battery, down the wire, to the bottom of the bulb ... right, and then there would be some electric current from the bulb to the battery. But there would be less electric current in here than there would be in here 'cause some of it got used up in the bulb." ("Yes.") "Okay, that's fine. Good."

INTERVIEW 3 - Roger Osborne with Ross

Rg. "This is one where we have connected the battery up by wires ... you were talking about wires before." ("Yes.") "... to a bulb, okay, and the bulb is glowing. Okay, in the way you think about electric current, would you say there is an electric current in the bulb?"

Rs. "When ... when ... when there is ... when the electricity is running through it ... yes."

Rg. "Yes, okay, so the bulb is glowing at the moment?" ("Yes.") "So you would think there'd be electric current in the bulb?" ("Yes, going through it.") "Going through it." ("Mmm.") "Okay, fine, what about this wire here, going from the top of the battery to the bottom of the bulb, would there be electric current in that wire?" ("Yes.") "Mmm ... and what about this wire here going from the back of the battery to the edge of the bulb here. Would there be electric current in that wire?" ("Yes.") "Aha ... why do you say that?"

Rs. "Well, it's a closed circuit ... it's going right round."

Rg. "Right, I see. Okay. How would the electric current in this wire [from the bulb to the base of the battery] compare to the electric current going from the top of the battery to the bottom of the bulb? Would it be ...?"

Rs. "Um ... well one of them would be coming out of the bulb and the other would be going back in."

Rg. "Sorry, can you explain that to me. Let's start from here."

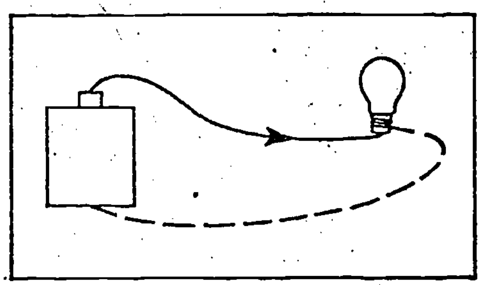
Rs. "Well, that one say, it could be going ... this ... electric current could be coming out of that [top of the battery] and going into the bulb, and this one could be going out of the bulb and back into the battery." [the base of the battery]

Rg. "Oh, okay. So it sort of goes round the circuit like that?" ("Hmm.") "How would the amount of electric current in this wire compare to the amount of the electric current in this?" [bulb to base of the battery] ("Equal.") "Equal, okay same amount of electric current in both wires?" ("Hmm.") "Okay."

CHILDREN'S VIEWS

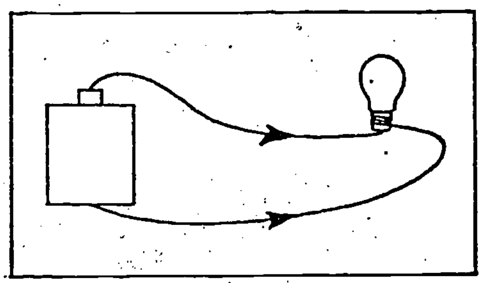
We have interviewed over 60 children and older students about their ideas on electric current. We have also followed up these interviews with paper and pencil surveys with some 500 children. What we find out is that while students soon learn a closed circuit is required for a bulb to glow, they could hold a variety of models about the electric current in the circuit.

MODEL 1



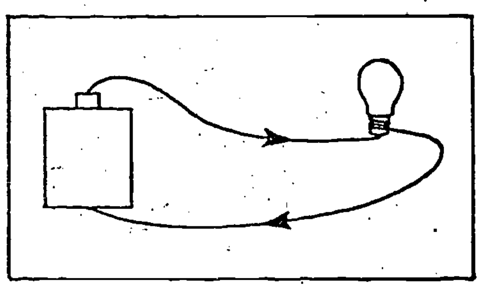
One of the common models, we will call it Model 1, is the model held by Wayne, the first pupil interviewed. The electric current is from the battery to the bulb in one wire. However, even though the return wire may be necessary for the bulb to glow, there is no current in that second wire. As one 11 year old put it, "The electric current gets used up in the bulb."

MODEL 2

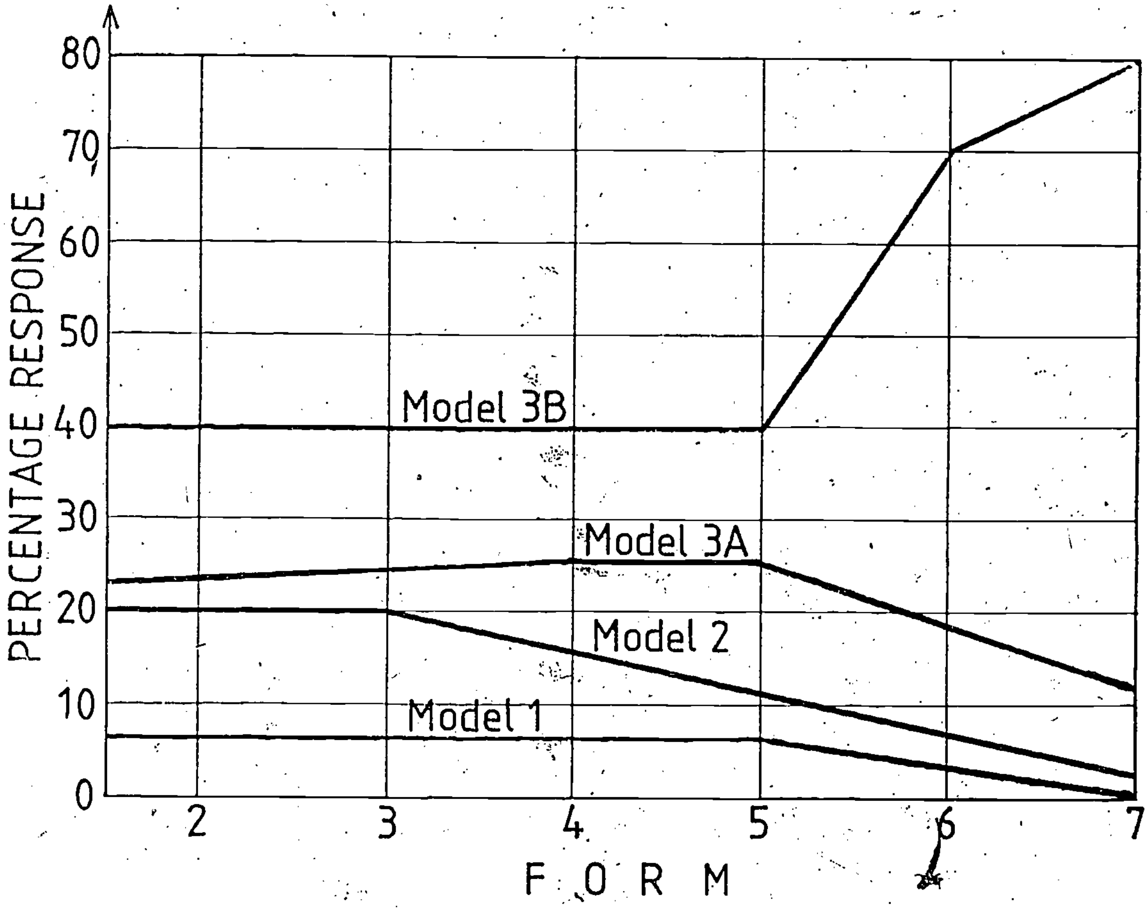


An alternative model held by some children is Model 2. Electric current flows towards the bulb from both ends of the battery. As one child says, "The electric currents clash in the bulb producing light."

MODEL 3



In Model three, the scientists' idea is to be found. The electric current is directed from the battery to the bulb in one wire, and in the opposite direction in the second wire. However there are two versions of this model as we saw in the last two interviews. Model 3A, Tracey's idea, that the current is less in the return path, and Model 3B, the scientists' view that the current has the same value in all parts of the circuit. Ross, the last pupil interviewed, already holds this scientific view quite strongly.



How prevalent are these various models? We have attempted to assess this by sampling about 100 students at each form level. The sample of F2-F4 students consisted of the full ability range. The F5 students were taking science, while the F6 and F7 students were all taking Physics. We believe these results from our survey work are conservative estimates of the prevalence of the non-scientific models. Model 1, that is no current in the return path, is held by at least one pupil in 20 from F2 to F5. Model 2, that is the clashing currents model, is held by at least 20% down to 10% of F2 to F5 students. Model 3A the circulating model with less current in the return path, is held by at least one pupil in every four from F2 to F5. Finally Model 3B, the scientifically accepted model, similar to model 3A except the electric current is the same value in all parts of the circuit, is held by less than 50% of children from F2 to F5. Of course there are other children who hold more idiosyncratic views which we have not included on the graph. What is interesting about this graph is the lack of significant change from F2 to F5. Yet, without the Model 3B view of electric current in a simple circuit, ideas of conductors, insulators, voltage, resistance and electrical energy, must be very confusing to students. We might also think about how much the significant change at the F6 and F7 Physics levels is due to teaching, and how much is due to students who have a scientific view at an early age, opting to take Physics at the 6th and 7th Form levels.

TEACHING

Let's now look at a lesson given to these children where we try to take into account their ideas, and not make too many unfounded assumptions about the ideas the children develop during the lesson.

i) At the beginning of this lesson, children have simply been asked to observe a bulb closely.

ii) Here we see the teacher discussing the children's observations.

T. "Good, Alister, how about a couple from you."

A. "It has a glass head."

T. "Yeah, something that you can see through. What else, what's inside there? Alister or Wayne?"

W. "It has a wire across the prongs."

T. "It's got a wire ... it has two very thin pieces. And you are calling them prongs. Yeah, and what about ... what else?"

A. "It has a cylinder with a fat head."

T. "With a fat head ... yes, that's a good observation."

iii) We now see the teacher introducing the main part of the lesson.

T. "Bear that in mind, because I have got an interesting little task for you to do now, and that is with that bulb and with one of these cells, or you might know them as batteries, call them cells as well, each group, quickly I want you to make up a ... some sort of circuit to get the bulb glowing. Alright?"

P. "Could you get an electric shock?"

T. "You have got to be careful ... you won't get an electric shock today ... fortunately ... one has to be careful of course when you are doing anything with electricity. Of course if you want three wires ... I would be quite happy to give you three. [children start attempting to get the bulb to glow] You might need two of you to hold onto it."

T. "Listen, as soon as you have done that I want you to draw the way that you have got that light bulb to glow. Alright, draw the circuit on that piece of paper I have given you. In fact I think I'll give out another piece of paper so that each individual can do it. Yes, I want you to draw how you are able to position the bulb, the cell and the wires to get the bulb glowing. Each individual ... each person can draw that."

We observe Samantha and Mahoney attempting to get the bulb to glow. They soon realise by watching other groups that they need two wires to get the bulb to glow. They attempt this by placing the base of the bulb on the join of two wires from each end of the battery - unfortunately shortcircuiting the battery.

S. "Ah, it's hot!"

M. "Did you get a shock?"

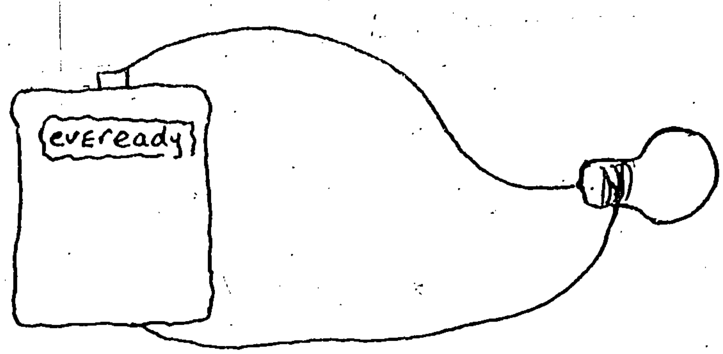
S. "No, it's hot!"

As you can see, Samantha and Mahoney have considerable difficulty getting the bulb to glow. Finally, with a combination of mimicking other groups and teacher's help, they finally get the bulb to glow after some eight minutes.

S. "Ah, it's going!!"

S. "Ah, we did it!"

They then completed their diagram;

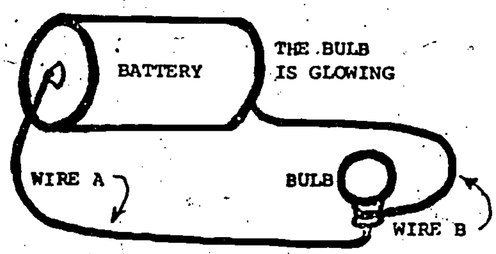


Later some of these are put on the board and discussed.

iv) We will now move on to the next phase of the lesson where children were encouraged to think about the electric current in the wire.

T. "Right, so I want you to really think carefully now about what we call electric current. Some of you use the terms, as I have gone around, ... force and power, or electric current ..., in getting that light bulb to glow. So, I've got a sheet here and you'll see that I have been able to do a diagram very similar to the ones that have been drawn out here. And I want you to think carefully, each person, about the wires ... I'll give it out, just talk about it for a while and then you can fill in your answer. Very similar to what we have done in other periods ... alright ... so you can put those down. We are very interested now in this electric current."

YOUR IDEAS ABOUT ELECTRIC CURRENT



	YES/NO	WHY DO YOU THINK THAT? YOU	YOUR GROUP
1. Is there an electric current in the bulb?			
2. Is there an electric current in wire A?			
3. Is there an electric current in wire B?			
Additional questions if you answered yes to Q.3.			
4. Is the current in wire B less than the current in wire A?			
5. Does the electric current in wire B go from the bulb to the battery?			

T. "The first thing to do, is all of you, you can connect up the circuit just exactly as it's shown there and then there's a series of questions. If you look at the first one it says 'Is there electric current in the bulb?' And you notice it says the bulb is glowing. So you can answer 'yes' or 'no' and why do you think that, and you put it in that little square ... your reason. And it may be different from the person beside you, see if you can put in your own words why you think that there is, or there is not an electric current in the bulb, and then in Wire A, you can see Wire A goes from this part of the cell, the part that's got the little knob on it, down to the bottom of the bulb. You connect it up and then answer those questions and we will see what the responses are. Right way you go. Connect it up just as it's shown, make sure you have got your bulb glowing."

[The pupils fill in the sheet and then the answers are collated]

T. "Right let's hear some of these reasons. Quickly, for a start though, we'll just get numbers and we'll hear about reasons in a minute ... right, how many say there is a current in the bulb? Hands up those who say yes. Those that say no. Good, right. 11 - 1. What about number 2. Is there an electric current in Wire A? How many say yes? How many say no? Right, 11 - 1 and there's a different person there this time. Number 3 - Wire B - how many say no, this time? How many say no? 9 - 3. If you answered yes, and we have got 9 who answered yes, is the current in Wire B less than the current in Wire A? I am only interested in the 9 who answered yes to question 3. Hands up those 9 who said yes to question 3. 1, 2, 3, 4, 5, 6, 7, 8, 9 ... good, okay, now keep your hands up. Now if you answered yes, you 9, to question 4, keep your hand up, if you didn't put your hand down. 1, 2, 3, 4, 5, 6, 7, ... good, thank you. And therefore 2 answered no. And question 5, again only for those 9, does the electric current in Wire B go from the bulb to the battery ... how many say yes? From the bulb to the battery? 3. And therefore 6 say no it's the other way around. Good let's go back to the reasoning."

Blackboard Summary

	YES	NO
Q.1	11	1
Q.2	11	1
Q.3	9	3
Q.4	7	2
Q.5	3	6

v) [The reasons are now discussed. Discussion for Q.3 follows]

T. "Alright, I think three is a more interesting question here. Is there an electric current in Wire B? Three people said no here, where are the three so we can get their reasons. Right Alister."

A. "Um ... there is nothing going through Wire B from the battery ... 'cause most of the power is going through that side of the battery. And not this side."

T. "Ah ... it's going from one side through to the bulb and there's nothing coming through the other side. Yes, and what about you? Wayne?"

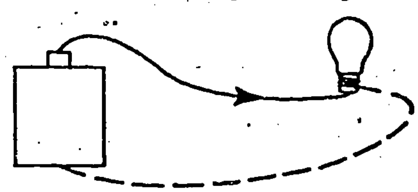
W. "I put no ..."

vi) Out of the discussion the models we discussed earlier emerged from the children's ideas. These models were put on the board by the teacher.

T. "Very good to hear your different opinions, and I think there's about three different ways in which you people are thinking about electric current and I want to put some diagrams on the board, and you think about the way you see an electric current. I think some of you are looking at what I'll call Model 1. And ... now we have got our cell here, or battery, we've got a wire going to the light bulb, and what we are saying is there's an electric current in there ....the bulb is shining, this other wire, well it's there but there's no electric current coming through it."

[Blackboard drawing by teacher]

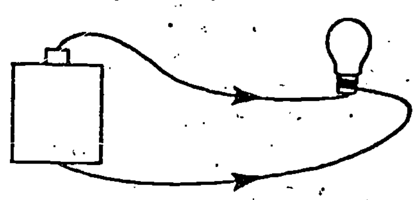
MODEL 1



T. "Some of you others are thinking about a model like this. You've got the cell, you've got the light bulb there, you have got the current going from the cell to the light bulb, you've got the other current going from the other end of the cell to the light bulb, right, and they mix and the light bulb shines. So that's different from Model 1."

[Blackboard drawing by teacher]

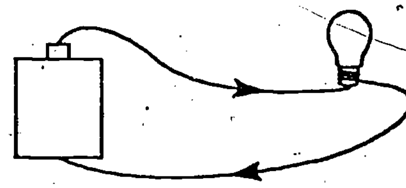
MODEL 2



T. "And there's others of you what I will call the third model. You've got a cell, and you've got the light bulb there, you've got two wires, and the current's going from one end of the cell to the light bulb, this other current flowing back in the opposite direction from the bulb to the cell. Some of you have got the idea that, I think, there's not as much current there ... some of it's getting used up. But the idea is that it's flowing around in a circuit and that's different from number 2.

[Blackboard drawing by teacher]

MODEL 3



T. "Alright, can you see there's a difference in those three models ... Now I want you to write down which of the models you think is most like the way you think about electric current in a circuit. Alright, so can you put down a number 1, 2, or 3."

[Pupils choose which model they prefer and results collated.]
[Wayne chooses Model No.1.]

Model	Number Choosing the Model
1	1
2	5
3	6

T. "Well, let's have a look at some of the reasons. Someone who chose number 2, for example, that seemed pretty popular. What's your way of thinking about electric current there? Alister, you tell us."

A. "Well, when we got the wires we put one wire on the bottom of the battery and one wire on the top and then we had the bulb there ... and when we had one wire connected it wouldn't go ... [attempts to demonstrate this] ... pretend that's joined ... it wouldn't go, so we had to put another one on, and put it on the end to make it go."

T. "So you think there was more current coming through to help make the bulb glow?" ("Yes.") "Yeah, who else has got that idea? Can you explain that in a slightly different way ... Paula?"

P. "Well they are sort of like he is .... but you have to have the same amount of current."

T. "The same amount in each of these two wires ... right ... the same amount comes in and it makes the light go ... they mix do they, in the light bulb? ... [Paula nods]. Tracey, what's your idea about it? You voted I think, for model number 3."

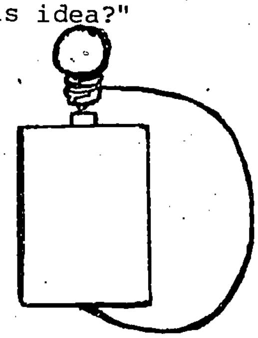
Tr. "Because the current, you need both wires, so that the current can go back to the battery, but starts at the battery, and goes to the light bulb and then goes back to the battery."

T. "Ross, what's your idea?"

R. "Alister said that you need two wires, well you can only have one..." ("Yes.") ... because you put the bulb and the ... plus ... and you put ... the wire around the bottom ... and connect it to the bulb, then it would go."

T. "Yes, I think you had this idea?"

[Blackboard drawing by teacher]



R. "Mmm ..."

T. "Like that isn't it? Yeah, so therefore one wire, can get current in it? Is that ... does that lead you to think about Model number 1 or not? Or are you sticking with model number 3?

R. "No ... No.3."

T. "No.3 ... but you can do it with one wire?"

R. "Yeah."

T. "Um, yeah, what's your idea about the amount of current there? Do you think it's much the same or do you think there's a bit less?"

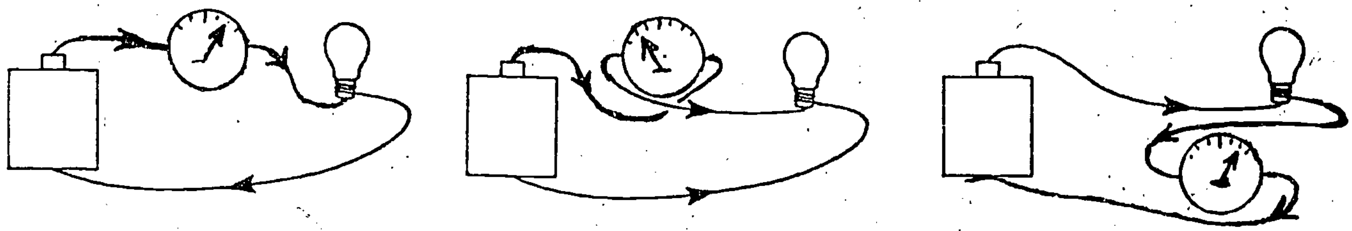
R. "Um ... yeah, it's the same."

T. "It's the same."

vi) Teacher led investigation to test pupil's models. The teacher uses an ammeter (current measurer). Needle is vertical for zero current. When a current flows through the ammeter the needle deflects to the left or to the right depending on the direction of the current. How far it deflects depends on the size of the current.

T. "Well, I think it's fortunate that we can show this. I have got a piece of apparatus, so we will set this up, we are going to do it just like you, except that we are using a bulb, a cell holder here, we can fit a cell in there just as I've done, and also you can fit a bulb into this, what's called a bulb holder, and we've made a circuit. Now, look at it from the top of the cell, top of the cell, top of the cell, [relates to the 3 drawings] goes through to the bottom of the light. Then, this yellow wire goes right round from the other side of the light back to the bulb ... to the cell. So there we are, we've got a complete circuit, and the bulb's shining. Just as you did it isn't it? Now what we are going to do is look at the amount of current in the two parts of the circuit. And we'll see which of these models seems to hold up. Alright? So, what we are going to do ... this is a piece of apparatus called a current measurer, and I've just broken the circuit and we are going to put in one lead into each section of this current measurer and what do you read there, ... Samantha?" ("Two.") "Yes, two, or point two isn't it ... so there's point two of current going through that circuit. Now you notice the needle went to your right didn't it? What do you think would happen if we turned the terminals here? Yes, what do you think there Wayne?"

W. "Well it would go the other way."



Ammeter reads 0.2 | Terminals reversed | Ammeter reads 0.2

T. "Alright, let's just check that. So we'll change the terminals around and ... yes, you're right. Aren't you? It's gone the other way ... let's go back to the way we had it ... just ... there it is ... and we're getting a current measure of point two ... alright is the bulb still going?"

Class "Yes."

T. "Yes, it is isn't it? Right, let's go over to the other side of the circuit. Now again, we just break this and ... we are going to put one in there and one in there ... and what do you notice happens?

Class "0.2 ... it's the same."

T. "It goes up ... it's the same. It's the same direction isn't it? It's moved to the right and it's the same amount. So from this, which model do you think seems to be the one that holds up? Yes, Wayne?"

W. "Number three."

T. "Number three. There's point two current going through the bulb and there's point two coming through in that same direction isn't it, coming back to the bulb."

It's not easy to change pupils' views as you have been able to see, and we have had a lot going for us in this lesson. We've had a smaller group of children than you normally have to cope with in a classroom. We've had the use of an ammeter. If you are in an Intermediate school, then perhaps you could borrow an ammeter like this from the local secondary school, if you want to try and do the things that we have been doing in this lesson. But more importantly than all that, we hope that what we've talked about encourages you to find out the views the children have, and in teaching attempt to build on those views.

ACKNOWLEDGEMENTS

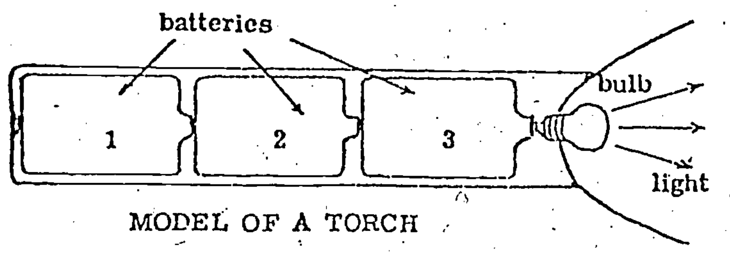
Our thanks to the pupils of Peachgrove Intermediate School, Hamilton.

ADDITIONAL NOTES

1. In retrospect, we see flaws in our teaching and no doubt you do too. What we hope might be achieved is that you will say to yourself, "Yes, I could do that", and perhaps "... I could even do it better than that." We hope you will then take up the challenge!

2. While we have managed to confront children who held Model 2 views so that they accepted the Model 3B views, these children then had a number of questions which we have not discussed in the video tape sequence. For example, if the same amount of current goes back into the battery as comes out, how is it that the battery wears out? [The battery is like a pump and it runs out of energy!]

3. While Wayne changed his Model 1 view to the Model 3B view and this was born out by a subsequent interview, this new view of the battery-bulb situation does not mean he changed his view about other situations. Confronted in the interview with the situation shown below he reverted to his Model 1 view in discussing this situation, presumably because the return path was not obvious.



MODEL OF A TORCH

The torch is switched on and the lamp is glowing.

[NOTE: In this situation the torch case provides the return wire]

4. No attempt was made in this lesson to discuss conventions about current flows (e.g. conventional flow or electron flow). Most students seemed to be happy to suggest the current circulates from the top of the battery. Of course we have no evidence for this and it could equally well circulate in the opposite direction (indeed electrons do!). However the problem wasn't raised and it seemed to us not an essential point to discuss at this stage (with 11 year olds).

5. For further information on children's views on electric current refer Osborne, R. (1981) Children's Ideas about Electric current. <u>N.Z. Science Teacher</u>, <u>29</u>, 12-19.

LEARNING IN SCIENCE PROJECT

VIDEO: FORCE

University of Waikato
Hamilton, N.Z.

WORKING PAPER 53

VIDEO : FORCE

Roger Osborne and Brendan Schollum

Learning in Science Project,
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This paper is designed to be used in association with the video tape 'Force' prepared by the authors.

INTRODUCTION

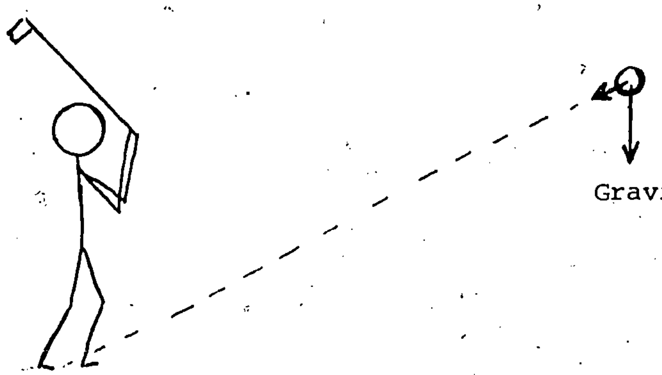
Why does a golf ball move through the air in the way that it does ? Both physicists and children would agree that there is a force on the ball. But do physicists and children use the word force in the same way ?

We have been investigating this and the implications for the teaching and the learning of science.

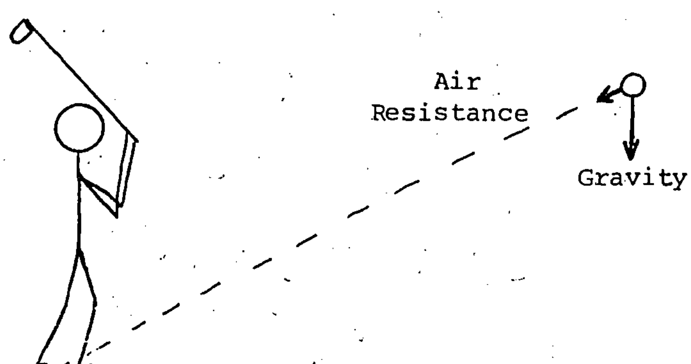
IDEAS ABOUT FORCE

Scientists' Ideas: First of all let us consider what scientists mean when they talk about the force on the ball. Force is a simple idea to a physicist; basically a push or a pull acting on the ball. Unfortunately with the golf ball the forces are invisible. However there are two forces acting on the golf ball.

First of all there is the force of gravity always pulling the ball downwards.

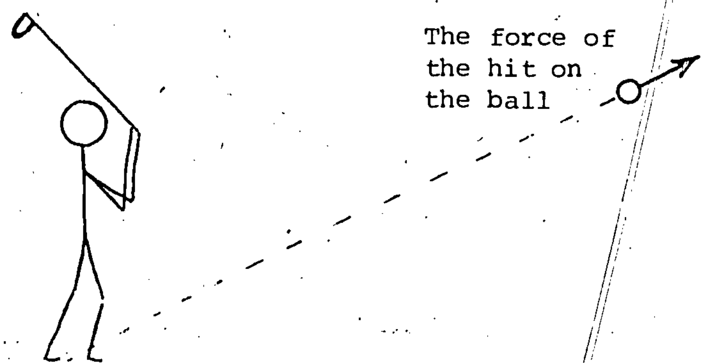


The second force is friction with the air, or air resistance.



The ball moves through the air in the way that it does because of these two forces acting on the ball.

Children's Ideas: Now let's consider what children mean when they talk about the force on the ball. Many of them don't think about air resistance at all. Some but not all, consider gravity to be a force. To many children the force that is acting on the ball, causing it to move through the air in the way that it does, is the force of the hit on the ball.



Both physicists and children talk about the force on the ball but as you can see they are talking about quite different things. Physicists don't talk about the 'force' in the direction of motion. When the ball is hit by the golf club then there is a force on the ball just while it remains in contact with it [the golf club]. The ball gains momentum and it is the momentum that is in the ball. Physicists don't think of momentum as a force.

Let's go and talk to some children to see how they talk about the force on the ball and we will see them talking basically about this force [the force of the hit] which physicists don't consider exists !

INTERVIEWS

The situation under discussion is one of a set of situations.

IS THERE A FORCE ON THE GOLF BALL?

Interview 1 - Roger Osborne with Mark.

R: "Now here is a golf ball. Someone has hit if off the tee here ... it is going up in the air ... and at the moment it is just up to that point there [points to the golf ball in the picture]. In the way you think about force would you say that there is a force on the ball ?"

M: "Yes, ... because it is made to go ... it has been hit by the club and it hasn't really got any option."

R: "It's got no option."

M: "Yes it starts going up."

R: "O.K. Is there a force on it when it is up here ?" [up in the air]

M: "Yes because it can't stop."

R: "It can't stop ... ah ha."

Interview 2 - Roger Osborne with Carol.

R: "Here is a golf ball. There is a person hitting the ball off the tee here and the golf ball at the moment is up at that point here. Now the question says is there a force on the golf ball ? It means when it [the golf ball] is there [in mid-air] going through the air would you say that there is a force on the golf ball ?"

C: "Yes ... I think so."

R: "Can you tell me about that ?"

C: "He has just used force to hit the ball and it is still travelling."

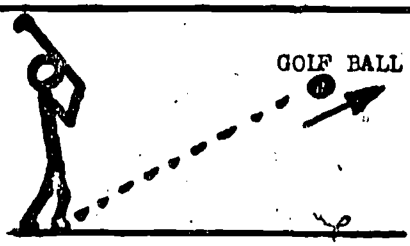
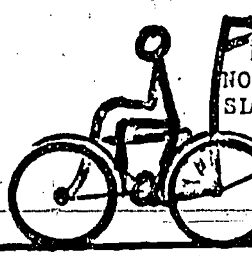
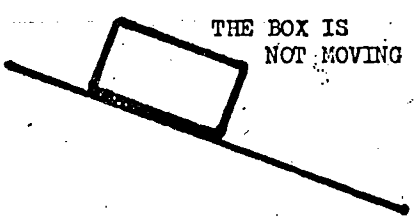
TEACHING ABOUT FORCE

> The scene opens with the teacher talking to the pupils, describing the golfer and the golf ball situation used in the interviews.
>
> T: "This is a man, there, with a golf club in his arm, and there is a ball right out in the air and the question is: 'Is there a force on the golf ball ?'"

How are we going to modify children's ideas towards the views of scientists ? We have been working on this problem for over a year now. With all our work on modifying children's ideas we have found it essential to allow children to first clarify their own individual views usually with a worksheet. Once children have done this they will later be able to realise the conflict between their ideas and those of scientists, and to realise the need to change their views.

T: "[giving out worksheet] just for the first couple of minutes it is your own opinion rather than you and your neighbour's (that you should write down)."

Let's have a look at the worksheet they are completing.

IS THERE A FORCE . . .	YES/ NO	WHY YOU THINK THAT WAY — YOU	YOUR GROUP
GOLF BALL  . . . ON THE GOLF BALL ?			
GOLF BALL FALLING FREELY  . . . ON THE GOLF BALL ?			
 NO BRAKES NO PEDALLING SLOWING DOWN . . . ON THE BIKE ?			
 THE BOX IS NOT MOVING . . . ON THE BOX ?			

After the pupils have [individually] completed their sheets the lesson moves on;

T: "Now we are going to have another couple of minutes when you have got to convince your partner, ... the person you are sitting beside, that your response is the more sensible one ... if there is a difference or if you are saying much the same thing, of course you agree. You will notice that in the next column [on the worksheet] there is "your group" so that all I want [written there] is a brief summary of the way that you two think about where there is a force on the ball, or the bike, or the box. So by all means talk ... about what you have written and come up with a consensus or common view ... right. Just a few minutes on that ... not too long."

The pupils discuss their individual answers in pairs.

M: "[re golf ball falling freely] if it had no force on it, it would just drop straight down ... there still has to be some force on it to make it go along ... "

After the pupils have discussed their ideas in pairs the lesson moves on to a class discussion.

T: "Here comes the interesting thing where we see what are the opinions. For a start I think we will just get a Yes No count just to see ... then we will look at reasons."

Teacher records the hand count for the four situations on the blackboard.

		Yes	No
1.	Golfball (up)	12	0
2.	Golfball (down)	11	1
3.	Bike	10	2
4.	Box	7	5

T: "Right ... we will probably spend a little more time on the last ones but [first] what are the reasons here for question one. Is there a force on the golfball? Let's just have some of your reasons. Right Paul ... "

P: "Um ... when the club swings through it is going through with speed and when it hits it has got force behind it ... and it forces the ball into the air."

T: "Yes, Mark ?"

M: "Because the ball is being made to move by being hit with the golf club."

T: "The ball is being made to move, yes. Now who has got something different ... has got a different way of expressing it. Yes ... Judith."

J: "The man had human force in his arms when he hit the ball so that has put force into the ball."

T: "Yes ... who has got something different ? No one ? How about reading out yours Marie ... what have you got there."

Ma: "I have got ... he forces the ball because for the ball to travel it must be powered by something."

T: "It must be powered by something ... and what is that something is it a force."

Ma: "Yes ... the man hitting the ball."

T: "The man hitting the ball ... all right and Carol what are your ... "

C: "Um ... because the ball is being made to move there must be some sort of force to make it move."

T: "... to make it move. And that is the same when you are looking at the ball ... right out there [away from the tee] the ball is moving ... you are saying there is a force on the ball."

C: and Ma: "Yes."

T: "Right."

A Series of Lessons: This introductory lesson is the first of a series of lessons, we have designed, to introduce children at the 10-14 year old level to the physicist's idea of force.

The Booklets: From all this work the LISP team has produced two booklets which you may find useful. The first of these booklets, "Force, friction and gravity : Notes for teachers" (LISP Working Paper No 33)[1], starts with a survey to enable you to see if you have a child's view or a scientist's view of force. It then describes the child's view of force and explains the scientist's view. We believe this information is essential for teachers if they are to teach force effectively.

The second booklet, "Teaching about force" (LISP Working Paper No 34) sets out the teaching strategies we have designed. The introductory lesson we have been watching, is the first in a series of lessons that we suggest. Once children have clarified their own ideas and found that different children use the word force in different ways we then introduce the idea of momentum; the correct scientific label for this "something" that is in the direction

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[1] LISP Working Papers are available for the cost of reproduction and postage from T.O.R. Centre, Hamilton Teachers College, Private Bag, Hamilton.

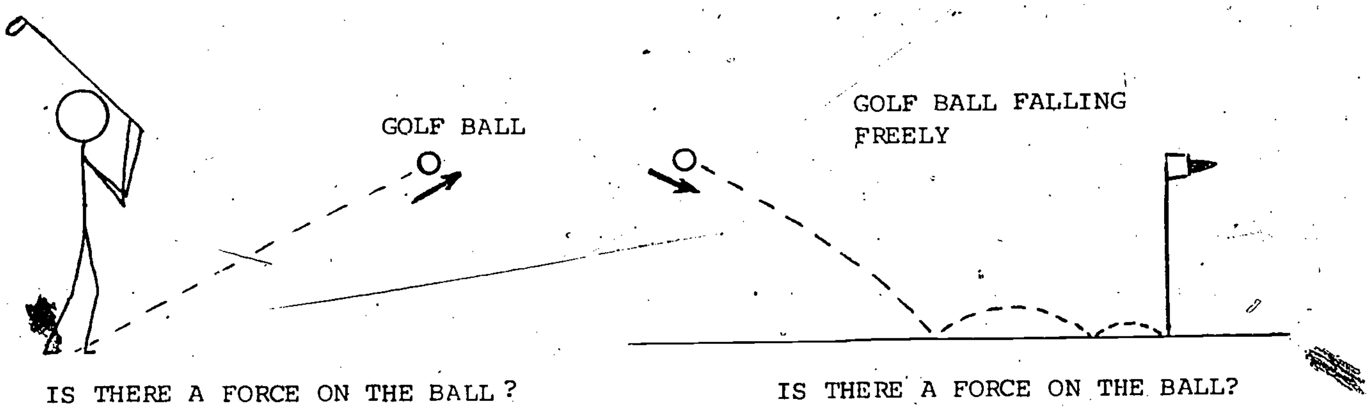
of motion. We therefore give a label to the children for their intuitive conviction that there is this "thing" moving the ball through the air. We then emphasize that momentum is not a force. In the suggested lessons, we then introduce pupils to changes in momentum and how these changes are caused by the total force on an object. In this way the lessons attempt to build on, rather than ignore, children's ideas.

REFLECTION

How successful are the teaching strategies which we suggest ? There is no simple answer to that, judging from our pre and post-test data[2]. What we can say is that teachers who have used this material, many of them, say that they will use it again next year. What we can also do is give you a glimpse of our successes and our failures. We will show you excerpts from two interviews of children who were taught using this teaching strategy one month previously.

The Interviews: The pupils you saw earlier were at secondary school, these children are at intermediate school.

The situations under discussion were:



Interview 3 - Roger Osborne with Kevin.

R: "Here is a golf ball ... the golf ball has been hit from a tee and is up in the air ... it has got to the point there ... O.K. [points to the position of the ball]. Now in the way you think about it, is there a force on the golf ball now ?"

K: "Yes."

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2 This information is to be found in LISP Working Paper No 32.

R: "Hm Hm ... Can you tell me about that ?"

K: "Gravity ... there is no force from the golf club because it is up here and it has been hit."

R: "O.K. ... now what about when it is on the way down and it has got to there ?"

K: "The force of gravity again."

R: "The force of gravity again ... O.K. fine ... How long ago was it that Mr. Schollum came and talked to you about these things ?"

K: "It would be a month or so."

Interview 4 - Roger Osborne with Susan

R: "Here we have got the golf ball ... the golf ball is up in the air ... we are going to talk about the golf ball when it is up there O.K. ... Is there a force on the golf ball ?"

S: "Gravity pulling it downwards ... and the force of the hit ... no there is not the force of the hit ... because ... oh yes the force of the hit ... and ... "

R: "So which way is that one. Which way is the force of the hit ?"

S: "That way [gives direction of ball's flight].

R: "Yes ?"

S: "Um ... I can't think of any more."

R: "Can't think of any more ... "

S: "I'm forgetful."

R: "You're forgetful ... O.K. we are all forgetful ... we are all forgetful ... Here is the ball on the way down ... what forces are on it now ?"

S: "There is gravity pulling it downwards."

R: "Yes ... gravity pulling it downwards."

S: "... and an upward one to make it bounce up."

R: "Well I want to talk about it when it is there [still up in the air].

S: "Oh ... there is gravity pulling downwards and there is still a little bit of the force of the hit ?"

R: "Still a little bit of the force of the hit ... which direction would that be ?"

S: "That way [points in direction of motion].

R: "O.K. ... That's all ?"

S: "Yes."

R: "O.K. That's very good ... the only thing ... just ... can I talk to you about the force of the hit because you said to me ... there is the force of the hit on it ... no there isn't the force of the hit on it ... Yes ... there is a force of the hit on it ... can you tell me about what you were thinking about there ?"

S: "I think the force of the hit ... Mr. Schollum ... I think he told me that the force of the hit stops the instant the golf club touches ... doesn't touch the ball."

R: "After it has been hit."

S: "Yes, I think."

R: "You think ... but that is not the way you think about it ? or that is not the way you thought about it before [pupil shakes head] you like to think of the force of the hit in the ball."

S: "Yes."

R: "Yep ... O.K."

As you can see by these interviews some children will modify their views but others, while accepting that there is another perspective, still find it more sensible to think about the situation in their own way; at least for the present.

I think we have to accept that, leaving both our own integrity, and the child's integrity, intact.

We certainly don't see our material as the last word on teaching about force. We hope that if you try the material you will certainly experiment with it, and improve upon it.

LEARNING IN SCIENCE PROJECT

VIDEO: SCIENCE ACTIVITIES

University of Waikato
Hamilton N. Z.

44 WORKING PAPER No. 54

VIDEO: SCIENCE ACTIVITIES

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This paper is designed to be used in association with the video tape "Science Activities" prepared by the author.

MAKING SCIENCE ACTIVITIES MORE MEANINGFUL

INTRODUCTION

Over the past three years we have observed a large number of children involved in science activities in typical classrooms. This has enabled me to sit alongside children and by listening to what they say and observing what they do gain insights into their world and ways of thinking. Insights which the responsibilities we normally have as science teachers prevent us from fully appreciating. What I discovered was a considerable gap between where we, as teachers assume our pupils to be and where they actually are in terms of their thinking about science activities.

In this video we consider a lesson where children are being introduced to the ideas associated with the dissolving of a crystal in water.

We will first give you some insight into children's views about what happens when a crystal is dropped into water. We then show an activity involving the dissolving of crystals in water, which is frequently used in 3rd form classes to help pupils gain some understanding of the particle nature of matter. Unfortunately, as we will see, the lesson makes unfounded assumptions about the ideas children bring with them to this lesson. Finally we show an alternative approach to the same lesson where an attempt is made to take the children's views into account.

CHILDREN'S VIEWS

We have listened to many children discussing what is involved when a crystal dissolves in water. Their comments make clear that a number of non-scientific ideas about this process are both widely and strongly held.

One idea relates to the colouring that is apparent when a coloured crystal dissolves in water. For many pupils, the colouring effect is not due to the particles of the crystal spreading out throughout the water. But, is in fact due to the colouring escaping from the crystal as the structure breaks down. Three typical views that we have found children use to explain what happens when a Condy's crystal is dissolved in water are exemplified by the following three pupil statements. (Turns to blackboard and reads)

PUPIL 1

"The Condy's crystal sinks to the bottom and the purple colouring in it is slowly squeezed out by water pressure."

This view is rather like the idea of a sponge full of colouring which is being squeezed to allow the colouring to escape. The structure of the sponge is unaltered except for the fact that it reduces in size.

PUPIL 2

"Purple particles of Condy's crystal go into the water as the crystal breaks up making the water look purple."

The ideas inherent in this view are similar to those of the scientist.

PUPIL 3

"Particles of Condy's crystal go into the water and allow the purple colouring to escape from inside the crystal into the water."

The ideas in this view, like those contained in the view of Pupil 1, see the colouring as not a property of the crystal structure.

Our experiences suggest that some 50% of pupils in the Form 1 to 4 range, hold a type 1 or type 3 view. A view that has the colouring as something that is quite independent of the crystal structure. Pupils who hold this kind of view would seem unlikely to be impressed, in the way we as science teachers would expect them to be, by activities which involve dissolving. Especially where the intention is that the activity is to give them insights into the behaviour of particles.

TYPICAL LESSON

Teacher: (looking at instructions and information set out on the blackboard) "Today we are going to look at a piece of work, it's actually an experiment that you'll be doing and it's related to investigating the behaviour of particles. (Turns to class) Who can tell me something about particles .... something we have done in the past? Tracy."

Tracy: "They're small pieces of something bigger."

Teacher: "They're small pieces of something bigger ... yeah, I think that not a bad description."

Robert: "Particles make up something."

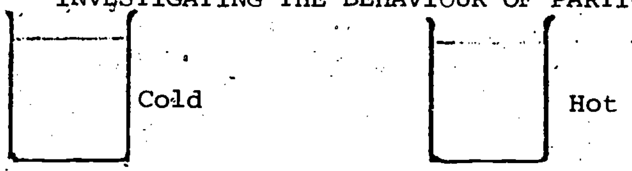
Teacher: "They make up something ... O.K. well I think that's perhaps all we need to think of at this moment. Particles are small bits of something ... they're things that make up something ... Now today what we are going to do is have a look at the way particles behave and we are going to use Condy's crystals to do this. Now Condy's crystals are these little blackish purple bits that are on the piece of paper beside you. You might like to have a quick glance at those ... you have got quite a number of little bits there ... alright? ... How many people have seen that sort of thing before? ... O.K. you used them last year or something. Now, what we are going to do is get two beakers fill one with cold water and fill the other with hot water and then drop a Condy's crystal into each of them ... alright? (turns to look at blackboard which has the method summarized, see below) then after you have dropped them in I want you to look very carefully at what's happening in there, because later on you are going to have to answer some questions. The questions are, this one here (refering to blackboard notes) ... what happens to the Condy's crystal in each beaker to start with and then after a while? ... O.K. ... Yes, Mahoney."

Mahoney: "How much water do you put in the beakers?"

Teacher: "Well I think if you fill it pretty well up ... say (holding up a beaker) up to the level where it has got 200 or something like that, I tried to draw it up there (on blackboard) I thought that might help ... didn't you."

Blackboard Instructions and Information

INVESTIGATING THE BEHAVIOUR OF PARTICLES



Method

Make sure the water has settled.
Drop a large crystal into each beaker.
Watch carefully.
What happens to the Condy's in each beaker
(a) to start with
(b) after a while.

Question

What do you think was the most likely cause of the different results?

Draw

A diagram of the two beakers showing what they looked like after a while.

Copy and Complete these Sentences

I think particles in water (can,cannot) move about.
These particles move (more easily, not so easily) if the water is hot.

Teacher: (cont.) "O.K. now this is a question I am going to ask you to think about (reads from blackboard). What do you think was the most likely cause of the different results? ... Now that is sort of suggesting you might get some different results, we'll have to wait and see ... So while you are doing this, you be thinking about what is happening and how you think it is happening. Let's see if we can get underway O.K. ... alright? You've got the water in the big beakers in (the centre of) each of the desks. Each group do this, you are to work in pairs. You can talk of course while you are doing this ... discuss what you are going to do and who's going to do what ... how you are going to do it and let's get under way ... If you need any help call out."

(The children begin to set up the experiment, Mahoney has trouble with the beaker of hot water, it's too hot to hold! However, after a few initial problems the Condy's crystals are added to the beakers)

Teacher: "Remember the instructions are on the board if you are unsure of things."

(Mahoney and Jenny look at their beakers and then, after a short while swing around to see what other groups are up to. The boys in the next group check briefly on Mahoney's beaker)

Teacher: (to boys in group next to Mahoney) "How's it going ... all right?"

Ross: "Yep."

Teacher: "Good (looks closely at their beakers) ... how many did you drop in there?"

Robert: "I actually put two in there."

Teacher: "You put two in there (moving on)"

(All pupils discuss among themselves what is happening)

Teacher: "Remember you've got certain things that you are expected to do ... oh ... so while you are watching what is going on I hope you are doing some thinking."

(Camera returns to blackboard, introducer reads)

Question

What do you think was the most likely cause of the different results?

Draw

A diagram of the two beakers showing what they looked like after a while.

Copy and complete these sentences

I think particles in water (can,cannot) move about.
These particles move (more easily,not so essily) if the water is hot.

(Camera returns to class)

The pupils take some 10 minutes to record their answers. Then pupils were asked to state to the class what they had seen happen ... replies included ...

Teacher: "You've got something different have you Tracy?"

Tracy: "On it's way down it left a trail of colour behind it in the hot water and when it hit the bottom it instantly started to spread out."

Teacher: "Was that in both of them ... or just in one of them?"

Tracy: "That was in the one I had ... the hot water."

Teacher: "What about in the cold water?"

Paula: (Tracy's partner) "Well, I dropped it in and it sat on the bottom for a while and then it started to dissolve."

Teacher: "I see ... so you had to wait too ... so you did the hot one (to Tracy who nods) and you did the cold one (to Wendy who also nods) ... oh, I see!"

Mahoney: "I found out that even though the ... ah ... Condy's crystal in the hot water spread out more the crystal was still in the bottom."

Teacher: "The crystal is still in the bottom."

Mahoney: "Mm, same as the cold one."

The lesson moves on to discuss the copy and complete sentences.

Teacher: "O.K. well let's go down to the sentences that you completed. Guess these are some of the things that you have been thinking about ... I hope. I think particles in water can/cannot move about? (reading question from blackboard) What did you write down for that ... ah let me see ... Robbie, what did you write down?"

Robbie: "I think particles ... can move about."

Teacher: "Can move about ... O.K. ... anybody think anything different from that? ... you did Tracy?"

Tracy: "I thought they did move about but not as the same thing, sort of as a liquid as it dissolved."

Teacher: "... not as the same thing, sort of as a liquid ... that's interesting isn't it ... well what about this one (second question on blackboard), these particles move more easily /not so easily if the water is hot? ... What did you choose there .... who's got a choice there? ... Mahoney, what did you choose?"

Mahoney: "More easily."

Teacher: "More easily ... did anyone say ... who said more easily? (with one exception all pupils raise their hands) Who said not so easily? (Therese raises her hand)

The general concensus that particles can move and the majority view that they move more easily if the water is hot suggests that pupils' thinking in relation to the particles is close to the thinking of the teacher. However, do these responses <u>really</u> tell us how children are thinking what is happening in the beaker?

CHILDREN'S VIEWS

Let us investigate what these children, as a result of the typical lesson experience, now think about what happens when a crystal dissolves in water. We confront these children with the three views discussed earlier. The pupil 1, pupil 2 and pupil 3 views described before are here labelled (a), (b) and (c) respectively.

> Views written on blackboard
>
> (a) The Condy's crystal sinks to the bottom and the purple colouring in it is slowly squeezed out by water pressure.
>
> (b) Purple particles of Condy's crystal go into the water as the crystal breaks up making the water look purple.
>
> (c) Particles of Condy's crystal go into the water and allow the purple colouring to escape from inside the crystal into the water.

Teacher: "How many people have an idea that is like person ... Put your hand up if you've got an idea like person (a) ... one of you."

Theresa: "There's two."

Samantha: "Oh, me too."

Teacher: "Oh, you've got that idea too ... good, two of you. O.K. ... what about (b)? ... The person who had (b)'s idea and it's now like yours ... (b), one, two, three, four, five, six ... and how many people have got (c)? ... one, two, three, four of you."

This spread of responses is not unusual for children of this age suggesting that the typical lesson experience has had little impact on how these children think about particles.

ALTERNATIVE LESSON

As we have seen from the previous lesson we sometimes make invalid assumptions about children's ideas. This can jeopardize our chances of acquiring the main ideas that we are trying to teach. What can we do about this?

Let us now consider an activity in which children first drop a single crystal into water and through a worksheet get to discuss their ideas about what they think is occurring; an activity which could lead to a discussion of the three children's views that we have seen influences their thinking.

In this alternative approach children would first drop a crystal into a beaker of water and observe what happens. After a while, the views children have about this could be discussed. All views, including those children hold about colouring being independent of the crystal structure could then be listed on the blackboard. Let us imagine that this alternative lesson has reached this point.

Teacher: "Has anybody got any thoughts about how we might carry out a little investigation that could tell us something about the problem ... Is it that purple colouring is coming out to make the water look purple, or is it the crystal that is actually made up of purple particles and that they're spreading out through the water and making the water look purple?"

Therese: "You could put this thing on the paper, crystal on the paper and put it in the water and see after a while if it is purple and if it's gone or still there."

By further questioning it is established that Therese is suggesting that the observation of a crystal that has been in water for a short time would clarify things. The teacher suggests that a comparison of one crystal dropped in the water for a time, with a similar crystal left on the bench might improve Therese's experiment.

Therese: "And it (the crystal in the water) might be a little white dot or it might be just the same size."

Teacher: "Right, I think that's a good idea Therese. If we could leave them there for a while ... get it out and have a look at it. If it has gone clear then it would seem perhaps that the purple is in fact a colouring that has come out of the crystal ... But if the crystal is still purple and if it is smaller, that might suggest to us ... what? ... Wayne."

Wayne: "That the particles, small, small particles are being broken away within the water."

Teacher: "Yeah, and what about those particles? ... someone down ...?"

Tracy: "They're purple."

Teacher: "They're purple ... Shall we try and do that and see what happens ... O.K.? ... So take one of your crystals and drop it into the water ... all right, ... have a look and see what's going on."

Let's move on to the class discussion.

Teacher: "What can you tell us about what's happened? ... What happened in your group, let's see ... Paula?"

Paula: "The Condy's crystal that we put in the water, it's got smaller but it is still the same colour."

Teacher: "O.K. What about the other group that have managed to do this successfully?"

Robert: "Same thing."

Mahoney: "It's got smaller, and then it's all dried up."

Teacher: "And now it's all dried up ... would you say it was the same colour or a different colour than what it."

Mahoney: "Same colour."

Teacher: "Same colour ... Samantha?"

Samantha: "Yeah, ours got smaller but it's still the same colour."

Teacher: "O.K. So, it looks as though at least four people who were able to get it (the crystal) out without it breaking are telling us the same thing ... all right? ... the crystal's the same colour but it's smaller."

A Pupil: "Yeah."

Teacher: "What do you reckon that means as far as our thinking about what's happening inside the beaker ... to the crystal ... Now let's ask Therese because she had a different view before. She was one of these people who thought that initially the colour was coming out ... and then after the colour had come out the crystal would break down and the particles of the crystal would go into the water ... What do you think now Therese?

Therese: "I think that, I think that ... [inaudible] ... ... I think ... the purple stuff is the actual crystal."

Teacher: "You think the purple stuff is the actual crystal ... who could put that in another way? Perhaps a way which is similar to how these people last year talked (pupil (a), (b) and (c)) ... Tracy?"

Tracy: "The Condy's crystal when it's put in the water, the little bits of crystal are breaking off and going into the water to make it smaller."

Teacher: "To make it smaller."

On completion of this activity and discussion children's views were resurveyed. Ten of the twelve pupils were found to have the scientific view.

Although there are still two children within the class with a view of what happens when a crystal is dropped into water that is different from

from that of the scientist. The class would now seem better placed to appreciate the significance of the different rates of colouration in the hot and cold beakers and relate what they see to the behaviour of particles.

The hot and cold beaker activity would perhaps now seem better placed to contribute towards the development of a particle model for matter.

ACKNOWLEDGEMENTS

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