TEACHER ATTITUDES AND KNOWLEDGE OF EARTH SCIENCES IN NEW ZEALAND: A SMALL-SCALE SURVEY AND SOME IMPLICATIONS

A. PETER W. HODDER
and
KATHRIN OTREL-CASS
Department of Earth Sciences
University of Waikato

ABSTRACT *The introduction of earth sciences into the New Zealand school science curriculum was long campaigned for. Although some elements of earth sciences have formed part of the geography syllabus in the past, those science teachers who did not teach geography might be expected to be unfamiliar with earth sciences. A survey of 156 teachers revealed a wide variation in knowledge of earth sciences, confidence in teaching, and involvement in teaching earth sciences, and showed an association between their confidence in and knowledge of the subject. It is argued that hands-on activities that demonstrate earth processes may help teachers to successfully implement the earth sciences component of the science curriculum.*

INTRODUCTION

In New Zealand, as in most other countries, science teaching is changing, as is the understanding of how to teach science. The responsibility of scientists and science teachers is to improve knowledge and widen understanding to help students understand the impact of science and technology on our society (e.g., Black and Atkin, 1996; Mayer, 1997). In the revision of the science curriculum that reflected this emphasis (Ministry of Education, 1993), earth sciences was introduced into it as a "learning strand" (viz., "Planet Earth and beyond").

This introduction was seen as an opportunity for science teacher development as well as for providing resources for teaching (Hodder, 1997). As one response to the new demands the curriculum imposed on teachers and students an exhibition - "Earthworks" -was designed. This exhibition (Hodder, 1996) gave teachers and students a hands-on activity-based experience to become familiar with some earth processes that are often described in earth science teaching. It was developed under a Learning Experiences Outside the Classroom contract with New Zealand's Ministry of Education. Informal positive responses from teachers attending the exhibition and a more formal post-visit evaluation of students' knowledge suggested that the exhibition was successful (Hodder and Otrel-Cass, 1998). The exhibition was scheduled to tour New Zealand's network of science centres from 1996 to 1998 and prior to its opening at every centre teacher

workshops were conducted, at which a teachers' resource book associated with the exhibition (Hodder, Jenks and Peters, 1996) was provided to every attendee.

Teachers who attended the workshops were invited to complete a questionnaire which investigated the teacher's relationship with earth sciences. This paper describes the questionnaire, its results and its implications.

THE SURVEY

The questionnaire was divided into two parts. In the first part participants were asked about the extent of their formal education in earth sciences or attendance at in-service courses with earth sciences as a theme, and their teaching experience so far with the subject. Teachers were invited to rate their own confidence and to give a written explanation for their rating. The second part of the questionnaire was designed to obtain information about the teachers' background knowledge in earth sciences. First, they were asked to say whether particular earth sciences and astronomy statements were "true" or "false"; there were also "not sure" or "never heard of" options. They were then asked to identify locations of past New Zealand volcanic activity and places where future activity was likely. Finally, teachers were asked to draw a volcano and to label their diagram.

RESULTS AND IMPLICATIONS

The participants

The teachers attending "Earthworks" workshops were either self-selected or nominated to attend by their school. Of these attendees, 156 participated in the survey, drawn from two cities in each of the North and South Islands. The overall percentage of male teachers (37%) was similar over the four cities. However, there was a higher proportion of female teachers from primary schools, with a more equal gender distribution for attendees from secondary schools. The highest proportion of teachers (33%) had 10-20 years of teaching experience, with a few having more than 35 years experience. The distribution of participants by gender and school type is given in Table 1. Of all teachers, 19% had some earth science pre-service training, but only 13% had in-service experience of earth sciences prior to attending the "Earthworks" workshop.

Table 1: Distribution of participants by school type and gender

School type	% by type of school	% by gender of school type	
		male	female
primary school years 1-8)	23	28	72
primary school (years 1-6)	24	22	78
intermediate school	13	30	70
form 1-7 school	3	50	50
form 3-7	30	55	45
form 3-7 with attached intermed.	5	25	75
area school	2	33	67

Teachers' confidence and experience with earth sciences

Only two participants elected not to rate their confidence. Eight percent of teachers rated themselves in the highest confidence rank (rank 1) on a scale of 1 to 5, and stated that they had taught between three and seven topics during the past year. Twenty five percent of teachers ranked themselves at rank 2. The majority (39%) were at rank 3; 20% were at rank 4; and 8% indicated that they were not very confident about teaching earth sciences (rank 5). When asked for a reason for their confidence ranking, it became clear that the teachers' overall opinion was that background knowledge, whether obtained through professional training or personal interest, seemed to enhance confidence in teaching earth sciences (Table 2).

Table 2: Examples of participants' perception of association of background knowledge in relation to their confidence ranking

Participant identifier	Confidence ranking	Comment about background knowledge
H14	1 [high]	"My previous education and natural interest lends to the subject"
H22	2	"I spend time collecting resources and developing programmes"
H32	3	"Lack of training, prior knowledge, experience, time to prepare"
D156	4	"I have a small knowledge base on which to draw"
D151	5 [low]	"Lack of own experience and training"

One teacher with a low confidence (D129, rank 5) felt that this might affect the students' interest in earth sciences: "While children often find this a fascinating area to study, I inhibit this enthusiasm through poor understanding myself." Conversely a more highly confident teacher (C92, rank 2) commented: "Both children and I have found earth science topics fun and fascinating."

Awareness of the availability of resource material seemed associated with the level of confidence; sample comments are given in Table 3.

Table 3: Examples of participants' perception of availability of resource material in relation to confidence

Participant identifier	Confidence ranking	Comment about availability of resources
DlSS	2	"Plenty of books available"
H10	3	"Hard to find interesting, easy, practical activities"
C77	4	"Lack of teaching resources

Based on the content of the "Planet Earth and beyond" strand of the science curriculum and on the major themes represented at the "Earthworks" exhibition, teachers were asked to tick all the earth sciences areas which they had taught during the past year. The subjects of earthquakes, volcanoes, and Earth as a planet within the solar system were taught by nearly two thirds of the teachers, but fewer teachers covered fossils (37%), soil and erosion (36%), and commercial use of Earth's materials (24%). This relative ranking of topics taught resembles that found in Springer's (1997) analysis of "hits" on geologic topics from American

newspapers and popular magazines. He found a preponderance of media reports on natural hazards (51%); followed by fossils, including dinosaurs, (22%); the "trendy" topics of global warming and climate change (12%); and minerals (8%), and notes: "Not surprisingly, many of the topics that appeared frequently in the publications examined directly concern human welfare. Earthquakes, floods volcanoes and minerals are all of immediate and vital interest to the public... Notice, however, that 'landslides' and groundwater contamination or pollution generated few hits. Perhaps these topics are perceived to affect fewer people or to be less spectacular phenomena - no big explosions, no fireworks, no raging waters .... ". Perhaps such considerations also influence teachers' choice of topics.

Teachers' knowledge of earth sciences

As mentioned above, the knowledge part of the questionnaire was divided into three parts. The first consisted of statements, as for example: "Seafloor is created along the mid-ocean ridge." Participants were asked to read the statement before ticking one of the boxes: "never heard of", "not sure", "true", or "false". All except two participants completed this part of the questionnaire. A majority of teachers (76%) scored between four and seven correct answers out of the nine questions. Teachers scoring highest were from Form 3-7 schools and from year 1-6 primary schools. Teachers from full primary (i.e., years 1-8) and intermediate schools had, on average, lower scores.

The next part of the knowledge test was based on the location of past eruptions of New Zealand volcanoes and the likelihood of a future eruption at the same location. There were regional differences in knowledge of this topic: teachers from the South Island had better knowledge of their local volcanic history than their colleagues from the North Island (Table 4).

Table 4: Distribution of knowledge about New Zealand volcanism

	Knowledgeable about volcanism in:	
Resident in:	North Island	South Island
North Island	95%	62%
South Island	100%	92%

Finally, teachers were asked to draw a volcano and label its features. In order to judge these features a hierarchy was developed which rewarded points for particular features. This hierarchy was developed after extensive trials with teachers and students. A point was given for each of the following five features, either in the drawing or as a written explanation: volcanic cone form, magma chamber, internal plumbing (e.g., from magma chamber to vent), involvement of water or gas, correct layering of erupted materials (i.e., parallel to the flanks of the cone). Thirteen teachers (8%) did not attempt this question. For the remaining participants the percentages of teachers with particular scores are shown in Table 5.

Table 5: Representation of features of volcanoes

number of correct features (*N*)	1	2	3	4	5
% participants who drew or explained *N* features	26	35	21	8	1

The results of Table 5 are of concern because 58% of all teachers had stated earlier in the questionnaire that they had taught about volcanoes during the past year. Teachers from form 3-7 schools had the highest proportions of three and four features correctly identified. Primary and intermediate school teachers on average identified one or two features (Table 6).

Table 6: Distribution of identification of volcanic features by school type

School type	Number of volcanic features (*N*) represented on drawings					
	0	1	2	3	4	5
	% participants who drew or explained N features [highest percentage for each N-value in bold]					
primary school (years 1-8)	11	40	31	14	3	0
primary school (years 1-6)	3	29	50	13	5	0
intermediate school	10	16	16	10	0	0
form 1-7 school	25	25	25	25	0	0
form 3-7	5	12	26	36	18	3
form 3-7 with attached intermed.	29	0	43	28	0	0
area school	33	33	33	0	0	0

CONCLUSIONS

These findings from a small and largely self-selected group of teachers presently or potentially teaching the "Planet Earth and beyond" strand of the science curriculum suggest that teachers may lack both the confidence and knowledge to implement that strand successfully. It is reasonable to expect a comparable - or perhaps even greater - lack of confidence and knowledge among non-attending teachers.

We noted that the teachers who were less confident and less knowledgeable about earth sciences were more likely to be unaware of resources to support their teaching of the subject. Furthermore, for those unfamiliar with geology, it may be difficult to visualise the processes on and in the Earth that give the "results" of those processes (i.e., the geology around us). Hands-on activities - like the "Earthworks" exhibition - that demonstrate these processes may help both teachers and their students appreciate earth sciences in a stimulating and non-threatening way.

REFERENCES

Black, P. & Atkin, J.M. (1996). Teachers and change. In P. Black & J.M. Atkin, (eds). *Changing the Subject. Innovations in Science, Mathematics and Technology Education.* London: Routledge.

Hodder, A.P.W. (1996). Earthworks: a guide to the exhibition. *Department of Earth Sciences, University of Waikato, Occasional Report* 23.

Hodder, A.P.W. (1997). Science-technology centres and science education in New Zealand. In B. Bell & R. Baker, (eds). *Developing the Science Curriculum in Aotearoa New Zealand.* Auckland: Addison Wesley Longman.

Hodder, A.P.W. & Otrel-Cass. K. (1998). Introducing geosciences to teachers and students with a touring exhibition of interactive models and simulations of Earth processes. *Visitor Behavior* [submitted].

Hodder, P., Jenks, A. & Peters, J. (1996). Earthworks: the teachers' guide. *Department of Earth Sciences, University of Waikato, Occasional Report* 20.

Mayer, V.J. (1997). Global science literacy: an Earth system view. In *Journal of Research in Science Teaching,* 24(2), pp. 101-105.

Ministry of Education (1993). *Science in the New Zealand Curriculum.* Wellington: Learning Media.

Springer, D.A. (1997). Geology in the popular press: paleontology's greatest hits. *Geotimes,* 42(3), pp. 20-23.