DOCUMENT RESUME

ED 236 031 SE 043 312

AUTHOR Happs, John C.
TITLE Soils. Science Education Research Unit. Working Paper 201.
INSTITUTION Waikato Univ., Hamilton (New Zealand).
PUB DATE Oct 81
NOTE 38p.; For related documents, see ED 226 976, ED 229 442, ED 230 594, ED 235 011-030, SE 043 285-302, and SE 043 305-315. Document contains some marginal legibility.
AVAILABLE FROM University of Waikato, Science Education Research Unit, Hamilton, New Zealand.
PUB TYPE Reports - Evaluative/Feasibility (142) -- Reports - Research/Technical (143)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Comprehension; *Concept Formation; Concept Teaching; *Curriculum Development; *Earth Science; Elementary School Science; Elementary Secondary Education; Interviews; Learning; Science Education; *Science Instruction; *Secondary School Science
IDENTIFIERS *Learning in Science Project; *New Zealand; Science Education Research; Soil

ABSTRACT

The Learning in Science Project has adopted the view that science teaching might be improved if teachers can be given some appreciation of students' views of the world and the beliefs, expectations, and language that learners bring to new learning situations. This investigation looks at the topic of soil, one of the basic resources of New Zealand economy. Areas examined include the nature, sources, age, and depth of soils, and changes which soils undergo. Data were collected from individual interviews (N=40) and from a questionnaire administered to 221 students. Findings (including interview transcripts) indicate a conflict between the views of soil seen through the eyes of children and adolescents when contrasted with views of soil scientists. Although there was general agreement in interviews/survey on the question of soil depth, several differences of a virtually bi-polar nature were noted for other areas (soils formed via environmental factors versus soils always there or dynamic versus static soils). These results indicate that the more important ideas concerning soils should involve a focus on the nature/origin of the age of soils, and the idea that soils are changing with time. (Supporting documentation, including survey instrument is provided in appendices.) (JN)

SCIENCE EDUCATION RESEARCH UNIT

SOILS

University of Waikato
Hamilton, N.Z.

WORKING PAPER 201

SOME ASPECTS OF STUDENT UNDERSTANDING OF SOIL

A working paper of the Science Education Research Unit

John C. Happs

October, 1981.

INTRODUCTION:

One of the underlying assumptions that is reflected in the Learning in Science Project (FREYBERG, OSBORNE AND TASKER, 1980) is that science teaching might be improved if attempts are first made to gain some appreciation of the beliefs, expectations and language that children bring with them to the learning situation

The emphasis throughout the L.I.S. Project has not been evaluative; rather it has strived to probe difficulties by means of small-scale, in-depth studies that can readily be related to science teaching, essentially at the Form 1-4 levels.

Many of the previous in-depth studies from the project have tended to concentrate on areas of physics (OSBORNE, 1980; STEAD, 1980), chemistry (HAPPS, 1980; SCHOLLUM, 1981) and biology (STEAD, 1980(a); STEAD 1980(b)). In comparison to these studies, very little research has been conducted into students' concepts and understanding in areas within the earth sciences (MOYLE, 1980).

This investigation attempts to focus attention on the topic "Soil". This is seen to be an important teaching area (HAPPS, 1980) and is included in the Infants to Standard 4 syllabus; in Section 4 of the Science: Forms 1-4 Draft Syllabus; and with provision for its inclusion in section 14 of the same syllabus. The 1968 science syllabus also introduces aspects of "soil" at the Form 5 level and the relevant extracts from these syllabuses are shown in Appendix A.

After several generations of the misuse of soils in New Zealand there is now a growing awareness about the role of soils in the environment and their importance as a life-supporting factor. The New Zealand economy is dependent upon basic resources such as soil and water; thus, an understanding of some aspects of soil would appear to be a desirable component in the scientific education of all New Zealanders.

THE SCIENTIST'S VIEW OF SOIL:

Before considering the views and ideas that children have concerning the world of soil, it may prove both useful and appropriate to look at the ways in which the scientist might regard those same areas under investigation.

(i) What is soil?

The New Zealand farmer, orchardist or market gardener will, no doubt, adopt a practical view of soil since plants normally live and grow in contact with the two components of air and soil. In this context, soil is likely to be seen as the medium in which crops grow, i.e., the loose surface materials which support vegetation. As an extension of this view, the biologist sees the soil as an ecosystem consisting of decomposed and chemically altered rock, integrated with biotic materials. The civil engineer generally views soil as being the loose surface of the earth, as distinguished from solid rock, and this contrasting view of soil is highlighted later, within an extract taken from an interview with a soil scientist.

The first important scientific study of soil was made by the Russian, Dokuchaev (1846-1903), who showed that soils can be distinguished by their characteristic properties, processes of formation and patterns of distribution. A general definition of soil has been adopted by the soil scientist:

> "a natural body of mineral and organic constituents which results from the interaction of environmental factors such as rock, climate, topography, plant and animal life".

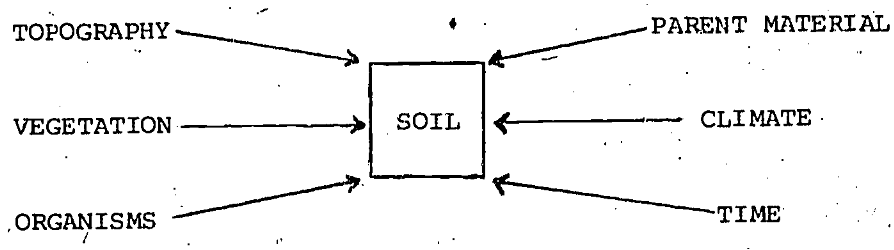
In this way, soil is seen to differ from the underlying material in appearance, in physical, chemical and mineralogical characteristics, and in the way in which it supports plant growth. The importance of an organic component in soil is always stressed by the soil scientist. The presence of only a trace of organic activity may be sufficient to allow the term 'soil' to be applied to the weathering material. This point of view has been stressed in the following extract, taken from an interview with a soil scientist:

I "So how does the soil scientist regard the material that would be taken say, from the moon? Would that be regarded as soil by the soil scientist - would that be regarded as a soil by engineers? What do you think?"

D "The stuff on the moon would be soil to the engineer, I'm sure - because you can dig it up with a trowel and bring it home. In terms of a soil scientist - no - because there's no life."

(ii) Where does soil come from?

Soils have formed as a result of the interaction between a number of environmental factors. These interactions occur at the site and soil, as such, is not transferred to a site by any other processes. Thus soil will develop at a site as a result of the interaction of climate, organic material, parent material, topography[1] and time. Therefore soil is both a part, and a product of the environment, wherever these factors operate:



These soil forming factors, along with soil itself, are part of a complex, interrelated network rather than of the simplistic model suggested by the above diagram.

The parent material need not only be weathered rock. Beach sand and sediment that is deposited via rivers, wind, glaciers and gravitational processes can also become parent materials for later soil development.

(iii) How old are soils?

Because there are marked differences between the effect of individual soil forming factors (or combinations of these factors) from site to site, the time needed for soil formation varies widely. Originally, the age of a soil was seen to be linked with the age of the parent material, although this approach can be misleading since the parent material is only one of the soil forming factors.

Following the onset of weathering of the parent materials, soil profiles may not emerge for about 30 years at the earliest (in a temperate climate) with some profiles requiring a thousand or more years for development. Thus the time needed for soil development will vary from site to site and the age of a particular soil site may not be the same as the geological age of the landform. Soil destroying events, e.g. erosion, and periods of sediment accumulation, will influence the age of soils. In a number of areas, soil sites that appear to be geologically old have been rejuvenated by being covered with more recent deposits.

In the Wellington area, for example, many of the soils are not developed from the weathered greywacke beneath them (the greywacke being approximately 200 million years old); rather these soils are formed on periglacial deposits which are little more than 10,000 years old. Because of such rejuvenation processes, soil sites in a temperate climate are usually younger in age than

[1] The glossary, in Appendix B, offers an explanation of those terms that are commonly used by the soil scientist.

equivalent sites that are found in the tropics and sub-tropics.

During a time period of thousands of years new parent materials for soil formation are formed. In the North Island of New Zealand, for example, volcanic eruptions have occurred at least once every 1000 years over the last 40,000 years. Each eruption produces a body of ash on which soil will form. Older ashes may be covered, or partly covered, by younger ashes so that soils on exposed old ashes may be up to 40,000 years old, but on the recent ashes only 300 years old, where this forms the modern land surface. This aspect has been outlined by a soil scientist:

> "We could say that most soils, in the Waikato, are geologically young, in terms of being mid-Pleistocene or younger. You could take the flood-plains as being the most extensive landforms we've got. We are talking about an age of 10-15,000 years but we've got older soils on the hills and, as we go further out of the basin, formed on materials older than that."

(iv) How deep are soils?

The 'depth' of a soil is taken here to relate to that distance between the surface litter layer and the point at which unaltered parent material is encountered.

The processes of soil erosion, sediment accumulation and the varying soil forming factors, such as climate, mean that soil profiles will show marked differences in depth from site to site. These contrasting soil depths may best be appreciated by considering that very deeply weathered tropical soils may show profiles up to 17 metres, or more. In comparison, some 'skeletal' hill soils may have very shallow profiles of only a few centimetres depth.

Variable soil depths are likely to be encountered throughout New Zealand and, in the Waikato region, it is generally considered that most profiles are not likely to exceed 2 metres from surface to parent material.

(v) What changes do soils undergo?

It has already been pointed out that soils can be destroyed by erosion and can never be transferred intact from one site to another by natural processes, e.g. flooding, avalanches, etc. Conversely, sediment deposition can take place to provide new parent materials for soil development and, in these two ways, soils can be drastically changed as materials are transferred into and out of the soil-forming cycle at a particular site.

Other, more subtle, processes (physical, chemical and biological) may occur within specific parts of the soil profile. It is not realistic to suggest that certain factors, which control soil processes, are more vital than others in soil evolution, because all soil-forming factors are important and contribute to change. It is likely, however, that one factor may have a particularly strong influence in a local setting. Some of these processes are simple in that they may involve a single mechanism. Other processes can be far more complex and involve a number of different mechanisms which are inter-related. Irrespective of which process(es) predominate, the soil body never remains unchanged and will evolve continuously with the passing of time.

THE INVESTIGATION:

40 students (6 x F1, 4 x F2, 3 x F3, 5 x F4, 5 x F5, 4 x F6, 3 x F7, 4 x T, 6 x U)[2] from 7 Co-educational Schools, 1 Teachers' College and 1 University, were individually interviewed. Students were selected by their teacher, who was asked to choose students of "average scientific ability".[3]

During the interviews, students were asked to consider a number of samples which were presented to them in sequence. These samples were: a loose portion of topsoil; a section of turf, with ample grass and a well-developed exposed root system; clay; dry grass; sawdust; potting-mix and pebbles. Such samples represented familiar materials which are likely to be commonly encountered outside the science laboratory and, during the interviews, students were asked to describe and identify what they observed. This line of questioning was shaped towards eliciting the students' concept of soil and soil development.

An explanation of phenomena, and their possible links within the environment, was sought, in terms of the students' own ideas. It was emphasised that what was required was the student's own explanation and viewpoints and that there would be no emphasis placed on 'right' or 'wrong' answers. The interviews were maintained in an informal and 'non-threatening' atmosphere throughout.

A number of cards were produced at the end of the 'sample' phase of the interview. A stimulus word[4] was written on each card so that the initial fixed sequence of open-ended questions could be supplemented by information offered by each student, in response to the stimulus-word. In this way, each student was invited to provide as much information as possible about each stimulus word,

[2] F1-F7 = Forms 1-7 (11-17 year olds); T = 1st year Teachers' College students; U = 1st year University students.

[3] The investigator considered that students were average to slightly above average in most cases. F6 and F7 students studied science subjects and geography, at the time of interviewing.

[4] These words were: SOIL; COLOUR; SILT; ROCKS; PODZOL; SAND; CLAY; CONSISTENCE; TEXTURE; STRUCTURE; PROFILE; LIVING THINGS; VEGETATION; WATER; PARENT MATERIAL; [illegible]

whilst relating this information to soil wherever possible. This approach also allowed students a further opportunity to offer information, concerning aspects of soil, that had been probed previously.

A QUANTITATIVE SURVEY:

A summary was prepared of the interview findings which concerned students' views towards aspects of "soil", and a multiple-choice survey (see Appendix C) was constructed to gain a more quantitative appreciation of these findings with a larger group of students.

The survey was checked independently, for face validity and then trialled amongst 30 students (5 x F3, 5 x F4, 5 x F5, 5 x F6, 5 x F7, 5 x T) as a check for instrument stability (GARDNER, 1975). During this procedure the 30 students were each given a survey and the results noted. A second instrument was given to these same 30 students after a lapsed time period of about 3 weeks. It was hoped that their initial responses would have been forgotten during this time and that the time interval was also brief enough to prevent any factors, of a long-term nature, from influencing their responses. 6 students (selected at random from the original 30) who had changed some of their responses during the second survey, were interviewed to establish reasons for such changes. None of these students reported a misunderstanding of the questions, as a reason for change. All of these 6 respondents indicated either a change of opinion or else the response was a complete guess.

The survey was finally modified and then administered to 221 students - (33 x F1, 29 x F2, 25 x F3, 32 x F4, 34 x F5, 32 x F6, 36 x F7) from 2 intermediate and 5 secondary schools from the Hamilton area.

Only a limited number of aspects of the students' view of soil can be discussed within the scope of such a brief article. These areas will now be considered in turn:

1. WHAT IS SOIL?

The first part of the interview[5] attempted to ascertain whether, or not, students recognised soil samples as such, whilst investigating those characteristics that were assigned to soil. General questions such as "What do you see there?" and "Why do you call it that?" were used.

17 students (4 x F1, 1 x F3, 2 x F4, 4 x F5, 3 x F6, 2 x T, 1 x U) used the words 'dirt' and 'soil' as synonomous terms and did not envisage any differences between the two. However, the majority of students did point to

[5] Interviews generally had a duration of approximately 45 minutes although this time-span varied between individual students.

differences between dirt[6] and soil although their criteria were often not the same:

"dirt's got little insects and that in it" (101)[7]

Older students tended to be more specific:

I Those two terms 'dirt' and 'soil', to you, are they the same or are they different terms, or what?

M Dirt, I think, is what you call any sort of stuff in the ground -- soil is more like what you plant things in - sort of, it's got more goodness and that in it. (804)

Only 1 student (1 x U) defined soil in terms of its dynamic character and its mineralogical and organic constituents. Descriptions from other students tended to be related to the physical nature of the soil:

I If I were to put a sample of something else down there, how would you decide whether, or not, it was soil?

S Well, you could tell by the colour of it and how it felt and what it smelt like. (702)

The bulk of responses to this kind of question, however, were met with answers relating to soil's ability to support plant life:

Only 2 students (1 x F1, 1 x F3) did not describe soil in terms of it being a medium for plant growth. This reference to living things was predominant:

"soil is a substance that's under the ground and helps growth of plants and things like that". (105)

I What do you mean by soil?

F More or less what can support plant growth. (904)

6 The soil scientist is not likely to place any scientific meaning on the term 'dirt', regarding it as a slang word with no specific connotation. This is in contrast to the term 'soil', which can be scientifically defined.

7 In this paper, Form 3 students are identified with a three digit number beginning with 3, i.e. 301, Form 4 students with a 4, e.g. 402, and so on. Teachers' College students are identified with an 8 and University students with a 9.

A response related to the number and role of soil organisms was provided by a younger student:

> "oh, there's untold living things in soil. They have to live there for protection and live there for a home kind of thing and that's just where they live to get food and that."
>
> (201)

However, less informative responses were offered by more experienced students:

T Some living things depend on soil. There are quite a few living things in the soil

I What sort of living things?

T Bugs

I Can you name any of them?

T No

(502)

and

I What are they (living things) doing in the soil?

R Eating it

(802)

One student (1 x F6) gave a response that approximated a scientist's view of soil with regard to its inorganic and organic components:

I What, to you, would make up a soil, if you were deciding whether something was a soil or not?

W Gravel and ground up rocks and decomposed material - with living things in it.

(603)

2. WHERE DOES SOIL COME FROM?

The idea of soil having evolved on site as a result of the interaction of a number of soil-forming factors was not appreciated by the vast majority of students. 16 students (5 x F1, 1 x F2, 2 x F3, 3 x F4, 4 x F5, 1 x T) believed that the soils they observed in the Waikato area were formed at the same time as the earth was formed. This was stated explicitly with no reference as to whether, or not, New Zealand existed at the time the earth formed.

G Umm - I'd say that it's always been there.

I Since the earth formed?

G Yes. (403)

Supernatural explanations were occasionally pointed to by younger students:

I How long has it been there - or has it (soil) always been there - or what?

K Um - since God created it. (103)

> "It's always been there when the earth got created." (104)

Even older students demonstrated that they did not see soil as having evolved over time:

> "I think the actual soil has always been there but - sort of - most of the - like the nutrients and that in it, sort of come from broken down things, like plants and that." (804)

Eight students (1 x F1, 2 x F2, 1 x F7, 2 x T, 2 x U) considered that soil was the product of rotting vegetation and/or animals:

> "I think it came from a rotting litter kind of layer." (201)

> "Well, it's all the dead matter and litter off the trees that has been broken down by the bacteria and that - and all the dead animals and things." (702)

> "Basically a lot of it - I think - comes from plants."

This same student later revealed that no relationship was seen between the origins of topsoil and clay:

> "A lot of it (soil) comes from plants -- like the topsoil and that, but the things like clay seem more like it - could be volcanic, or something like that." (902)

Five students (1 x F3, 1 x F4, 1 x F5, 1 x F6, 1 x F7) felt that volcanic activity was the source of soil:

"When you have a volcano erupting you've got lava coming out -- it dries up and turns into stone. It could be something like that comes up and turns into soil."
(402)

"I think it (soil) would be uplifted - from volcanic activity."
(604)

"Well, when we were doing volcano studies we saw how - umm - found out how - umm - lava - umm - the magma rose from beneath and all this. That could have been one process which might have contributed to soil being there."
(703)

Seven students (2 x F6, 2 x T, 3 x U) recognised that soil development may involve a multi-source mechanism:

"It's (soil) been weathered from parent material, like rock, and it's had other stuff added to it - nutrients."
(601)

"From rocks in river beds and seas - grinding against each other and particles getting smaller and smaller and getting either washed over the land or - umm- distributed by wind and stuff like that. Oh, and bird droppings and animal manure."
(801)

Similarly:

"I should imagine general weathering processes and they fetch fresh plants. They die and decay and you'd have your humus laid down. Then you'd probably have animals feeding on the humus and you'd have excretion added to it and man coming along with his fertilizers and water, wind, rain and sunlight."
(905)

Some unusual and more idiosyncratic theories of soil genesis were proposed by some students:

I If somebody said "you tell me how that soil arrived there. Has it always been there - has it arrived recently? Or -

B Manure from dinosaurs.

I Manure from dinosaurs?

B Yes.
(202)

M River deposits - mm - stuff which builds up the soil.

I Would you find the soils where there were no rivers - do you think?

M I suppose so.

I Well, how would they get there?

M Umm - like over in Europe - an ice age - due to glaciation and that. When it melts brings the stuff down from mountains and deposits it on the plains.

I So you always see a river involved in soil formation?

M Yes.

(701)

Two students (1 x F4, 1 x F6) had no ideas about how soil was formed:

"It (soil) has been formed - I don't know how."

(602)

Specifically directed questions showed that the idea of soil being a product of the environment and the need for several soil-forming factors was not appreciated by the majority of students[8]:

I Why do you not think there would be soils on the moon?

L Because I never heard anyone say there was.

(505)

3. HOW OLD ARE SOILS?

The sample of topsoil was used to ask students about the age of a 'typical' soil in the Waikato area. A significant proportion of students visualised soils, presently located in the Waikato, as having been formed at the same time as the earth was formed. Twenty-one students (5 x F1, 2 x F2, 3 x F3, 4 x F4, 4 x F5, 3 x T) stated this explicitly or implicitly:

"It's always been there."

(204)

The word "always" can mean a number of different time spans, depending upon the age of the student and this was followed up during the interviews:

G I'd say that it's always been there.

I Since the earth formed?

G Yes - virtually - yes.

8 Thirty-nine students (all except 1 x U) were not able to relate to soil-

I How long ago is that?
G Oh - millions.
I Millions?
G No - about billions of years ago.
I Billions?
G Yes.
I What's a billion - to you?
G About a million million.

(405)

T It has probably always been there.
I Since the earth was formed?
T Yes -- the same time or a bit afterwards.
I A bit afterwards?
T After the world started forming.
I But it's more or less the same age - do you think?
T Yes.

(504)

Three students (1 x F4, 1 x F6, 1 x U) stated that they had no idea of an 'age' for soils in the Waikato region and they were not prepared to speculate.

Other 'estimates' ranged from less than 20 years (1 x F1, 1 x F6) through less than 100 years (1 x U), 500 years (1 x U), less than 1 million years (1 x F6, 2 x F7), 2 million years (1 x F5), a few million years (1 x F6), to 100 million years (1 x T).

Three students (1 x F2, 2 x U), considered that the soil would have an age that was dependent on when the vegetation, that formed the soil, started to break down. Similarly, three students (1 x F2, 1 x F7, 1 x U) stated that the age of the soil would depend upon whatever formed the soil and when the process started.

A rate of formation, albeit rather rapid, was offered for New Zealand soils in general:

"Two metres form in 500 years in New Zealand."

(901)

Three statements in the survey probed students' ideas of the age of a 'typical' Hamilton soil sample and the data are displayed in Figures 1-3:

The notion of soils having been formed at the same times as the earth was formed (Figure 1) appears to be held by many of the F1-3 students, with less than 50 per cent of these age levels rejecting the statement that "soils in the Waikato area were formed at the same time as the earth was formed". A

Soils in the Waikato area were formed at the same time as the earth was formed

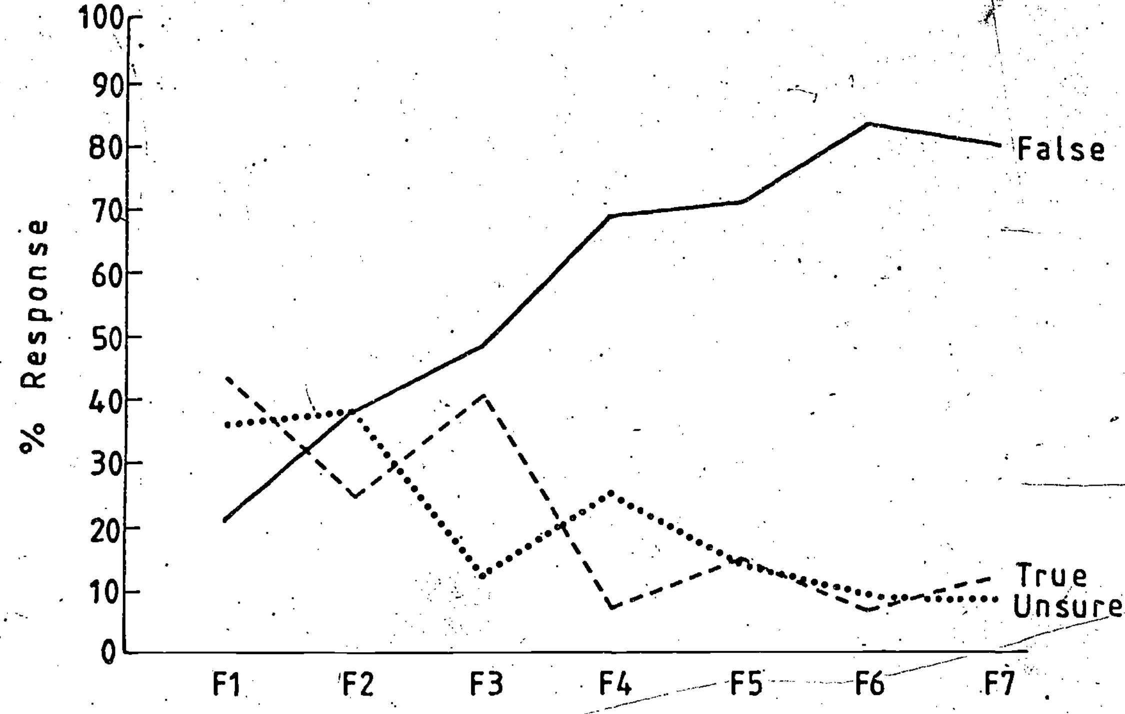


Figure 1

Soils in the Waikato are many millions of years old.

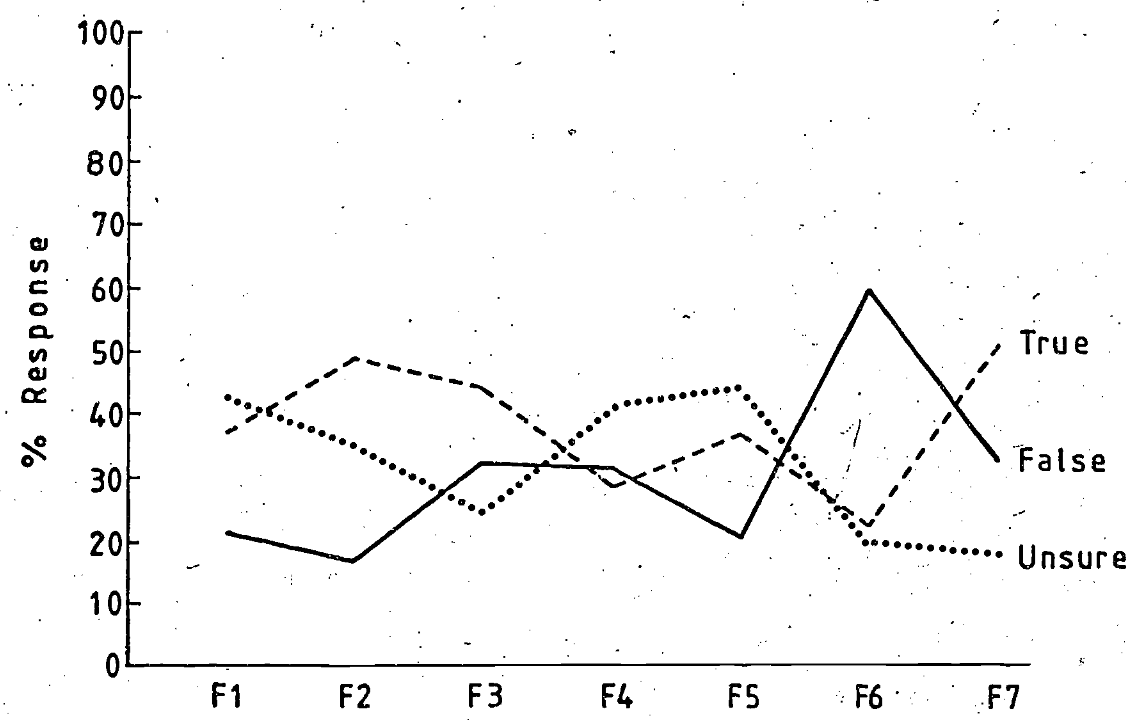


Figure 2

rejection of this statement is seen to occur progressively throughout all age levels. However, this improvement of responses from a scientific viewpoint, may reflect the realisation (by some students) that New Zealand did not really emerge as a discrete landmass until the late Jurassic - early Cretaceous periods (150-115 million years B.P.).

Data that is summarised in Figure 2 suggest that many students (the majority at the Form 7 level) consider soils in the Waikato area to be many millions of years old. These results (across all levels) would indicate that the idea of geologically young soils is not appreciated and, in this regard, very few students would appear to hold the scientist's view of soil age.

The idea of rapidly developing and very young soils (5 years or less) appears to have been rejected by the majority of surveyed students (see Figure 3) although a significant number (38 per cent) of F2 students were unsure about the statement that "soils in the Waikato are not very old and have only been formed during the last 5 years."

4. HOW DEEP ARE SOILS?

The hypothetical situation was proposed whereby the student could dig down indefinitely in his/her back garden, checking to see if soil was still there as the depth of the hole increased. The question was asked "How far down do you think that soil would go?" Estimates ranged from 6 inches to about 10 miles, with the following distributions:

Thirteen students (2 x F1, 1 x F2, 2 x F3, 2 x F5, 2 x F6, 1 x T, 3 x U), considered that the average depth of soil would be up to 1 metre:

"about 1 foot" (101)

T Probably a metre.
I About a metre?
T Yes. (803)

Fourteen students (1 x F1, 1 x F2, 4 x F4, 2 x F5, 2 x F7, 2 x T, 2 x U), suggested that the soil depth would be in the region of 1-10 metres, three students (2 x F1, 1 x F7), estimated depths between 11 and 100 metres.

Four students (1 x F1, 1 x F4, 1 x F6, 1 x T), were sure that the soil depth would lie between 100 metres and 1 kilometre with five students (1 x F2, 1 x F3, 1 x F5, 1 x F6, 1 x U), considering soil to be over 1 kilometre in depth.

Soils in the Waikato are not very old and have only been formed during the last 5 years

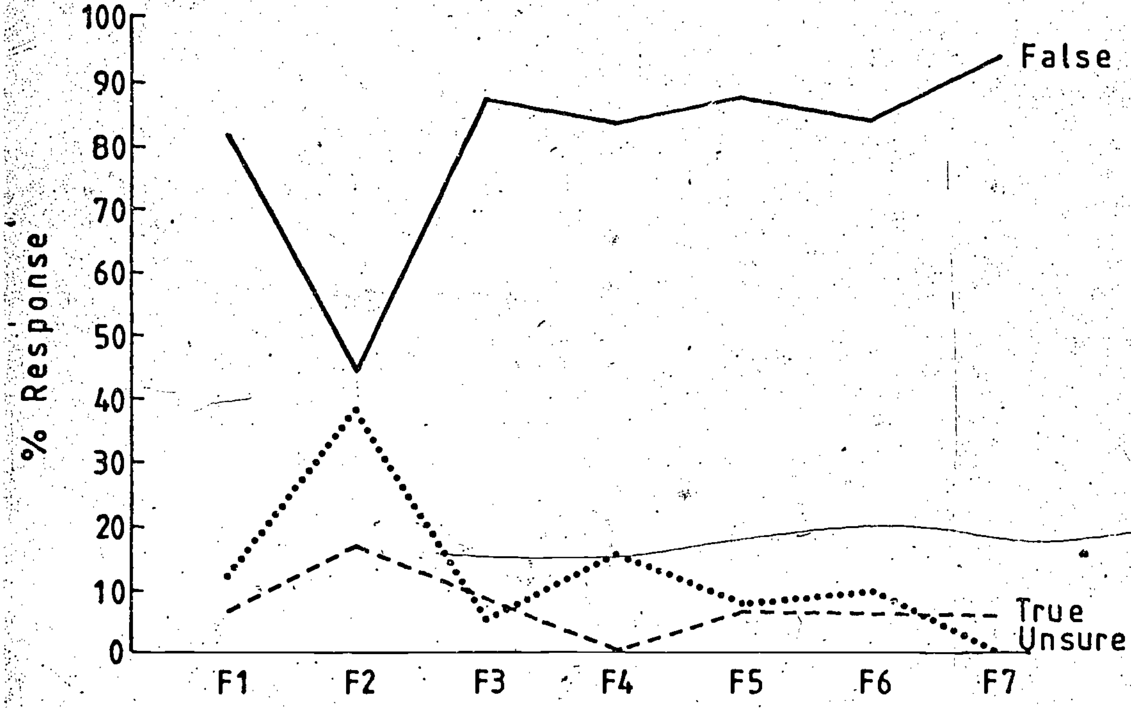


Figure 3

Most soils, in New Zealand, extend only to a depth of:

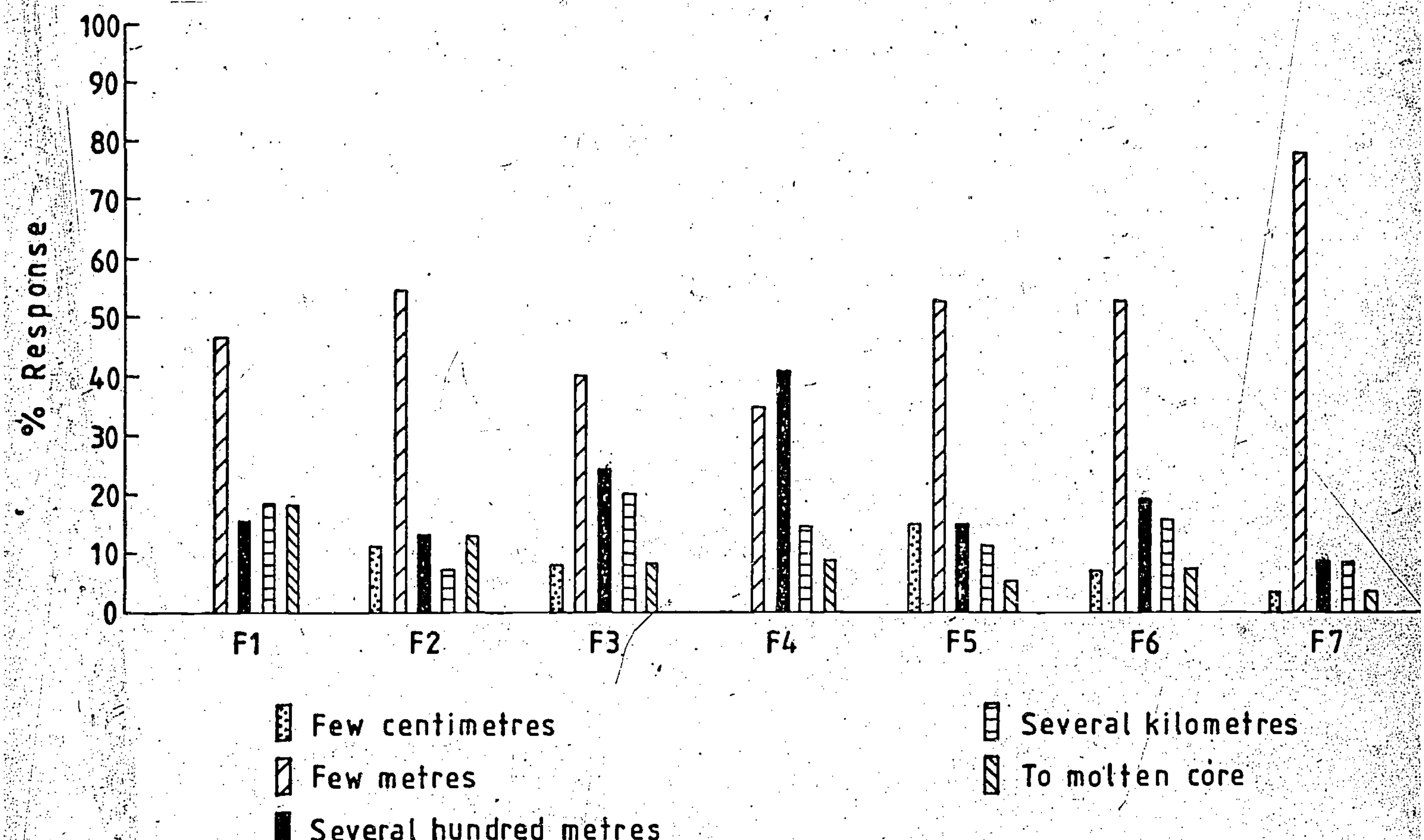


Figure 4

I If you were digging in your garden at home - if you carried on digging down - let's pretend it's possible - how far do you think soil goes down before it runs out?

J A few miles - 3 or 4.

(204)

One student (1 x F3), could not provide an estimate of soil depth.

The survey provided the opportunity for students to indicate the depth of most soils in New Zealand, with the following options being available:

(a) to a depth of a few centimetres
(b) to a depth of a few metres
(c) to a depth of several hundred metres
(d) to a depth of several kilometres
(e) to the molten core of the earth

The distribution of results is shown in Figure 4.

The responses to any statements or questions concerning soil depth are likely to be experience-dependent, with the likelihood that older students have actually seen a soil profile in a road cutting or have dug a deep hole themselves.

The majority of students in the F2, F5, F6, and F7 levels retained a scientifically acceptable response to the statement (see Figure 4). However, it is of note that a significant number of students across all levels, tended to envisage soil as being quite extensive, with depths ranging from several kilometres to the earth's core (the core-mantle boundary being approximately 3,000 kms from the earth's surface).

5. WHAT CHANGES DO SOILS UNDERGO?

Information concerning possible changes that might occur within soil, was probed by asking students to firstly describe the individual samples, with later questions being directed towards possible relationships between materials:

"Do you think that the soil will change at all with time?"

Further opportunity was provided for students to discuss words such as soil, sand, silt, clay, rock and living things. These terms being presented on separate cards so that perceived relationships might be discussed.

Nine students (3 x F1, 1 x F3, 1 x F4, 3 x F5, 1 x F7) failed to see any changes that might be experienced by a soil body.

I Do you think the soil is changing at all?

G No.

(104)

I And the soil that is there today - do you see that as changing or not?

G (shakes head)

I Pretty much the same?

G Yes.

(703)

Some changes suggested were ones that would be considered quite superficial from an earth scientist's point of view.

I Does it (soil) change at all, do you think?

M Yes - when it rains it will get soggy and wet.

(501)

Eight students (1 x F1, 1 x F2, 2 x F4, 1 x F6, 1 x F7, 2 x U) were aware of changes to soil, with additions or losses over a period of time.

I Do you think it (soil) would change or stay the same?

R It'll change a little - with water and things like that - erosion.

(604)

The survey included the statement that "none of the soils in the Waikato have changed at all over millions of years." The responses to this statement are summarised in Figure 5. and indicate that the large majority of students, across all levels, realise that soils will not remain completely unaltered.

Another survey statement: "soils in the Waikato area are continually changing because of a variety of conditions," provided results (see Figure 6.) which assessed students' ideas of continual change in soils rather than some change over millions of years.

Again, the majority (with the exception of F1 students) adopted the scientist's point of view, although there were significant numbers at all levels who rejected or were unsure about this statement.

Twenty-two students (2 x F1, 3 x F2, 2 x F3, 2 x F4, 2 x F5, 3 x F6, 1 x F7, 3 x T, 4 x U), did envisage changes to soil with time and these changes were seen to fall into the following categories:

(i) SOIL → CLAY

Four students (1 x F2, 1 x F4, 1 x F5, 1 x T), saw the possibility of soil changing into clay and, once again, this was seen to be a result of

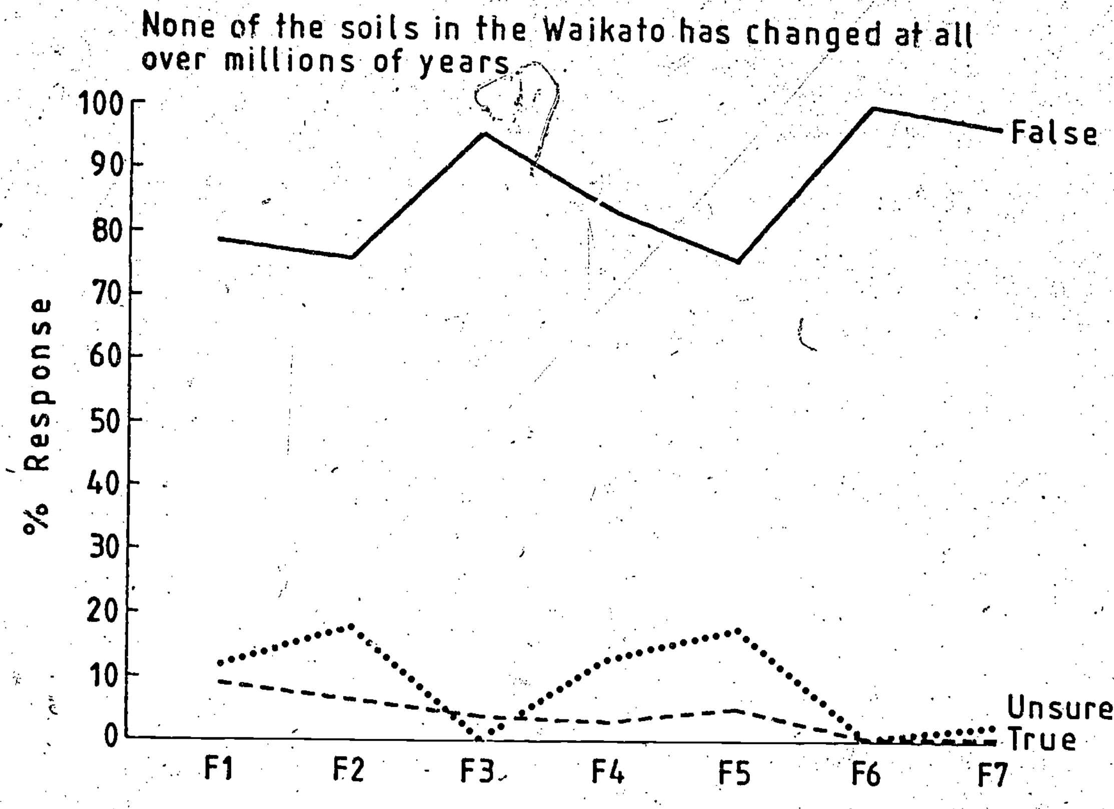


Figure 5

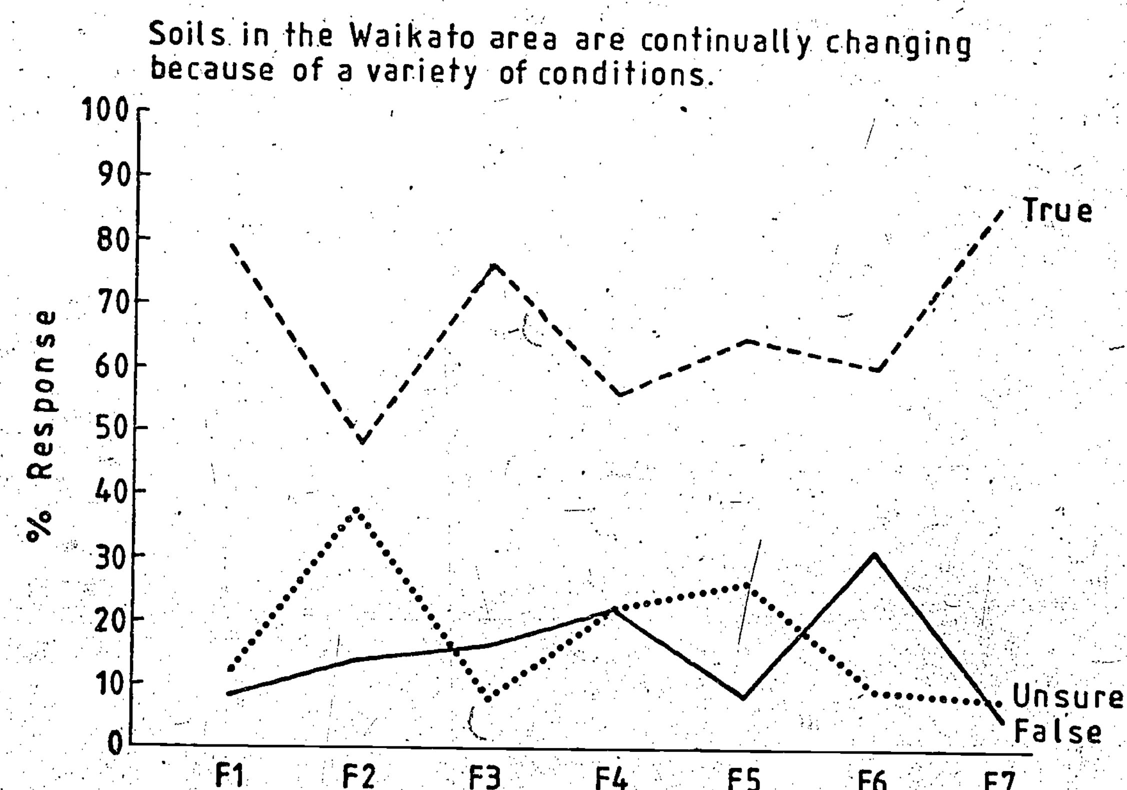


Figure 6

All soils will eventually change into clay

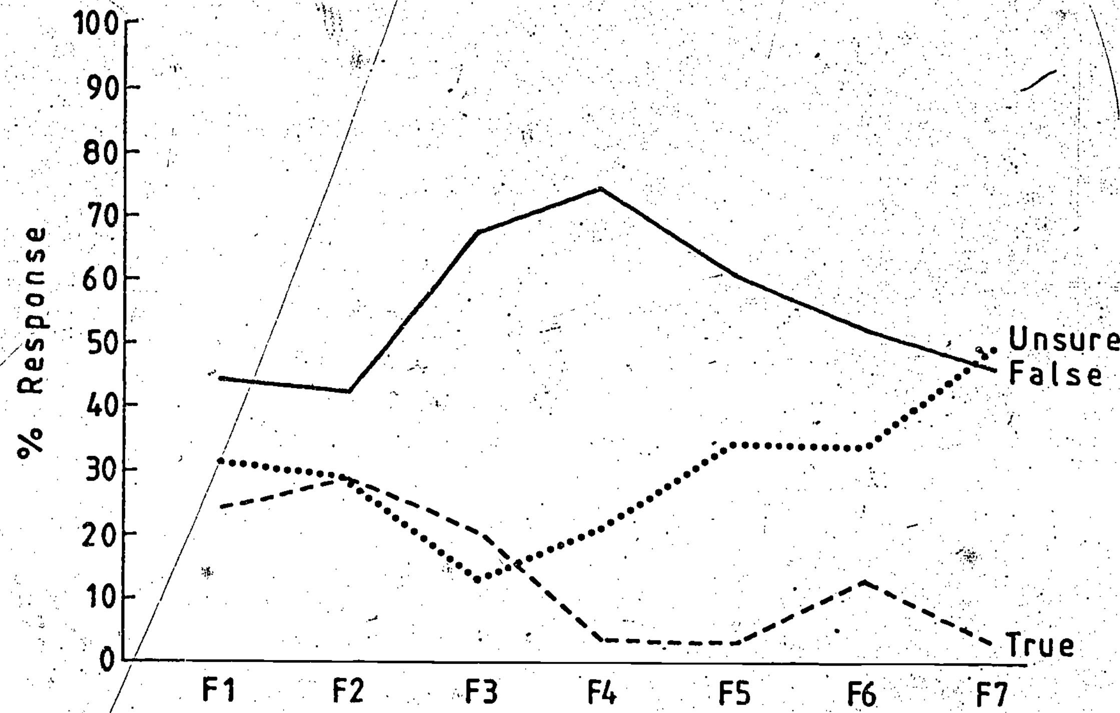


Figure 7

All clay will eventually change into rock

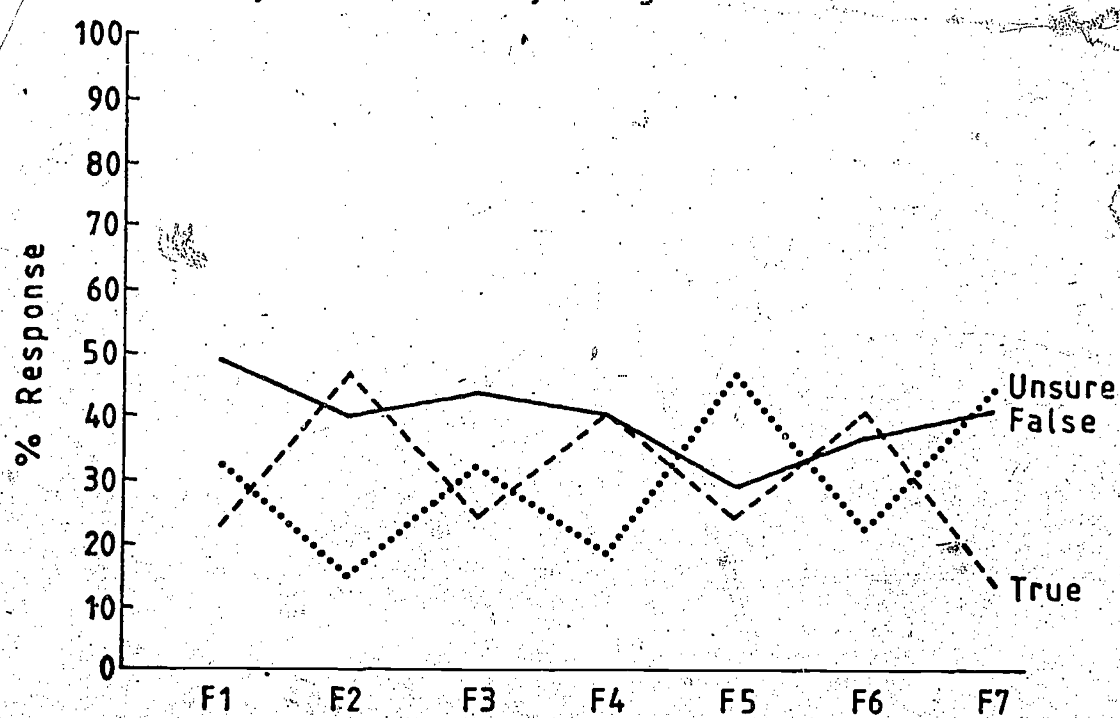


Figure 8

All clay will eventually change into soil.

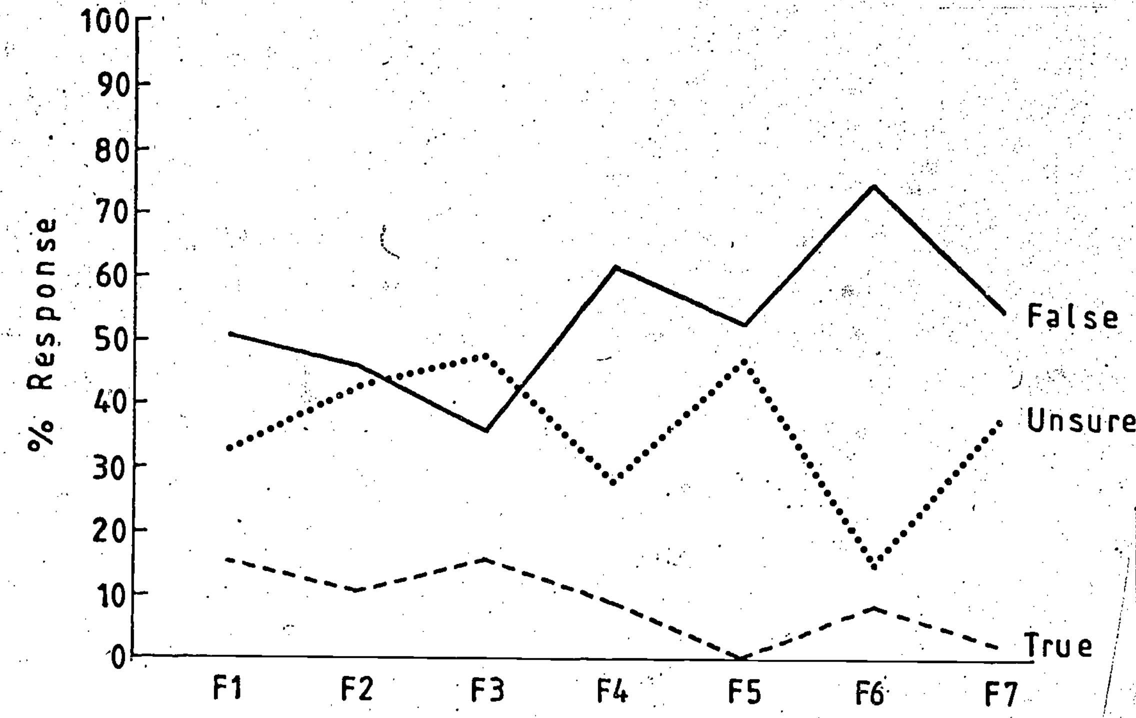


Figure 9

Clay can be formed as the soil is weathered

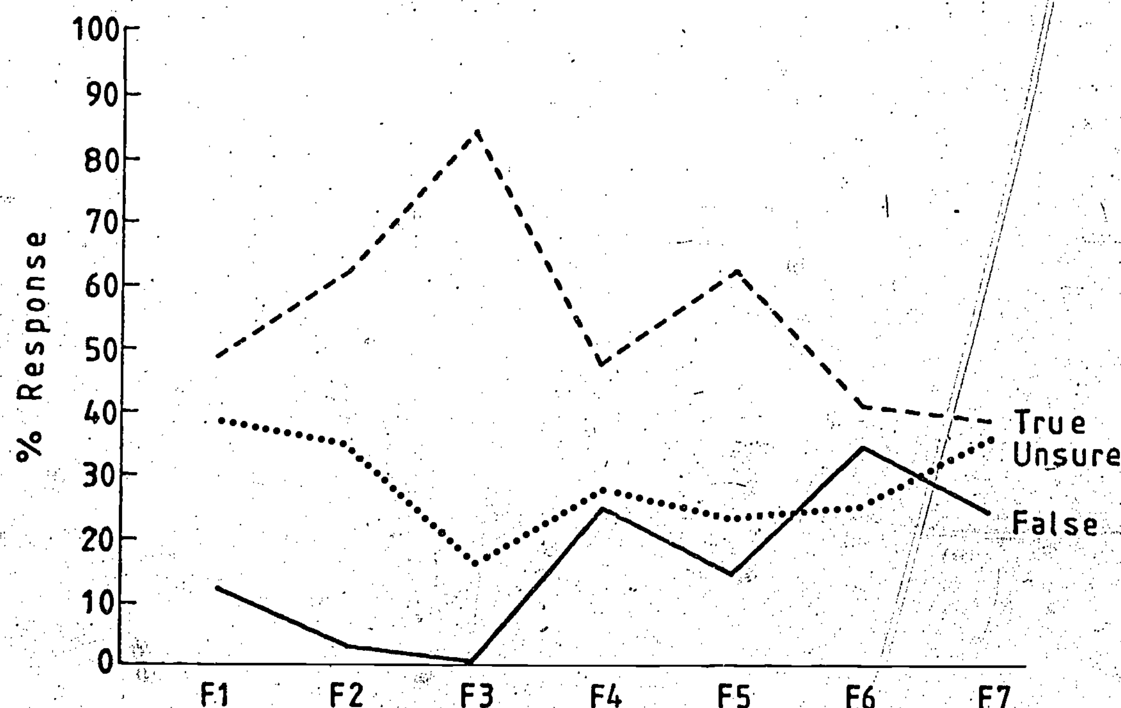


Figure 10

compression. This physical process was commonly used to explain the link between soil and clay;

The survey statement: "All soils will eventually change into clay" produced the results as shown in Figure 7. The majority of students from the F1, F2, and F7 levels did not provide the scientifically acceptable repsonse, indicating either that they felt that all soils will eventually change into clay, or that they were unsure.

(ii) SOIL → CLAY → ROCK

Nine students (2 x F1, 1 x F2, 2 x F3, 1 x F7, 2 x T, 1 x U), thought that soil will sink downwards, changing into clay with the increased pressure. The end-point was seen to be the further sinking of clay with conversion into rock at a greater depth;

This idea was tested in the survey with the inclusion of the statement: "All clay will eventually change into rock". The results are shown in Figure 8 and suggest that the majority of students, across all levels, do not see clay as being a weathering product; rather they envisage it as being part of a simple cycle: soil → clay → rock.

(iii) SOIL → CLAY → ROCK → SOIL

Five students (1 x F2, 3 X F6, 1 x T), extended the last model further, to outline a cycle from soil, through to rock. The rock was then seen to be exposed at the earth's surface, by erosion, with rock fragments ultimately adding to the soil. Sub-surface erosion of rock was not recognised by these students;

(iv) CLAY → SOIL

Three students (1 x F4, 1 x F5, 1 x U), considered that clay could be changed into soil and one of these students (1 x F5), saw this soil as later changing into rock;

The response to the survey statement: "All clay will eventually change into soil" (Figure 9) shows that a significant proportion of students from all levels did not reject this statement. The scientist's stance, which acknowledges that clay is a weathering product of the initial parent material, was not realised by many of these students, with similar misunderstanding being reflected by the response to the statement: "Clay can be formed as the soil is weathered" (Figure 10).

(v) SOIL → ROCK → SOIL

One student (1 x U), felt that soil could form rock, at depth, whilst later exposure of this rock could lead to surface weathering. The resulting rock fragments were seen to be a major contribution to new soil developments.

Only one student (1 x U)[9] appreciated the soil forming factors and the dynamic aspect of soil. Sand, silt and clay were described in terms of particle size, (by student 903) with the latter being seen as an important soil mineral, formed by the chemical decomposition of primary rock minerals.

CHILDRENS' VIEWS CONTRASTED WITH SCIENTISTS' VIEWS

This investigation has revealed that there is conflict between the views of soil as seen through the eyes of children and adolescents, when contrasted with the views that are likely to be held by the soil scientist. Results from both the interviews and the survey indicate that only over the question of 'soil depth' is there any general agreement. An exploration of ideas concerning the nature of soil, the origin of soil, the age of soil and changes to soil, reveal a marked lack of scientifically acceptable ideas, as displayed by children and adolescents alike.

IMPLICATIONS FOR TEACHING

Both the qualitative interview data and the more quantitative survey data indicate that children and adolescents generally do not hold the views about soils that are compatible with those views held by scientists. In many ways these differences are virtually bi-polar in nature and require much in the way of modification, e.g.

soils formed via environmental factors	v	soils always there
soils geologically young	v	soils geologically old
soils are dynamic	v	soils generally static.

Teaching the more important ideas concerning soils should involve a focus of attention on the nature and origin of soils; the age of soils and the idea that soils are continually changing with time.

9 Student (903) cannot be regarded as being typical within the group of 1st year university students interviewed during this investigation. This student had started the 1980 1st year programme in earth sciences at Waikato University but had to withdraw through illness. At the time of these interviews, student (903) had been exposed to several lectures in 1st year soil science, during 1980.

A comparison between childrens' views and scientists' views are summarised in Table 1.

	SCIENTISTS' VIEW	CHILDRENS' VIEWS	IDIOSYNCRATIC VIEWS
WHAT IS SOIL?	A product of the environment comprising mineral and organic constituents.	A medium for plant growth and a home for small animals	(a) food for living things (b) synonomous with dirt
WHERE DOES SOIL COME FROM?	Results from the interaction between factors of the environment.	(a) soil has always been there (b) soil has formed from various materials - chiefly vegetation. (c) volcanic source	(a) God created it (b) dinosaur manure (c) river deposits
HOW OLD ARE SOILS?	Different soils have different ages. Soils can be rejuvenated by the addition of recent deposits. Soils in the Waikato range from 1800 - 15,000 years old, i.e. geologically very young.	More or less the same age as the earth: millions of years old i.e. geologically old	Less than 5 years in age
HOW DEEP ARE SOILS?	Soil depths will vary from a few cm (skeletal soils) to 17 metres or more (deeply weathered tropical soils). Most profiles in New Zealand are not likely to exceed 2-3 metres	(a) few metres (consensus) (b) several hundred metres (c) several kilometres (d) extending to the molten core of the earth.	A minority of students envisaged soil depths of only a few cms.
WHAT CHANGES DO SOILS UNDERGO?	The soil body is dynamic and physical chemical and biological processes ensure that soils are evolving continuously with time.	(a) soil does not change (b) changes only via additions or losses (c) soil is part of a cycle which results in the transition from soil to clay and/or rock.	(a) clay can change into soil (b) soil can change into rock which may then change back into soil but only via surface weatherin

TABLE 1.

(i) What is soil and where does it come from?

The fact that soils take long periods of time to develop (in comparison to the child's experience of time) makes teaching this point difficult. The 'creation' of soils in the presence of children is not a feasible proposition and, if they cannot actually witness the formation of such natural materials, they may well adopt the view that soil has always been available, since the earth was formed.

Field trips are extremely useful in showing students how soils, with a different appearance, can develop on different parent materials. In this way it can be demonstrated that not all soils are the same. A hillside can show how soils can change with topography and how material which moves downslope (colluvium) can affect soil development. Soils from the same area, but which are developing under different vegetation, e.g. grass, forest, might be compared. Soils can be compared as they develop from similar parent materials which have been deposited at different point in time.

In these kinds of ways some appreciation of a 'developing soil' might be gained by students as th[illegible] are alerted to soil forming factors, such as climate, organic matter, parent [illegible]rial, topography and time.

(ii) How old are soils?

It would appear that two problem areas exist here:

(a) children generally do not appreciate that soils can be different bodies whose development are controlled by unique sets of environmental factors. This point can be brought out as discussed previously;

(b) the concept of time, and especially geological time, is difficult to transmit to students across all levels. When the geologist refers to time (s)he is likely to view a million years in much the same way as the young child is likely to view a second on an everyday time scale.

It might prove useful to refer children to a geological time scale, showing the point at which man 'arrived' (last 2 million years) in comparison with the estimated age of the earth (4.6×10^9 years). On this scale, the geologically young soils are seen to be relative 'newcomers'.

The notion of soil erosion and renewal might be stressed, at this point, to show that few soils are likely to evolve undisturbed for long periods of geological time.

(iii) What changes do soils undergo?

It is apparent that a significant number of students are likely to envisage some change(s) occurring within the soil body over a given period of time (see Figures 5 and 6). However, because of their lack of experience and possibly as a result of the need to rationalise their observations, many students refer to a simplistic cyclical change from soil to clay and then possibly to rock and back to soil, via surface weathering (see Figures 7 and 8).

Amidst a confusion of ideas, concerning soil transitions, the following 'childrens' views are also seen to be in need of some modification:

	CHILDRENS' VIEWS	MODIFICATION REQUIRED
1.	Soil changes to clay	Clay can be formed as the soil weathers but not all of the soil will be converted, as many students suspect Clay is part of the soil fraction and not the end product of soil compression.
2.	Soil changes to clay and then into rock.	Sub-surface rock (parent material) can weather and contribute to soil development. Soil cannot be 'pushed downwards', compressed and turned into rock.
3.	Clay can change into soil.	Clay is generally regarded as being one component of soil, resulting from the weathering of minerals that have their origin in the parent material. Clay cannot 'change' back into soil.

SUMMARY:

The results of this investigation suggest that children and adolescents have views, concerning soils, which are likely to be incompatible with the views held by scientists.

Whenever a student is introduced to a new topic, during a science lesson, (s)he will almost certainly have an existing conceptual framework which relates to that topic. However, there may be special problems associated with those study areas which contain obvious references to everyday terms, such as 'soil' and 'rock', and it might be considered that aspects of these topics are mutually understood because they deal with the familiar. Thus, the danger exists that educators might assume that students hold scientifically acceptable concepts, concerning such frequently encountered words. This kind of assumption should be viewed with caution

APPENDIX A

Ideas on which to base experiences with matter which can knowledge, understanding, skills and attitudes.

LEVEL 1 (5 to 7 years)

EARTH SCIENCE

- Rocks have different physical properties - size, shape, colour, texture, smell.
- Rocks can be useful to man.
- Soil covers parts of the earth.
- Soil is important for plants.

SKILLS Develop the ability to:

- classify rock samples according to size, shape, colour, texture.

LEVEL 2 (6 to 9 years)

- Rocks have different physical properties - hardness, content.
- The use made of rocks depends o physical properties.
- Soil is a mixture.
- Soil varies in its ability to retain water.
- Some minerals are precious stone
- The surface of the earth is changing - some changes are rapid, some slow.

SKILLS Develop the ability to:

- classify rock samples according to hardness;
- separate a soil sample into layers of similar particles - settlement from moving water.

FORMS 1 - 2

SECTION 4 Earth Science

AIM: To introduce students to the variety of landforms, rocks and soils; and through an investigation of their formation emphasise their changing nature. To involve students in outdoor observations and in a variety of communicative skills.

After completing this section, a student should be able to:

Content

1 a identify the major landforms in his local area;

b explain how these landforms may have been formed;

c describe the agencies of change acting on these landforms including not only such agencies as volcanism, earthquakes, water, wind, ice etc. but also Man and his machinery;

d explain the three major ways in which rocks are formed;

e describe how different rock types give rise to different kinds of soil;

f discuss how differences in landforms, rocks and soils influence Man's use of an area.

Skills

2 a Read simple geological and topographical maps of the local area;

b classify rocks in various ways e.g., structure, hardness, colour;

c observe and describe the characteristics of local rocks and soils using a hand lens;

d dig a soil profile and infer how the layers may have been formed.

Attitudes

3 a Appreciate the changing nature of the earth's surface and the importance of conservation practices;

b show a willingness to expand their knowledge and interest in landforms, rocks and soils by continuing their personal observations investigations and reading.

FORMS 3 - 4

SECTION 14 Resources and the Environment

AIM: To involve students in activities which will familiarise them with the range and properties of chemical resources available to man, especially water and air and its components; to draw their attention to problems of pollution associated with such resources, and the need for conservation practices.

After completing this section, a student should be able to:

Content

1 a Recognise air and water as renewable but finite resources, the causes of their pollution and the need for their conservation;

b list of components of air;

c describe the extraction of oxygen from air, its properties and uses;

d describe the properties and uses of carbon dioxide;

e describe the properties, purification and uses of water;

f describe a local resource, e.g. fuel, mineral, its use and conservation.

Skills

2 a Prepare samples of oxygen and carbon dioxide and conduct tests to identify them;

b investigate the roles of oxygen, carbon dioxide and water in combustion, photosynthesis and respiration;

c investigate the purity of the local water supply;

d produce a report on a natural resource;

e evaluate evidence of problems created by man, e.g. pollution, misuse of resources;

f debate the problems in (e) and their solutions.

Attitudes

3 a Have an appreciation of the interaction of science and society;

b show a willingness to care for the environment;

c show open-mindedness in discussing the problems of pollution and use of resources;

d show a willingness to remain informed on matters affecting the environment.

FORM 5

(1967 SYLLABUS)

The physical environment : the earth's crust; solar system; cosmology.

Man's environment and his efforts to control it : the atmosphere, water; man's use of the earth's resources.

Man's environmental problems : management of resources of soil, water, air and space.

APPENDIX B

GLOSSARY OF TERMS

That soil fraction which is made up of particles <0.002 mm in diameter. A clay soil may be typically made up of more than 55 per cent clay, less than 30 per cent silt and less than 50 per cent sand.

Loose deposits that are deposited at the foot of a slope or cliff by gravitational action.

(of soil) can indicate the presence of iron-oxides (red-brown-yellow), whereas dark topsoil may reflect organic matter, a grey layer beneath an organic horizon may indicate leaching, whilst poorly drained soils may result in grey, reddish-brown and yellow mottling.

The degree of cohesion of soil which is assessed at different moisture levels. Some terms for consistence are: loose, friable, firm and plastic.

The central portion of the earth, located at a depth of approximately 2900 kms., consisting of an iron-nickel mixture.

The transportation of weathered materials by wind, water, glaciers and gravitational processes.

Hard, grey coloured sandstone.

A subdivision of the soil profile.

The layer of the earth located between the crust and the core, extending from about 35 km below the continents, to the core at about 2900 km.

That material (consolidated or unconsolidated) from which a soil has developed. The parent material is the initial state of the soil system.

Materials associated with those areas and conditions found adjacent to the margin of a glacier.

That part of geologic time which commenced approximately 2 million years B.P. and continued until 10,000 years B.P.

A vertical section through the soil to reveal all of the horizons, extending into the parent material.

SAND: That soil fraction which is made up of particles between 0.02 mm and 2 mm in diameter.

SILT: That soil fraction which is made up of particles between 0.002 mm and 0.02 mm in diameter

STRUCTURE: This reflects the way in which soil particles combine into units or peds. Such an arrangement gives a characteristic pattern within the profile. Some terms for structure are: nutty, blocky and prismatic.

TEXTURE: The relative proportions of the various soil fractions (excluding organic matter) as determined by particle size analysis. Some terms for texture are: sandy loam, clay and silty-clay.

TOPOGRAPHY: The physical features (relief and contour) of the region.

WEATHERING: The breakdown of the earth's materials by physical, chemical and biological processes.

APPENDIX C

A SURVEY ABOUT SOILS

THIS IS NOT A TEST

This is a survey to find out some of the ideas that students may have about soil.

Place a tick in a box to indicate what you feel is the best answer for each question.

Thank you for helping with this survey.

The following 5 statements are trying to find out what your ideas are about the age of soils in the Waikato area.

1. Soils in the Waikato area were formed at the same time as the earth was formed.

   TRUE ☐ FALSE ☐ I'M NOT SURE ☐

2. None of the soils in the Waikato has change at all over millions of years.

   TRUE ☐ FALSE ☐ I'M NOT SURE ☐

3. Soils in the Waikato area are not very old and have only been formed during the last 5 years.

   TRUE ☐ FALSE ☐ I'M NOTE SURE ☐

4. Soils in the Waikato area are continually changing because of a variety of conditions.

TRUE ☐ FALSE ☐ I'M NOT SURE ☐

5. Soils in the Waikato area are many millions of years old.

TRUE ☐ FALSE ☐ I'M NOT SURE ☐

These next 5 statements are seeking your ideas about possible changes to soil and clay.

6. All soils will eventually change into clay.

TRUE ☐ FALSE ☐ I'M NOT SURE ☐

7. All clay will eventually change into rock.

TRUE ☐ FALSE ☐ I'M NOT SURE ☐

8. Clay is part of the soil we see.

TRUE ☐ FALSE ☐ I'M NOT SURE ☐

9. All clay will eventually change into soil.

TRUE ☐ FALSE ☐ I'M NOT SURE ☐

10. Clay can be formed as the soil is weathered.

TRUE ☐ FALSE ☐ I'M NOT SURE ☐

Suppose that someone you know was talking to you about how deep the soil might be in New Zealand. Place a tick against one of the following statements which you feel is the most correct.

11. Most soils, in New Zealand, extend only:

(a) to a depth of a few centimetres ☐

(b) to a depth of a few metres ☐

(c) to a depth of several hundred metres ☐

(d) to a depth of several kilometres ☐

(e) to the molten core of the earth ☐

Imagine that a fiend of yours has some ideas about soil. How do you feel about the following ideas?

12. Living things can die and become part of the soil.

AGREE ☐ DISAGREE ☐ I'M NOT SURE ☐

13. Rocks can break up and become part of the soil.

AGREE ☐ DISAGREE ☐ I'M NOT SURE ☐

14. The weather can help soils to form.

AGREE ☐ DISAGREE ☐ I'M NOT SURE ☐

15. The passing of time is important for things to form soil.

AGREE ☐ DISAGREE ☐ I'M NOT SURE ☐

16. Living things, rocks, weather and time all help soils to form.

AGREE ☐ DISAGREE ☐ I'M NOT SURE ☐

REFERENCES

FREYBERG, P.S., OSBORNE, R.J. and TASKER, C.R., 1980. Problems and Difficulties: The Working Papers of the Exploratory Phase of the Learning in Science Project. Hamilton, University of Waikato.

GARDNER, P.L., 1975: Attitudes to Science: A Review. Studies in Science Education. V.2., p.15.

HAPPS, J.C., 1980. Particles: Working Paper No. 18 of the Learning in Science Project. Hamilton, University of Waikato.

HAPPS, J.C., 1981. Towards an Earth Sciences Curriculum at the Forms 6 and 7 Levels in New Zealand Secondary Schools: A Survey and some Proposals. M.Sc. Thesis., University of Waikato.

MOYLE, R. 1980. Weather: Working Paper No. 21 of the Learning in Science Project. Hamilton University of Waikato.

OSBORNE, R.J., 1981. Children's Ideas about Electric Current. New Zealand Science Teacher, 29, 12-19.

SCHOLLUM, B., 1981. Chemical Change: Working Paper No. 27 of the Learning in Science Project. Hamilton, University of Waikato.

STEAD, B.F., 1980(a). Living: Working Paper No. 14 of the Learning in Science Project. Hamilton, University of Waikato.

STEAD, B.F., 1980(b). Plants: Working Paper No. 24 of the Learning in Science Project. Hamilton, University of Waikato.

STEAD, K.E. and OSBORNE, R.J., 1981. What is Gravity?: Some Children's ideas. New Zealand Science Teacher, (in press).