ABSTRACT

Studies of students’ understanding about rocks indicate most young students do not have a scientific understanding about rocks. This persists into adulthood. Students’ first encounters with rocks are frequently conducted through descriptive observational studies. This approach is inductive and can create difficulties in leading students to compartmentalise rocks and see each rock as a singular entity. This fails to help students recognize and derive generalizations about the fundamental characteristics common to different generic rock groups. Researchers have suggested that input about techniques and conceptual frameworks which geologists use may prove more successful in developing students’ understanding, providing they are intellectually safe and accessible. A new pedagogic approach which matches these requirements has been used to create a sequence of investigative activities enabling students to speculate, hypothesise, observe, test, reason and infer about the characteristics of rocks. The approach is framed by two questions (i) What are the key characteristics of different rock groups?, (ii) How did the rocks acquire these characteristics? Using the knowledge and understanding acquired, students have demonstrated they can assign rocks into appropriate generic groups using the same criteria as Earth scientists. They can relate the textural characteristics to a range of rock properties.

Keywords: Education – precollege; earth science – teaching and curriculum; petrology – general

INTRODUCTION

In the UK the study of rocks has become an increasingly established part of the science curriculum. In the 1970s and 1980s there were several influential science curriculum development projects that included the study of rocks and some of these selected rocks as a major topic (Harwood, 1987). In 1989 a National Curriculum for Science was introduced and throughout several revisions the study of rocks has remained a component in the program of study for students aged 5 to 16 years. (Department for Education and Employment and Qualifications and Curriculum Authority, 1999). One of the main reasons for studying rocks within the context of a science curriculum should be to help students to gain a scientific perspective and understanding about rocks, with the aim of enabling students to use the methods of the Earth scientist to investigate and classify rock, develop interpretations about the modes of formation of rocks and assess the properties of rocks. However investigations into children’s understanding and perceptions of rocks indicate that their concept of what constitutes a rock, their perception of the important attributes and how rocks are classified, do not appear to match those held by Earth scientists.

The particular characteristics of a rock to which an Earth scientist assigns significance are not necessarily those characteristics that are most obvious to students. Earth scientists classify rocks by their processes of formation into igneous, metamorphic and sedimentary rocks (generic rock groups). The mode of formation affects the texture and composition of a rock. It is the observation and description of the textural and mineralogical characteristics of a rock that enables an Earth scientist to classify a rock and make inferences about its mode of formation. To gain a proper scientific understanding about rocks, it is important to be able to firstly recognize the determinant characteristics of a rock, and secondly to understand their significance.

The purposes of this paper are: (i) to review the findings of research into students’ ability to understand, classify and identify rocks; (ii) to suggest reasons why approaches to teaching about rocks have proved generally ineffective in developing scientific understanding about rocks; and (iii) to outline a pedagogic approach and teaching methodology which develops a sound conceptual framework about rocks for students.

PREVIOUS RESEARCH

In a study of thirty-four 11-17 year old students from New Zealand, Happs (1982) found that the term rock was used in a non-scientific way. Learners considered factors such as physical appearance, shape or weight of a sample as critical attributes. Happs found that students frequently indicated that they had heard of rock names, such as ‘granite’, but were unable to identify these rocks from the samples provided. He suggested that if the term ‘rock’ was not understood in its scientific context then it would be reasonable to ‘predict that the classification of rocks and the terms sedimentary, igneous and metamorphic may not be perceived by the students in the way that teachers think they might be perceived’ (Happs, 1982). He concluded that children’s views of rocks are at variance with the Earth scientist’s view (Happs, 1982).

A study of students’ ideas about rocks drawn from students in primary schools in Australia and New Zealand revealed an interest by students in asking questions about rocks. However, the questions asked and students’ speculations about the answers to those questions indicated that students had little conceptual understanding about rocks (Symington, Biddulph, Happs & Osborne, 1982). In a detailed case-study of 14 year old students’ understanding of rocks and minerals, Happs confirmed his earlier researches and found that students did not group rocks in terms of their origin, but sorted according to everyday categories, such as ‘shiny rocks’ and ‘ordinary rocks’ (Happs, 1985). Some 10 years later an investigation in seven primary schools in north west England by the Science Process and Concept Exploration (SPACE) project revealed similar conceptual
difficulties held by students aged 5 to 11 years to those exposed by the Australasian studies (Russell et al., 1993). This study found the children used bi-polar criteria in reaching their decisions as to whether or not a specimen was judged to be a rock, using the attributes rough/smooth, hard/soft, large/small, light/heavy. These criteria were relatively superficial and used inconsistently. The observation data confirmed that children lacked a meaningful conceptual framework within which to consider and compare the attributes of a rock. The report of the investigation commented, ‘the decision (about a rock) seemed to be that a rock is ‘all or nothing’; ‘a rock is a rock’ rather than thinking about the materials’ hardness, texture, constituent components, porosity, presence/absence of crystals etc’. The report summarises, ‘it would seem that children need to consider a whole range of common but distinguishable rocks forms and explore similarities and differences along a number of dimensions. There is also a case for some input about techniques and conceptual frameworks which geologists use, providing these are intellectually safe, accessible and practicable.’ (Russell et al., 1993). However, the SPACE project did not go on to suggest what input would meet these criteria.

Oversby (1996) conducted an investigation into the level of understanding about some key ideas in Earth science with 139 students aged 9 to 16 years, who had been given some instruction in elementary Earth science, which included investigations and classification of rocks, and 42 post-graduate trainee-teachers, with varying levels of scientific background. In response to the questions ‘What is a rock?’ and ‘What is a stone?’, he found a large proportion of those taking part in the inquiry gave no response, particularly in the 9 to 11 year age range, The majority of the remaining responses indicated simplistic notions. The confidence of respondents’ ability to answer increased with age, there was not a corresponding increase in the scientific accuracy of their answers. This suggests that while concepts about rocks had become established, they remained concepts founded in non-scientific understanding.

In an investigation into the abilities of first-year trainee-teachers of science and humanities to identify rock types Dove (1996) found that the term rock was widely misunderstood among the trainees. Rocks were identified on the basis of feel and color, having seen similar rocks in the landscape, used as building materials, or guessing from a list of rocks. In other words, the trainees tried to match the rocks with past experiences, rather than make any decisions about the rock type based on any scientific criteria. Consequently where the perceived characteristics were not met in the specimens, the rocks went unrecognized.

Independent from the above research, the author recognized similar conceptual difficulties in school students’ understanding about rocks. The author observed that students attempt to make sense of rocks in a non-scientific way. Any ability to name a rock sample resulted from recall, i.e. the matching of a rock sample to a ‘fixed image’ of that rock, usually obtained through having previously seen a photograph or hand specimen of the rock sample. For example, students who identified a specimen of ‘white granite’ as granite would frequently not be able to recognize a specimen of ‘pink granite’ as a granite. Instead they respond with ‘I don’t know’, or suggest it is ‘pink rock’, or guess by giving another name that they know to be a rock. These observations of students’ struggles to make sense of rocks suggest they have no clear conceptual framework with which to investigate, classify, and associate rocks and rock types. Such an interpretation may also explain the findings of Dove (1996).

DISCUSSION OF TEACHING APPROACHES USED IN DEVELOPING UNDERSTANDING ABOUT ROCKS

The findings of Dove (1996) and Oversby (1996) are not surprising in that the teaching methodologies to be found in text books and teaching manuals for students aged 7 to 14 years, suggest descriptive-inductive approaches to learning about rocks. Commonly, these recommend that students be given opportunities to ‘sort’ a variety of rock types in different ways. This is done by choosing simple criteria such as color or shape, and by comparing and identifying rocks using secondary sources, such as photographs or drawings (for example see Nuffield Primary Science, 1995). In arguing that rock identification is an appropriate skill for primary students, Harwood suggests that 10 and 11 year olds can be expected to move on to distinguishing between crystalline and fragmental rocks and to use these criteria in dichotomous keys to identify individual rock samples. The method he suggests students use to gain these concepts can be done by placing a dozen different rocks on a table and simply asking each individual pupil to divide the rocks into two boxes labelled respectively ‘crystalline’ and ‘fragments or grains’, (Harwood, 1987).

In such teaching approaches, there is an assumption that students will gradually learn to distinguish between the scientifically most important attributes (defining attributes) and less important characteristics (correlational attributes) of a rock through a process of ‘trial and error’ discovery and classification, if they are exposed to a wide range and large number of rock specimens. This requires students to derive abstract generalizations from many individual observations, i.e. an inductive approach. However, as indicated by the example of students’ difficulty of granite recognition, the inductive approach leads students into compartmentalising rocks and seeing each rock as singular (Johnston, 1990). Consequently, the inductive approach is poor at helping students recognize the fundamental generic characteristics (defining attributes) that categorize different rock groups. So, while a descriptive approach may result in the pupil being able to name a rock sample at a very specific level, there is little development in conceptual understanding about how that rock fits into the scientific scheme of classification of rocks or the rationale behind it. Such conceptual understanding is imperative if students are to make full sense of rocks and especially if they are to progress on to meaningful interpretation of rocks. To enable students to
scientically classify rocks into appropriate generic groups, rather than simply attach a particular name or label to individual rock specimens, students need to develop generalized concepts of the characteristics of each generic rock group. Thus, when confronted with an unfamiliar rock, they have a conceptual framework against which they can compare, hypothesise, test, and modify. As a result, students’ ability to classify, identify, and name rocks is enhanced because rocks are no longer conceptualized as singular entities but as unique specimens (Johnston, 1990) which belong to a wider group of rocks accounted for by general laws. Moreover, the scientific conceptual understanding they develop will form the basis for questioning, reasoning, speculating, and inferring about rocks. This helps students to understand and predict some of the properties of rocks, such as susceptibility to weathering processes.

The importance of developing such a conceptual framework to enable students to ‘see’ and interpret rocks is outlined by Frodeman (1995). In recognizing the strong visual component to geological science he states, ‘Most of us are familiar with the interpretive aspect of understanding. That is the shift in our awareness of an object when we approach it with a fresh set of concepts or expectations. The outcrop or rock means nothing to the uninitiated until the geologist introduces concepts for ‘seeing’ the rock.’ (Frodeman, 1995). Consequently, descriptive-comparative and/or trial and error-discovery learning methods are inappropriate for effecting sound conceptual understanding about rocks because these approaches leave to chance the prospect of students learning to distinguish between the defining and correlational attributes of rocks. Developing a sound conceptual framework about rocks requires a pedagogic approach, which enables students to reorganise their perception of the defining and correlational attributes of a rock.

### A NEW PEDAGOGIC APPROACH

An action research approach was adopted to develop a pedagogic approach that would enable students to develop a sound conceptual framework about rocks. It aimed to devise an intellectually safe, accessible and practicable teaching methodology, grounded in the responses and reactions of students.

The pedagogic approach described here has been used successfully with students aged 7 to 11 years, to enable them to classify a range of different rock specimens into the generic rock groups. In addition, the approach has enabled students to make deductions about the properties of different rocks. The approach has also been used with students aged 11 to 14 years, as a foundation for investigating processes of rock formation. In the case of these older students, two key questions framed the teaching:

(i) ‘What are the key characteristics of different rock groups?’

(ii) ‘How did the rocks acquire these different characteristics?’

The second key question builds on knowledge and understanding, acquired through the teaching methodology described here, to facilitate meaningful conceptual progression in learning about rocks. It leads students to be able to interpret and speculate about the processes of formation of a rock from the textural characteristics of individual rock specimens. The approach has also been used successfully to develop teachers’ understanding of rocks through initial teacher education programs and In-Service Training, with the aim that the training be translated directly into the classroom. Reports by teachers who have used the approach in the classroom have confirmed successful outcomes through using this methodology.

#### Organization of teaching materials and students -

The students were organized into working groups of about four students for all the stages of the teaching. Each working group was given a range of different rock samples to examine and classify throughout the stages of the teaching. In the trials described here three examples of igneous rocks, two examples of metamorphic rocks and five examples of sedimentary rocks were used (Table 1). Most of the examples used were coarse-grained varieties, which facilitated easy observation of the textural characteristics, but the inclusion one medium grained and two fine-grained samples provided representatives of rock types with less easily observed textures.

### Stage 1: 1.1 What is a rock?

This activity aims to clarify students’ perceptions of what constitutes a rock and to focus on the idea of a rock being composed of grains.

Students were presented with a tray containing the different rock types and asked to mix and match the rocks to sort them out into groups. When students had completed this sorting they were asked to explain the reasons why they had grouped the rocks in a particular way. The most frequent rationales used to group were color variations, “shininess”, “speckliness” and “roughness”, and occasionally the size and shape of specimens presented. This might be expected, as both Happs (1982) and Russell et al. (1993) found that students focus on obvious physical characteristics.

#### 1.2 The Question and Answer game

In order to move students to thinking about a more fundamental concept of rocks a word game was played.

The teacher explained that some questions would be asked about the way the students had grouped the rocks. One member from each student group was selected and asked to listen carefully to the answers given by the remaining group members. The selected student was asked not to join in the answering, but to identify any word that seemed to keep appearing in the students’ responses. When students gave a reason for grouping, e.g. ‘these are all shiny’, the teacher probed their thinking by asking, ‘What is
it that makes them shiny? What can you see in the rocks?’. This type of questioning was followed for each of the criteria the students had used for classification. At the end of the questioning the selected pupil was asked which word was mentioned most frequently in the students’ answers. The result was invariably ‘bits’. It was an easy step to then ask the students ‘What are the rocks made of?’ and for the students to realise that a rock is made up of ‘lots of bits’.

The teacher introduced the term ‘grains’ as the technical vocabulary for ‘bits’.

Stage 2: Are there any differences between the grains of some rocks?

The aim of this activity was to focus students’ observations on the grains of igneous and sedimentary rocks. Students were given two rocks, a sample of coarse-grained granite and a sample of coarse-grained sandstone, and a magnifier. Students were asked to invent a name for each rock sample, with the intention of personalising the samples and forestalling any desire on behalf of students to provide a geological name for the rocks, which might set up preconceptions. They were asked to observe and describe the grains of each rock sample. The most frequently noted characteristics were as in the Stage 1 sorting activity, relating to easily observable characteristics. However, many students also observed that the grains in the granite were ‘sharp-edged’, i.e. angular, and the grains of the sandstone were ‘round’. This is an important step in moving towards a scientific understanding of rocks. The overall characteristics of the grains of each sample were drawn out through discussion and listed on the board.

Stage 3: Predictions and Explanations

The aim of this activity was to give students concrete experience from which they could reason about the differences between two rock textures.

Students weighed each rock sample of sandstone and granite to the nearest 0.1g and recorded the results. It was explained that the rocks were to be covered with water. The students were asked to suggest what they thought would happen to each of the rock samples. They were asked to bear in mind the characteristics of the grains of each rock type observed earlier. Students then completely immersed the rocks into a tub of water and asked to observe what happened. Students reported that the sandstone produced bubbles and the granite was inert. Some students described the bubbles as ‘fizzing’ and others as ‘air bubbles’. Students were asked to explain the presence of the bubbles and two ideas were predominantly offered:

1) the rock was dissolving (the fizzers);
2) water was rushing in (the air bubblers).

These explanations were presented as alternative hypotheses to the whole class. A class discussion followed on how it would be possible to test which hypothesis is most likely. Students were asked to predict whether they thought each rock would weigh more, weigh less, or stay the same weight. This gave rise to discussion about the process of solution and the relative weight of water compared to air.

After the samples had been immersed for a minimum of five minutes they were re-weighed and the results for each group were tabulated on the board using a tally. This strategy allowed any anomalous results to be easily identified and if necessary, further weighing of the specimens. It was noted that the weight of the granite was unchanged while the sandstone gained after immersion in water. In one trial, following the soaking in water, control samples were re-weighed then left in a warm place overnight. The following day these samples were weighed again and students noted that the sandstone had ‘dried out’ and returned to its original weight. Students were asked to hypothesize on the origin of the extra weight in the sandstone. Responses almost invariably invoked water as the source of the increased weight.

The next question asked students to consider how water penetrated the sandstone. Most responses involved ‘gaps’, ‘tiny holes’, ‘spaces’, ‘air pockets’ and ‘air space, which water, has got into’. About 10% of students reasoned ‘there must be air to let the water in’.

Table 1. Rock selected for development of the teaching methodology.

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Rock Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granite (grey)</td>
<td>Igneous</td>
</tr>
<tr>
<td>Granite (red)</td>
<td>Igneous</td>
</tr>
<tr>
<td>Gabbro</td>
<td>Igneous</td>
</tr>
<tr>
<td>Schist (coarse-grained)</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Slate</td>
<td>Metamorphic</td>
</tr>
<tr>
<td>Sandstone (coarse-grained, red)</td>
<td>Sedimentary</td>
</tr>
<tr>
<td>Sandstone (medium-grained, buff)</td>
<td>Sedimentary</td>
</tr>
<tr>
<td>Limestone (oolitic)</td>
<td>Sedimentary</td>
</tr>
<tr>
<td>Breccia</td>
<td>Sedimentary</td>
</tr>
<tr>
<td>Mudstone (red)</td>
<td>Sedimentary</td>
</tr>
</tbody>
</table>

Table 1. Rock selected for development of the teaching methodology.
thereby implying displacement. A smaller proportion gave explanations that did not accord with the notion of adding water to the sample. Students were asked to explain why the granite did not let water in, and nearly all answers mentioned ‘no holes to let water in’.

**Stage 4: Modelling**

This stage of the teaching aimed at helping the students understand about grain relationships in rocks. The teacher posed the following questions to the students: (i) how do you get grains to fit together so that there are no spaces between the grains? and (ii) how do you get grains to fit together so that there are spaces between the grains?

Students were given a tessellation activity to help them answer the questions. Each group of students was provided with two sets of gummed paper shapes. One set contained rounded shapes (circles and ovoids) and another set comprised of angular shapes. Both sets contained a variety of sizes. With each set of shapes, students were asked to try to cover a square drawn on a piece of paper. It was emphasised that the shapes must not overlap and that they must attempt to cover all the space (Figure 1). Students quickly realized that it was possible to fit together the angular shapes to cover the square but that the rounded shapes always left spaces. Students were asked to match the rock samples to the gummed shapes which they thought most closely matched the patterns of the grains in the rock. All students were able to match the rock samples correctly. The teacher introduced the terms interlocking and non-interlocking to describe the different grain relationships.

The next step was to develop the concept of interlocking and non-interlocking in a three-dimensional form, with the aim of more realistically representing rocks. A Japanese wooden puzzle was used to simulate an interlocking rock. The puzzle consisted of a series of individual wooden blocks in a variety of angular shapes, which the students were able to relate to the angular grains of the interlocking rock. When the puzzle is assembled the pieces interlock to form a cohesive octahedron. Glass marbles were used to simulate the rounded grains of the non-interlocking rock. These were placed in a transparent container and students were able to observe the pore spaces between the marbles. The teacher asked the students what they thought would happen when the container was turned upside down. Students were unanimous in their view that ‘the marbles would fall out’. Inverting the container and allowing the marbles to fall and scatter demonstrated the non-interlocking nature of the simulated rock. The teacher noted how the ‘rock’ had ‘fallen to bits’.

Students were asked to consider how much glue would be needed to stick the non-interlocking rock. Typically their responses gave suggestions such as, ‘each grain would need a little bit where it touches another grain’. The concept of lithological cementation was not pursued further. A simulation of the precipitation process may have been useful at this point, as some students appeared to develop the idea that the ‘rock glue’ needed to be applied drop by drop. A lithification simulation would help to clarify the nature of the process. Finally, the students were asked to distinguish the ‘rock glue’ from the constituent grains in a variety of sedimentary rock samples. First students examined the conglomerate, where the white quartz pebbles could be clearly seen and the distinction was obvious, and then a range of finer-grained sandstones.

**Figure 1. Pupil’s example of the tessellation puzzle (see ‘Stage 4. Modeling’) which models the relationship between interlocking and non-interlocking rock textures (redrawn).**

‘cement’, ‘mud and clay’, or ‘dried mud’. Cement is the technical geological term for the material that fills the pore spaces in sedimentary rocks. In order not to confuse students with ideas of manufactured cement being mixed and added to sedimentary rocks the teacher used the term ‘rock glue’, drawing analogies with manufactured glues.

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Stage 5: ‘Crumbliness’ - using understanding to make inferences

The goal of this activity was to help students see the relationship between the grains in a rock and use this knowledge to speculate and make inferences about the susceptibility of different rock types to weathering processes.

Students were presented with a sample of granite and a sample of sandstone; no technical names were used, and asked to decide which was interlocking and which non-interlocking. All students were able to identify the texture of these rocks correctly. They were then asked to suggest which rock might crumble more easily, the rock with interlocking grains or the rock with non-interlocking grains. There was widespread agreement that the interlocking rock would not crumble and some divergence of opinion about the non-interlocking rock. The majority of students suggested that the sandstone would crumble more easily than the granite. When asked to explain why, students’ responses recognized that the interlocking texture of the granite would give the rock greater cohesion. Typical responses included ‘the rock will not crumble easily because all the bits are jumbled together and jaggled around each other and it will be difficult for them to drop off because they are holding each other in place’, and, ‘the grains in the rock fit together so lock in with each other.’

Students were asked to test their hypothesis. Groups of students were given the two rock samples, a steel teaspoon and a sheet of white paper. They were instructed to scrape each rock over the white paper using the spoon. They were to save any bits that crumbled from the rock. As predicted, scraping the sandstone produced grains and fragments on the paper, while scraping the granite had no effect on fragmentation. Students were asked to suggest why the sandstone had ‘crumbled to bits’ and responses generally gave rise to two ideas: (i) the ‘rock glue’ was not very strong and had come undone, (ii) there was not much ‘rock glue’ holding the grains together. Most groups of students suggested only one of these alternatives, while in all the classes there were a small number of students who suggested that both ideas might explain the crumbliness of the sandstone.

In a follow up discussion students were introduced to different types of ‘rock glue’ through demonstration of three sandstone rocks. One sample had iron oxide cement, another calcium carbonate cement, and a third with silica cement. Students were asked to sort these rocks in order of the strength of the ‘rock glue’. Students were also shown one sample of sandstone that was very porous and another sandstone, which displayed pores filled with lithological cement. The teacher concluded this part of the teaching with a summary outlining how both reasons suggested by the students may be correct. Through discussion, the class devised a list of different possible combinations, such as ‘a rock with strong rock glue filling all the spaces’, ‘a rock with strong rock glue only where grains touch each other’, ‘a rock with a weak rock glue filling all the spaces’ and, ‘a rock with weak rock glue only where grains touch each other’. The teacher also suggested that some rock glues could be made weaker by reacting with water, as in some synthetic glues. With some classes, the concept of rock porosity was taken further. Students were asked to consider the implications of ‘rock-locking’ and ‘rock-gluing’ for constructing a well.

Stage 6: Classifying rocks: the Earth scientist’s way

This stage of the teaching aimed to (i) consolidate students’ new understanding about grain relationships in rocks, (ii) to introduce the concept of grain arrangement, and (iii) to allow students to classify a selection of rocks using the newly formed conceptual framework. Students’ learning was summarised by the teacher using a diagram as an aide-memoir (Figure 3), which focussed the students’ observations on two key characteristics: (i) grain relationships, (ii) grain arrangement.

6.1 Grain relationships

The teacher reviewed the importance and significance of determining by observation how the grains of the rock fit together to distinguish between interlocking and non-interlocking textures. The usefulness of grain shape in helping to make this decision was outlined. The limitations of this observation were discussed, demonstrating with samples how a non-interlocking rock might contain angular grains with pore spaces filled or partially filled with ‘rock glue’. Through the concepts developed by the practical activities and investigations earlier in the teaching, students were able to sort a selection of rocks with little difficulty into two groups, (i) crystalline rocks and (ii) fragmental rocks. However, the fine-grained rock specimens caused some uncertainty, with students frequently placing them in a separate group or positioning them tentatively on the periphery of one of the groups.

6.2 Grain arrangement

The second key observation expanded students’ understanding of the importance of observing rock characteristics at grain level and introduced the concept of grain arrangement. Two forms of arrangement were introduced: (i) random, and (ii) aligned, illustrated on the ‘Looking at Rocks like a Geologist’ worksheet (Figure 2). Samples of granite and schist were used to demonstrate the differences. To focus on recognizing the different arrangement of the grains in the granite and the schist, students completed a labelled sketch of each rock sample. A rectangular hole, 1 cm by 1.5 cm, provided a frame and a magnifying glass was used to enable the students to make precise observations (Figure 3).

6.3 Classifying rocks

In the final teaching activity the students were given an assortment of rock samples (see Table 1) and asked to arrange them into different types of rocks using the
LOOKING AT ROCKS LIKE A GEOLOGIST

- You know that a rock is made up of 'bits' or **grains**. Scientists who study rocks (called geologists) look carefully at the grains in the rock to help them sort rock into groups with similar types of grains.

- To start with a geologist looks for grain shape – because this is often easy to see and will help give a clue as to whether the rock is an interlocking or non-interlocking type.

**Grain SHAPE**

1. Angular
2. 3. 4. 5. 6. Rounded

- **BUT** be careful....because grain shape is only a clue and you can sometimes get caught out!
- **NEXT** you need to check to see **how the grains fit together**. Remember the non-interlocking rock may have glue filling all of the space between the grains.

- **HOW** do the grains **FIT TOGETHER**

- Interlocking
- Non-interlocking and glued

- Now a geologist will look for **HOW** the grains are **ARRANGED**

- No particular order
- Grains are 'Lined up'

Using the clues, see if you can sort rocks like a geologist.

**Figure 2. Worksheet used to help students focus their observations in classifying a range of rocks.**
principles learned from their investigations. Students were allowed to use the ‘Looking at rocks like a geologist worksheet (Figure 2), if they wished.

All students showed confidence in undertaking this activity and most of the rocks presented little difficulty. Initially the rocks were sorted into interlocking and non-interlocking types. The first rocks to be categorized this way were the granite and the coarse-grained red sandstone. This was undoubtedly because of familiarity from earlier investigations. Groups of students adopted different strategies for making their decisions. Some students carefully observed the grains of each rock and then made an independent decision about its type, while other students used the worksheet (Figure 2) as a reference for making their decision. A smaller number of students used the two ‘key’ rocks, the granite and the coarse-grained red sandstone, for reference and comparison. In most cases the interlocking rocks were then sub-divided according to grain arrangement.

Two rocks seemed more problematical to the students, the slate and the red mudstone. After initial inspection these rocks were almost always placed to one side and revisited after all the other rocks had been examined and sorted. This is not surprising as it is not possible to see the grains clearly because of their fine-grained character, thereby removing the main basis of observation and classification. Some students separated these rocks in two distinct categories. Others placed them in a tentative holding group and these admitted to being puzzled as to how to categorize these samples, realising they could not see the grains. A small proportion of students placed these rocks according to color, the red mudstone being placed alongside the red sandstone and the slate alongside the gabbro. To solve this problem students were asked to draw upon their knowledge about ‘crumbliness’ and grain relationships and test the fine-grained rocks by scraping. This allowed all students to make inferences about the category of rock to which the fine-grained samples belonged. Students were asked how an Earth scientist could confirm the results of such an inference and two suggestions were prevalent: (i) ‘soaking the rocks and weighing’, and (ii) ‘putting the rocks under a microscope’. This indicated that students had grasped the importance of the textural relationships of grains in identifying rocks.

Overall, a significant majority of students confidently sorted the rocks into three categories. Furthermore, when asked why they thought rocks belonged to a particular category students were able to offer clear explanations which focussed on the different textural characteristics of the grains. At this stage the teacher introduced the names Igneous, Sedimentary and Metamorphic for the three groups of rocks. Students then produced name labels for each group. In a few classes, students were asked to subdivide rocks within each of the three groups. No instruction was given from the teacher. Interestingly, most students used grain size as the major criterion for sub-division. This suggests the concepts of rocks being constituted of grains and the importance of grain relationships had been firmly planted in students’ minds. In addition, some students began to sort using the color of the grains, thereby laying the foundations for exploring the idea of different mineral content. Finally, these classes were given formal identification keys, allowing the students routes through which they could find the specific names of rocks. Students found their way through the keys with minimal support from the teacher, easily equating the term crystalline with interlocking textures and fragmental with non-interlocking textures.

**SUMMARY**

The pedagogic approach described here resulted in young students learning to determine, recognize and explain fundamental textural differences in a range of rocks, equivalent to the key textural characteristics of igneous, sedimentary, and metamorphic rocks. Furthermore, students were able to relate these characteristics to a range of rock properties. They arrived at this understanding through a series of practical activities and observations, which tested and modified their speculations about the characteristics of rocks. The
results of this work demonstrate that this investigative approach, which focuses on grain relationships in rocks, develops students’ ability to meaningfully generalize about the abstract relations of rock groups in the way required for making sense of rocks scientifically. In achieving this, the teaching methodology fulfils the key recommendations drawn from the investigations outlined in the Science Concept and Concept Exploration project (Russell et al, 1993) to provide ‘input about techniques and conceptual frameworks which geologists use’, which are ‘intellectually safe, accessible and practicable.’

REFERENCES