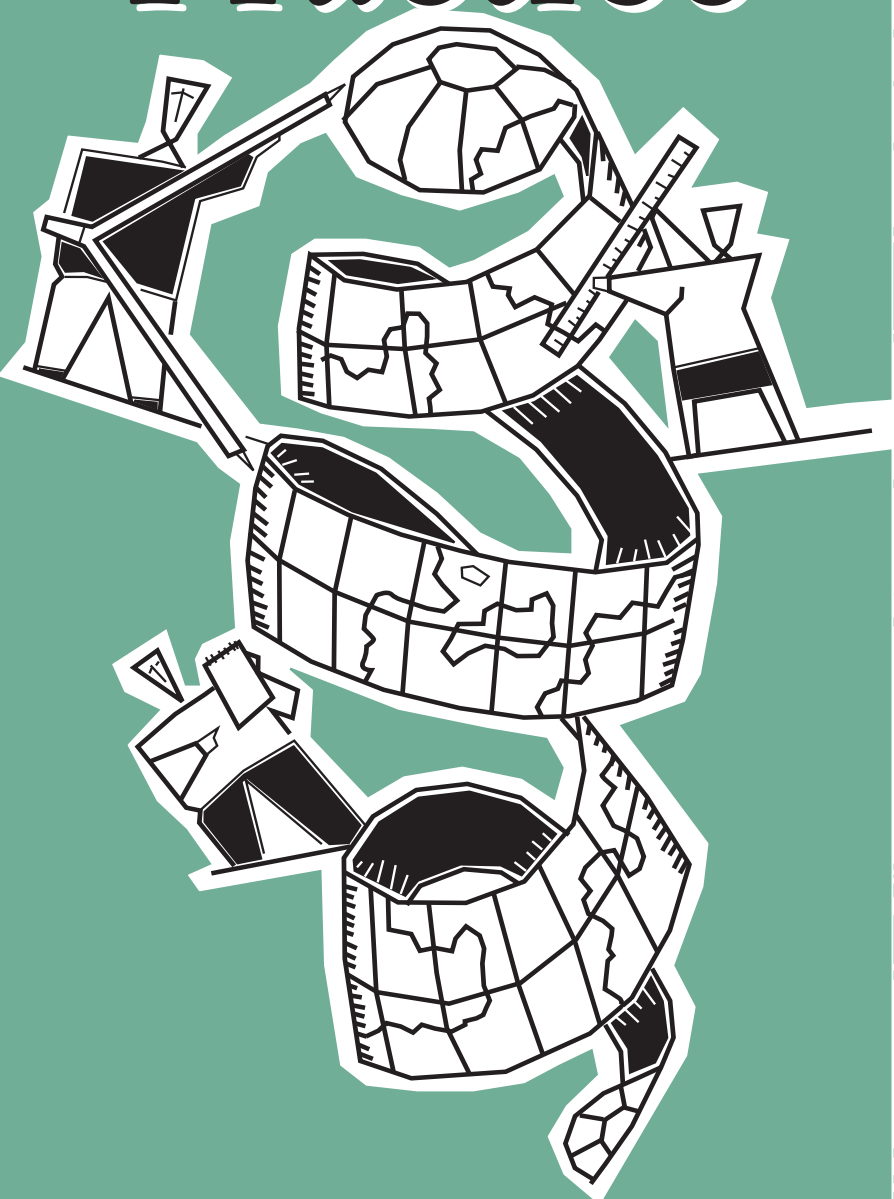
Theory INTO Practice



PROFESSIONAL DEVELOPMENT
FOR GEOGRAPHY TEACHERS

Series editors: Mary Biddulph and Graham Butt

Immaculate Misconceptions

JANE DOVE

The Geographical Association

Contents

Editors' preface 6
Introduction 7

1: Some definitions 11
2: Physical geography 15
3: Natural environments 21
4: Environmental issues 27
5: Pedagogical implications 35
6: Conclusion 41

Bibliography 42

Introduction

Identifying and explaining misconceptions is an intrinsically interesting field of research, and an understanding of common student misconceptions is a requirement in teacher training. The TTA *Standards for the Award of Qualified Teacher Status* guidance for novice teachers states they must:

- 'know for their specialist subject(s) students' most common misconceptions and mistakes,
- be aware of, and know how to access, recent inspection evidence and classroom-related research evidence on teaching secondary students in their specialist subject(s), and know how to use this information to improve their understanding'
  (TTA, 1997, p. 4)

Being aware of student misconceptions and finding strategies to address them, should also be part of more experienced teachers' continuing professional development.

The ideas which students bring to the classroom about a wide range of scientific and geographical concepts (Driver *et al*., 1985) have been variously referred to as 'misconceptions', 'children's science', 'alternative frameworks', 'preconceptions', 'untutored beliefs', 'intuitive notions' and 'alternative conceptions'. Although debate about which term is most appropriate remains unresolved, the term 'alternative conceptions' is the definition used throughout this book.

The aim of this book is to raise awareness in secondary school geography teachers and students of the nature, extent and causes of alternative conceptions in physical and environmental geography. Chapter 1 discusses definitions used in alternative conceptions and outlines why a study of this topic is important. It also identifies possible sources of alternative conceptions. The following chapters review some of the most common alternative conceptions and the associated understanding students have reached about specific topics. Chapter 2 explores physical geography; Chapter 3 considers natural environments and meteorology; and Chapter 4 looks at selected environmental issues. Some chapters include brief descriptions of specific strategies for helping students overcome their misconceptions. Chapter 5 develops these strategies further and considers the pedagogical implications on more effective teaching and learning methods. Chapter 6 briefly relates this to both geography and the wider curriculum.

As the research findings are explained in each chapter the methods currently used to detect alternative conceptions and bias due to stereotyping are reviewed. Suggestions are made throughout as to how students' alternative conceptions can be used to support the professional development of geography teachers in secondary schools.

5: Pedagogical implications

What students already think and understand is the starting place for the introduction of new concepts in geography and from which conceptual understanding is developed. What teachers need to explore is why students have a particular understanding of key geographical concepts and where that understanding comes from. This information can provide a basis for challenging alternative conceptions and supporting students' understanding. This process should be seen as part of the continuing professional development of experienced, as well as novice teachers. By anticipating potential 'alternative conceptions', teachers can plan learning opportunities to develop students' understanding while avoiding, rather than compounding, misunderstandings. To avoid students confusing closely-related concepts (a common cause of misconceptions) use unambiguous words and expressions which accurately describe the subject matter (see also Dove, 1998a).

For learning to be a challenge, teachers need to encourage students to evaluate their ideas against hard evidence. Teachers can counter alternative conceptions by using a range of strategies in the geography classroom: for example, developing students' questioning skills, asking more open-ended questions, and extending their use of 'argument' as opposed to learning by 'consensus' (Lambert, 1997). This type of learning can only take place if teachers are clear themselves about the distinctions between key concepts. A degree in geography does not necessarily denote expert knowledge, and as 'expert knowledge' constantly changes, teachers must remain alert to developments in research in geography as well as in relevant fields.

Keeping a critical eye on all forms of teaching resources and constantly re-evaluating your teaching approach should ensure that students' alternative conceptions do not go unchallenged. Some of the contexts in which alternative conceptions may arise, and ways of dealing with them are described below.

Contexts

Teaching resources

Popular geography textbooks can be a source of misinformation and geographical inaccuracies. For example, Sparks has identified errors in students' understanding of plate tectonics:

> 'The main errors involved are the confusion of the Earth's crust with the plates and the absence of any definition or explanation of the term "lithosphere". The ocean crust and continental crust of the Earth are layers of distinct composition. They are parts of the great plates of the Earth, but are entirely unrelated to the concepts of lithospheric plates, and plate tectonics, which is fundamental to plate tectonics. A plate is defined as the cold outer layer of the earth which behaves in a rigid manner so that the earth's broken surface is broken up into plates. This layer is called the lithosphere and is defined and recognised on the basis of mechanical physical properties' (Sparks, 1999).

Sparks attributes these 'errors' to the confusion embedded in some geography textbooks and goes on to identify elements of the illustrations and text which he describes as 'confusing, inconsistent and in serious error'. Sparks refers specifically to the use of sial and sima concepts which, he states '... had been abandoned by earth scientists in the 1960s as these ideas were superseded by plate tectonics'. The consequence of this is that students' knowledge is based on dated information of key geographical concepts and their understanding of plate tectonics contains major errors. Such errors then feed into students' answers to questions during GCSE and post-16 examinations and into their undergraduate studies. This example indicates that the onus is on the geography teacher to critically evaluate resources such as textbooks from both the pedagogical and the geographical point of view. This can be done by asking: 'Does this resource support learning?' 'Is this resource interesting and well presented?' And, perhaps most importantly, 'Is the content correct?'

Photographs and images

Teachers and students should bear in mind that photographs in textbooks reflect the authors' or illustrators' stereotypical images. Their choice can lead students to believe that some physical features are the same the world over; whereas features such as beaches and valleys, for example, vary considerably in form. Teachers, therefore, need to provide students with a variety of different examples of each landform (see pages 21-22).

One example of a stereotypical image is the persistent appearance of the Niagara Falls as 'the example' waterfall in geography textbooks. As a consequence the Niagara Falls may unwittingly be 'over-quoted' by students in a range of different contexts such as coursework and examinations. This use of a single example does not necessarily indicate a clear understanding of what a waterfall is. What is important is that students should be able to transfer their understanding of a waterfall from the Niagara Falls to other contexts.

Another source for photographs used in geography classrooms are the 'idealised' photographs in glossy tourist brochures, designed to sell the destination to the public. Carefully-composed shots of the Grand Canyon, for instance, are often taken at sunrise or sunset when the colours in the landscape are more intense, but these photographs cannot and do not capture the third dimension or the scale of the Canyon. The use of any such image in the classroom needs to be evaluated and carefully planned into the lesson to ensure that students are not unwittingly left with an alternative conception which will prove difficult to challenge at a later date.

By encouraging students to draw on their life experiences beyond school teachers can make learning feel relevant to them. For example, teachers can ask students to obtain a

selection of images which illustrate their conceptions of say, rivers and then 'check out' any misconceptions of rivers by looking at the appropriateness of each image. The teacher can also challenge any images which appear to be based on alternative conceptions. This approach enables teachers to attach new learning to students' existing cognitive framework.

The plus side of photographs is that they can be used to develop students' visual literacy skills and to encourage them to 'interrogate' images from a range of sources, including textbooks and brochures.

Fieldwork

A potentially interesting and useful fieldwork activity is to ask students to critically evaluate interpretative boards located near sites of geomorphological interest. An example of this type of activity (based on features found in Arizona and southern Utah, USA) is suggested in Dove (1998e). A-level students were invited to assess the success of interpretative boards Rainbow Bridge, the world's largest natural stone arch, and The Goosenecks, a set of incised meanders in explaining geomorphological features to the general public.

Students were also asked to design their own interpretative boards to explain the formation of *hoodoos* (earth pillars) at Bryce Canyon and the formation of mesas and buttes in Monument Valley. Although this activity was used in an international context the approach can be transferred to fieldwork with younger students in the UK. For example, the Giant's Causeway on the coast of County Antrim, Northern Ireland, is a popular tourist attraction, but without effective interpretative aids visitors may leave the site with little understanding of how the basalt columns formed. This type of fieldwork activity encourages students to question what they are reading and thus their understanding of the concepts/processes involved. The teacher should support the discussion in the field, between students and between student and teacher. This approach should enable the teacher to identify and challenge alternative conceptions as they arise.

With a range of possibilities from which to make rational choices, students can begin to question and perhaps adapt their conceptions in the field. For students this learning is more meaningful than that achieved by, for example, rote learning. It also ensures that the students have a sense of ownership of the fieldwork outcomes.

Practical demonstrations

Practical demonstration of concepts in the geography classroom can help develop understanding of concepts and change misconceptions related to specific issues. Research by Baxter (1989), for example, suggests that students have a variety of explanations for day and night: some recognise that this phenomenon is caused by the Earth spinning on its axis once every 24 hours, while others falsely believe day and night are the result of the sun travelling round the Earth or vice versa. One practical approach, which helps students to resolve this debate, is to provide them with models of the Earth and sun and ask them to consider which possibility is most likely, given the cycle takes only 24 hours.

A similar approach can be adopted to explore ideas about the seasons - a topic which Baxter (1989) and Mant and Summers (1993) have found students of all ages have difficulty explaining. They found that some students understand that the seasons are caused by the Earth's tilted axis moving round the sun, while others believe that winter and summer are the result of annual variations in the distance between these two bodies. Given a globe tilted on its axis and a 'model' of the sun, with the information that the northern and southern hemispheres experience winter and summer at different times, students could be asked to consider which of the possible explanations was more likely.

Open-ended questioning

The use of appropriate questions can go a long way to counter alternative conceptions. These can be related to specific issues on which students hold misconceptions: for example, evidence suggests that students commonly incorrectly identify rock types because their judgements are based on stereotypical images of colour. Students frequently confuse white or yellow varieties of sandstone with limestone or assume that all sandstones are orange and, therefore, do not recognise the white and brown varieties (Dove, 1996a). One way to counter this misconception would be to provide students with a variety of different examples of limestone and sandstone, but this would only increase their knowledge of known rock types. A better approach is to encourage students to devise questions which will help them to discriminate between two rock types and apply the questions to a range of specimens. For example: 'Does limestone have a significantly higher fossil content than sandstone?', 'Do the rock types react differently to dilute hydrochloric acid?'

As identified on page 12, a further common cause of misconception is for students to assume that landforms of similar appearance have one origin. Again teachers can discourage this belief by asking more open-ended questions when a topic is introduced. During a lesson on the formation of rapids, if a teacher shows students photographs of the feature and asks closed questions (e.g. 'What is obstructing the flow of water in the river?'), students will probably respond with 'A resistant band of rock'. (Although many rapids are formed in this way, some develop when a waterfall migrates upstream, while others occur where debris fans (deposited during flash-floods from side-canyons) fail to be removed by the main channel, as in the Colorado.) A more opened-ended question, e.g. 'What do you see in the picture?', followed by 'How did the rocks get there?', will allow the students to respond with a variety of explanations.

Teaching argument

The term 'argument' here refers to purposeful procedure or activity. Teaching students to use 'argument' as part of their reasoning is another strategy for dispelling their misconceptions about geographical concepts. Students need to be taught 'argument' in the same way they need to be taught other mental skills (see Andrews, 1993). Often students are given the 'consensus view' - for example, of desert processes or global climate change - without addressing the arguments. Students need to recognise that what is 'consensus' today may become a 'misconception' tomorrow. This can be illustrated by the example of desert varnish. Desert varnish was originally thought to form when iron and manganese were drawn to the surface and oxidised, but this belief was challenged when the varnish was found on rocks with a low manganese and iron content. Current

theory suggests that desert varnish forms when wind-blown manganese and iron-rich clays are deposited on rocks dampened by dew, where the presence of bacteria and lichen on the surface of the rocks helps fix the elements to the stone (Cooke *et al.*, 1992). To encourage students to think about this concept, ask them to suggest possible explanations for desert varnish from a description. When they have done so tell them that varnish occurs on rocks of low manganese and iron content and ask them if they wish to revise their original ideas in the light of this information.

Another issue which could be debated in the geography classroom is the effects of global climate change. Ten years ago some scientists predicted that global climate change would lead to a 5m rise in sea-levels and at one time scientists believed that Antarctica was too cold to be altered by global climate change. Original estimates of sea-level rise have now been reduced and recent research revealed that the Riiser-Larsen Ice Shelf which borders the Atlantic Ocean and Weddell Sea is disappearing. Students might debate this topic by evaluating the evidence used to make the original predictions and considering what changes occurred to make scientists revise their estimates.

These examples indicate the need to be aware of new evidence on specific topics. The evidence may consolidate or challenge existing understanding of the concept and consequently arguments need to be fully debated before a consensus is reached.

What is in it for me?

Both you and your students are likely to benefit from the information you can gather on alternative conceptions. The data collection methods need not be sophisticated to be useful. For example, a ten-minute activity exploring perceptions at the beginning of a lesson may reveal ideas which you had not considered before. As a consequence, you may re-examine your own understanding and try to improve on it. You may seek explanations for your own perceptions and decide next time the topic is introduced to present it in a different way.

It is important to disseminate findings to a wider teaching audience. Not only would this benefit students, but you may well discover that you hold some of the alternative ideas which have been identified in students. I would welcome feedback via the GA of any students' alternative conceptions you have observed. Alternatively, you may like to consider submitting articles to *Teaching Geography*. There is also considerable scope for research into specific alternative conceptions at degree and post-graduate level. All of these activities contribute to the continual professional development of all teachers.

Key ideas

- Teacher use of ambiguous and inaccurate language can help to produce students' alternative conceptions.
- Textbook photographs and other images need to be used selectively and critically.
- Alternative conceptions can be challenged by developing students' skills in a variety of contexts, e.g. using questions during fieldwork and practical demonstrations.
- The teaching of 'argument', rather than learning by 'consensus', encourages students to confront their alternative ideas.