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Fostering progress in children's developing geoscience interests

Roger Trend

Summary

Interest is a complex construct, yet is often treated by researchers and other authors as being a non-problematic uni-faceted concept. Negligible research has been undertaken into the geoscience interests of teachers and students, with even less probing of interrelationships between individual, situational and topic interest. Interest research is very weakly-developed in the UK, with many recent publications emanating from several pivotal countries including Canada, Germany, Australia and the USA. In recent years the interest research community has been developing theory, including a four-phase model which provides a framework for analysing the progressive development of learners' interest from "triggered situational interest" to "well-developed individual interest" (HIDI and RENNINGER, 2006).
In order to identify teachers' possible instructional starting points, a questionnaire survey of 652 children aged 11 and 12 years was undertaken to investigate the nature of their individual geoscience interests. Selected data from a second study of 51 serving teachers were also used to compare the geoscience interests of teachers and children and to compare those interests with actual classroom experiences of selected geoscience concepts. Several mismatches between teachers' and children's interests were identified, alongside further mismatches between interest and classroom geoscience experiences. In order to illustrate children's growth towards a 'well-developed individual geoscience interest', comprising both cognitive and affective elements, the four-phase model of interest development was examined in the context of the planning of geoscience learning activities. The implications of this model for geoscience education are examined in relation to the empirical results reported here and in the two previous related papers.

Study framework: what is interest?

What do we really mean when we use the word 'interest' in relation to school students' attitudes towards geography and geoscience? Do we all mean the same thing: do we work to a shared understanding, and what are the most appropriate techniques for probing children's interests? If these questions can be answered satisfactorily, we are surely making some progress towards disentangling the numerous interrelated concepts which help us to understand children's developing geoscience learning. It is this learning, after all, that lies at the heart of much of our research endeavour, so an investigation into children's geoscience interests must articulate the interest/learning link. Motivation is central in such analyses. One aim of this paper, therefore, is to explore further the meaning and pedagogical implications of 'interest' in the context of geoscience teaching and learning, especially in relation to the evolution of children's interest from a relatively insecure and transient form to one which is more permanent and robust.

There is no doubt that interest, however defined, exerts a strong influence on children's evolving attitudes towards all school subjects, including geoscience and its various knowledge content and process constituents. Research surrounding children's educational and career choices indicates that some children develop career and choice trajectories that become relatively fixed from young ages, possibly from as early as 8 or 9 years (CLEAVES, 2005). By contrast, other students remain open to a range of career options until well into their post-16 studies (FOSKETT et al., 2004). The implications of these contrasting pupil biographies are visited at the end of this paper, in the context of an empirical study into the geoscience interests of 11- and 12-year-old children across 27 UK classrooms (TREND, 2005), with a brief visit to an earlier study of teachers' geoscience interests (TREND, 2001a).

The picture is further blurred when the object of this 'interest' is considered. There is a clear hierarchy in place, certainly within the field of geography and geoscience content. At the apex we find clusters of disciplines or subjects, such as that employed by the UK Higher Education Academy: GEES (Geography, Earth and Environmental Sciences) (MAGUIRE and GUYER, 2004). At the next level down we have single subject disciplines such as geography and geology. Further down the hierarchy we have broad fields such as palaeontology and geomorphology and at the lower levels we have progressively larger numbers of progressively smaller and more restricted topics. Although some empirical research addresses this diversity (eg, CHRISTIDOU, 2006; eg, TABER, 1991), most studies treat school subjects as single entities (eg, HARRIS and HAYDN, 2006; eg, MURPHY and BEGGS, 2003; PALMER, 2004; WEEDEN, 2007) although interest in various smaller topics is also investigated (eg, QUALTER, 1993). The implications of the assumption that children develop a single 'interest' level towards entire school subjects warrants consideration since, for example, many government attempts to foster the continued study of science at post-16 levels ignore such diversity within each subject. PALMER (2004) cited it as a potential weakness in his study and "there is evidence in the literature that students' interest and involvement in science is not homogeneous: it varies according to different factors, among which are science subjects, or specific science topics, science-related activities and gender. What is more, these factors seem to be strongly inter-related and therefore cannot be considered in isolation" (CHRISTIDOU, 2006, p. 1182).

To what extent are children interested in geoscience? Are they more interested in some geoscience topics than in others? Which geoscience topics engender the greatest interest, why is that so, and are there any gender contrasts in pupils' attitudes towards these topics? What is the influence of learning activities on topic interest? What is the precise nature and extent of that interest among children? Does "interest" relate mainly to the learner's psychological state, the material to be learned, the learning activities, prior knowledge, or some combination of these variables? These and other questions have been addressed elsewhere (TREND, 2005), although it is necessary here to revisit some of them below in the light of the discussion that follows.

Teachers and teaching make a difference. The empirical studies addressed in this paper address not only the geoscience interests of 11- and 12-year-old pupils (N=652) but also those of teachers (N=51) of this-aged students (TREND, 2001a). The interrelationships between teacher interest, pupil interest and curriculum content need further investigation in the context of geoscience in order to identify interest-related factors that best stimulate children's learning.

Although researchers have been probing the phenomenon of 'interest' for a century (DEWEY, 1913), the current research activity focusing on the nature of 'interest' itself stems only from the 1970s. Activity has been steadily increasing over the past 30 years (BOEKAERTS and BOSCOLO, 2002; HOFFMAN et al., 1998; RENNINGER et al., 1992) and in recent years the pivotal concepts of situational and individual interest have become widely established in the literature as theoretical perspectives for advancing understanding (HIDI and HARACHIEWICZ, 2000; HIDI and RENNINGER, 2006). An analysis of the relevance of such interest research for geoscience education has been presented elsewhere (TREND, 2005): here it is appropriate only to review the two main categories of interest (individual and situational) in order to interpret the results presented below.

In any work on interest it is important to distinguish between "individual (or personal) interest" and "situational (or context) interest" (HIDI, 1990; HIDI and BAIRD, 1986; HIDI and RENNINGER, 2006; KRAPP, 1989; KRAPP et al., 1992; RENNINGER et al., 2002; SCHIEFELE, 1991). On the one hand, individual interest refers to interest (in something external to the learner) that is highly personal, robust, long-lasting and often wide-ranging. It tends to develop over time as it becomes more sophisticated and an increasingly permanent aspect of the person's psyche. On the other hand, situational interest arises from the immediate context of the learner, including the learning activities and recent happenings. It has been described as "the appealing effect of an activity or learning task on an individual, rather than the individual's personal preference for the activity" (CHEN et al., 2001, p. 384). Situational interest is closely tied to the learner's psychological state whereas individual interest is less dependent on that condition. It is perhaps a truism to state that one of a teacher's goals is to stimulate each student's situational interest, through the learning activity and classroom ambience, so that it can foster the more robust and long-lasting individual interest. The psychological pathways followed by learners as they move from transient situational interest to a secure individual interest

Although individual and situational interest dominate the theoretical literature, a third variety is frequently quoted: "topic interest". There is no consensus over its definition. Some see it as individual interest focused on a small topic (SCHIEFELE and KRAPP, 1996; TOBIAS, 1994). However, the majority represent it as a composite psychological construct which arises from the interaction of individual and situational interest. AINLEY, HIDI and BERNDORFF (2002) argue that, "given the basic interactive nature of interest, both the characteristics of the person (individual factors) and the features of the environment (situational factors) can potentially influence topic interest" (p. 547). Given that geoscience topics figure large in the present study, it is important to note that the composite definition is used here.

Theoretical background and research questions

Educators and researchers need to address children's interests. TOBIAS (1994) gives five reasons for this. First, interest influences children's motivation which is closely tied to their learning. Second, the stability of interest (or certain types of interest) among learners can be exploited by teachers. Third, interests are ubiquitous. Fourth, interest research has face validity since it has been shown that people work harder on tasks related to their interests than on others. Fifth, interest research provides a direct link between motivational research and cognitive processing. It is the second and third of these five reasons that have the greatest relevance for the current research, although none is totally irrelevant.

Tobias's five reasons have stimulated both empirical and theoretical interest research in recent years (KRAPP, 2002). As part of these developments in theory, HIDI and RENNINGER (2006) propose a four-phase sequential model to enhance understanding of the relationships between the two types of interest. They emphasise three distinctive attributes of interest which distinguish it from other motivational variables: it involves both cognitive and affective elements; both elements have biological roots; and interest always involves a both the person and some object of interest which is external to that person. They then elaborate their four-

Figure 1: Summary of the Four-Phase Model of interest development (Hidi and Renninger, 2006)

The four phases	Key characteristics according to Hidi & Renninger (2006)	Possible manifestations in geoscience learning, according to present author
Phase 1: Triggered Situational Interest (TSI)	• "a psychological state of interest that results from short-term changes in affective and cognitive processing" (p.114) • deals with attracting initial interest, typically by the teacher • active learning fosters TSI • possibly a precursor to more autonomous subsequent interest • almost always externally maintained	• Teacher takes care to ensure that both affective and cognitive domains are addressed in the early parts of the lesson, by drawing on pupils' awareness of local landscapes or pupils' recent holiday visits. • Teacher introduces a lesson on plate tectonics using active learning strategy which involves children moving around the classroom to simulate moving plates • Teacher uses spectacular video footage to show the events during an earth-quake
Phase 2: Main-tained Situational Interest (MSI)	• "a psychological state of interest that is subsequent to a triggered state, involves focused attention and persistence over an extended episode in time" (p.114) • sustained by learners' meaningful engagement with activities • usually externally maintained • often involves collaborative groupwork or projects	• Teacher establishes a unit in which students undertake research into the possible causes of dinosaur extinction, so students engage with changing global palaeogeographies and palaeoclimates • As a result of an ongoing research project, students maintain interest in iden-tifying possible causes of global warming
Phase 3: Emerging Individual Interest (EII)	• "a psychological state of interest as well as …. the beginning phases of a relatively enduring predisposition to seek repeated reengagement with particular classes of content over time" (p114) • students value new learning and choose to re-engage with tasks and/or content previously encountered in MSI and TSI. • students start to identify their own questions or self-set challenges within the new area of learning • typically self-generated interest, but not completely • fostered by particular learning environments • may or may not lead to WDII	• Teacher provides framework for learning within which children have some choice, eg in study of selected locations, weather systems or plate boundaries • Teacher addresses differentiation to accommodate children's variable needs in relation to interest phase. • Student chooses to investigate local geology while on family visit: encouraged by teacher who is alive to such opportunities to support EII • During visit to museum, teacher devises learning activities that allow students in EII to undertake autonomous
Phase 4:Well-De-veloped Individual Interest (WDII)	• "the psychological state of interest as well as …. a relatively endu-ring predisposition to re-engage with particular classes of content over time" (p.115) • relatively high levels of stored knowledge and stored value • given choice, student chooses to engage with relevant content, valuing the opportunity to do so • generates and seek answers to curiosity questions • students are resourceful when conditions do not provide ready answers • typically self-generated, but not always • benefits from external support, including that from peers and experts •learning context provides for challenge and interaction that leads to knowledge building	• Student identifies local geological phenomenon, such as a recent cliff collapse, and seeks guidance from teacher on appropriate learning activities • Teacher maintains contact with student once s/he has left school, for support in relation to developing geoscience expertise • Teacher provides opportunities for students to engage in extra-curricular geoscience work, such as a weekend field visit • Teacher arranges for visiting geoscience expert to meet with students to address geoscience issues at a level appropriate for students with WDIIr

phase model which takes the learner from "triggered situational interest", through "maintained situational interest" and "emerging individual interest" to a culminating "well-developed individual interest" phase. Each phase has clear distinguishing features and the phase boundaries are distinct: see Fig. 1 for a summary. This model is revisited in the conclusion to this paper.

In relation to motivation and goal theory, HIDI & HARACHIEWICZ (2000) point out that "as children get older, their interests and attitudes towards school in general, and toward specific subject areas such as mathematics, art and science, tend to deteriorate" (p. 151). Research in science education confirms this (MURPHY and BEGGS, 2003; SKAMP and LOGAN, 2005) although there is no equivalent work relating to geoscience: perhaps attitudes improve over this period?

It is children's and teachers' individual interest that has most relevance for the current research, since that represents the main object of scrutiny. Uncovering students' long-lasting, robust and personal geoscience interests will provide teachers and curriculum developers with foundation knowledge which can be drawn upon in their work. Furthermore, research and theory in this field suggest that the geoscience topics which constitute this individual interest at the age of 11 and 12 years are likely to remain intact through the coming decades, regardless of teaching or other intervention. That is not to say, however, that additional topics will not similarly become incorporated into that body of each child's individual geoscience interest.

The enhancement of children's individual geoscience interest can be seen as an honourable goal for any teacher, not least because of the motivational role of interest in fostering wider learning. HIDI and HARACKIEWICZ (2000) describe individual interest as "a relatively stable motivational orientation or personal disposition that develops over time in relation to a particular topic or domain and is associated with increased knowledge, value, and positive feelings" (p. 152). This identification of "increased value" over time is important and is developed by RENNINGER, EWEN and LASHER (2002) who suggest that individual interest "includes two interrelated components: stored knowledge and stored value, where stored value includes feelings of competence, as well as positive and negative feelings that emerge in the process of figuring out what is understood and what still needs to be clarified. Individual interest differs from other motivational concepts because it always refers to a particular person-environment relation that is operationalised in terms of a person's levels of both stored knowledge and stored value relative to the other activity in which he or she is involved" (p. 469).
The present geoscience interest research probes children's individual interests on the assumptions that

(i) they arise from prior learning and engagement with concepts and (ii) they are currently perceived by the children in terms of their stored value (affective) and their stored knowledge (cognitive) (RENNINGER, 1992). Both children and their teachers confer value on their acquired individual geoscience knowledge and interest. Such stored value provides the context for future learning and potential widening of individual interest.

Since it arises from the learning context, situational interest generates its own distinctive "interestingness" of learning environments (HIDI and BAIRD, 1986; KRAPP, 1989). Situational interest in science education has been exhaustively researched over the last few decades, often in the language of the efficacy of certain learning activities (e.g. field work, practical work; group work; engaging with texts, plenaries, whole-class teaching). Research activity of this kind has now been replaced by more sharply focused studies of the construct of situational interest itself, rather than cognitive gains from selected learning activities. For example, PALMER (2004) investigated the extent to which a set of instructional interventions could stimulate pre-service teachers' situational interest in science, concluding that attitudes toward science had been enhanced by the teaching. However, the time difference between his pre- and post-test was only 5 weeks, so it remains unclear if the respondents had experienced any raised individual (ie robust and permanent) interest.

The sources and characteristics of situational interest have been investigated by several authors (BERGIN, 1999; CHEN et al., 2001; DECI, 1992; MITCHELL, 1993; PALMER, 2004) and reviewed briefly by AINLEY, HIDI and BERNDORFF (2002). Little of this has immediate relevance for the present study which takes situational interest as essentially contextual. Suffice to note that CHEN, et al (2001), in relation to various physical activity tasks, conclude that situational interest is a five-dimensional construct and that "instant enjoyment" has the greatest affect on that interest. They note that similar results have been reported for learning activities which are classroom-based.

Although individual interest is paramount in the present questionnaire-based empirical study, the context of the questionnaire administration had the potential to stimulate situational interest. The level of children's motivation and concentration were inevitably influenced by the prevailing milieu, partly influenced by the researcher. Furthermore, situational interest also has some relevance because geoscience topic interest is deemed by some to be the progeny of individual and situational interest. In other words, the level of topic interest expressed by the respondents is likely to be a composite of individual and situational interest.

Individual and topic interest have received considerably less research attention than has situational interest, most likely because both teachers and researchers attach great importance to children's learning activities. Teaching is all about stimulating children's situational interest so that they will engage with their classroom work with interest and enjoyment. In order to create such an environment, teachers need to have some idea of the pre-existing interests, aptitudes and skills that children bring to their new learning: data normally acquired through baseline assessment. It is at this point that individual interest becomes highly pertinent since "there are too many examples of teachers who assume that children of a certain age, gender, or ethnicity like to read and hear about certain topics in the absence of any confirming information from the best possible informants, the students" (GARNER et al., 1992 p. 252).

In UK schools geoscience matter is included in both geography and science courses, although there is a difference in emphasis between the two school subjects and there are variations between different parts of the UK (TREND, 1993; TREND, 1995; TREND, 2003). The body of UK-based research literature on interest is not large, although it is increasing as researchers address children's geoscience related educational choices in an increasingly sophisticated way (PALMER, 2004; WEEDEN, 2007). As noted above, most of the school-based interest research treats each school subject as a single curriculum entity, be it science or geography, and, therefore, sheds little light on children's or teachers' individual interests in the various geoscience components.

The exceptions are those studies that examine children's interests in selected science or geography topics, including geoscience. The empirical research into children's geoscience interests which was constructed on that existing research foundation (TREND, 2005) took topic interest to be a multidimensional construct derived from the combination of two complex concepts: interest and geoscience. First, 'interest' has several facets, notably situational and individual. Second, 'geoscience' is not a single phenomenon: it is a complex amalgam of concepts, facts, methods, assumptions, processes and skills which can generate a multitude of learning contexts and styles. Interest in science is essentially multidimensional since different children will be interested in different topics and various ways of working (GARDNER, 1995).

The research questions addressed in this paper are:

- What are the main characteristics of 11- and 12-year-old children's geoscience interests and how do these contrast with those of teachers of children of this age?
- How do children's and teachers' geoscience interests relate to actual classroom geoscience experiences?

- How can a four-phase model of interest development be applied in the context of geoscience education?

Design of the study and methods

This research employs a scientific methodology, using both quantitative and qualitative methods. "The truth is out there", and this research aims to illuminate that existing truth via questionnaire and other instruments. However, no claims are made for any degree of positivism: the researcher has an inevitable role to play beyond being a mere collector of data, so interpretivism is the order of the day. Indeed, it is the researcher's world-view and professional values and imperatives that have driven this research and its dissemination.

Questionnaires were administered to 652 children aged 11 to 12 years in 27 classrooms across 11 secondary (11-28 years) and middle (8-12 years) schools in parts of Devon, UK. Full details are basic results are given elsewhere (TREND, 2004; TREND, 2005). The questionnaire was designed to reflect National Curriculum content (Department for Education and Employment & Qualifications and Curriculum Authority, 1999) and the breadth of geoscience content, with a particular focus on human interest, aesthetic factors and deep (geological) time. The 28 questions were worded to cover four main Geoscience Themes (People; Past Time; Present Time; Future Time) and seven Geoscience Topics (Big Events, Planet Earth, Weather, Places, Water and Oceans, Earth Materials, Land Surface), with one question relating to each of the 28 theme/topic cells. For example, "why is the sea salty" occupies the "Present Time – Water and Oceans" cell. A sharp focus on children's interest in deep time was included because (i) deep time is arguably one of the defining characteristics of geoscience, or at least geology, and (ii) it permits comparisons with previous research findings reported by the author (TREND, 1998; TREND, 2000; TREND, 2001a; TREND, 2001b; TREND, 2002). Respondents were asked to respond to each question using a 5-point scale, according to their level of interest in finding out more about it, the same technique used in a major UK survey of children's science interests (QUALTER, 1993). The main questionnaire was piloted with a focus group of 6 students.

Quantitative data were analysed using factor analysis and between-groups t-test and Mann-Whitney (which gave identical results).

In order to investigate the influence of teachers' geoscience interests on children's interests, it is appropriate to compare the results from this children's study with selected results from a study of primary teachers' (7-11 years) geoscience interests and classroom encounters (TREND, 2001a). The research was designed to identify the relationships between teachers' interests and the extent to

Table 1: Children's questionnaire items (arranged by overall rank), with mean scores and ranks

Questionnaire Item	Rank	Mean score
What exactly was the big event that killed off the dinosaurs?	1	2.75
Will there be explosive eruptions in Britain in the future?	2	2.46
What will people do if an asteroid hits planet Earth?	3	2.42
What would Antarctica be like in the future if all the ice were to melt?	4	2.29
What was the weather like at the time of the dinosaurs?	5	2.22
What causes some volcanic eruptions to be massive and explosive?	6	2.20
What was it like in Devon millions and millions of years ago?	7	2.17
How quickly is sea level rising? Will London soon be under the sea?	8	2.17
How old is the world's water, and where did it come from?	9	2.14
How are large crystals formed?	10	2.09
Why is the inside of the Earth so hot?	11	2.04
How old is planet Earth and how was it formed?	12	1.97
How fast is global warming happening and what will climate be like in 50 years?	13	1.96
How do the world's poorer people prepare for devastating hurricanes?	14	1.95
How do some people survive in climates of extreme cold or dryness?	15	1.91
Will Earth's magnetic field disappear or change in the future? If so, how soon?	16	1.83
Why are clouds so changeable and why don't they fall down to the ground?	17	1.75
How big is the Grand Canyon?	18	1.73
Why is the sea salty?	19	1.60
Will mountains eventually be worn down to sea level by erosion?	20	1.49
Why do people wear jewellery made from crystals such as diamond and ruby?	21	1.47
How were mountains formed, and how long ago?	22	1.41
Will the sand on the sea bed be turned into solid rock? How long will it take?	23	1.34
Why do so many people visit the Grand Canyon?	24	1.32
How were rocks formed and how long did it take?	25	1.07
Why do so many people enjoy watching moving water, like a mountain river?	26	1.05
Why do some rivers flow in very smooth bends (called meanders)?	27	0.99
Why do so many people enjoy walking in areas of hills and mountains?	28	0.86

which various geoscience concepts were encountered in the classroom, regardless of the formal curriculum. Selected results from this study are introduced in the following section. This study comprised a sample of 51 serving teachers of 7- to 11-year-old children and involved a range of instruments designed to elicit not only their geoscience interests but also their perceptions of geo-events which have occurred through deep time. The data addressed below were obtained from the first 2 sections of the main questionnaire, each section comprising 20 geoscience topics such as "Big Bang" and "earthquakes". The first of the two sections addressed teachers' individual interest and the second addressed the extent to which teachers encountered those topics in the classroom.

Results, with implications for geoscience education

Some of the results of this children's survey have been reported elsewhere (TREND, 2005), but a resume of those findings is given here to allow ready comparison with teacher-related data. Raw results are given in Table 1. Factor analysis indicated that an interest in 'relevant change' is all-pervasive among 11- and 12-year-old children, with no gender contrast. Children have relatively strong interests in geoscience matters which are likely to impact on humankind, such as global warming, changes in the Earth's magnetic field, melting ice sheets and sea level change. A second factor comprised an interest in 'extreme events' such as asteroid impact and volcanic eruptions, although with stronger interest among boys compared with girls ($p<0.01$). A third factor, labelled 'gentle past', reflects the children's interests in gradual change through geological time, regardless of its impact on humans. This appears to be an interest in uniformitarianist interpretations of Earth's origins and evolution which is equally manifest among boys and girls: Earth history appears to be fascinating and worthy of study for its own sake. These results suggest that children's interest in Earth's deep past is not inconsiderable, yet many teachers avoid it (TREND, 2001a). Two further factors were identified ("environment" and "aesthetics"), but neither was so convincing as the first three. In terms of the developmental four-phase model of HIDI and RENNINGER (2006), it is suggested that children with high factor scores in any of the three most secure factors are exhibiting "Emerging Individual Interest" in that geoscience field (ie 'relevant change', 'extreme events' or 'Earth's gentle past') and possibly even "Well-Developed Individual Interest". Teachers may well find such data useful in their planning and careers-guidance experts may find it useful in their judgements.

Gender contrasts were conspicuous by their absence, the "Big Events" topic and "extreme events" factor generating greater interest among boys than girls ($p<0.01$) and the "aesthetics" factor having a higher mean score for girls. Of the 28 individual items, only 6 generated gender differences, those mentioned above arising from the cumulative effects across many items. In particular, both the dominant "relevant change" factor and the important "gentle past" factor involved no gender contrast in interest.

Results from the study of teachers' geoscience interests and classroom encounters indicated relatively uniform and high levels of geoscience

Table 2: Comparing children's and teachers' geoscience interests and encounters

Teachers Encounters	Teachers' Interests	Children's Interests
Highest	*Highest*	*Highest*
• Landforms • Origins of the Solar System • Fossils • Earthquakes • Rocks • Volcanoes • Dinosaur extinction	• Earthquakes • Volcanoes • Origin or formation of planet Earth • Changes in global climate through geological time • Current landforms and processes • Origins of the Solar System • Dinosaur extinction	• Dinosaur extinction event • Future UK explosive eruptions • Consequences for humanity of asteroid impact • Consequences of Antarctican ice melt • Weather conditions at time of dinosaurs • Origins of explosive volcanic eruptions • Conditions in the geological past
• Living fossils • Big Bang • Changes in global climate through geological time • Development of mountain chains • Ice ages • Plate tectonics • History of geological ideas	• Living fossils • Ice ages • Development of mountain chains • Rocks • Fossil energy resources • History of geological ideas • Minerals and/or crystals	• How were mountains formed • Sandstone from sand: how long will it take? • Why do so many people visit the Grand Canyon? • How were rocks formed? • Why do so many people enjoy watching moving water? • Why do some rivers flow in smooth bends? • Why do people enjoy walking in mountains?
Lowest	*Lowest*	*Lowest*

interest, with none of the 20 selected geoscience topics stimulating low or very high interest. Derived from a response scale of 1 to 5, the mean scores across the 20 items ranged from 3.03 to 3.86 (range of 0.83), compared with a range of 1.81 for their "classroom encounters" (1.49 to 3.30). Table 2 shows the highest and lowest 7 items in each study, alongside the rates of classroom encounter from the teacher study.

A comparison of results from the two studies suggests some possible avenues for further research and teacher intervention. First, rocks appear to generate low individual interest among both teachers and students, yet they figure large in classrooms. Rocks are not included explicitly in the Geography National Curriculum (NC) for this age, although they are often chosen by teachers to illustrate or exemplify wider principles or concepts. In NC Science, however, children are required to be able to describe and classify rocks on the basis of their appearance, texture and permeability: teachers appear to have low interest in rocks despite this formal curricular requirement. Second, landforms and related topics engender very low interest among pupils, but teachers rank these topics high in both interest and encounters. The explanation is simple: surface processes and landforms are legally-required curriculum content and teachers see it as their professional responsibility to develop an interest in (almost) everything they teach. Despite these two potentially positive influences, it is clear that 11- and 12-year-old children have very low interest in geomorphology.

Third, both teachers and children have high levels of interest in climate change through the geological past, yet such matters are rarely addressed in classroom activities. Even the familiar concept of 'ice age' occurs relatively infrequently in classrooms, in this case perhaps reflecting the low teacher interest rather than the high pupil interest in this concept. Fourth, earthquakes and volcanic eruptions figure high on all counts: teacher and pupil interest and classroom encounters. Given that these are familiar events which often cause spectacular consequences, and that they have a high profile in the National Curriculum (Department for Education and Employment & Qualifications and Curriculum Authority, 1999), such results are to be expected. Fifth, the origin of mountain chains hold relatively little interest for teachers and children and are infrequently encountered in the classroom, alongside the relatively low interest levels among teachers for plate tectonics. Given that plate tectonics provides a powerful and universally accepted explanatory model for many geological processes, including high interest topics such as earthquakes, volcanoes and climate change in the geological past, this low interest level among teachers might have implications for the development of higher level cognitive skills (notably application) among their pupils in relation to geoscience.

Finally, it is not surprising that dinosaur extinction ranks high in all three lists. Although it is not given as a required geo-event in the National Curriculum, children's interests no doubt stem from their informal learning and teachers' interests probably arise from their professional imperative to engage with children's interests. Given the widespread engagement with these global extinction events of 65 million years ago, which may or may not have been triggered by an asteroid impact, it is of some concern that neither teachers nor students are able to locate these events in any secure temporal framework (TREND, 1998; TREND, 2000). It is unlikely, therefore, that further refinement of the geoscience concepts surrounding this popular event is possible without planned intervention by geoscience educators with both pre-service and in-service teachers.

Conclusions

The pattern of children's and teachers' geoscience interests outlined above provides a small glimpse into the realities and complexities of geoscience perceptions, values and attitudes. It suggests implications for teaching and teacher education, not least in relation to the mismatch between teachers' and children's individual interests, the National Curriculum and classroom experiences. Some of the more significant mismatches identified above may be addressed through a relaxing of required curriculum content, with teachers being given greater scope to select the geoscience content appropriate to their situation. However, it is likely that the majority of primary school teachers are not in a sufficiently well-informed position to make such judgements, so systematic pre-service and in-service support is needed if children are to develop their geoscience interests along the lines described by the four-phase model proposed by HIDI & RENNINGER (2006).

This model of interest growth may be applied in geoscience education, provided that teachers can develop an awareness of its likely or possible manifestation in geoscience learning. Figure 1 summarises the model alongside some possible geoscience manifestations. Interest development needs a starting point for both teachers and learners: the comparative data analysed in this article suggest areas where there are good matches between existing levels of individual interest across teachers and children, and also where there are mismatches. The results also suggest similar relationships between interest and classroom experiences.

The four-phase evolutionary model of interest needs to be applied alongside an understanding of children's changing perceptions of geography, Earth and environmental science (GEES), the subject cluster employed by the UK Higher Education Academy to support higher education teaching. A survey of the literature in relation to an ongoing GEES research project indicates that some children develop strongly-held attitudes towards these subjects around the age of 11 or 12 years, attitudes which subsequently influence their educational and career choices (Trend, submitted). Clearly for those children the shift from transient situational interest to well-developed individual interest is significant: research is needed to establish the causes of this relatively rapid shift, compared with other children who follow more conventional educational choice trajectories.

The four-phase model takes us beyond this mere description of existing individual interest and the identification of various methods of boosting situational interest (such as stimulating lesson 'starters'). It sheds light on a more systematic and dynamic state in which teachers and the wider geoscience education community can harness theory to provide learning opportunities to take children carefully from a state of 'triggered geoscience situational interest' to one where some (or many?) attain 'well-developed individual interest' … and then perhaps choose to become geoscience teachers themselves!

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