A Study of Children's Classroom Questions in Relation to Elementary Science Teaching

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Abstract

Scientific enquiry is a creative process, commonly beginning with a question or problem, then generating a tentative answer or solution, and testing it. In the classroom, the question, perhaps in the form of a problem, is generally given, ready-made, to students by the teachers. With the aim of providing young students with a fuller experience of the scientific process, and wanting the potential of self-generated questions for interest and motivation, we explored various ways of inducing children (8-11 years, and of various sample sizes) to ask questions in science. Question-asking was found to be complex, involving the construction and articulation of descriptive and causal mental models of situations. We suggest several factors which influence and order the process, especially the situation or stimulus, the teaching and learning environment, and the attributes of the child. It takes time to produce questions which could lead to scientific enquiry, and it needs teaching skill to provide efficient and effective opportunities for children to ask questions, and help them put them into a suitable form. Question-asking seems worthy of further study.

Keywords: Question-asking; problem finding; descriptive/casual mental models.

Introduction

Problems, creativity and science

Popularly, creative behaviour is something that tends to be associated with the Arts, but, of course, people can be creative in any area of human endeavour (Newton & Newton, 2010). In science, mathematics, and technology, creative behaviour is more likely to be seen as problem solving (Newton, 2010). (Some practitioners in the Arts also see their creative activity as problem solving, see, for instance, Burnard and Younker (2004).) In science, there is:

- a problem – typically in the form of a puzzling observation or event in need of explanation;
- creative thought in the hypothesis space – applied to construct one or more plausible causal explanations;
- creative thought in the experimental space – applied in the design of tests of the potential explanations (Newton, 2010; Newton, 2012a). In applied science, there is also the potential for creative thought in the application space, where knowledge and know-how are used to solve practical problems (Newton, 2010). Some teaching programmes include the applications of science with the potential for creative thinking to solve practical problems found by the student. Other programmes leave this for technology education.

These creative activities may be undertaken by a single scientist, or different scientists (jointly or independently). While the aim is to move from the problem to the practical test of potential explanations, progress may not be smooth. In practice, there may be some iteration or backtracking with notions being revisited, clarified, redefined or reinterpreted, with consequences for later thinking. Although for decades problem-finding has been seen as a first step in creative thinking and a *sine qua non* (e.g. Getzels, 1975), it has tended to attract less attention than other mental processes. Hokanson (2018, p. 67) is of the view that, 'If we want to be more creative, we also need to become more fluid with problem-finding.' As a puzzling question, it can be a starting point for inventiveness and imagination (Costa et al., 2000). Yet noticing or finding a problem, clarifying and reframing it may be neither routine nor simple.

Students in schools are not, of course, professional scientists. Nevertheless, they may be expected to engage in creative thinking that parallels that of the scientist. For example, a young child, faced with the problem of explaining why a lamp connected to a battery by only one wire does not light may explain (the hypothesis space) that the battery should be held higher than the lamp so that the ‘electricity can run down the wire’ to it. The child may then suggest that this can be tested (the experimental space) by raising the battery and observing what happens. As beginners in the world of science, the thinking of children may rarely produce novel, plausible ideas, but it can be novel and plausible to them (instances of what has been called ‘little-c’, personal creativity as opposed to ‘Big-C’, new to the world creativity, see e.g. Boden, 2004). Here, the child was *presented* with or *given* the problem to solve, a common classroom practice.

If, however, children can *notice* or *find* a scientific problem to solve themselves, the benefits are at least twofold. There is the opportunity for a fuller educational experience of the scientific creative process, and there is the potential for arousing interest and engagement in satisfying the child’s curiosity, a need to feel competent, and a need for autonomy (Jarman, 1996; Ryan & Deci, 2002; LaBanca, 2012). Runco and Nemiro (1994) have thus pointed out that problem finding is partly an emotional activity. But, can children raise scientific questions?

Children asking questions

Problem construction and identification is generally seen as the first step (for a concise review, see Reiter-Palmon, 2017). Here, we are particularly interested in children raising scientific questions with the potential for it to become a problem to solve in class. In the course of teaching, what conditions favour this first step? The teacher may have much to do to help the child turn a question into a clear problem open to safe, feasible investigation in the classroom, but, without this first step, there is nothing to work with.

From time to time, we can expect a child to feel curious or puzzled about the world. To satisfy curiosity or resolve the puzzlement, they may ask questions (the problem space). For instance, they may ask for facts and descriptions (e.g., ‘What are volts?’) or for explanations (e.g., ‘Why did the lamp not light?’). While any of these might be the basis of some kind of investigation, of particular interest are requests for explanations. According to Piaget (1978), causal explanations are the most important because they make the world predictable, and are central to the scientific process, underpinning thinking in the hypothesis space, (‘The lamp is not on because I believe that electricity runs downhill and it can’t do so with this arrangement), providing purposeful thought for the experimental space (‘If I lift the battery higher, the electricity can run downhill into the lamp’) (Newton, 2010). Such questions could lead to a cascade of generative activity, and initiate productive discussion (Chin and Brown, 2000; Chin, Brown & Bruce, 2002). Chin (2004) also suggested that students’ questions may be ‘encouraged’ by providing question stems for the children to complete. Earlier White and Gunstone (1992) had the similar idea of providing ‘question starters’, like ‘What if ..?’, ‘Why does ..?’ and ‘How would ..?’ They concluded that such starters can produce questions that may be used in the classroom, and a small scale replication by us supported their conclusion. This approach, however, *requires* children to respond to the stem. While the stems can be directed at desired kinds of question (e.g., asking Why questions), the questions these generate are forced responses to the task, and not necessarily spontaneous, motivating questions generated by a child’s curiosity or interest. Factual questions can be suppressed and explanatory questions increased, and the task made into a game using giant dice with question stems written on the faces (as we tried). Nevertheless, we have doubts about suppressing or limiting factual questions as these may serve an important function on the way to understandings. Furthermore, non-spontaneous questions may not be those of interest to the child, simply those which meet the requirements of the task. For these reasons, we gave our attention to the production of less constrained questions.

In a study in Northern Ireland, Jarman (1991, 1996) asked primary and secondary school science teachers to keep a diary of the questions students asked during a four week period. She concluded that, although there were some science-related questions, they were few in number. Broadly speaking, their questions most often sought directions, reassurance, information, and clarification. Only a few lent themselves to classroom investigation. She noted that young children asked more questions than older children, mostly of the teacher. Older children were more likely to direct their questions at other students. She felt that confident children were more likely to voice their questions, while less assured children tended to wait for a private word with the teacher. Moods can also influence the process of problem finding, and noticing something in need of an answer. Positive moods in particular seem to produce a state of mind which fosters the process while fear inhibits it (Chen, Hu & Plucker, 2014; Newton, 2014, 2016). Amongst older children, boys voiced more questions than girls, although girls lost some of this reserve when they were in girls-only groups. Although questions were asked whatever the teacher's approach, they were more likely during less-formal practices, as in discussions. However, the nature of the question may be moderated by students' familiarity with the topic: unfamiliar topics may generate requests for factual information, while familiar topics, for which facts are known, may prompt more speculative questions of the 'I wonder . . .' kind (Seradamalia & Bereiter, 1992). In other words, the children's domain specific knowledge is important. A later study of 13-year-old students by Chin, Brown and Bruce (2002) also found that when the emphasis was on acquiring information, questions tended to be requests for 'basic information'. When questioning was directed at making mental connections and understanding, there were more 'thoughtful' ideas. These differences in response seem to reflect the effect of different teaching methods on problem finding. In this respect, an inquiry approach is better than the transmission of information, while a combination of both is most favourable (Erdogan, 2017; Jia, Hu, Cai, Wang, Li, Runco & Chen, 2017).

Factors determining problem finding in the form of children's questions

Bringing the findings of the literature together, problem-finding is more likely if there are:

- favourable expectations (e.g. learning goals favouring deep or higher level thinking, such as the construction of understandings);
- opportunities (e.g. teaching strategies and attitudes encouraging question-asking); and,
- favourable personal attributes and states of mind (e.g. confidence, a favourable mood and, we might reasonably add, student interest).

These elements are, however, unlikely to be everything. Presented with a situation, we recall or construct a mental model of that situation (Barrett, 2017). If the situation is novel, it seems likely to begin with the building of a descriptive, situational model (e.g. some attributes and the spatial disposition of the components (van Dijk & Kintsch, 1983; Johnson-Laird, 2005). At this stage, it is likely that questions about the situation will support this process (i.e. asking for matters of fact). If the questioning goes beyond this stage, it could then enable or prompt thought about causal relationships and generate *Why?* questions. With the answers, a descriptive mental model may develop into a casual, explanatory model (Newton, 1995, 2012b). The (unanswered) questions are of particular interest, as they could be starting points for problems to investigate. If there is movement from descriptive to explanatory models, the movement may show itself in the sequence of children's questions, and, if so, it has implications for practice.

This process may be more likely when the topic generates interest and curiosity, and leads to spontaneous questions. Novelty alone may be insufficient; some novel topics may be dull, and some may not present causal puzzles that are noticed by or evident to children. For such topics, questions may be fewer, and barely go beyond matters of fact. In addition, we might expect older children to have more experience of the world, so that what interests and engages younger children may fail to do so with older children. Together, this suggests three overarching variables are interacting:

- the *situation* or *stimulus* with subjective attributes, such as, perceived novelty/familiarity, interest/dullness, and complexity/simplicity;
- the *teaching and learning environment* which determine expectations and opportunities; and,
- the *child* with attributes like age, experience, confidence, and mood.

These variables make for potentially complex and multifarious interactions. Such interactions would determine the nature of an attempt, if any, to construct or adjust a mental model of a situation.

This attempt is informed by information, some of which may come from the senses, but, crucially, it may be supplemented by asking questions. Spontaneous questions are more likely to reflect interest and engagement, but these may not be entirely absent when children are prompted to ask questions.

One aim of this study was to explore the effect of some relatively simple strategies intended to stimulate children to raise questions related to science. The findings could also inform reflection on the determinants of children's question-asking in science-related contexts.

The studies

Four short, exploratory studies are reported, reflecting on different aspects of children's problem finding. Each will be described in turn.

1. Vicarious experience as a stimulus to question generation

Method

A novel and interesting stimulus is known to arouse curiosity and a desire for knowledge (Graham & Helen, 2011). Accordingly, in this exploratory study, photographs (i.e., vicarious experience) of an elephant in the wild, one in captivity, and one of an elephant embryo in the womb were shown to 116 children aged 8 to 11 years from two, similar primary (elementary) schools in the UK. The children were in mixed ability classes, and comprised equal numbers of boys and girls.

The photographs offered something novel to the children and did attract interest and curiosity. The children were asked to write some questions about the elephants that they would like to know the answers to. From the children's interest it was clear that that the photographs, particularly the embryo picture, presented information that was new to the children.

Results

Figure 1 shows the numbers of questions that asked for facts, and those that asked for explanations in the children's first, second, third, etc. questions. Description questions predominated, while explanation questions grew in number, peaked then fell away. The distributions are significantly different ($p < 0.001$, Kolmogorov-Smirnoff test)

The findings are consistent with the view that a descriptive mental model is first constructed, and this then facilitates further thought of a more causal nature, prompting explanation questions. This pattern of questioning was similar for boys and for girls.

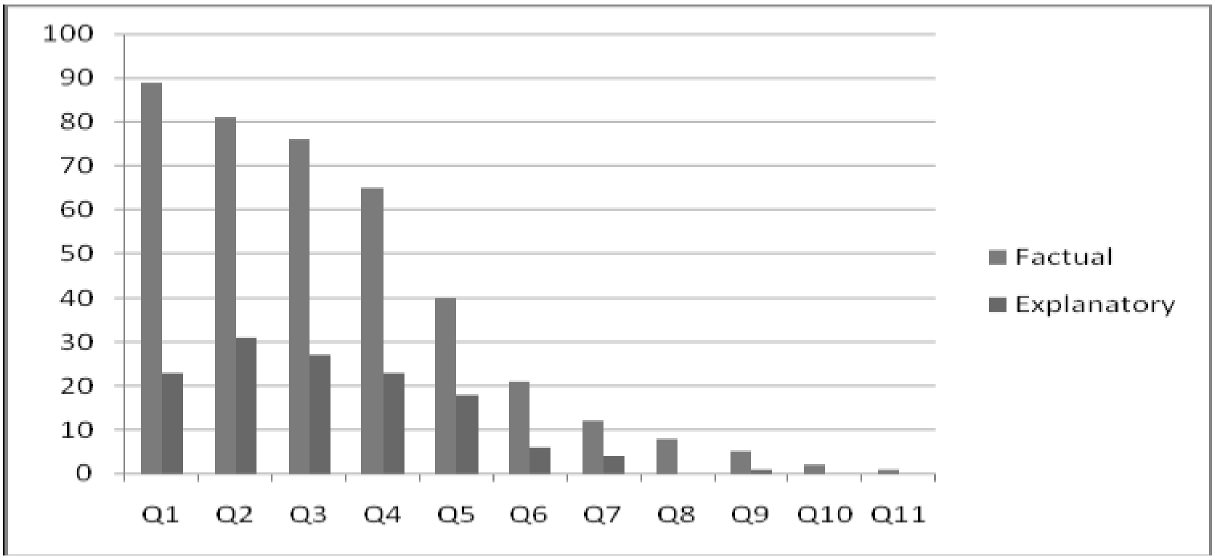

Figure 1: Children's questions generated by the elephant photographs (in each pair, the left blocks indicate the number of requests for facts, and the right blocks the number of requests for explanations).

2. Direct experience as a stimulus to question generation

Method

Clearly, direct experience with elephants in classrooms is not usually feasible in the UK. Piaget highlighted the benefits of providing concrete objects to support the thinking of younger children (Inhelder & Piaget, 2007), so two, more practical displays were constructed, one about eggs and one about bags. In the UK, most children are familiar with the hen's egg; other kinds of egg are less common in shops. The collection of eggs included an ostrich egg and others that are not frequently seen by children. In other words, the experience presented something likely to be new, particularly for younger children. The bags, although varied, were more mundane and offered little that would be novel to a UK child of 8 years and more.

The displays were presented to 76 children aged 8 to 9 years (39 boys, 37 girls), and to 84 aged 10 to 11 years (38 boys and 46 girls). These children, from four schools, varied in ability like those in Study 1. The children were invited to write scientific questions (*What would you like to know?*) about the objects on display.

Given that Eggs were more likely to be new to the younger children, it might be predicted that they would tend to ask for facts, and then explanations. On the other hand, these children are more likely to know about bags at the outset, and bring descriptive mental models to the task, resulting in a different pattern of questioning. Older children are likely to have more informal experience of both eggs and bags so the patterns of their responses could also reflect that.

Results

Figure 2 shows the patterns of description and explanation questions for the younger children. Figure 3 does likewise for the older children.

Figure 2a:

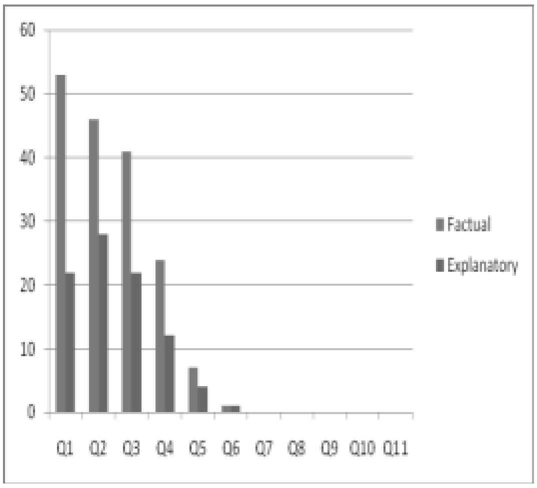

Figure 2b:

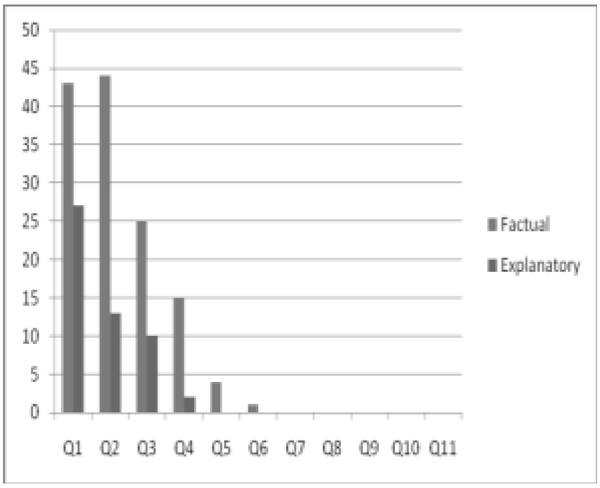

Figure 2: The younger children's questions generated by the Eggs (left, figure 2a), and by the Bags (right, figure 2b. In these and the following graphs, Factual questions appear to the left, and Explanatory questions appear to the right of each pair of bars).

Figure 2a shows a similar pattern of responses to that of Figure 1. This is consistent with the earlier notion that these children would give some attention to supplementing or building their descriptive mental models, and then turn to questions needing explanations. Bags, on the other hand, followed the patterns expected for more familiar topics, with both kinds of question declining together. In the case of the older children (figure 3b), Bags generated fewer questions, perhaps for the same reason. The distributions of 3a and 3b are significantly different ($p < 0.025$, Kolmogorov-Smirnoff test).

Figure 3a:

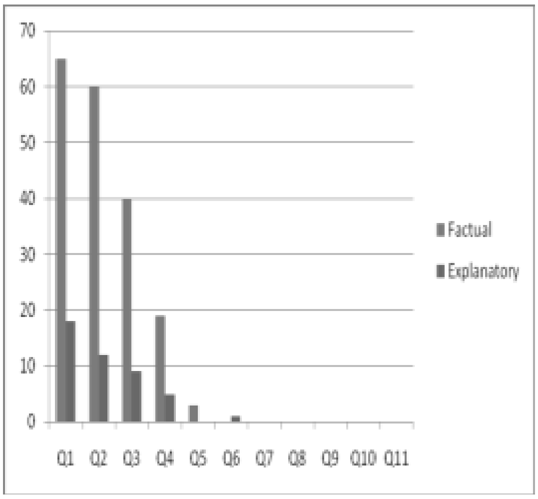

Figure 3b:

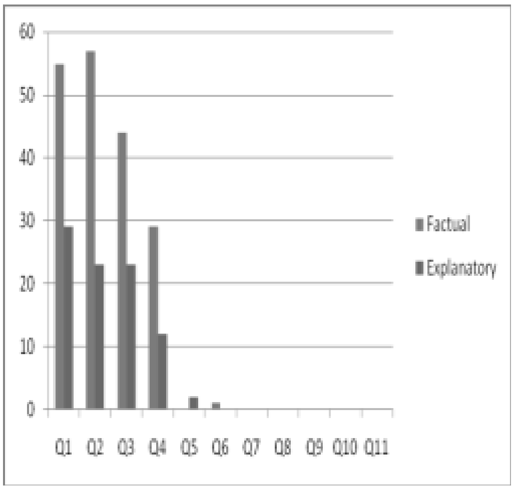

Figure 3: The older children's questions generated by the Eggs (left, figure 3a), and by the Bags (right, figure 3b).

Although the patterns of explanatory questions for the Eggs and Bags were different for the younger children, the overall numbers of explanatory questions were similar (i.e., not significantly different, $\chi 2$ test). A contingency table of the numbers of factual and explanatory questions for Eggs and Bags for the older children indicated that the number of explanatory questions for Bags was significantly smaller than for Eggs (p <0.001, $\chi 2$ test). In short, this supports the view that the novelty of the topic matters.

3. Providing factual contexts to support question generation

Method

Piaget (1978) considered causal explanations to be amongst the most powerful we can construct in science because they enable prediction, application and adaptive behaviour in new situations. A way of helping children ask causal questions early could be of practical use in the classroom. Doing so might be achieved by helping children construct a descriptive mental model to think with before they construct their questions. Telling children a story is a common activity which requires them to construct a descriptive mental model of events and update it as events change.

Accordingly, a photograph of a double yolk egg, accompanied by some brief facts about the parts of an eggs, and a very short 'story' about Rahul's joy at finding he had a 'twin egg', were presented to the children on one half of a sheet of paper. Presented similarly, was a photograph of a cow foraging in domestic refuse in India accompanied by some brief facts about the source of plastic refuse, and a very short 'story' about Gowri, the cow who ate so many plastic bags that she died. Of the two 'stories', the second seemed to attract more interest. The accounts were read with the children, and they were invited to write up to four questions about what they would like to know about the situations in the remaining space.

The children comprised 85 who were younger (8 – 9 years: 42 boys and 43 girls), and 86 who were older (10 – 11 years: 44 boys and 42 girls), of mixed ability from four different primary/ elementary schools in the United Kingdom. As before, their questions were divided into description and explanation.

Results

The pattern of responses of the younger and older children to the Double Yolk Egg scenario was similar so they were combined. This also applied to the Foraging Cow scenario. Figure 4 presents these.

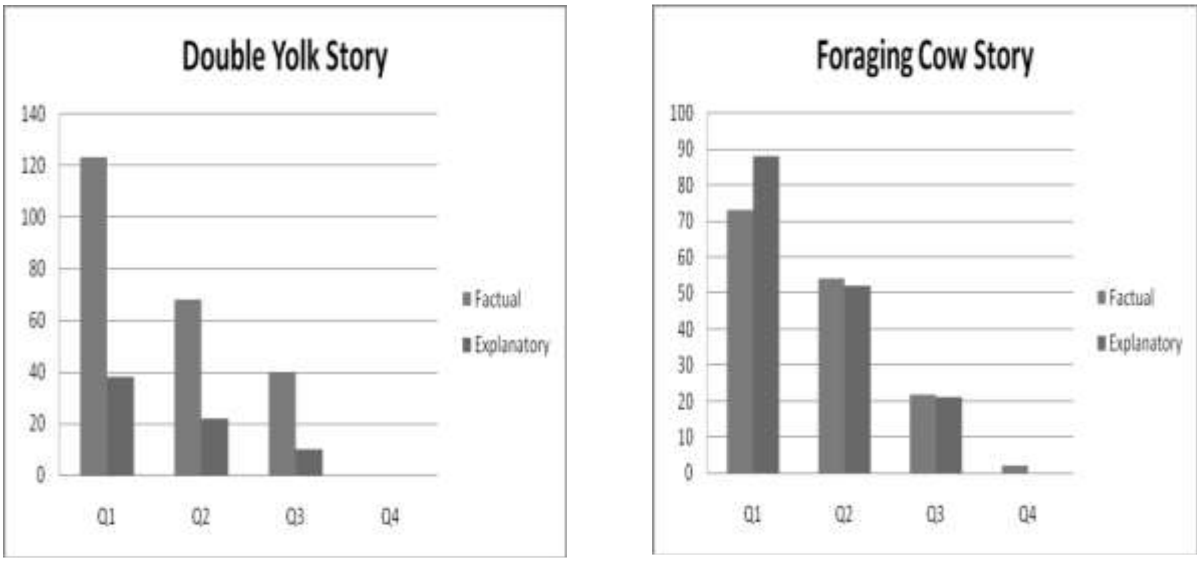

Figure 4: The children's responses to story-supplemented pictures.

For the cow eating plastic scenario, the proportion of explanatory questions was strong from the outset. The proportion was much more muted in the Double Yolk Egg scenario. A contingency table of the numbers of factual and explanatory questions in each of the story scenarios shows that the Foraging Cow produced significantly more explanatory questions (p <0.0001, $\chi 2$ test).

Once again, this response is consistent with the view that the novelty of the topic is important, and also how it is introduced.

4. The 'I Wonder' board to support question generation

While the above strategy increased the number of explanation questions asked early, teachers are unlikely to have a story for every occasion. At the same time, waiting for each child to ask sufficient questions to reach those Piaget (and scientists) would value highly, may take a long time. (For example, if each child asks only two questions, each taking 20 seconds of teacher/child interaction, a class of 30 children could take some 20 minutes of a lesson asking questions – and this may not be enough to reach the explanatory questions.) Is there another strategy which could save lesson time? The 'I Wonder' board, used after a teacher introduces a topic, may be one answer. The children write their questions on individual notes and attach them to the board for the teacher to sort, and bring back to the next lesson.

Method

Four teachers (in three schools) agreed to participate. Each introduced a science topic (Younger children: Food Chains, Plants; Older children: Electricity, Earth and Space) then the 'I wonder' board was explained. The children (45 younger and 38 older, mixed ability and gender, as described above) posted their questions (each child's questions numbered in order) on the board. The questions were collected and sorted. The topics were not in the control of the researchers, being what would have been taught at that time. This clearly limits what might be said about the outcomes, but there were some practically relevant observations.

Results

The strategy was able to generate questions, and was not time-consuming to apply (although the teachers would have to sort and consider the questions after the lesson). Figures 5 shows the relative frequencies of description and explanation questions collected from the 'I Wonder' board, both Natural Science topics combined for the younger children and both Physical Science topics combined for the older children. The strategy elicited similar numbers of factual questions from the younger and the older children, but fewer explanatory questions from the older children. A contingency table (factual and explanatory questions for the younger and older children) indicated that the younger children produced significantly more explanatory questions (p <0.001, χ_2 test), but it should be noted that the topics which produced these questions were not the same. It is not clear whether the variation was due to differences in teacher, in topic, in the children's prior experience, or to some other variable. With the older children, there is again the hint of a delayed peak in explanatory questions, but what weight could be put on this is uncertain.

The questions children asked

Children may ask for explanations, reasons, causes, and why phenomena occur, but it may be that their questions cannot become problems which lend themselves to useful classroom activity in elementary science. The questions, therefore, were sorted into those that might provide a basis for answering through:

- Research (the finding of answers by the children using sources of information, such as books and digital media; e.g. 'Why are some eggs bigger than others?');

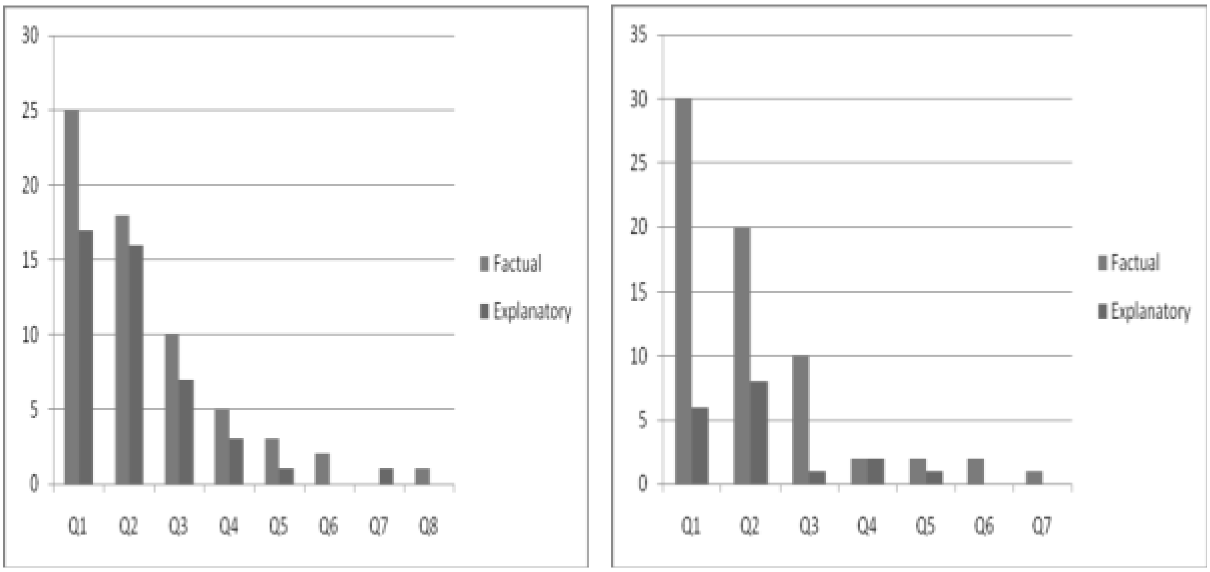

Figure 5: The younger children's questions (left), and the older children's questions (right) using the 'I Wonder' board.

- Observation (the direct observation of phenomena, objects and events by the children; e.g., 'Which [egg] is the biggest?');
- Demonstration (the managed, direct presentation of phenomena, objects and events by the teacher so that the children may see them, but are not involved directly in their manipulation, although they may ask the teacher to do so on their behalf; e.g. 'How big is the yolk inside the egg?');
- Investigation (hands-on practical activity by the children intended to answer their question, either about a matter of fact, or to test a tentative explanation; e.g. 'Why do paper bags rip in the rain?');
- None of these (ambiguous or unclear questions, or those not relating to the purpose of the activity; e.g. 'Where did you find [the eggs]?').

Clearly, allocation to these categories depends on context. For instance, questions answerable by direct Observation in one part of the world, may be answered only by Research in another. Similarly, what may be an appropriate, hands-on Investigation for older children may become a Demonstration with younger children. At the same time, one teacher may be better than another at reframing a question to make an opportunity for an Investigation. And, of course, cultural forces, expectations, opportunities, time, resources and classroom routines can determine how, or if, a question becomes a found problem (Runco & Nemiro, 1994). For these reasons, sorting questions in this way is somewhat subjective and context bound. Here, it reflects common expectations and practices in science teaching in England, although differences between teachers are still to be expected. Nevertheless, when a sample sort of almost 1000 questions was undertaken by two researchers familiar with teaching science in this context, the inter-rater agreement was over 95%. We would expect it to be lower if raters were from different contexts. Bearing this in mind, we offer some comments on the kinds of questions asked in each of the above studies.

Reflecting the geographical context, the overwhelming number of questions about elephants (516) lent themselves only to Research. Eggs and Bags, however, are more available in this context, and, while the majority were Research questions, 40 and 84 questions respectively could be, or could readily be reframed to become, Investigations. (The smaller number arising from Eggs was largely because some of the eggs (e.g. ostrich) are not readily available in the UK.) While the provision of factual content, partly via stories, greatly increased the number of explanation questions (particularly for the Foraging Cow), all questions were seen as better answered by Research. (This finding is probably an artefact of the scenarios as they did not lend themselves to generating questions for acceptable Investigation in elementary, UK classrooms.) The time-saving, 'I wonder' board concluded four teacher-led topics. The question patterns were similar for all topics, again with the majority open to Research. This pattern was not surprising, given that two of the topics (Food Chains and Earth and Space) were not of a kind which led readily to feasible, short term, classroom Investigations. In the Investigation groups for Plants and Electricity, however, there were some questions which could provide useful starting points for practical enquiry. For example, one child asked, 'What would happen if plants didn't get any water?', and another asked, 'What other circuits can be made?' which are or could become practical investigations.

Even given the essentially context-bound nature of this classification of children's questions, there are some useful messages for teaching practices in these data which will enter into the discussion.

Discussion

This study sought to gain some insights into young children's questioning, and to see if their questions might underpin their further learning in the science classroom. Explanation questions, particularly those asking for reasons, are of especial interest as reasons enable the construction of powerful understandings, which can lead to prediction. The process of question-asking, however, is clearly complex and likely to depend on many variables and their interaction. Because of this complexity, we cannot be sure that our findings would be the same for all possible contexts. Nevertheless, we feel there are some useful observations to be made, which educators may be able to apply directly or, at least, relate to their work with children and teachers. The notion of 'relatability' is a useful one in contexts such as these, where variables are manifold and are rarely fully controlled or even controllable, as is the case in most realistic educational contexts (for the notion of relatability, see Bassey (2001), and for the inherent complexity of human behaviour outside the laboratory, see, e.g. Deaton and Cartwright (2018)). With these cautions in mind, we offer some observations.

First, the primary/elementary children here showed they could ask questions when given the opportunity, or when expected to do so. These questions were most often about matters of fact; requests for reasons or causes were fewer in number. Where the stimulus material was novel and interesting, the pattern of questioning was consistent with the view that the children constructed a descriptive mental model of the situation, and this may then prompt questions to make it an explanatory model. The construction processes are not entirely separate, and, at least here, can overlap to some extent, or stop with the descriptive model.

It was suggested that younger children, being less experienced, would find more that was novel in the world than older children. This notion is consistent with the responses to Eggs in Study 2 above. It also seems likely that Bags would be of less interest to the older children, which may be why they elicited fewer explanatory questions from them. (It could also be, of course, that they were able to make causal connections without asking for explanations.)

Providing factual information in the form of brief contexts and short 'stories' could be expected to help children construct a descriptive mental model and so ask *Why?* questions sooner. There was evidence of this with the Foraging Cow scenario, but, of course, the effect is only as good as the information or story provided, and it depends on the interest that the topic generates. It may be that either (or both) of these was deficient in the case of the Double Yolk egg scenario. If there is value in such questions, this strategy may have practical use in the classroom, but attention probably needs to be given to several variables simultaneously to ensure a useful effect (e.g., stimulus (e.g., interest/novelty); environment (e.g., expectations); child (e.g., age/experience/mood). It might be expected that the effect of introducing a lesson first and asking for questions for the 'I Wonder' board at the end would also be useful as it has the potential to provide a descriptive mental model to think with. This strategy appeared to be effective for the younger children learning about Natural Science topics (Study 4), but was not evident with the older children learning about Physical Science topics. Of course, it could be that the older children were already familiar with Electricity and Earth and Space, so these topics failed to attract their interest. If this was the case, a general suppression of both kinds of questions might be expected, but many factual questions were asked. And, of course, if the topics were known to the children, why would the teacher choose to teach them? It was suggested that topics will be neither equally interesting, nor will they be equally easy to process (or presented in equally interesting ways). In other words, such differences may be due to attributes of the topic. Nevertheless, it does show that the 'I Wonder' strategy could have practical application as it did produce questions with economy of effort and classroom time.

Even given its limitations, the sorting of the children's questions into the activities best suited to answer them, suggests that those which could lead clearly to feasible practical investigations are not always prolific. Many topics do not lend themselves to such questions. In topics which do, such investigations were often of a factual (e.g., 'What happens if you leave a bag outside?'), rather than of a causal nature (although they do occur, as in, 'Why do paper bags rip in the rain?'). These findings point to the need for a teacher to have some skill in helping children reformulate their questions, and make them more clearly causal. Where there is a paucity of causal questions, such a skill is probably a valuable attribute of a teacher. While strategies, like the use of question stems and question dice (Chin, 2004) may remove some of the motivating spontaneity of children's questioning, teachers may still find them useful on occasions, both to remind children of the variety of questions possible, and as activities to hold in reserve.

In a useful review from 1994, Runco and Nemiro noted that certain broad approaches, like a blend of inquiry-led and more didactic teaching, can prompt deeper thinking. Many teachers of younger children do not have a strong scientific background, and so tend to lean towards didactic teaching (Newton & Newton, 2000). Given appropriate topics, some of the question-generating strategies are easy to apply, but a teacher may need to reformulate children's questions if they are to become feasible activities in a blend of teaching which includes practical inquiry. Runco and Nemiro (1994) suggest it might be useful if teachers modelled their thinking, and in this context, that would mean modelling the asking of Investigation questions, and recasting them into a practical form.

Conclusion

Hattie (2009, p. 183) is of the view 'that insufficient attention is given to children's questions', and that analysing their questions could be very useful for supporting their thinking and learning. This view, of course, assumes that children have the opportunity and are encouraged to ask questions. As might be expected, the studies described here show that children of primary/elementary school age can ask questions about science, but question-asking which reflects interest and curiosity (rather than an obligation to respond) is not a simple matter. It is likely to involve multifarious variables, which probably interact in a variety of ways. When teaching something new to children (something which is, after all, a central aim of education), the children need to construct a descriptive mental model, and their questions reflect this constructive process and dominate questioning. In the quick-fire, teacher-learner interaction of the classroom, this expectation of level of questions be as far as it goes. Such questions do, of course, provide a basis for children to engage in research using, for example, direct observation, digital media and text. But, to develop a causal mental model, questions need to lead to explanations. Such questions may have the potential to underpin hypothesis construction and testing in the classroom. Some topics facilitate this process better than others. Depending on the topic, we found that, although not numerous, some questions are generated that could lead to feasible, practical investigations, but the teacher may need some skill in question reformulation to make them suitable for the classroom. If the children's own problem-finding is to be encouraged, teachers will have to recognise that children's question-asking should not always be the short interaction it often is, and that more useful questions can take time to emerge.

These findings also highlight the need to ensure that teachers, both in training and in service, are equipped with these skills. To that end, we suggest that teachers' reflect on the overarching variables: the situation or stimulus, the teaching and learning environment, and the child's attributes, the mental model construction process, and how these may affect children's responses in particular contexts. Teachers may also need to be aware of various strategies for eliciting children's questions, and the strengths and weaknesses of these strategies in a given context. Facilitating children's question-asking is a process which needs forethought about the stimulus, the environment, and the child. We also suggest that these are worth further, systematic investigation, both in science-related contexts, but also in other areas of the curriculum.

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