Banishing misconceptions with prototype theory – Andrew Percival

"But sir, a whale can swim so it must be a fish"

One of the stark memories I have of my NQT year was teaching my Year 3 class about animal classification and having to convince a group of disbelieving 7-year olds that a blue whale was actually a mammal and definitely not a fish. After ten minutes of attempting to convince a sea of bemused faces, I think they would have just been happy if I'd suggested we forget it and agree to disagree on the matter.

What was going on here that meant these children had such a misconception that was so difficult to shift? The pupils were matching the images of the whale I was showing them with their own internal idea of what a fish is. Seeing the commonalities between the whale and the fish they made the obvious leap that this was indeed a fish. In other words, if it looked like a fish and acted like a fish then it must be a fish.

Maybe the concept of 'prototypes' from cognitive science can give us some insights here. American psychologist Eleanor Rosch explored this phenomenon in the 1970s defining a prototype as 'a classical typical member of a category.' As part of her research Rosch asked people to rate whether certain words were good exemplars or 'prototypes' of a particular category and which items were less prototypical. For instance, a chair was seen as a very strong example of a piece of furniture but a stool was less so and a refrigerator was on the cusp of being something entirely different. When asked to rate bird species, she found that people rated robins and sparrows as highly prototypical, parrots and owls were somewhere in the middle and ostriches and penguins were perceived as barely birds at all. Alongside the rating of each word, subjects were also tested on how quickly they responded to different examples. As you might expect more prototypical responses were answered quickly while those less typical were deliberated over for longer. Her findings suggest that some members of a category are more central than others. The idea that we have these prototypical exemplars in our heads might help us think about how we can pre-empt potential misconceptions and tackle them through a coherent curriculum.

What might this mean for us as teachers and how can we reduce the risk of misconceptions occurring? Here are three suggestions ...

1. Teach rules and definitions

Providing a very clear and precise definition of each concept can go a long way to alleviating some of these problems. To help clarify the misconception about whales, children need to understand the definition of both a fish and a mammal and then have some helpful knowledge of the animal to place it in the correct category i.e. blue whales give birth to live young and breathe air through a blowhole, therefore, it must be a mammal.

Definitions can help in other subjects too. In geography, when we ask people to name a desert they are more likely to conjure up an image of a hot, sandy expanse populated by camels, sand dunes and perhaps a lush oasis in the distance. People will tend to see the Sahara as the prototypical example here. Try telling people that the Antarctic is a desert and you will typically be met with disbelief. Knowing the definition of a desert as an area with

little vegetation and an absence of precipitation we can then accommodate the idea that actually the freezing wasteland around the South Pole is also a desert (just not the prototypical one we immediately think of). Knowing this definition is helpful and enables us to overcome the pressure from our internal prototype to dismiss atypical examples.

2. Extending banks of examples

We might also consider enriching the pupil's bank of known items in a category. In the case of mammals, we might ensure that the school curriculum covers a wide range of examples. Perhaps starting with the prototypical mammals such as foxes, badgers and lions moving on to bats and armadillos and then looking at the least prototypical mammals which might include dolphins and the aforementioned blue whales. Extending the range of ideas can help give real and varied context to the more abstract definition.
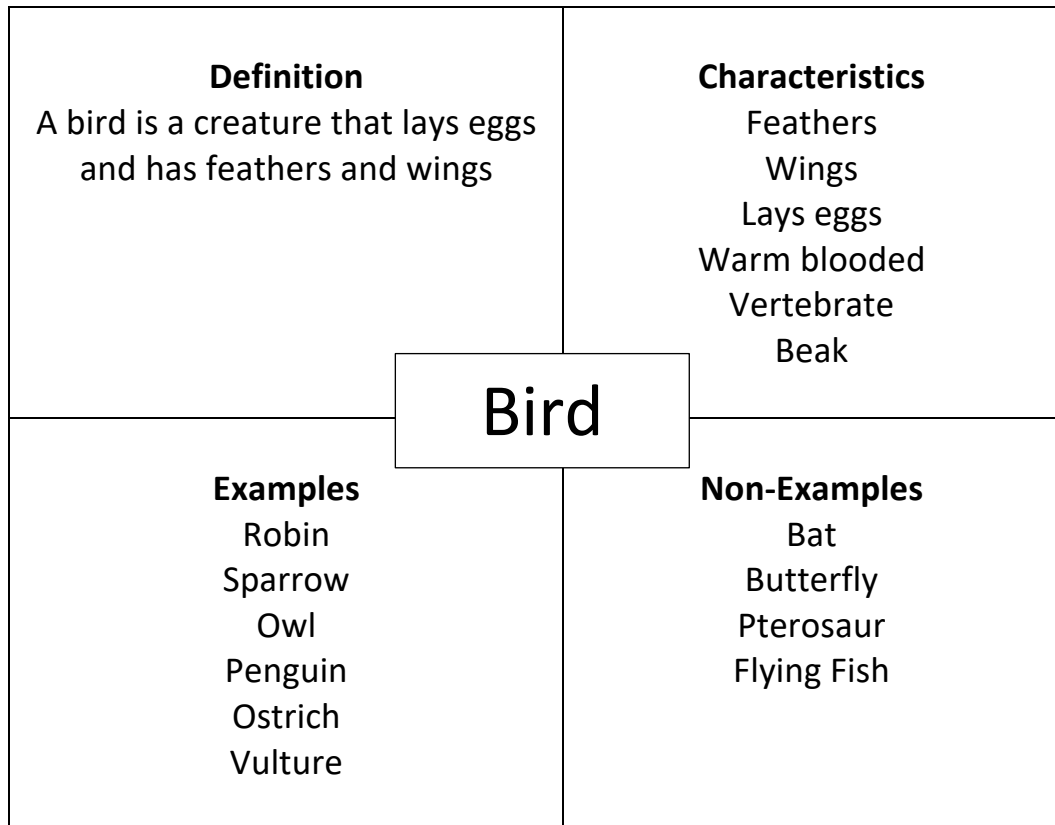
3. Using non-examples

The use of 'near non-examples' can support pupils here to identify the boundaries of the concept more clearly. For example, when learning about bird species it may be helpful to know that bats and butterflies are not birds although they are bird-like in a number of ways. These 'near non-examples' are far more useful than cases that are obviously incorrect such as a snake or polar bear.

Pupils shown pictures of prototypical deserts might form a misconception that a sandy beach is just another example. If the beach is taught as a specific non-example of a desert (alongside the definition and wide-ranging examples) then we can hope to prevent this misconception. Indeed, a picture of Blackpool beach might look like a huge sandy wasteland but, as anyone living in the North West will attest, it does not suffer from a lack of precipitation that would define it as a true desert.

A useful way to tie all this together is with a simple but powerful graphic organiser called a 'Frayer Model'. This is a model developed by psychologist Dorothy Frayer and colleagues in the late 1960s to develop deeper understanding of the meaning and application of vocabulary.

A typical Frayer model consists of the following headings set out in 4 quadrants - definition, characteristics, examples and non-examples. The word being studied is typically placed at the centre of the diagram and notes made under each of the four headings.

This is what a Frayer model might look like when studying the term 'bird'.

Definition A bird is a creature that lays eggs and has feathers and wings	**Characteristics** Feathers Wings Lays eggs Warm blooded Vertebrate Beak
Examples Robin Sparrow Owl Penguin Ostrich Vulture	**Non-Examples** Bat Butterfly Pterosaur Flying Fish

Bird

Although a Frayer model is not something you can use with every new word that pupils encounter, they are certainly helpful for some of the more challenging concepts where misconceptions may be rife.

One of the jobs of a good curriculum should therefore be to provide growing knowledge of the range of examples for different concepts as pupils move through school. These examples should be carefully selected to ensure that they include both highly prototypical and atypical items. Alongside these, we also need to mindfully select the range of near non-examples we might use to support pupils in gaining a more nuanced and accurate understanding of the concept. When faced with stubborn misconceptions these tools might help us to avoid having to 'agree to disagree'.

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