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Taber, K. S. (2015). Alternative Conceptions/Frameworks/Misconceptions. In R. Gunstone (Ed.), ***Encyclopedia of Science Education*** (pp. 37-41). Berlin-Heidelberg: Springer-Verlag.

**Entry:**

***Alternative conceptions/ frameworks/ misconceptions***

Synonyms or Key Words:
*alternative conceptions;*
*alternative conceptions movement;*
*alternative conceptual frameworks;*
*alternative frameworks;*
*conceptual change;*
*implicit knowledge elements;*
*intuitive theories;*
*knowledge-in-pieces;*
*misconceptions;*
*personal constructivism;*
*pre-conceptions;*
*p-prims;*

There are a great many studies into learners' ideas in science topics, focusing on learners at different levels of the education system. These studies reveal that learners often present ideas relating to science topics which are at odds with the target knowledge set out in the curriculum. These ideas have been described using a wide range of terms, including misconceptions, preconceptions, alternative conceptions, alternative frameworks, alternative conceptual frameworks, intuitive theories, and mini-theories. Sometimes particular authors distinguish between meanings for some of these terms, but usage varies across the literature so often the different labels are, in effect, broad synonyms.

Interest in students' ideas came to prominence in science education in the 1980s when a considerable research programme (sometimes labeled the 'Alternative Conceptions Movement') developed around eliciting such ideas. The theoretical perspective that informed much of this work was personal constructivism, which considered knowledge to be developed iteratively within the minds of individual learners. Teachers were seen as being able to support and scaffold learning, but learning itself was considered an act of personal construction of knowledge. From this perspective the notion (inherent in much discourse around teaching) that knowledge could somehow be 'transferred' or copied from teachers and textbooks to learners in a straightforward way is untenable. The learners' prior knowledge and beliefs were recognised as providing the conceptual resources for interpreting teaching, and studies showed that students commonly held informal ideas about science concepts and topics that were inconsistent with the target knowledge set out in the curriculum.

The constructivist perspective was influenced by a range of thinkers including Jean Piaget, George Kelly, David Ausubel, Jerome Bruner and Lev Vygotsky, among others. The personal constructivist perspective, and the research programme it informed, have been significantly criticised from various standpoints, although robust defenses against these different criticisms have also been offered, and the constructivist perspective continues to be widely adopted in science education. However, it has become clear that it is important to distinguish between constructivism as a theory of learning (which is widely accepted) and constructivism as a wider epistemological stance (which is sometimes characterised as inconsistent with the epistemology of science). Those adopting a personal constructivist perspective have had to acknowledge an increasing focus on the importance of cultural and social influences on learning, with some commentators seeing social constructivist perspectives as contrary to (rather than complementary with, or able to be accommodated within) personal constructivism.

The initial motivation for research in this area was the claim that students commonly held alternative ideas inconsistent with the science to be learnt that were tenacious, and which would impede the learning of canonical scientific concepts. It was widely argued that it was important to diagnose learners' alternative conceptions in a topic before teaching, and then to explicitly challenge them. Ideally learners would be presented with activities, demonstrations and opportunities for dialogue that would allow them to recognise the superiority of the scientific concepts and models presented in the classroom to their own alternative conceptions. All aspects of this argument have been subject to criticism and counter claims. In particular there have been debates about the key issues of the nature of learners' ideas about scientific topics, and the significance of alternative conceptions for subsequent learning.

Some initial characterisations of learners' alternative conceptions were that these were of the form of personal theories to which learners were strongly committed. However, critics argued that learners' ideas were more akin to 'fragments' of knowledge, often of very limited ranges of application, and readily disregarded. Some argued that giving attention to 'alternative conceptions' in teaching would seem to give them more status, and was likely to reinforce rather than challenge them, whereas such ideas were otherwise likely to be readily abandoned when scientific knowledge was authoritatively and persuasively presented in teaching. The empirical evidence suggests that neither view is generally correct. The range of results reported in diverse studies suggests that learners' ideas about scientific topics are actually quite diverse in nature, as might be expected when considered as knowledge 'under development'.

Some ideas have been found to be widely applied across broad ranges of application, and to be retained despite teaching designed to explicitly challenge them. Two examples would be the idea that a moving object must be subject to a force (sometimes referred to as the impetus framework or F-v thinking), and the idea that chemical reactions occur so that atoms can fill up their outer electron shells (the octet alternative conceptual framework). These ideas seem to become well established, to be linked to explicit principles (and so can be seen to form the core of a framework of related conceptions), to be applied consistently and across diverse contexts, and to be largely retained despite teaching of the scientific models. These ideas have been reported across many different educational contexts.

However, not all of the reported alternative conceptions have these features, and some of the ideas reported in studies are more labile (as learners are not strongly committed to them), and do indeed seem to be better characterised as knowledge fragments. Clearly such characterisations are important in considering potential implications for teaching. Where students hold fanciful and weakly committed ideas about science topics, then these are likely to have limited influence on learning of target knowledge, and there is limited value in spending time devising teaching strategies that take them into account. However, it is known that an idea like the impetus framework is highly intuitive to many learners, and often tends to be retained after school and even college instruction. Research also suggests that even when students learn to answer regular classroom exercises correctly from the scientific model, they may still apply their alternative intuitive ideas when facing a problem that cannot be solved by standard algorithmic approaches, or when asked a question set in an everyday context, or when facing real-life problems beyond the classroom.

Moreover, even apparently persuasive demonstrations that seem to convince students that their alternative conceptions are wrong may only dominate their thinking over short periods before they revert to their longer-established ways of thinking. For example, students who initially assume that current must decrease at each lamp in a series circuit, are often found to change their minds once they have seen their predictions of lamp brightness and ammeter readings are wrong. However, after some weeks have passed they are likely to revert to their original view, and may actually 'recall' the demonstration as having shown that lamp brightness or ammeter readings did indeed diminish around the circuit.

An important theme for research concerns the origins of students' alternative conceptions. A number of possibilities have been suggested, although in reality there will be interactions between these and many alternative conceptions cannot be understood to have a single distinct origin. One potential influence is genetic, in that our genetic inheritance provides the framework within which we can develop. Although it seems unlikely that specific ideas are coded in our genes, it does seem that we have genetically directed predispositions to perceive the world in particular ways. One well known example is the ability of neonates to recognise faces (i.e. the general pattern of a face, not specific faces) suggesting this ability is innate. The ability to identify a face in what William James referred to as the 'great blooming, buzzing confusion' a newborn baby experiences clearly has value, but leads to people readily recognising faces in all kinds of inappropriate places - so a vague resemblance to faces in images of the surfaces of the moon and mars is taken by some as evidence that aliens have deliberately sculptured faces there.

The importance of the cognitive apparatus responsible for recognising familiar patterns in perception has been emphasised in an approach to thinking about students' ideas referred to as knowledge-in-pieces. In this approach (championed by Andrea diSessa and David Hammer among others) the importance of implicit knowledge elements not open to direct introspection is emphasised as the basis for intuitive understanding of the world. Certain patterns recognised as recurring in experience become so familiar that we come to see them as natural and part of how the world works. These implicit knowledge elements (sometimes called p-prims or phenomenological primitives) act as basic cognitive resources that are recruited to make sense of diverse phenomena. This processing is pre-conscious, so the individual is not aware of the p-prim, just the outcome of its application.

The knowledge-in-pieces perspective emphasises how many ideas elicited from students which might be labelled as alternative conceptions may not be established ideas, but rather could be constructions undertaken in response to a researcher's questions offering a new (and perhaps transient) nexus drawing upon the more stable underlying knowledge elements. An example might be a research participant explaining the seasons in terms of the earth's distance from the Sun, drawing upon a more general intuition that effects are greater closer to the source. However, even if many elicited conceptions begin in this way, once such conceptions are made explicit (e.g. verbalised, or built into a mental image or simulation), they may often become incorporated into the individual's explicit knowledge base: i.e., coming to believe that Summer is the time when the earth is closer to the sun in its orbit. The common alternative conception that objects will only continue to move when acted upon by a force does not match scientific understanding, but actually fits most people's experience of moving objects. Given its constant reinforcement in everyday life, it is not surprising that this has been found to be an especially tenacious alternative conception.

Although many of our formal conceptions of the world may begin as applications of intuitive knowledge elements (what Vygotsky called spontaneous conceptions), a key feature of human learning is the role of culture, and in particular language, that allows us to learn vicariously from the experiences of others. For such learning to be more than rote learning, it needs to be interpreted in terms of our existing stock of conceptual resources - with the inherent risk of misinterpretation. Nonetheless, formal learning of 'academic' concepts allows us to learn vastly more than is possible if we relied on our spontaneous concepts alone. Unfortunately many of the ideas with currency in popular discourse are themselves inconsistent with scientific concepts, and so 'folk-theories' may act as sources of individuals' alternative conceptions.

Language is the key mediator of meaning between individuals, although inevitably communication is imperfect. Sometimes language has been considered to influence the development of alternative conceptions such as when a technical term has associations from everyday life that do not match the scientific meaning (e.g. particles, electron spin, ...), or when it is used metaphorically (plant 'food'), or is misleading (e.g. *neutralisation* of an acid with a base does not always lead to a *neutral* product as students may assume is implied by the term).

Teaching may itself be the source of students' alternative conceptions. This may either be because students do not realise when such teaching devices as analogy, models, metaphors and anthropomorphisms are being used to help make the unfamiliar familiar, and so take these representations too literally; or because alternative conceptions are taught. The common alternative conception about chemical reactions being driven by atoms seeking to fill their shells is clearly not based on students' direct experiences of atoms, and therefore seems to be based on the interpretation of teaching which either presents inadequate models, or offers ambiguous descriptions that students then misinterpret in terms of their intuitions of the world. Research has shown that some alternative conceptions in this particular topic area are found widely among trainee school teachers suggesting that some alternative conceptions are being directly taught to new generations of learners by their teachers.

Research to understand the nature and characteristics of students' conceptions continues because understanding the precise nature and status of different types of reported conceptions is important in understanding how conceptual change may be best brought about: e.g. by directly challenging student conceptions; by ignoring them and simply teaching the canonical ideas; or by seeing learners' conceptions as useful (or necessary) starting points that need to be modified over time through a multi-stage conceptual trajectory. Each of these approaches is likely to be most sensible in some cases - and counter productive in others. Research into implicit knowledge elements such as p-prims may even lead to strategies to recruit the most helpful intuitions in learning particular concepts. So where much early research on alternative conceptions was concerned with cataloguing the range of ideas presented by learners, current research in this area is closely linked to models of conceptual change and designing appropriate strategies for teaching different curriculum topics.

o [Suggested] Cross-References:

*Alternative Conceptions and Intuitive Rules*
*Alternative Conceptions and P-Prims*
*Ausubelian Theory*
*Cognitive Structure*
*Conceptual Change in Learning*
*Constructivism*
*Cultural Reproduction*
*Knowledge, Acquisition of*
*Learning Theories and Models*
*Metaphors for Learning*
*Piagetian Theory*
*Prior Knowledge*
*Scaffolding Learning*
*Socio-Cultural Perspectives on Learning Science*
*Teaching for Conceptual Change*
*Vygotsky*

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