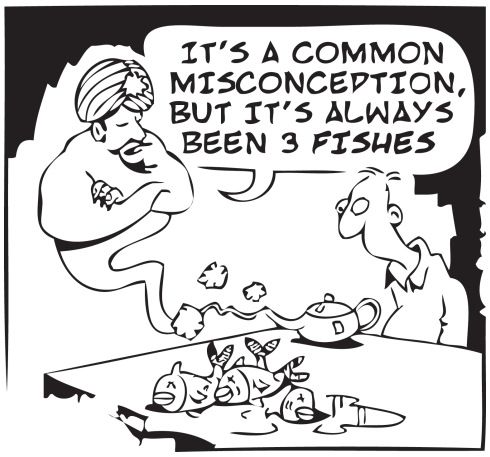
Coursework wiki

Misconceptions: Students, Teacher Roles and the 'Blame Game'



Misconceptions: An introduction

Both children and adults develop conceptions about the world through their experiences with the world and other people. These conceptions are reinforced and transmitted to others through peer interaction. At times these conceptions are factually incorrect and in opposition to currently accepted scientific opinion. If this is the case, then these conceptions are termed 'misconceptions' or 'alternative conceptions'(Lumpe & Staver, 1995). These theories are said to give rise to 'cognitive construals', defined as 'informal, intuitive ways of thinking about the world (Coley & Tanner, 2012). Examples of these will be detailed later.

Mayer (1987) defines learning as “changes in the learner’s knowledge, where such changes are due to experience”. Therefore, misconceptions can be learned.

Champagne, Klopfer, & Gunstone (1982) explain science misconceptions as follows:

1. Individuals of all ages have descriptive and explanatory systems for scientific phenomena which develop before they experience formal study of science.

2. These naive descriptive and explanatory systems differ in significant ways from those students are expected to learn in their study of science.

3. The naive descriptive and explanatory systems show remarkable consistency across diverse populations, irrespective of age, ability or nationality.

4. The naive systems are remarkably resistant to change by exposure to traditional instructional methods.

Studies suggest that misconceptions originating in childhood as well as these naive thought processes may never fully disappear and thus need to be inhibited for valid processes to be initiated and valid conclusions drawn (Masson, Potvin, Riopel & Foisy, 2014). Using fMRI studies during task participation allowed for identification of activation of brain areas associated with inhibition.

Difficulty arises when individuals begin to receive formal education and acquire formal knowledge through schooling. This formal knowledge is likely to differ from the naïve concepts which they have acquired previously.

Given the challenge which misconceptions can present to effective learning, much educational and psychological research has been conducted to gain a greater understanding of misconceptions. Whilst it was previously believed that prior knowledge could facilitate future learning, this has now been shown to be a misconception. So whilst before it was postulated that having some knowledge of the concept or skill to be learned was helpful (Gagne & Briggs, 1974), research now suggests that student's existing knowledge of science typically interferes with new learning, as opposed to enhancing it (Klopfer, Champagne & Gunstone, 1983). The problem science teachers face, is that they must effectively use formal education to initiate conceptual change so the science knowledge can be successfully learned and applied. However, as will be discussed, teacher's have also been found to hold misconceptions about the subjects which they are required to teach. In fact there are several ways in which misconceptions can be generated, each of which will be discussed in turn.

**NOTE: Blue text signifies key topic papers **

Misconceptions as learners' mistakes

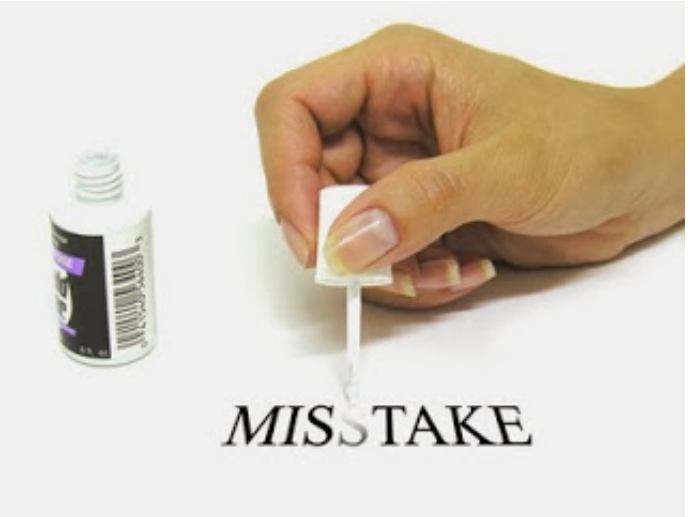
As a result of informal education and everyday experience individuals come to form ideas and concepts about the world. With experience and years these concepts become strongly rooted. For this reason, students' naïve conceptions are very resistant to change (Klopfer, Champagne & Gunstone, 1983).

So, children and also adults, have some particular misconceptions already formed before undergoing academic education. This suggests that misconceptions can often be learner's mistakes, however it is ill-informed to consider misconceptions as exclusively the fault of learners. Students may already have misconceptions formed when they first go to, say a lecture, but it is the teacher's role to ensure that the student acquires the correct information to dispel of the misinformation. Mathematical and chemistry concepts, for instance, are not common to everyday life nor lay persons knowledge, and therefore it is understandable that students would have to be taught these formally, and in knowledge they hold of them prior, is likely to be misinformed to an extent.

Research shows that we can also gain misconceptions about things which we encounter with in academic settings for the first time (Sbaragli & Santi, 2011). This links with the idea of misconceptions being thought as bad teaching or spontaneously re-generated.

What students face while learning science is a conflict between their naïve knowledge or misconceptions and the actual scientific concept meaning (Champagne, Klopfer, & Gunstone, 1982). In the next sections, we are going to deal with the question of what is the teachers' role here.

- A good paper to read here is -> Naive knowledge and science learning (1983) Klopfer, L. E., Champagne, A. B., & Gunstone, R. F.



Misconceptions as teachers' mistakes

Students can acquire misconceptions from their teachers. Whilst it is frequently the case that the student has procured the misconception through their own fault (either by having a lack of understanding or a misunderstanding of an issue which has been explained to them) there is also a substantial body of research which supports the idea that teachers themselves possess misconceptions and therefore students may acquire misconceptions through inaccurate or incorrect teaching. There are many ways by which a teacher may develop these misconceptions, including through reference to inaccurate media sources or textbooks and through their own experience.

A study by Graeber et al (1989) found that pre-service teachers possessed the same misconceptions regarding multiplication and division as students (e.g. “the divdor must be a whole number”.) If teachers retain the same misconceptions as their students, then this renders them unable to notice when student’s misconceptions are leading to mistakes in reasoning. Moreover, by reiterating misconceptions to students, the misconceptions are perpetuated and will therefore never be eradicated.

Other key subjects in which teachers have been found to hold serious misconceptions include environmental studies and biology. A study by Kahlid, (2001) demonstrated that pre-service teachers have inaccurate ideas about the nature of global warming including “ozone depletion will cause global warming” and “the increased greenhouse effect may cause skin cancer”, both of which are false.

It is frequently found that biology teachers have many misconceptions regarding the aspects of biology which they are required to teach (see. Barass, 1984; Yip, 1998). Yip (1998) found that even very experienced biology teachers held the same misconceptions regarding issues such as the capillary system as the students whom they were required to teach. Teachers may not only be perpetuating science myths, but may also at times be the instigators of them. If teachers misconceptions pose a serious problem to learning, then this would suggest that teachers should have a less instrumental role in

learning. It lends support to the importance of independent learning and student self regulation (Paris & Paris, 2001). It also suggests that peer discussion and debate is crucial and that many sources should be utilized to gain knowledge, to ensure that the information being obtained in reliable.

Indeed, it is possible to postulate on how teacher's misconceptions could hinder learning. Imagine, for instance, a student records an answer which is factually correct but which is contrasting to what the teacher's misconception. This would likely result in the teacher telling the student that their answer is wrong when in fact it is correct, and it is the teacher's knowledge which is lacking. Teacher's misconceptions become particularly apparent when they attempt to condense highly complex issues into simplified, easily understood concepts.

It is often assumed that if an individual has a degree in a subject, then they necessarily have a full, comprehensive understanding of the subject, and therefore teaching courses tend to focus on the practice of teaching as opposed to refreshing knowledge about the subject. Changes in the way teaching is taught are required if teachers misconceptions are to be dispelled off before they pass them to the students. These changes could include refresher courses of the subject in addition to making the teacher more aware of the impact which misconceptions can have on learning.

However, it should be noted that a recent study by Dekker et al, (2012) found that teachers who are enthusiastic about incorporating neuroscience into the curriculum, regrettably, often have many misconceptions about the brain and brain processes. Therefore, the issue of teacher's misconceptions should be approached with care as if teachers are made to feel like they do not have adequate knowledge on a subject then this may deter them from teaching the subject all together which is an undesirable outcome.

Spontaneous Generation: 'Cognitive Construals'

What is noticeable about much of the research within the literature relating to misconceptions is that it has an air of 'blame' associated with it i.e. misconceptions are derive from faults within knowledge stores of students and teachers, as detailed above. However, it may be more fruitful to address potential issues in human cognitive processes as a whole rather than mistakes at the more individual level. As such, the concept of 'cognitive construals' comes to the fore.

****Key Paper**** - Coley, J.D., & and Tanner, K.D.(2012). Common Origins of Diverse Misconceptions: Cognitive Principles and the Development of Biology Thinking. *CBE Life Sciences Education, 11(3),* 209-215. Doi: 10.1187/cbe.12-06-0074 (http://dx.doi.org/10.1187/cbe.12-06-0074).

This paper highlights the idea that misconceptions are present throughout the human population and are essentially a natural phenomenon which everyone is open to. There is less of a 'blame' element and more of an explanation of the phenomenon featuring examples pertaining to the study of biology. These examples help to illustrate the concept well and give the reader a better understanding of the principle from a cognitive psychology perspective.

The authors suggest that cognitive construals arise in three main forms: teleological, essentialist and anthropocentric thinking.

- Teleological thinking: a way of thinking about the world in terms of entities existing for a specific purpose or function (Kelemen, 1999). This allows for individuals to process why events occur or why objects have certain characteristics.
- Essentialist thinking: based on the belief that certain traits (of individuals or groups) may be relatively

consistent and unchanging over time (Gelman, Heyman & Legare, 2007).
- Anthropocentric thinking: the tendency to process unfamiliar situations or information by drawing analogies to humans (Coley & Tanner, 2012). This allows individuals to draw an understanding using a more well known or familiar phenomenon as a reference point.

Whilst the thought processes above may still be seen as an element of learner mistakes, they represent broader schools of thought that are undertaken by individuals. Thus misconceptions may not necessarily be due to 'mistakes' in understanding at the individual level but rather due to an inconsistency between beliefs and new information within a **broader population**. In a sense, it removes the focus on individual difficulties.

It may then be suggested that research into misconceptions should be less of a 'blame game' and tailored more towards adaptive intervention methods. Luz, Oliveira and Da Poian (2013) found that introducing dialogic teaching methodology allowed students to revise original concepts immediately after teaching and eight months after implementation of the strategy, although some misconceptions were still evident.

Threshold Concept

Threshold concepts are relevant to the discussion about misconceptions in education.

The term 'threshold concept' describes a new and previously unconsidered way of approaching or thinking about some concept related to learning (see: Meyer, J., & Land, R. (2003). *Threshold concepts and troublesome knowledge: linkages to ways of thinking and practising within the disciplines*. UK: University of Edinburgh, for a full review of examples of threshold concepts and the implications which they have for learning.)

A threshold concept aims to progress a learner's understanding of a given topic, and once a threshold concept has been understood, it will dispel previous misconceptions. Whilst the threshold concept will allow for easier and more comprehensive understanding of a topic, it also means that previously held and rehearsed ideas must be let go, and for this reason threshold concepts are not always perceived favourably; accepting them can be uncomfortable for some learners (Palmer, 2001).

There are several factors characteristic of threshold concepts. Firstly a threshold concept is likely to be *transformative*, in that it transforms our way of thinking about a topic, possibly even leading to a shift in values or attitudes. The transformation which a threshold concept generates is likely to be *irreversible,* so once a threshold concept is understood, the knowledge is unlikely to be forgotten and will probably influence future judgement on the relevant issue. So, for example, once an individual has fully grasped the idea of sampling distribution and can now view statistics with a statistical mind-set, it is likely that from henceforth they will attempt to solve all statistics problems this way and are unlikely to revert to the mathematical mind-set they previously tried to apply to physics (Kennedy, 1998).

Additionally, threshold concepts are *integrative* in that they emphasize the relatedness of concepts which were previously considered to be unconnected. Given threshold concepts are likely to undermine and be incongruent with misconceptions and tacit, inert and ritual forms of knowledge; they can also be described as *troublesome* (see Perkins, 1999, for a full understanding of troublesome knowledge).

Whilst it is highly likely that in order for learners to obtain a full understanding of a topic, it is necessary that they understand threshold concepts, it is likely that they may find the threshold concepts difficult to accept owed to the strength of their misconceptions. Also, for subjective subjects such as English, where

there may exist multiple ways to approach an issue, there may be some ambiguity over what the threshold concept is or which threshold concept should be applied (Meyer et al, 2003). Certainly it is easier to define threshold concepts in subjects such as Maths and Physics, than in more subjective subjects such as subjective subjects such as English and Philosophy, in which there are less set rules and knowledge.

Literature Gaps and Limitations

Much of the literature focuses on studies which are relatively short term, usually investigating learning over a period of months. Whilst this is better than simple one-off studies, learning is still a lifelong feature. Thus, more longitudinal work would intuitively seem to be more fruitful in assessing the impact of misconceptions as well as the validity of subsequent interventions in the longer term.

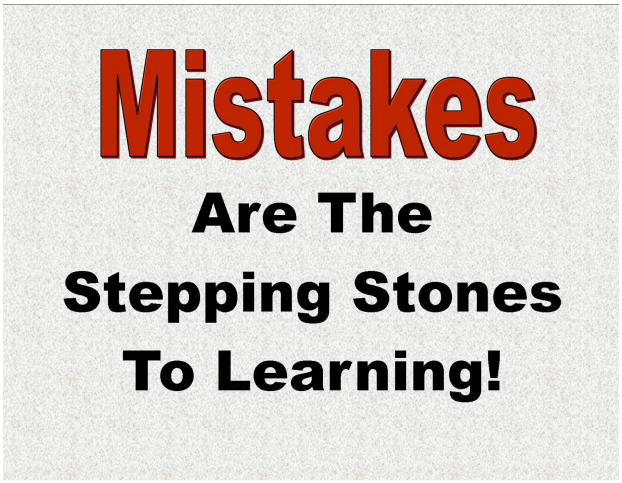
Interestingly, Coley and Tanner (2012) highlight that the majority of literature to date focuses on learning during childhood, from birth to puberty. **Individuals in adolescence and adulthood are thus a largely unexplored cohort within the domain of misconceptions**. As students within higher education tend to fall within these two categories, they should essentially be a primary focus for research.

Further, Hamza and Wickman (2008) highlight that, until recent times, much of the research relating to the impact of misconceptions on learning has been largely theoretical as opposed to evidence based. Therefore, more in depth empirical investigation into the phenomenon would undoubtedly be more informative so as to direct future intervention if necessary.

Concluding Thoughts

Masson, Potvin, Riopel and Foisy (2014) suggest that learning science isn't about discounting or replacing misconceptions but rather controlling and inhibiting spontaneous responses which may be erroneous. There seems to be a largely negative attitude towards misconceptions which, on the one hand may be understood as it can lead to erroneous learning. On the other hand, however, some authors consider misconceptions to be of significant importance in learning science: meaningful learning means replacing misconceptions with valid ones and the ability to do so requires rational consideration from the learner (Hamza & Wickman, 2008). Thus, encountering misconceptions and overcoming them may be a learning experience within itself: it's not all bad!

Here seems to be an appropriate place to re-introduce the age-old idea that **you learn from your mistakes!**



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