

In this reading we provide a broad outline of educational research on student ideas about forces and motion. The last 20 years of research on children's ideas has revealed that there are some common ideas that students use to explain their experiences with moving objects. In the educational research literature, student ideas have been referred to as misconceptions, pre-conceptions, intuitive knowledge, and/or naïve theories of motion. These ideas are often consistent, reliable, and reasonable to students even though they are not necessarily consistent with scientists' ideas.

Educational researchers Gunstone and Watts (1985) classified the findings of the research on students' ideas about force and motion into general categories. Physics education researcher Michael McCloskey (1983) also studied the types of ideas students have acquired about motion through experience with moving objects. He found that a large majority of college students interviewed consistently explained motion using what McCloskey calls the "impetus theory." This naïve theory of motion leads to common student ideas that are not consistent with scientists' ideas. Common ideas from the work of Gunstone and Watts (1985) and McCloskey (1983) are described below.

Common Idea 1: *Impetus Theory—Internal Force.* According to this idea, the act of setting an object in motion imparts to the object an internal force or "impetus" that serves to maintain motion. In the physics class this is often stated in terms of "force being transferred" from one object to another during an interaction.

Common Idea 2: *Impetus Theory—Force Runs Out.* According to this idea, the moving object's impetus gradually dissipates, and as a result the object gradually slows down and comes to a stop. In the physics classroom this often appears in statements such as "the force runs out."

Common Idea 3: *Forces have to do with living things.* This idea was investigated by Jean Piaget in the 1920s. By interviewing children while they worked on force problems, he found that children tend to think of force as something having to do with living things. Children often use animistic terms to describe how inanimate objects can exert a force. For example, children often refuse to believe that a spring exerts a force on a car because the spring is not alive.

Common Idea 4: *Constant motion requires constant force.* Children of all ages (including many undergraduate physics students) often develop a general rule that an object moving at a constant speed must be experiencing a constant force. This idea is expressed in statements such as, “If it is moving, there must be some kind of push on it,” or “it is moving, it has to have some kind of force *in* it.” The former illustrates the notion that objects cannot “do something” without a reason, in this case a force. The latter is an example of the idea that during a mechanical interaction such as a push, force is transferred from the hand to the object. This force is now “in” the object and when it runs out, the object slows down and eventually stops moving. This idea is very common in elementary school, middle school, high school and college. It is possible that part of the reason that these types of ideas develop is that people never actually experience a world with no friction. As a result, there is always an invisible force acting against the motion of objects, whether it is friction or air resistance. In most people’s experience, some kind of push is indeed often needed to keep objects like blocks and couches moving at a constant speed.

Common Idea 5: *The amount of motion is proportional to the amount of force.* The idea that constant motion requires constant force (Common Idea 4) often implies that no force means no motion. This is further generalized by many students to mean that the quantity of force is proportional to the quantity of movement. So, for example, a child might say that an object slowed down because a small amount of force was applied. The child might go on to explain that this means that a small amount of force will give rise to a “slow” speed but a large amount of force will give rise to a “fast” speed. This is very different from the scientists’ idea that any unbalanced force in the direction of motion will cause an object to speed up and any unbalanced force opposite the direction of motion will cause an object to slow down.

Common Idea 6: *If a body is not moving, there is no force acting on it.* There is a subtle difference between this idea and the idea that no-force-means-no motion, discussed in the previous section. In this case, the learner believes that a stationary object has no forces acting on it. This does not account for an apple hanging on a tree or a person standing on the ground. This idea is not consistent with the scientists’ idea that an object with balanced forces acting on it might not be moving at all.

Common Idea 7: *If a body is moving, there is a force acting on it in the direction of motion.* Children typically associate the direction of motion with the direction of the force acting on the object. A classic example of this can be found when students study circular motion. When students are asked to hit a moving ball with a club so that it goes in a circle on the floor, they often try to hit the ball around a circular path. After trying this several times, they ultimately discover that the ball must be hit towards the center of the circle.

Summary

Common Ideas 3 through 7 initially reported by Gunstone and Watts (1985) fall under the broader heading: *Motion Implies Force*. The Common Ideas 1 and 2 were originally reported by McClosky and fall under the broader heading of *Impetus*, or something imparted to and contained within an object. Researchers and practitioners have found that these ideas are common at all grade levels up to and including college. These ideas are often found to be consistent with students' everyday experiences, largely because we live in a world full of friction. For this reason, the idea that motion implies force and the idea that impetus is imparted to an object is very resistant to change, even in the face of evidence. Gunstone and Watts (1985) quote physics education researcher John Clement:

'In conclusion, the data support the hypothesis that for the majority of these students, the 'motion implies a force' preconception was highly resistant to change. This conclusion applies to the extent that students could not solve basic problems of this kind where the direction of motion does not coincide with the direction of force'. (p. 97)

As learners, it is important to keep in mind that we come into the classroom with our own ideas about how the world works. Some of these ideas work very well in the conditions under which we live. In science, however, we are often asked to imagine a broader range of possible conditions and to extend our explanations to account for them. As learners, we must become aware of our own ideas and the ideas of others. We must also become aware that our own misconceptions, pre-conceptions, naïve theories or ideas are seeds from which more powerful ideas can grow. We should always be mindful of the fact that we are not blank slates; we have ideas—good ideas. Our initial ideas may not always be consistent with the ideas of scientists. Awareness of these ideas has allowed teachers and curriculum developers to design lessons and curricula that can help students build on their own ideas. Our ideas, and our children's ideas, should be respected and valued. Through carefully crafted classroom experiences, children's ideas can be modified and developed by the children themselves into ideas that have a broader range of application.

References

Gunstone, R. & Watts, M. (1985). Force and Motion. In *Children's Ideas in Science*, R. Driver, E. Guesne, and A. Tiberghien, Eds. Taylor and Francis Inc. Chapter 5, p. 85-104.

McCloskey, M. (1983). Naive Theories of Motion, in Genter and Stevens Eds., *Mental Models*, Lawrence Erlbaum associates, New Jersey.