# COMMON SENSE
## IN THE SCIENCE CLASSROOM

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**Students can sometimes perceive scientific ideas to be in conflict with their common sense. How do we approach such conflicts in the classroom? Do we see these commonsense ideas as being wrong or, at best, misconceived? Alternatively, do we see them as resources and assets essential for the development of true understanding?**

*"...creative scientists are not only exceptionally gifted human beings — they are also human beings with a biological and social make up like all of us. The problem-solving strategies scientists have invented and the representational practices they have developed over the course of the history of science are very sophisticated and refined outgrowths of ordinary reasoning and representational practices."*

— Nancy Nersessian.

Children understand and perceive the world around them intuitively, imaginatively, and socially — developing what we could call a commonsense understanding of the world (see **Fig. 1**). They know, for example, what is likely to happen if a small car stuck on the railway tracks were to collide with a massive fast-moving train. While the much smaller car will get crushed or be thrown violently away, the bigger, more massive train will fare much less damage. It is no surprise, therefore, that students tend to believe that the car will be hit by a greater force than the train.

Their teacher, however, tells them that as per Newton's third Law (every action has an **equal** and opposite reaction), **the forces acting on both, the car and the train, are the same!** This is in direct contradiction to what the students believe. One would expect, therefore, that a furore would erupt in class as students clamour to present **their** perspective. However, this does not happen in the classroom, barring rare exceptions. Even though it flies against their intuition (what they know by common sense to be true), the students are likely to listen to the teacher in silence. The more conscientious of them may even note down what the teacher has just said. But this doesn't mean that they have changed their minds. Their silence is not agreement or understanding of Newton's Third Law.

There is, in fact, ample empirical evidence to show that most students actually think that the force exerted on the car by the train is much greater than the other way round. They tend to hold on to this intuitive understanding even after extensive instruction. This is true not just in India, but across the world. When common sense meets direct instruction,


**Fig. 1. Children understand and perceive the world around them intuitively, imaginatively, and socially — developing a commonsense understanding of the world.**

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common sense usually wins — though this may not always be obvious from students' responses in class.

The question for us, as educators, is — what do these commonsense understandings mean for learning in science? If they are important, how do we get students to voice them? How do we get students to use them to discuss, argue, and engage in building scientific knowledge? We believe that the answer to these questions lies, at least partly, in **how we have been thinking about** student ideas. Do we see them as a hindrance, a deficit, or as a resource for the development of true understanding?

## The Dark age, Renaissance, and Enlightenment

*"...I couldn't see how anyone could be educated by this self-propagating system in which people pass exams, and teach others to pass exams, but nobody knows anything."*

— Richard Feynman.

In the car and train collision example, many students believe that the force exerted by the train is greater than that exerted by the car. Educators and education researchers conceive the nature and role of such student ideas in three main ways:

### 1. Student ideas as being either right or wrong — a binary assessment

Looking at student ideas as being either right or wrong is perhaps the oldest and the most traditional approach, widely prevalent even today. This approach is based on the assumption that scientific knowledge is absolute and not amenable to change or revision. A student's understanding either matches this or it does not. Any idea that does not match is wrong, and has to be replaced.

This perspective is often part of a larger narrative wherein the instructor is considered as the provider of knowledge. Thus, knowledge is transmitted from the instructor, and students are expected to receive it as is. Their understanding is evaluated in terms of its accuracy and fidelity to what the instructor has said. Student ideas, their nature, and their origins are irrelevant to the process of learning.

### 2. Student ideas as misconceptions — an impediment to expertise

Based on the work of people like Jean Piaget, this perspective acknowledges that most student ideas, even if incorrect, have a structure and robustness to them (see **Box 1**). In other

**Box 1. Did you know?**

Jean Piaget systematically studied how children learn, recognize, and identify patterns of thinking and knowledge building both through the process of cognitive development as well as their interactions with the world. Building on his insights, researchers in science education have identified a broad array of misconceptions or alternative conceptions that students have about various scientific topics.

words, rather than having arbitrary ideas, students develop their own coherent understanding of the world.

From this perspective, the goal of science education is to identify and confront incorrect ideas, and replace them with correct ones. Though a bit more progressive than the binary (right/wrong) approach, this approach still views student misconceptions as an impediment to expertise. Described more crassly, the message that is conveyed to students is that *"we will listen to your ideas, but you should get rid of them at the earliest, if they don't match ours."*

### 3. Student ideas as resources — essential to the development of expertise

If we consider the two perspectives described before as the dark ages and renaissance of science education, the next stage can be called the age of enlightenment. This approach recognizes and celebrates the creative, generative potential of student alternative conceptions. It recognizes that even scientists carry rich, complex and, sometimes, divergent understandings within themselves.[1] Thus, rather than being seen as hindrances, alternative conceptions are seen as nascent attempts to develop coherent frames to understand the world.

This means that students are now placed in a continuum with scientists. Student ideas become the building blocks out of which more sophisticated knowledge structures get constructed, with the added benefit of elevating their sense of ownership and agency. This approach, where students construct their own knowledge by building on what they already know, is at the heart of constructivism. It changes the role of students, their status in relation to experts, and the metaphors underlying teaching and learning.

## Is Newton's Third Law an assault on common sense? Not really!

When the collision of train and car is discussed in the context of Newton's third law, students usually imagine the scenario based on their experiences (see **Fig. 2**). What unfolds in their imagination is a huge, fast-moving object hitting a smaller object. In their

**Fig. 2. When the collision of train and car is discussed in the context of Newton's third law, students usually imagine the scenario based on their experiences.**

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experience, this almost always results in the smaller object being flung away or getting crushed. It is from this mental simulation that students infer that the force on the car by the train is much higher than the other way round. While physics defines force as a quantity involving both acceleration and mass of the colliding bodies, students' inference about the force of collision relies solely on features of acceleration (implicitly incorporated in their common-sense reasoning). This perceived discontinuity can be mitigated if we deconstruct the collision example in such a way that commonsense notions are recognized and connected to the formal definition of force.[2] What are the implications of this approach on instruction?

## Implications for instruction

Topics like Newton's Third Law are often taught by directly stating the definition of the law, then giving an illustrative example, and finally doing word problems based on the same. This is not only ineffective as far as learning is concerned, it also ignores how students understand the development of ideas in science, and denies them any agency in their own learning. Research offers these guidelines to a more effective approach:

### (a) Give voice to student ideas:

Instead of thinking of students as passive recipients of knowledge delivered by teachers, invest in more proactive efforts to give voice to student ideas. The culture of silence prevalent in our classrooms should pave way for a culture of discourse and argumentation. How do we facilitate this in a traditional lecture-based classroom?

**How to implement:** Take 5-10 minutes after introducing a topic to pose multiple-choice questions to the whole class. The questions should be designed in such a way that the different choices incorporate students' ideas and alternative conceptions. In other words, the choices should act as scaffolding for students to voice their ideas in the class. Then, facilitate a discussion among students where they are encouraged to argue, and try to convince each other about the correctness of their choices.[3,4]

### (b) Incorporate human elements in classroom discourses on science:

Rather than teaching only the core content of a subject, it is important to provide students with a clear picture of the **processes** that scientists use to think about and develop ideas. Seeing the human element in the enterprise of knowledge construction in science helps students understand that scientists are not always correct, and that they engage in constant refinement of their ideas. It also helps them appreciate how scientists often disagree greatly with each other. Seeing science as a human activity, laden with all the errors and biases that all humans have, helps students recognize their own role in its collective (or social) process of generating better understandings of the nature of the world.

**How to implement:** Present historical episodes that illustrate how great thinkers in the past harbored ideas similar to the conceptions students themselves have now.[5] For example, Aristotle, like many students, believed that rest was the natural state of objects, and motion implied a force.

## Parting thoughts

Einstein once remarked that *"The whole of science is nothing more than a refinement of everyday thinking."* However, this image of science as a public and negotiated process of thinking, rooted in everyday experiences and imaginations, often gets obscured and lost in classroom contexts. With it are lost many prospects for authentic and engaged learning. This disconnect in the popular perception of science can be addressed by bridging the gap between student ideas and science concepts. We emphasize the need to adopt a pedagogical approach which helps students see that many formal concepts in science emanate from conceptions similar to the ideas they hold, and these are progressively refined by scientists in light of a larger body of evidence.

## Key takeaways

- Children develop a 'commonsense' understanding of the world based on their everyday experiences. Sometimes this understanding appears to be in conflict with formal concepts taught in the science classroom.
- Students' ideas need not be treated as right or wrong, or as impediments to learning. They can be viewed as resources important to develop a more refined understanding of scientific concepts.
- Breaking down scientific principles to acknowledge commonsense notions and then connecting them to formal definitions could help bridge the gap between students' ideas and scientific concepts.
- Giving voice to students' ideas and bringing the 'human' element in a science classroom could help students identify science as a human activity, and recognize their own role in the process of knowledge construction in science.

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