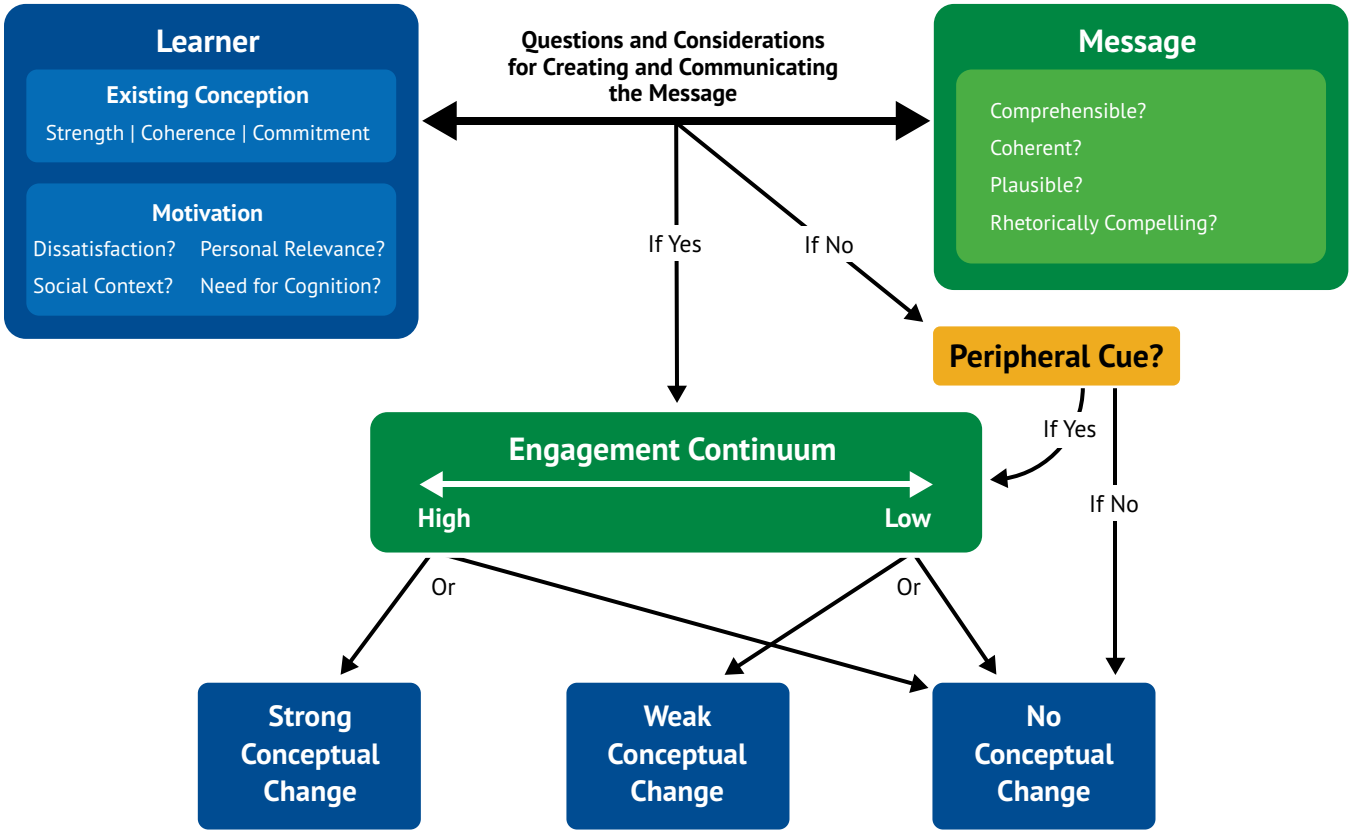
NCSE
National Center for Science Education

The NCSE Approach to Resolving Misconceptions

Cognitive Reconstruction of Knowledge Model



Adapted from: Dole, J. A. & Sinatra, G. M. (1998). Reconceptualizing change in the cognitive construction of knowledge. Educational Psychologist, 33(2-3), 109-128.

NCSE's curricular and pedagogical approaches were created with thoughtful consideration for how teachers can effectively identify and help students to resolve misconceptions that they may have about scientific principles and ideas. These misconceptions – also known as naive conceptions, conceptual misunderstandings, or existing conceptions – that are inconsistent with a current scientific understanding are complex.* Therefore, addressing them requires consideration of the many different variables that influence these misconceptions as well as what is required from the curriculum and teaching strategies to resolve them effectively. Below is a brief explanation of the factors represented in the model above.

* For simplicity's sake, the word misconception will be used to refer to all variations of this term.

Learner

The first step in resolving misconceptions with students is to identify the misconceptions that students bring into the classroom, how entrenched these misconceptions are, and what factors are necessary for students to resolve them. Teachers can do so by building relationships with students, getting to know their interests and experiences, and using intentional formative assessments throughout the lesson.

Existing Conception

Strength: *Are their misconceptions well-formed and detailed or weak and fragmented?*

Thorough nature of science (NoS) instruction is key to weakening the strength of misconceptions. If students understand what science is and how it is conducted, they will be more likely to see how their misconception fits outside a scientific framework.

Coherence: *Do their misconceptions provide explanations that fit together with all other available evidence?*

While NoS instruction can also be an effective tool to demonstrate the lack of coherence of a student's misconception, analyzing authentic data to build new models supported by this evidence is the best way for students to see that their misconception lacks coherence with the best available scientific data.

Commitment: *Is their commitment to this misconception an integral part of their social, cultural, religious, or political identity?*

Because people often become defensive when presented with information or ideas that contradict their deeply held beliefs, loosening a student's commitment to a misconception is more effective if the message is presented in a positive manner in the classroom. This manner includes using NCSE's BRAVE classroom practices. Science education aims not to change a student's cultural identity, political affiliations, or religious beliefs but to help them understand and appreciate the scientific perspective on natural phenomena. Reserving judgment, maintaining a friendly demeanor, finding common ground, listening to students' concerns, and easing tensions are crucial to having BRAVE conversations and allowing students to be more open to new ideas and ways of knowing.

Motivation

***Dissatisfaction**: In order to move to a more complete scientific conception of an idea, students must first be dissatisfied with their misconception.*

Students must experience cognitive conflict by seeing anomalies or contradictions between their misconceptions and new data or by being shown that their misconceptions are internally inconsistent. Again, this is most easily achieved through NoS instruction and interaction with authentic data.

***Personal Relevance:** Students must have a stake in the outcome, an interest in the topic, and/or an emotional involvement in the topic in order to move from their misconception to a new scientific conception.*

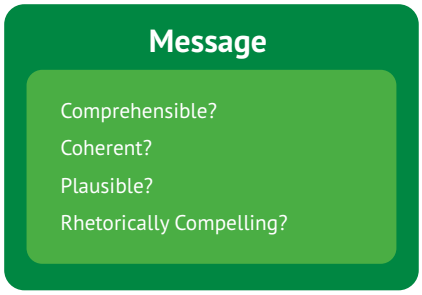
Using interesting, engaging, and/or familiar phenomena to anchor a lesson can be an effective way to make a concept relevant. Building relationships with students and getting to know their interests and experiences will help teachers find these relevant connections that can draw students into learning about a new concept.

***Social Context:** Because all learning happens within a social context, teachers should keep in mind that members of a student's community, family, peer group, or other networks can motivate them to process information that they would not otherwise have considered or inhibit them from considering that information in the first place.*

By leveraging these various groups, teachers can reinforce personal relevance and motivate students to consider a new concept. This leveraging can be done through peer tutoring, group work, classroom discussions, parental conversations, or bringing in examples of mentors or other sources that the students find trustworthy and reliable.

***Need for Cognition:** Students must be motivated to engage with ideas, information, or concepts in order to consider and be challenged by new sides of an issue.*

Learning about common science denial techniques, data manipulation, and unreliable and biased sources of information using resources such as FLICC, CRAAP, and FABLE can enhance these motivational factors. Nobody likes being lied to or manipulated; by showing students how these techniques can be identified and countered, they can be motivated to think metacognitively about their misconceptions and be on the lookout for similar ways of thinking in the future.



Message

After considering the misconceptions and motivation for resolving those misconceptions on the part of the learner, the next step is looking toward the message: investigating the factors directly related to the curriculum and its implementation that play a role in resolving misconceptions.

Comprehensible: *The curriculum must be developmentally appropriate in order for the student to understand the new concepts.*

Students must either have the appropriate background knowledge and skills or be provided with adequate scaffolding from the teacher to understand the new concept being taught. When the curriculum is too challenging or not rigorous enough, it has little chance of resolving students' misconceptions.

Coherent: *The curriculum must provide an explanation of the concept that is placed in a logical progression and links the idea to a larger conceptual whole.*

Phenomenon-based storylines are effective because they allow students to begin at their current level of understanding, investigate an engaging problem or question, and work toward building new conceptual models as they explore ideas and content in a structured learning progression. Opportunities for transferring this understanding to new situations should also be provided in order for students to see how this concept relates to similar phenomena outside of the anchor.

Plausible: *The curriculum must be reasonably credible to the student.*

For the student to accept the plausibility or credibility of the concept, they should have opportunities to weigh the quality of evidence to decide the probability of its truthfulness. Providing students with the opportunity to engage with authentic data in order to form their own conclusions is an effective method for ensuring the plausibility of a new concept.

Rhetorically Compelling: *The language, sources, and justifications of the argument being presented in the curriculum must be convincing and persuasive to the individual.*

Effective NoS instruction coupled with source evaluation techniques and instruction regarding science denial techniques and logical fallacies allows students to understand and evaluate their misconception and weigh it against the new conception to judge the reliability of each. The curriculum and its presentation should be delivered in straightforward and objective language backed by authoritative and unbiased sources and supported with clear justifications. Following the guidelines of BRAVE conversations will set a tone that allows students to be open to a new message, even if it contradicts their existing conception.

Engagement Continuum

The most important element of the knowledge reconstruction process is the students' interaction level with the engagement continuum. Engagement includes both "hands-on" and "minds-on" interaction with the curriculum throughout the learning process and occurs on a spectrum from high to low.

Highest Engagement

Intentional learners in inquiry-based classrooms fall near the higher end of the engagement continuum. These students are engaged in deep processing and significant metacognitive reflection, and they use strategies to model or elaborate on their learning throughout the lesson. These learners ask questions like "How do I learn and think critically?" "Am I aware of my existing conceptions?" "What would it take to convince me otherwise?" "How do I know if I am truly understanding this concept?"

Lowest Engagement

Unintentional learners in more "traditional" classrooms fall near the lower end of the engagement continuum. These students rely on rehearsal or mnemonic devices to remember content in the short term but do not fully conceptualize it or retain the knowledge in the long term. They engage in little to no reflective thought or metacognitive evaluation during the learning process and do not work to model their learning or thought process during the lesson.

Peripheral Cue?

Peripheral Cues

Students respond better to new concepts or ideas that conflict with their misconceptions when they have role models who do not find conflict in scientific conceptions. These role models are especially powerful if they complement the teacher's voice and come from a person the students see as an authority who shares their cultural, religious, or political identity or belief. Sometimes, just hearing the same concept or idea from another person besides the classroom teacher can draw students into the engagement continuum or move them to a higher level of engagement. This person could include outside speakers that the students can relate to or see as trustworthy sources of information, such as local professionals, farmers, healthcare workers, engineers, scientists, meteorologists, administrators, members of the clergy, politicians, or even social media influencers who the teacher has vetted.

Putting It All Together

For science teachers to produce strong and lasting conceptual change, students must receive a well-formed message that they find coherent, comprehensible, plausible, and rhetorically compelling, and this message must be presented in a way that will motivate them to interact with the new concept at a high level of the engagement continuum. Peripheral cues, NoS instruction, and metacognitive strategies implemented throughout the learning process enhance students' chances to form a new conceptual understanding that resolves their existing conception.