Assessment in the Sciences: A Cognitive Perspective

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Introduction

Reliable and valid assessment is important for the identification of students' knowledge and for the assessment of learning outcomes.

Disciplines such as Physics and Mathematics have made significant steps towards creating valid and reliable assessment tools. Recently there has been also an initiative in the Earth Sciences (GCI by Libarkin & Anderson, in preparation) .

A common approach of these initiatives is to base the development of such instruments on theories and methodologies from research on cognition. We present a few examples guided by this approach that suggest how such methodologies can be used to inform researcher's and educator's understanding of students' knowledge and learning.

Assessing Students' Knowledge

When assessing students' knowledge it is important to make a distinction between quantity (i.e., amount) and quality (i.e., accuracy) of knowledge (Kendeou, Rapp, & van den Broek, 2004).

Traditionally, researchers have focused on quantity rather than quality. It is a well known fact, though, that students possess intuitive ideas they use to explain everyday life events. These intuitive ideas are often incorrect and can result in difficulties during learning of new scientific information.

Therefore, the ultimate goal of instruction is now viewed as conceptual change learning, namely, helping students replace faulty beliefs and ideas with the scientifically correct ones. A necessary condition for doing so involves identifying students' beliefs prior to instruction. Below we consider some of the methodologies employed in research settings.

Methodologies

Clinical Interviews

Typically, the interview consists of a hands-on activity with accompanying questions. The process is open-ended with the ultimate goal of revealing (and informing) students' ideas (Vosniadou & Brewer, 1994).

Questionnaires

Questionnaires are often constructed by the experimenters and go through several iterations to increase reliability (Diakidoy, Kendeou, & Ioannides, 2003). There are also 'standardized' tests in several knowledge domains (e.g., Physics, Math)

Verbal Protocols

Verbal protocols can be obtained using a structured or non-structured think-aloud procedure (Ericsson & Simon, 1993). During think-alouds, students are instructed to talk aloud about their thoughts while reading or completing a task.

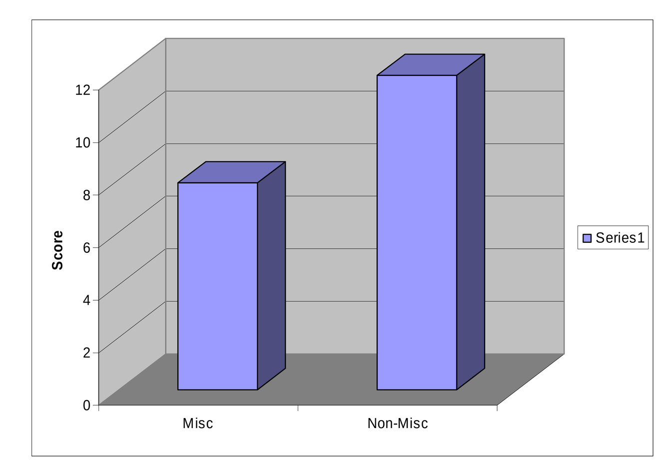
Reading Times

Reading times at the word, sentence, or text level have been used extensively in psychological research as an indicator of processing (Rapp, Gerrig, & Prentice, 2001).

Example from Physics

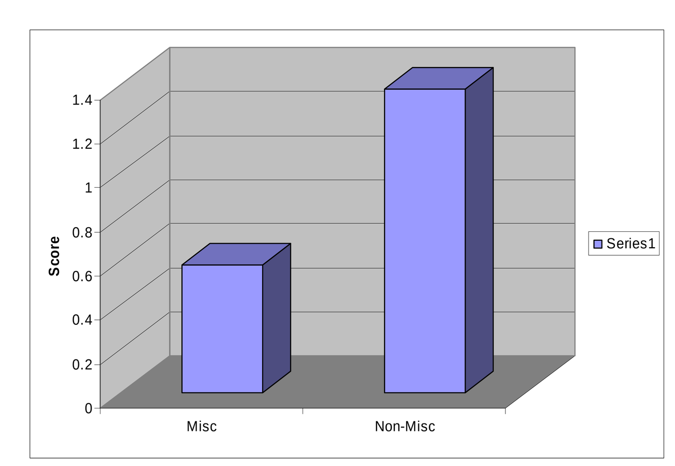
Kendeou & van den Broek (in press)

We assessed students' knowledge in physics (specifically, the domain of electricity) using an interview and a questionnaire. Converging evidence from both measures helped us define two groups of students: (1) students with misconceptions about electricity and (2) students without misconceptions.



Both measures resulted into two significantly different groups of students.

When we assessed students' understanding of electricity texts using verbal protocols, we observed different patterns in processing that were a function of students' prior knowledge.

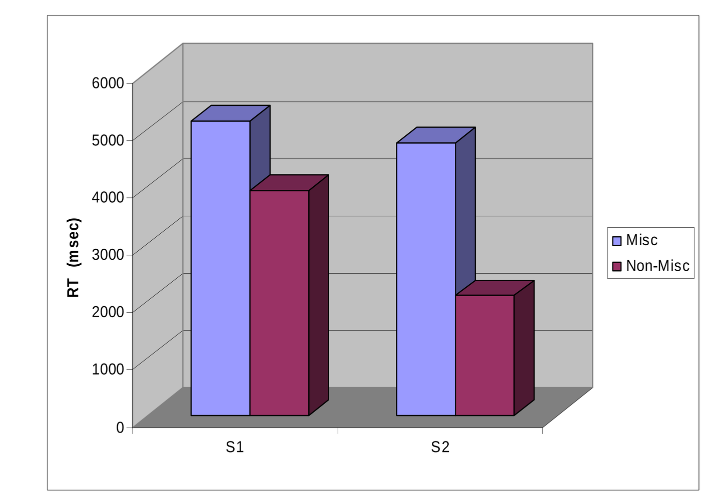


For instance, readers with misconceptions generated fewer valid knowledge-based inferences.

Kendeou (in preparation)

Students' knowledge in physics was assessed using the Force Concept Inventory and defined two groups of students: (1) students with misconceptions in Newtonian Physics and (2) students without misconceptions.

Students were asked to read a text that included information contradicting their misconceptions. Reading times for target sentences were collected.



S1 and S2 were scientific facts related to Newton's First and Third Law, respectively.

Students with misconceptions spent more time reading sentences that contradicted their prior knowledge than did students without misconceptions.

Conclusions

The methodologies described here have strong psychological validity in assessing students' knowledge and learning outcomes. Researchers and educators in the Sciences can benefit from adapting these methodologies to their research and/or classroom interventions.

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