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Conceptual change in school science: Using evidence from tacit awareness

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Background

It is well known that when children are asked to reason in school science, they call upon conceptions that are at variance with received ideas. Thus, science education is widely construed as needing to support processes of conceptual change. For the past 25 years, most attempts to effect change have involved children in making comparisons between the conceptions they initially call upon and the received ideas of science, and providing evidence for the greater power of the latter. Although there are examples of successful teaching following this approach, success is not guaranteed, often because the evidence is not given its intended force. Classroom exercises can misfire, they can be treated as irrelevant, and their meaning can be distorted. Indeed, neuroscience research suggests that the brain structures associated with learning will not necessarily be activated when evidence diverges from preconceptions.

Research Questions

However, the evidence that is used in classrooms to challenge children's conceptions often comes from outside their personal experiences, and will not necessarily prove meaningful to them. By contrast, the research to be reported in this paper (funded by ESRC) uses evidence that is optimally personal and meaningful, because it is already embedded within children's knowledge. The research is based on four earlier studies under the author's direction (Howe, Taylor Tavares, & Devine, 2009a, b), where primary school children aged 6 to 10 years were asked to judge the naturalness of computer-simulated object motion. In some cases, the scenarios that the children viewed showed natural motion and in other cases, it was non-natural. Regardless of age, all children showed an excellent ability to differentiate between the natural and non-natural scenarios, suggesting tacit appreciation of how objects move. On the other hand, when the children were asked to predict object motion rather than merely observe this, i.e. to reason as in science classrooms, they made numerous errors. The research to be reported uses children's tacit understanding to boost the conceptual level of their scientific reasoning.

Methods

Two studies will be reported, both employing computer software. Study 1 used billiards scenarios to support understanding of horizontal motion, and Study 2 used hot air balloon scenarios to support understanding of object fall. In both studies, the problems associated with the scenarios had the same basic structure:

- Children were invited to predict an outcome, e.g. which pocket on the billiards table a ball will fall into after being struck by the cue ball, will the speed of a ball increase, decrease or remain the same as it falls through air.
- If predictions were correct, children were told that they were correct and invited to observe the pattern of motion that they had predicted.
- If predictions were incorrect, children were told that they were incorrect and invited to observe the pattern of motion that they had predicted plus the correct pattern of motion. They were asked to compare the two patterns. It was hypothesized that children's tacit understanding would lead them to recognize the anomalous nature of what they predicted and the appropriateness of the correct alternatives, and that they would learn from this.

Frame

In both of the studies, around 150 children aged 8 to 12 years were pre-tested with a series of relevant problems where they were invited to predict outcomes and explain why they had made their predictions. Billiards problems were supplemented with problems using other sports (e.g. marbles, putting) in Study 1, and hot air balloons were supplemented with other sources of fall (e.g. helicopters, trains) in Study 2. Subsequent to the pre-test, c.33% of the sample used the software in one-to-one sessions with adults who offered guidance as appropriate (single condition), c.33% used the software jointly with a classmate with minimal adult guidance (pair condition), and c.33% had no experience of the software (control condition). A few weeks later, all children were post-tested using problems that were equivalent to the ones used at pre-test. Pre-tests, teaching software and post-tests covered both the direction and speed of motion under various combinations of significant factors, e.g. high vs. low surface friction in Study 1, fall from a stationary or moving carrier in Study 2.

Research findings

Comparison of pre- and post-test scores as a function of condition proved encouraging, suggesting that the approach could be developed for educational usage:

- In Study 1 (billiards), the single, pair and control children were all equivalent at pre-test. At post-test, the single and pair children made superior predictions to the control children, and the explanations offered by the single children contained fewer erroneous ideas. The only area where there were no differences between the three groups was over the inclusion of correct ideas in explanations.
- In Study 2 (hot air balloon), the single, pair and control children were again equivalent at pre-test. At post-test, the single and pair children made superior predictions to the control children, with the pair children performing even better than the single children. There were on the other hand no statistically significant differences over the quality of explanations, despite trends towards greater progress (over exclusion of irrelevant ideas and inclusion of relevant ideas) in the single and pair children.

References

- Howe, C., Taylor Tavares, J., & Devine, A. (2009a). Beliefs and children's tacit understanding of horizontal motion: a challenge for theories of consciousness. Paper presented at 12th Annual Conference of BPS Consciousness and Experiential Psychology Section, Oxford.

- Howe, C., Taylor Tavares, J., & Devine, A. (2009b). Children's conceptions of object fall: tacit and explicit understanding in middle childhood. Paper presented at BPS Developmental Section Conference, Nottingham.