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Categorization of Emergent Processes by Students at Different Levels of Expertise

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Introduction

Chi and Roscoe (2002) proposed that one reason for the persistence of scientific misconceptions is that students classify scientific phenomena into incorrect ontological categories. In particular, Chi (submitted) has hypothesized that many commonly misunderstood science concepts (like evolution and electric current) are emergent processes in which a macro-level phenomena emerges from complex interactions between entities at a micro-level. Rather than correctly categorizing them this way, students are thought to miscategorize them as non-emergent processes in which there is a more direct relationship between the two levels.

To test this hypothesis, we are conducting a study comparing how participants at different levels of expertise categorize science problems across domains, using a card sorting task modeled on Chi, Feltovich & Glaser (1981). The prediction of Chi's theory is that participants with more expertise will be more likely to distinguish emergent from non-emergent problems while those with less expertise will often conflate them. Experts will also be more likely to refer to the 11 features of the emergent schema (e.g., disjointness, parallelism; see Chi, submitted) in defining their categories.

Method

Participants

Participants consisted of 10 undergraduate and 9 doctoral students from the biology, chemistry, or physics departments at a local university. Undergraduates had all completed 1st year courses in biology, chemistry, and physics. Eight were single majors in one of these disciplines and two were double majors in biology and chemistry. Doctoral students were in their third year or above.

Materials

Participants sorted 24 science problems, 8 drawn from each discipline's 1st year course. Within each discipline, half were emergent and half were non-emergent processes.

Procedure

Participants were asked to sort the problems into piles with similar mechanisms for linking the macro and micro levels. In the 1st sort, they were allowed to make as many piles as they wished. In the 2nd sort, they were asked to divide the cards into just two piles. In the 3rd sort, the experimenter sorted the cards into emergent vs. non-emergent processes, and participants were asked to infer the distinction. In all cases, participants were asked to explain the explanatory mechanism each pile represented and why each problem fit.

Results

As a preliminary measure of the degree to which participants distinguished emergent from non-emergent processes, we calculated a weighted average (by pile size) of the absolute difference between the number of emergent versus non-emergent processes in each pile by the number of cards in the pile. For example, 3 piles—one with 5 emergent & 5 non-emergent problems, a 2nd with 1 emergent & 7 non-emergent problems, and a 3rd with 6 emergent & 0 non-emergent problems—would get a score of $[10(0/10) + 8(6/8) + 6(6/6)] / 24 = 12/24 = .50$. A value of 1 on this score represents perfect separation of emergent versus non-emergent processes while 0 represents perfect 50/50 mixing. Mean separation scores were .58 for doctoral students, .53 for single majors, and .73 for double majors, although none of these differences are statistically reliable.

A complicating factor is that participants sometimes put, for example, only emergent problems in a given pile for reasons unrelated to their emergence. Thus, we analyzed participants' definitions of their categories to determine whether they referred to any of the 11 features of the emergent schema. Doctoral students' categories referred to more emergent features (1.78) than single majors (0.13; $t(9) = 3.08$, $p < .05$). Double majors referred to even more of them (3.50), but more data is needed to see if this is reliable.

Discussion

Doctoral students and double majors used more features of the emergent schema in sorting science problems than single majors, although they were no more likely than single majors to create piles that distinguished emergent and non-emergent processes. In future work, we will include in our sample more double majors as well as professors to further investigate the nature of expertise in emergent processes.

References

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