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What Can the Study of Representation Tell Us About Learning?

K. Ann Renninger
Susan L. Golbeck

The "working papers" included in this issue of *The Genetic Epistemologist,* like those of the first issue on Representation and Learning, reflect the diversity of questions being addressed by researchers in their efforts to study representation and its meaning. Common to all of the papers is the assumption that the representation of knowledge is an active construction on the part of the individual. This active knower/known relationship may be reflected through the efforts of the individual working more or less alone, or through co-construction with other individuals. Also common to all four papers is the assumption that the structure of representational knowledge undergoes change with development, and an adequate theory of learning must take this factor into account.

While all four papers explicitly address representation and learning, the problems explored by these authors also differ along at least three dimensions. First, the authors are concerned with different domains of knowledge. Kaplan, Burgess, and Ginsburg explore factors interacting or interfering with children's understanding of mathematics. Beilin and Futterweit consider representation in the pictoral domain with a special emphasis on photography. Chaille and Freeman examine representation in children's play as a function of task. Finally, Winegar uses his work with young children's understanding of social process to inform his response to discussions of the zone of proximal development.

A second dimension along which the papers vary is the role of a particular theoretical framework in informing the study of representational processes. The work of Kaplan et al. has clear roots in both Piagetian and Vygotskian theories, although they do not explicitly draw upon a particular theoretical framework in their discussion of the connections between the social contextual features of the classroom and children's mathematical problem solving strategies. Beilin and Futterweit draw on both Piaget and cognitive theorists in their discussion of pictoral representation. Chaille and Freeman use Piagetian theory to inform their questions about representation in preschoolers' play. Finally, Winegar's response reflects a social constructivist orientation to development.

A third feature differentiating these papers concerns contexts for studying representation and learning. Kaplan et al. focus on formal learning. Beilin and Futterweit focus on learning more generally. Chaille and Freeman intend to evaluate the contributions of tasks to children's learning. Finally, Winegar's response, while drawing to some extent on his research, is in fact based on his sense of current discussions of Vygotskian theory generally, and the zone of proximal development in particular.

Despite differences between the papers, they also complement each other in important ways. Each focuses on representation as a process by which the individual organizes or symbolizes information in the service of subsequent activity. Moreover, the process of representation is described by each as ongoing, constrained by individual experience, and formed, even if indirectly, through relationships to others (others' presentations and/or representations). Taken together these papers offer us some ways to begin to think about the relation between the study of representation and the way individuals learn.

In the first paper, Kaplan, Burgess, and Ginsburg address the question of whether task content in fact reflects the content of students' representations. In their videotape study of children's mathematical problem solving, they find that representation might be better described "as a system of beliefs, attitudes, and strategies that lie at least partially in the domain of social-cognitive development." They found that much of what children associated with mathematics tasks involved pleasing others, not engagement in mathematics per se. While their argument is debatable, the cases reviewed offer solid support for differences between teachers and students in their interpretation of mathematics tasks. This may in fact be particularly true of mathematics as a domain in which product, rather than process is often the emphasis of classroom practice—not so subtly communicating to students the importance of being right.

The essay on pictorial representation by Beilin and Futterweit offers further insights about the mathematics learning discussed by Kaplan et al. In particular, their paper suggests that the process of transformation in representation cannot be ignored. Even if the mathematical symbols that are the focus of the Kaplan et al. study can be considered like photographs to represent the particular, one still can be asked whether what the viewer (student) sees in the photograph (numbers) is the same as what our own phenomenological experience might lead us to expect. This question, as Beilin and Futterweit point out, has had a long tradition in psychology. Focusing on present day computational theories, they articulate differences between theories that are analogous (mimic) and those that are digital (symbolic). A basis of each, from their perspective is, however, whether that which is depicted (by drawing, photograph, etc.) undergoes a substantive transformation in creation and then is once again transformed as another attempts to understand it/represents it to him/herself. Thus, rather than suggesting that a domain (such as mathematics or photography) affords a particular set of actions, they suggest that representation entails at least two transformations. Furthermore, they suggest that the medium of the first transformation influences the variance in the second transformation. Such a suggestion implies that those working with children on comprehension (regardless of whether the subject area is mathematics, graphics, or photography) might usefully work with children on deciphering the task at hand either by focusing on those instances that are probably truly discrepant for the children (e.g. abstractions such as duodecohedrans, recursive models, or patterns of light) to make the case that the "task" is by definition symbolic, or by introducing children to materials that involve increasingly more complex transformations relative to the children's present understanding.

Extending Beilin and Futterweit's ideas to the domain of math further suggests that the task of mathematical word problem solving might be thought of as a two-step procedure—the first step involving interpretation of task demands, the second step involving employment of strategies that allow the child to meet those task demands. One approach to working with children around such complexity generally involves practice with algorithms, followed by work with algorithms nested in word problems. Such an approach generally means that children adopt strategies for solving problems (e.g. always adding if the word "and" appears in the sentence), many of which do not generalize across problems. Based on the conception of transformations, it seems reasonable to think about breaking children's work with mathematics into parts—first working with the child around the numbers as symbols (not something to be memorized, rather something to be understood), and then working with the child around the relation between these symbols whether this involves words or not.

Another tact for working with children to develop representational competence involves specific attention to the manipulability of the tasks themselves. This in some ways is quite similar to the first transformation to which Beilin and Futterweit refer, as well as to the process through which one might work with children to understand numbers as symbols. As Sigel (1986) has pointed out, the first step in the process of understanding rules of transformation is "conservation of meaning." The child needs to understand that the three-dimensional representation of the object and the picture of the object retain a common identity. Once understood, the child then begins developing the capability to anticipate, to use hindsight to think about alternative action and/or to transcend the given task.

The Chaille and Freeman paper describes a project in which the authors are studying young children's transformations with apparently simple manipulables such as playdough and construction toys. In their work they are studying the role of social context—the immediate playmates and classroom climate—in influencing children's actions. The way in which social exchange interacts with materials that vary as a function of possibilities for manipulation could make an important contribution to the way in which we think about helping children to conserve meaning. In particular, findings that describe the conditions under which such sharing exists could inform the selection of tasks (play objects) available to children during free play. In this way it would be possible to provide young children in free play with a variety of tasks, each of which would challenge the children in different ways. This would move away from our typical "bag of tricks" approach, in which a lot of play objects are provided but many appear to be overlapping in terms of potential actions afforded. Findings from this study should also enable us to begin to document how malleable the child's logic, once developed, is—in other words, will the social context lead the child to change from one pattern of actions to another? Similarly, would altering the social context mean that the student's inability to focus on the "mathematics" of a mathematics task would be reorganized?

It seems obvious that we first need to know something more about how the process of representation works and how it varies across tasks in order to answer questions about how representations are transformed. The Kaplan et al. paper argues for this kind of study. The Chaille and Freeman paper outlines the way in which such information is beginning to be detailed. The Beilin and Futterweit paper suggests ways in which differences in tasks might be conceptualized.

In his paper, Winegar extends this discussion of representation and learning by considering both the social context within which representation occurs and the multiple ways in which we might assess learning. As he might suggest, decontextualizing processes of representation outside of a larger theoretical context may be an inappropriate goal. Rather, he argues for study of both actual and potential learning under conditions of both independence and assistance as contributing to a description of basic structures of development and how these hold across contexts. From this perspective, the study of context provides an opportunity to replicate and validate "prevailing patterns of complex processes." This tact emphasizes the importance of the precursors of emerging abilities and the potential role of context in facilitating their development. In terms of practice, such an approach renders terms such as "failure" meaningless and instead raises questions about the role of peer grouping (or more generally, tasks which involve social exchange) in developing the child's ability to conserve meaning, to begin anticipating, to reconstruct alternatives to past action, and to transcend the task.

What can the study of representation tell us about learning? Taken together, the present papers urge us to recognize the various dimensions of child-task engagement and the role of others in facilitating the child's emerging representational compentencies. They suggest that consideration of each child's actual level of development and past performance does not necessarily tell us about the child's potential performance. Rather, closer study of how children understand the tasks with which they are presented and the conditions of presentation may in fact yield more specificity about how to order tasks, when to present them and under what conditions, given individual children's emerging capabilities. Such information may also enable us to work better with students whose "faulty rules" (Ginsburg, 1982) have led them to make the tasks with which we present them into something other than that which we intended. Study of representation may mean that eventually learning will almost always include "the mathematics" intended by particular assignments.

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