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Encyclopedia of Education, Second Edition

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Gene I. Maeroff

CATEGORIZATION AND CONCEPT LEARNING

Education in every form entails the acquisition and modification of conventional categories and labels, as well as processes for inferring category membership. Consider these statements: "Fractions are numbers between two integers"; "Plants get energy through photosynthesis"; and "A noun is a person, place, or thing." The first claims a formal relation between well-defined number concepts. The second explains a biological concept by analogy. The third specifies (erroneously) a linguistic category. Teachers frequently make statements like these to elementary and secondary students. How, in fact, are the named concepts learned? How do concepts change with age, experience, and particularly education?

Form and Format of Conceptual Knowledge

A common misconception is that concepts are well defined, like dictionary entries. Though hundreds of concepts, particularly scientific ones, are well defined within a community of experts, most are "fuzzy" and metaphorical. Even patently well-defined categories like "odd number" are treated as if some examples are better than others.

Adults' concepts fall into a wide variety of abstract representations, such as taxonomic hierarchies, kinship systems, and legal definitions. Some representations mirror the structure of the physical environment, whereas others are rather arbitrary products of their cultural and linguistic environments. Most are a synthesis (e.g., biological categories reflect real patterns among organisms, yet are shaped by culturally specified theories). Children's concepts also reveal abstract representations, but these are generally less elaborate and less well-defined than those of adults.

Conceptual knowledge, as symbolic as it seems, is encoded as patterns of electrochemical activation within powerful neural networks in the neocortex. These concept patterns are derived from repeated experience. Experience trains massively interconnected systems of neural units (analogous to groups of neurons) by changing connection strengths. Over time, associated input patterns (e.g., sights and sounds of a cat) will activate a characteristic response pattern. This response is a concept (cat). Critical features of these concept patterns are graded activation (i.e., some inputs activate the response more strongly than others) and learning algorithms that specify how connection strengths change with experience. This pre-symbolic view of conceptual representation, though unintuitive, is dominant among cognitive scientists, and work in the mid-1980s through 1990s has answered some early criticisms. Still, questions remain about how conceptual thinking emerges from in neural networks. For example, it is not clear how current theoretical models can capture intricacies of conceptual knowledge (e.g., nonliteral usage of concepts, as in the ironic use of *award* in the "Golden Turkey Awards" for the year's worst movies).

A comprehensive proposal by Lawrence W. Barsalou in 1999 holds that concepts are inherently perceptual and experiential. So-called abstract conceptual knowledge is in fact the productive activation of remembered aspects of perceptual and internal experiences. As experiences are retained in memory, the associations among them permit new mental simulations that support a variety of functions. These functions include conceptual redescription, inference, imagination, and productive combination of concepts. These functions are traditionally ascribed to symbolic, completely abstract concepts, but Barsalou argues that they can more simply be attributed to a powerful system for manipulating stored perceptual knowledge. The power of the system rests on selective simulation: when the concept *cat* is activated, one does not recall every cat experience, but the experiences evoked by current contextual demands and recently activated information. Thus, the word *skunk* might normally activate

the property *smelly,* but after watching a documentary showing footage of skunks foraging at night, the property *nocturnal* might be activated as well.

Educators should judiciously use definitions to teach new concepts. Students will not typically use definitions to judge category membership. Exposing students to multiple examples that highlight the distinctive properties of the category of interest, or comparing contrastive categories, is more effective. A common misunderstanding of concept learning can be seen in the traditional western approach to mathematics education that emphasizes abstract or "content-free" knowledge. There is no evidence of such decontextualized knowledge, and it should be assumed that mathematical concepts are derived from organized experience with concepts of quantity (e.g., cardinality, equivalence) and operations on quantities (e.g., concatenation; transformation), in a variety of familiar materials. Although it is trivially apparent that diverse, rich experiences eventually increase knowledge of mathematical and scientific concepts, the general, powerful principles for optimizing the presentation of multiple examples in classrooms, so that students' conceptual knowledge is effectively and efficiently enriched, have not yet been derived.

Theories of Category Learning

How do experiences give rise to new categories? Presumably individuals are exposed to various members, and sometimes told about category membership. Parents use various strategies for teaching children new categories, category labels, and associated properties. But how does experience generate new categories?

In the 1994 model of Robert M. Nosofsky and his colleagues, people distinguish contrasting categories by gradually modifying the degree of attention allocated to various features of possible category members, until the simplest and most diagnostic decision rule (i.e., set of attention "weights" focusing on the fewest possible features) is attained. Atypical category members (e.g., ostriches, which differ from typical North American birds in many regards) are represented separately, as exceptions. Current controversy focuses on the information retained from multiple experiences, exact algorithms for describing changes in represented categories with experience, and the uniformity of category learning across domains. For example, there is evidence that people treat atypical examples differently across the domains of natural, object, and social categories.

How do children learn categories? Little research addresses changes in category learning processes during and after childhood. Research on children's categories often confounds their conceptual knowledge with their comprehension of category labels. A current debate concerns what categories children acquire first. Though prelinguistic infants differentiate related categories (e.g., *cats* vs. *lions*), their knowledge might not transcend surface similarity. Knowledge of the dynamic or hidden properties of categories becomes evident after the first six months, but two-year-olds still sometimes fail to differentiate related categories (e.g., calling any water fowl *duckie*) or categorize different-looking entities. In such cases parents can shape children's naming. Children, however, select and organize social input about categories and labels. For example, parents predominantly use basic-level labels when talking to children. Basic-level categories (e.g., *car, bird*) capture a useful intermediate level of generality, compared to very broad (e.g., *animal*) or narrow (e.g., *parakeet*) categories. Compared to parents, however, preschool children use a much higher proportion of basic level labels, suggesting that children's inductive dispositions (or limitations) shape their acquisition and use of category labels.

Adults can help children focus on similarities of, and variability between, category members. Both social input and selection and tailoring of available examples can facilitate category learning. An unresolved question is how analog (i.e., rich, realistic), versus digital (i.e., reduced, electronic), examples can facilitate children's concept learning. This is a practical question, given the growing availability of computer technology for young children. A problem is that children sometimes mistake which features define a category (e.g., rejecting a barren island but accepting a tropical peninsula as examples of island). Predicting children's misconceptions about categories is therefore crucial for teachers. Verbal instruction about critical features can be ineffective or misleading, so teachers must orchestrate creative experiences and instruction to advance children's grasp of conventional categories.

Conceptual Change in Children

Children, adolescents, and adults enter classrooms with naive preconceptions about the world. Shifting these preconceptions can be onerous. In 1985 Susan

Carey documented children's changing biological concepts and related inferences about biological properties. For example, a child who conceptualizes people as prototypes of animals will extend traits of humans (e.g., respiring, sleeping) to similar creatures (e.g., gorillas), but not dissimilar ones (e.g., worms). In contrast, adults often generalize biological properties in a less anthropocentric manner.

The process of conceptual change is mysterious, and frustrates educators' desires to facilitate it. Researchers have suggested many procedures to promote conceptual change, but naive concepts can be extraordinarily intractable. For example, even after formal physics instruction, older students make pervasive errors about concepts like force. One approach to teaching stipulates having students articulate their concepts, setting up a demonstration that would yield different results under the naive and the conventional belief system, having students predict an outcome, and then conducting the demonstration. Apparently articulating and confronting the discrepancy between own and others' beliefs, and seeing relevant evidence, can provide a powerful springboard for conceptual change. Note, however, that this approach is effective with older students revising well-defined concepts in a mature science. Its effectiveness for young children, whose capacity to recognize disconfirming evidence is limited, has not been established.

The Functions of Categorization in Children's Thinking

The content of children's categories changes with age, but what of the uses of categorization and concepts? Concepts constrain perception, language, social interaction, and problem solving—every aspect of cognition. Categories permit economic thinking, inferring properties of novel instances, organizing memories, making analogies, and solving problems with flexibility. It is not known how education, informal learning, and maturation separately alter these functions. In short, there is a lack of a developmental theory of the ecology of categorization that takes into account development and schooling. Outlining this theory is a major task for developmental and educational psychology in the twenty-first century.

See also: Language Acquisition; Learning, ***subentry on*** Conceptual Change.

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Gedeon O. Deák

CATHOLIC SCHOOLS

In 1783 Philadelphia Catholics established the first Catholic parish school in the United States, and over the next two centuries, Catholic parochial schools would educate tens of millions of American citizens. By the middle of the 1960s, when the Catholic parochial school movement had reached its high point, there were more than 5.7 million children in parish elementary schools—12 percent of all of the children enrolled in schools in the United States at that time. The challenges of providing parish-based education have changed from one generation to the next, but Catholics schools have survived in spite of substantial obstacles.

Foundations

During the sixteenth, seventeenth, and eighteen centuries, colonial Catholics struggled merely to survive in that vast territory that would become the United States of America. In fact, the progress of the church in all of the colonies of the New World (Spanish, French, and English) was due largely to the personal sacrifices and skills of a cadre of great priests. Their willingness to give their all, including their lives, left a Catholic imprint on virtually every region of the country.

That is not to say that Catholic schools emerged because of these missionary efforts. It would take many generations for American Catholics to feel secure enough to establish their own schools. In fact, the very survival of Catholicism as a religion in America was in doubt until the late eighteenth century. Those Catholic schools that did emerge in the early decades of the American Republic were the direct result of a collaboration of interested parents, determined pastors, and compassionate sister teachers. Of special note was the persistence of Elizabeth Seton, who recruited and trained the sister teachers who were the backbone of the parish school system for nearly 125 years.

Yet the most important ingredient in the eventual spread of Catholic education in the nineteenth century was parental support. Beginning in the early 1800s, many American Catholic parents were willing to build and support parish schools. These parents believed that the future of Catholicism in the new nation was tied to educating the next generation in the ways of the faith.

Rapid social change and population growth, accompanied by misunderstanding, hostility, and resistance, were important ingredients in the process of Catholic educational development in the years before the Civil War. Civic leaders argued in favor of common schools that would transform a diverse population of children into a homogeneous, deferential, and very American citizenry. Catholics resisted these common schools because of their distinct Protestant overtone, and they built their own schools.

The tensions between public and Catholic schoolmen forced the two sides to modify the content of their curricula. After a decade of violence in the 1840s, both sides sought other ways of winning the hearts and minds of the Catholic population. Public schoolmen took measures to make their schools less sectarian. Catholic schoolmen countered with measures to make their schools more secular. Both sides were competing for the attention and loyalty of Catholic parents and their children. It was a competition that would continue well into the twentieth century.

Educational Choices

In the later decades of the nineteenth century, Catholics shifted their attention to controlling the growth and development of Catholic education from within