Thinking About Learning

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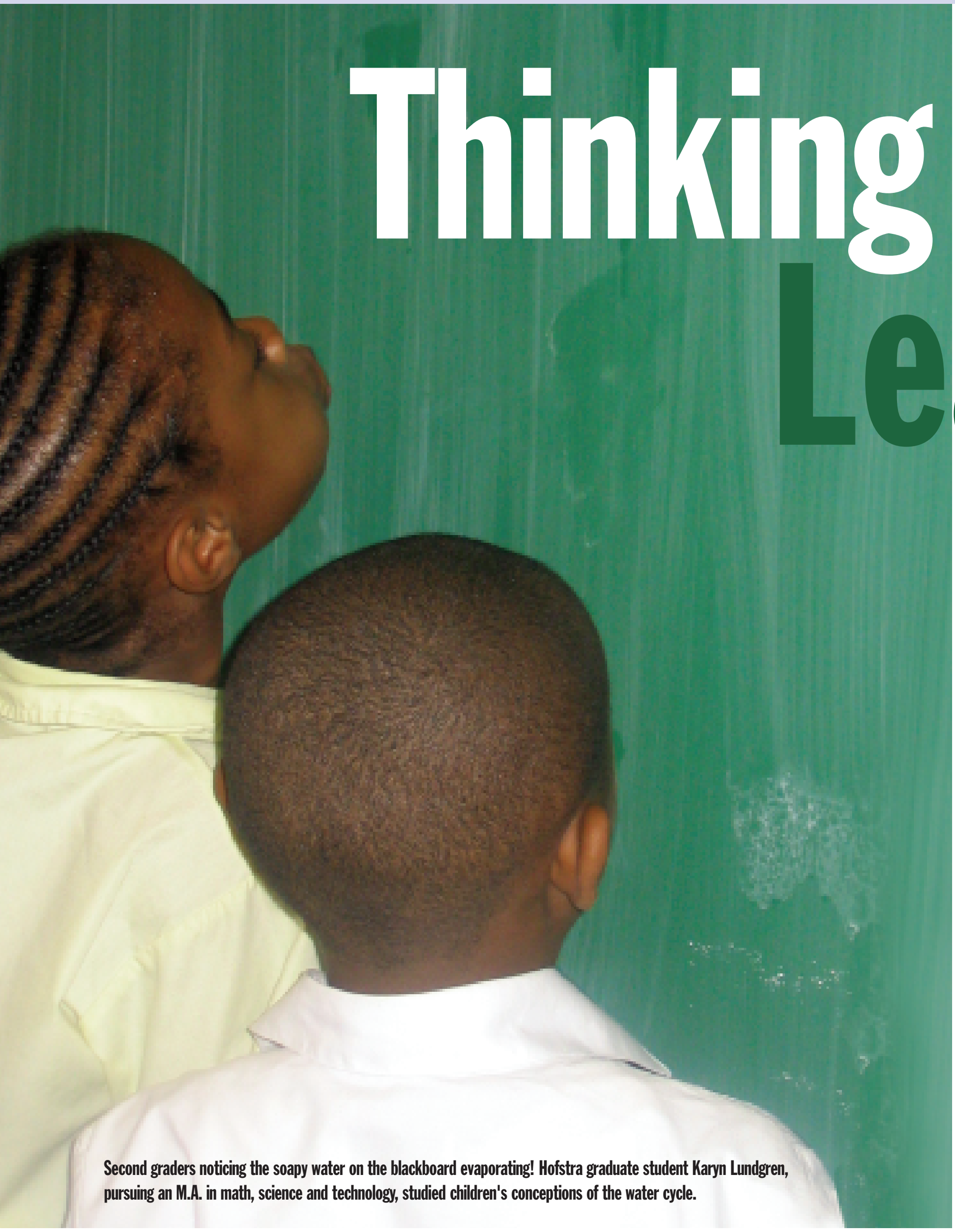


Second graders noticing the soapy water on the blackboard evaporating! Hofstra graduate student Karyn Lundgren, pursuing an M.A. in math, science and technology, studied children's conceptions of the water cycle.

Despite what many believe, learning isn't simply the mental act of adding to what we already know. It's the mental act of reformulating — morphing, so to speak —what we thought we knew into something new and different that might be more inclusive, or more specific, or something that under a banner of different descriptions involves new ways of thinking. Learning occurs through conceptual change, a phenomenon that can be described through constructivist learning theory.

But constructivism is controversial. It is cited as the fundamental theoretical basis of position statements and learning standards published by many national educational associations, such as the National Council of Teachers of Mathematics, the National Science Teachers Association, and the National Council of Teachers of English, to name a few. However, it is also targeted by many political groups as the reason why Johnny and Jane "can't." Why they can't read, can't compute, can't recall historical events, can't locate cities on a map ... just can't.

The Controversy

So, what is so controversial about constructivism? Constructivism is the theory that learners generate meaning through the active mental process of formulating and reformulating knowledge. Broadly, this framework stands in contrast to other assertions that the learner's mind is a clean slate ready for inscription through direct instruction, or an empty vessel ready to be filled by the instructor. After all, it's much easier to think of learners as blank slates or empty vessels than as everyday theoreticians with intellectual autonomy who formulate, reformulate, and reformulate ideas yet again. It's easier to think of education as "test them, teach them, and test them again," than as a process essentially controlled by the learner and mediated by the teacher. The controversy about constructivism is rooted in the debate over how people learn (and, therefore, how teachers teach), with some attributing the power to learn to the learner, and others attributing it to the teacher.

Bernel Connelly-Thomas, a Hofstra graduate student, studies children's conceptions of surface tension by guiding them in their observations of swirling food coloring in milk.

Constructivism has become the lightning rod for critics of progressive education because of their contention that in constructivist classrooms, basic skills (for example, calculating the circumference of a circle using a formula) seem to take a back seat to larger conceptualizations (for example, the relationship between the circumference of any circle and its diameter consistently being a little greater than 3:1, regardless of the size of the circle, π:1, to be more precise!). But, the general public does not well understand the relationship between the ability to compute effectively and the ability to understand the essential relationships that give rise to the formula used in the computation. This is why it often appears to critics that the curriculum is being watered down and that teachers spend too much time on ideas that don't really matter. But, neither is true. To the contrary, there is research (TIMSS, 1995, 1998, 2003; NAEP, 1999) showing that students taught math and science in the so-called "traditional" ways often perform in the fair to poor range on national and international measures of success, the very type of measures used as indicators of success of basic skills teaching.

Perhaps Johnny and Jane "can't" because schools have become quite proficient at doing the wrong things with students. When learning is thought to be the result of meticulously scripted delivery systems, prescribed curricula and regulated assessment systems, rather than the making of meaning by the learner, Johnny and Jane spend their time following directions and getting "right" answers rather than experimenting, being wrong (and right, too), and learning from their own errors. Sometimes Johnny and Jane spend their time on activities that, on a glance, look like they're part of a constructivist classroom, but aren't. For example, students in a traditional class might build model structures of different types of bridges in order to investigate different types of forces. In these classes, students design, build, weigh, and load the models until they collapse. There are many of these classes in which the tumbling of the bridges signals the end of the activity and thus, the end of the thinking. In these settings, students often focus only on who had the "best" bridge.

On the other hand, constructivist classrooms that offer opportunities for rich learning require teachers who can extract basic, organizing principles and content from student inquiries (Baker and Brown, 1991; Hawkins, 1992). In the constructivist classroom, the lesson described above only begins when the bridges tumble. The purpose of the bridge building is to provide a contextual problem in which the teacher situates the learning of patterns. The teacher might encourage students to identify the generic designs represented, support students in their attempts to group the designs, challenge students to consider what these groupings imply about forces, provide resources for students to compare their results with other published sources, foster the selection of appropriate text material for further information, and facilitate student documentation of results. These teacher prompts foster pattern recognition. At the end of the research, the teacher might ask the students to build another set of bridges, and compare the performance of the new set to that of the previous set. Within this scenario, the students demonstrate their capacities to explain their reasons, thereby exhibiting what they have learned.

Pattern Recognition Is Key in Constructivism

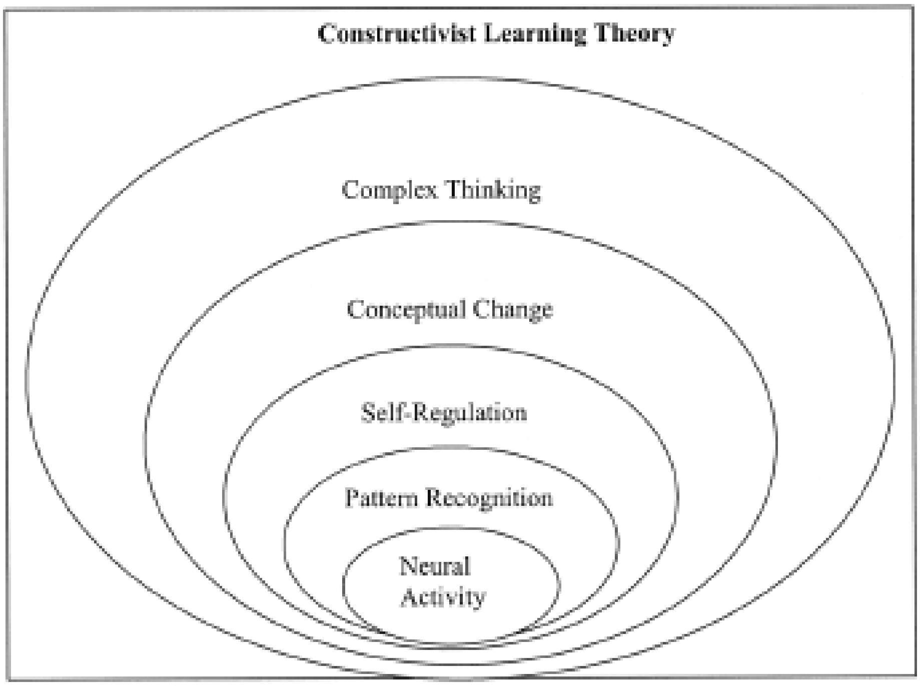
The study of pattern recognition, described as learners' quests to map relationships among parts of a concept, and to group those relationships into ever-more inclusive mental structures, has become increasingly noted within the research literature. There are many studies pointing to the importance of pattern finding. For example, the large-scale ARC Center Tri-State Student Achievement Study (2000-2001) examined the performance of students using three elementary mathematics curricula based on constructivist theory that were developed and researched through the National Science Foundation. While each of the curricula takes a unique approach, all three, to varying degrees, invite young students to study mathematics as a pattern-finding science, stressing communication of mathematical content through critical literacy, and building teacher knowledge of how students learn mathematics. Not surprisingly, it was found that students in classrooms using these curricula consistently outperformed the comparison students on a number of state standardized achievement tests. These significantly higher average scores held true across grade levels, reading levels, SES, racial/ethnic identity and other variables. In another example, two well-known science curricula generated at the Lawrence Hall of Science at the University of California in Berkeley focus broadly on pattern recognition, and research on those programs report student transferability of skills, among other successes (Klentschy, Garrison, & Amaral, 2001; Franklin-Leach, 1992; Jones, 1990). It is hypothesized by this author that pattern recognition facilitates the mental self-regulatory strategies that result in conceptual change, with continual conceptual change resulting in increasingly complex thinking.

Learning About Learning

Do students interacting with teachers who foster the discernment of patterns learn to seek efficiency in the self-regulatory strategies that produce complex thinking? This research question brings us closer to the core of learning about learning and provides opportunities to create educational environments based on new understandings (See Figure 1). How close we can get to understanding complex thinking on the neural level is an open question, and beyond the scope of our current efforts. We hope to answer these questions in the future by forming professional alliances within the neuroscience and educational communities, by creating clear research protocols within these alliances, and by relying on the future development of instrumentation in the imaging field.

Jill Greismeyer, a Hofstra graduate student, studies children's conceptions of density by inviting them to make their own salad dressing.

Figure 1. **Conceptual Framework**



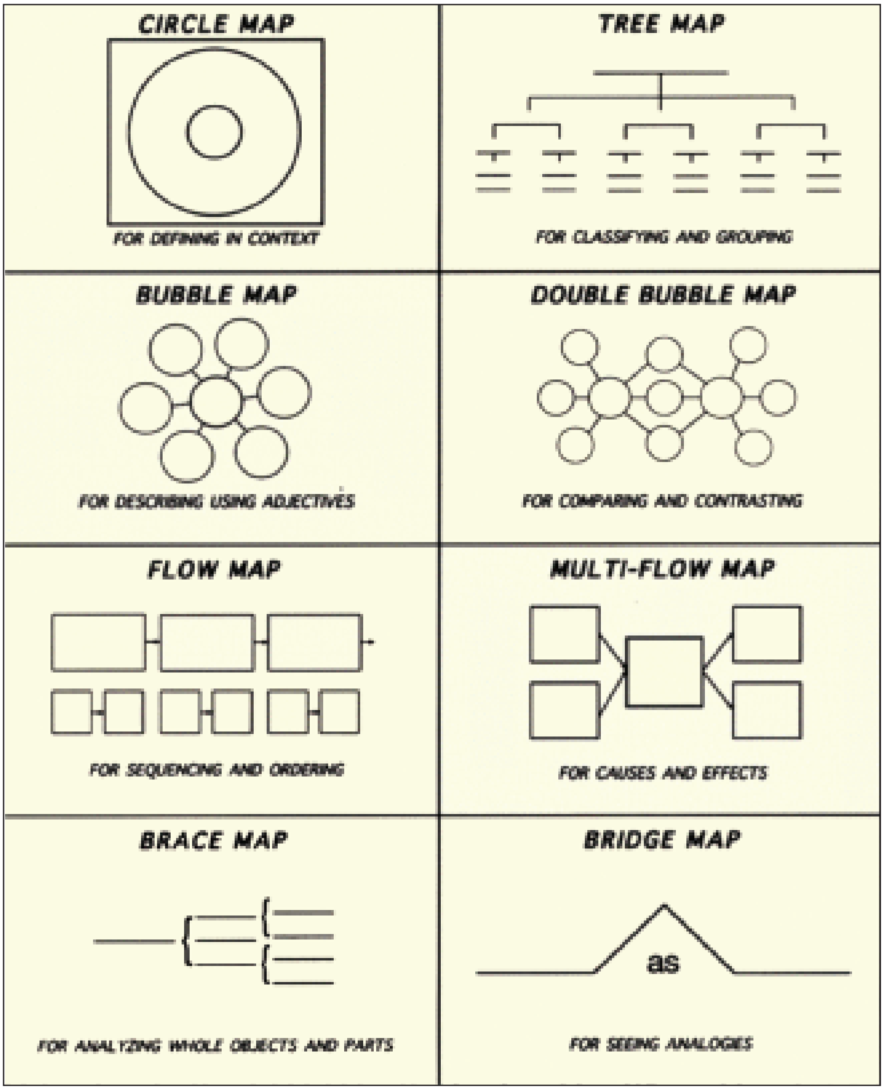
Still, there are many exciting developments already underway. Current neuroscience research uses a number of methods to detect brain activity. The process of using sensors to detect the magnetic field created as brain cells communicate is called magnetoencephalography (MEG). Recent advances in instrumentation and the present day design of the helmet-shaped magnetometer used in MEG studies have allowed for a number of new understandings of brain function by combining the temporal information gained through MEG with the structural information gained through magnetic resonance imaging (MRI.) Although new and very promising understandings of brain function are being generated through MEG and functional magnetic resonance imaging (fMRI), we are not ready to apply this technology to brain mapping studies useful to teachers. A number of technological and research protocol advances must be made to take the step from generating the types of brain maps available today to generating types that may, or may not, in the future, link teaching strategies with brain cell activation. Alliances between researchers conducting cognitive science investigations on conceptual change and researchers conducting brain-mapping studies of brain cell communication could set the stage for a new era in learning about learning. Imagine being able to compare brain cell activity during lessons requiring rote computation versus complex problem solving! Not insignificantly, these advances in research may someday offer neurological evidence of the power of constructivist pedagogical approaches.

Studying Concepts, Mapping Patterns

But back to today's research and today's classrooms. It is widely recognized that what students learn in school is rarely generalized into applications, theories and principles subject to further investigation. Therefore, deep understanding is often absent and, with it, a basis for reasoning and explanation (Schoenfeld, 1988). In order to further educational practice targeted at promoting pattern recognition and also generate a research approach that studies learners' pattern recognition and conceptual change, the Thinking Maps™ language (Hyerle, 1996) is a useful tool (See Figure 2). This language helps the teacher look for and find patterns within the concepts under

Andrea Schmidt and James Ufier, Hofstra graduate students, exchange some laughs as they use apples and oranges and the very air around us to study children's conceptions of the process of oxidation.

Figure 2. Thinking Maps as an Educational Tool



study for him/herself, helps the teacher replicate that opportunity for the students in his/her classroom, and provides a vehicle for the collection of data on student pattern finding. The thinking maps are based on the theory that there are fundamental cognitive skills that can be dynamically represented through visual mapping.

The Thinking Maps™ constitute a common visual language that teachers and students can use, either independently or within cooperative structures, for making sense of stored knowledge and for building new concepts, linear and nonlinear. Each of the eight maps can help a thinker generate new ideas, consistently organize those ideas, and process them on a deep and dynamic level. The simple maps, called graphic primitives, can be configured into more elaborate ones. Each map is associated with a fundamental cognitive skill, and each provides a language for cognitive terms: representation of context, description of attributes, comparisons/contrasts, inductive/deductive classification, part/whole relationships, sequences, cause/effect, and analogies. These maps are effective, and approximately 3,500 whole school faculties, mostly at the elementary school level, use thinking maps in their educational programs. As a result of their use, initial case studies report increased recall of content when reading, greater capacity to communicate abstract concepts, and the transfer of thinking processes learned in one setting to another (Hyerle, 2004).

As described by Donald Stokes in *Pasteur's Quadrant* (1997), research on student learning must occur in the natural settings of schools because only there is it use-driven, systematic and strategic. In his book, Stokes eloquently makes the case for needing to fuse two types of research: research to understand the nature of learning, and research to apply learning principles to practice. In order to document student learning that is correlated with the nature and development of pattern recognition, the student learning being researched must take place within an environment that fosters such processing. As recommended by the National Research Council in its important book *How People Learn* (2000), the fusion of research and practice through professional learning communities provides pathways for teachers to re-frame practice based on their own action research, research that contributes to understanding the processes by which learners construct meaning from the objects, texts and phenomena of everyday life and of educational settings.

Using a wide range of research tools in both traditional and innovative settings, many of us within Hofstra's Department of Curriculum and Teaching seek to address the essential need to better understand and more fully implement methods of teaching consistent with what we know about learning. Within many of Hofstra's undergraduate and graduate teacher education programs, novice teachers participate in action research endeavors. They generate essential questions and continually revisit hypotheses as they examine their practices, monitor the impact of student understandings and observe the expansion of learners' repertoires of knowledge to expanded contexts (Sagor, 1990). These novice teachers' settings include diverse learners, diverse subject areas and diverse learning environments. The broad aim of their action research studies is to facilitate discovery and understanding of learning processes while promoting teaching and learning based on those newly derived understandings. Pattern recognition is emerging as an area of interest on the national research horizon, and we are offering our Hofstra students the perspectives, skills and tools needed to understand this dynamic way to think about teaching and learning, and to implement research-based pedagogy as professionals in the field.

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Jacqueline Grennon Brooks' interest in how people learn began with her first job as a sixth grade teacher and has led to her current study of the role that pattern recognition plays in conceptual change. Dr. Grennon Brooks' education is diverse, and includes an Ed.D. from Teachers College, Columbia University, where she researched the development of constructivist teaching practices; an M.A. in developmental psychology from Teachers College, Columbia University, where her study of constructivism began; an M.S. in urban and policy sciences from the State University of New York at Stony Brook, where she analyzed mathematical forecasting models at the Congressional Budget Office; and a B.A. in education from the State University of New York at Stony Brook, where she learned just how complex teaching really is!

Dr. Grennon Brooks has been studying learning processes for many years and has written widely on the subject. As an advocate for change in today's educational system, she is a frequent contributor to school districts and educational associations. Her 1993 book, *In Search of Understanding, the Case for the Constructivist Classroom*, co-authored with Martin G. Brooks, has been translated into four languages and continues to be one of the publisher's best sellers. Her recent book, *Schooling for Life: Reclaiming the Essence of Learning* (2003), has received highly positive reviews in the field. Her work, cited in many texts and multimedia programs, was recently selected by the National Science Teachers Association for inclusion in its *Exemplary Science Monograph Series*. Her chapter "Teaching Science With Student Thinking in Mind" will appear in a volume to be released this fall. Dr. Grennon Brooks was also recently recognized by the American Educational Research Journal for outstanding service in publications.

Dr. Grennon Brooks joined Hofstra's Department of Curriculum and Teaching in 2003. Previously, she directed the secondary science teacher preparation program at Stony Brook University, where she was the founding director of both the Biotechnology Teaching Laboratory, a learning center for students and the general public on emergent research techniques and issues, and Discover Lab, a clinical practice site for pre-service and in-service teachers. Dr. Grennon Brooks has held many other positions in the field of education, including middle school science and math teacher, alternative education teacher for at-risk students, coordinator of gifted programs, and guidance counselor.