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A Certain Sameness: Structuring the Curriculum for Higher Order Thinking

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What do we do when we solve problems in mathematics or science? How do we think when we write or read? What processes do we use? What can teachers do to teach their pupils to think?

Educators frequently associate higher order thought with the upper levels of Bloom's taxonomy of educational objectives (Linn & Gronlund, 1995). These entail the analysis, synthesis and evaluation of concepts, rules, strategies, etc. Carnine (1991) argued that the process that underlies concepts, rules, strategies and so on is noting samenesses.

Every concept, rule, or strategy is defined by a *sameness*. For example, the concept "new" can be applied to new clothes, new ideas or new car. Each of the new things has the sameness that they are not old, or not previously known or possessed. We can also look for sameness according to polar concepts (e.g., full, hot), comparatives (e.g., bigger, faster), positional concepts (e.g., on, beside), colours, and class concepts (e.g., dogs, cars).

Merely being able to identify something as blue, or big, or hot is not evidence of concept learning. To demonstrate knowledge of a concept, a learner must be able to identify novel instances of an object or event as belonging to a particular class of objects or events. The learner notes the sameness of the objects or events. For example, a car, the sky and a T-shirt may all be classified as blue. They may be different shades of blue, but still identifiably blue, and not green or indigo.

Expert learners organize their knowledge in an interconnected and hierarchical structure around explanatory or causal relationships (Feltovich, 1981, cited in Carnine, 1991). Samenesses in mathematics include solutions, methods and numerical patterns, while in science the important samenesses are underlying laws and in history they are methods of analysis.

Noting samenesses is an indiscriminate process and can lead to misconceptions. For example, a young child may learn that the four-legged creature in the house is a cat. When the child sees a dog, she may notice some of the samenesses (e.g., animal, four legs, fur or hair) and call it a cat. As her learning becomes refined and she also notices differences, she will be able to classify both as animals and even as mammals because of the samenesses they share. She will also learn to discriminate between them because of differences. Within a class such as dogs, she may eventually be able to classify dogs as terriers or not terriers. This involves noting samenesses and differences.

Slightly older children may note a sameness between the letters *d* and *b* and between the words *was* and *saw*, while failing to notice their differences. Later they should be able to identify *b* when it is written in different fonts and sizes because they all possess the sameness that makes them *b*.

As students seek samenesses, they sometimes attend to irrelevant features. While subsequent experience often causes students to revise or refine their understandings, many do not and proceed with faulty information. Even if students do eventually self-correct, their learning has been less efficient than if they had learned correctly at first. Well-designed curriculum materials can provide frameworks that cause students to notice relevant samenesses and learn efficiently. The sections that show examples in some curriculum areas.

Mathematics

In geometry students learn equations for surface area and then for the volume of various figures. They are usually expected to memorize seven formulas to calculate the volume of seven solids:

Rectangular prism: $V = lwh$
Wedge: $V = (lwh)/2$
Triangular pyramid: $V = (lwh)/6$
Cylinder: $V = \pi r^2 h$
Rectangular pyramid: $V = (lwh)/3$
Cone: $V = (\pi r^2 h)/3$
Sphere: $V = 4/3\ (\pi r^3)$

Merely memorizing equations does not require or encourage higher order thinking about volume. A sameness analysis reduces the problem from seven separate formulae to slight variations of one formula: the area of the base times the height ($b \times h$). It also introduces an important concept: volume is a function of the area of the base and the height. Programmes that present seven diverse formulae, and encourage rote memorization of them, obscure this function (Carnine, 1991).

The first step is to classify the solids as rectangles (prism, wedge, cylinder), pyramids (rectangular, triangular, cone), and the sphere. The second step is to transform the formulae using prior knowledge of how to calculate area of bases, *b*: ($b = l\,w$ or $b = \pi r^2$).
Rectangles: $V = b\ h$
Pyramids: $V = (b\ h)/3$
Sphere: $V = 2\ (b\ h)/3$
(For the sphere, the base is the area of a circle that passes through the centre and the height is the diameter.)

Engelmann, Carnine and Steely (1991) provide several other examples of sameness analyses in mathematics. For example, they apply the sameness principle in the number family to word problems requiring comparisons, sequencing, classification, data tables, multi-step problems, fractions and percentages.

History

History often concerns the decisions and actions of people and governments in response to problems. Kinder and Bursuck (1991) proposed teaching students to use a *problem - solution - effect* structure for analyzing historical events. In their analysis of American history, they found the causes of the problems to be small in number and that there were a few, common solutions to those problems. The outcomes or effects of the these solutions frequently resulted in other problems. This pattern (*problem - solution - effect*) is a sameness that can facilitate understanding of relationships between events, facts, and concepts.

Most of the problems they analysed shared the sameness of being economic in origin, although they also identified issues such as human rights and religious freedom. Solutions could be classified as fighting, moving, inventing, accommodating, or tolerating the problem. Kinder and Bursuck (1991) suggest that, if learners can identify the problems, solutions and effects in historical events, they may look for these features when reading history. This framework will assist them to organize and understand information. This approach does not eschew the need to teach knowledge such as the basic economic principles necessary to make a problem analysis, and skills such as note taking.

Science

Learners may apply underlying scientific principles to a range of scientific phenomena. that share the sameness of the scientific principle. Woodward and Noell (1991) propose that students learn conceptual models that will help them think systematically and apply their knowledge to other problems.

To describe the principle of *convection*, Woodward and Noell (1991) use the example of a pot of boiling water. Heat transfers from an element to the molecules of water which then move in a roughly circular pattern. Several principles are imbedded in this. These include the principle of dynamic pressure (movement from high to low pressure), the principle of conduction, and relative density (expansion reduces density). Woodward and Noell describe how to teach each principle independently and then cumulatively link them to other principles. Students can generalize their understanding of how convection cells work in a pot of boiling water, to phenomena such as circulation patterns in the atmosphere, the oceans and the earth's mantle. Students learn that explanations of these include the model of the convection cell. It is also important for students to also learn relevant differences between these phenomena. For example, the rotation of the earth also influences atmospheric movements.

Knowledge of the samenesses and differences provides an explanatory framework for higher order thinking. Woodward and Noell (1991) describe the following problem: A person is standing on a beach watching the sunset. A mild wind is blowing and no special weather factors are present (e.g., an approaching storm). In which direction is the wind blowing and why? Students should be able to draw on their knowledge of convection cells and changing heat sources (as the sun sets the land cools faster than the ocean). Once they deduce that air will rise over the ocean and begin a convection pattern, they will be able to state that air will move from the land towards the ocean and explain why.

Composition

A source of sameness in writing is the recurring patterns or structures in text (Englert & Mariage, 1991). A number of structures underlie the organisation of text. These include the narrative structure and the expository text. Narrative text shares the samenesses of having a setting (characters, time, place), a problem, a response to the problem, an outcome and a conclusion. This sameness enables students to analyze a narrative text and to structure and create their own narrative passage. Following such a structure will help students to include all of the necessary elements and to use correct sequencing.

There are several expository text structures to guide writers. These include comparison/contrast, explanation, problem/solution, and thesis/statement (Englert & Mariage, 1991). Each of these structures answers different questions. For example the comparison/contrast structure answers the questions: What is being compared and contrasted? On what features? How are they alike? How are they different? The explanation structure answers questions such as: What is being explained? What materials are needed? What are the steps? What happens first? Second? and so on.

Students need some prior knowledge and skills to use these text structures. For example, they need a semantic knowledge of terms such as alike, different, similar etc. They also need to be able to classify a writing or analysis task as requiring a particular structure and to identify the correct elements within the structure (e.g., what is to be compared or explained).

Conclusion

Students can learn information more efficiently and think conceptually about their learning if samenesses are made explicit in the curriculum. For example, the sameness in the formula for calculating the volume of solids is not only more efficient to learn, it requires students to think about volume as a concept. Teachers can teach students to apply the sameness principle to academic skills such as writing or analyzing history.

The structure of the curriculum shapes how it is taught. Curricula sometimes appear as collections of facts to be memorized and recalled during examinations. Such structures and examination procedures sometimes lead teachers to present the curriculum as a memory task. This does not promote higher order thinking. Instead, it restricts learning to Bloom's simplest educational objective: the memorization of unconnected facts.

Note

This paper is based on the work of Douglas Carnine and his colleagues. A detailed overview may be found in a special series of articles in the *Journal of Learning Disabilities*, Vol 24 (5 & 6), 1991.

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