Department of Teaching and Learning

Teaching and Learning Presentations

Tennessee State University *Year* 2007

The Use Of Vee Diagrams With Third Graders As A Metacognitive Tool For Learning Science Concepts

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The Use Of Vee Diagrams With Third Graders As A Metacognitive Tool For Learning Science Concepts

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Much school learning consists of rote memorization of facts with little emphasis on meaningful interpretations. For example, students are often asked to solve scientific problems and conduct laboratory experiments in a rote rather than in a meaningful way (Novak, 1988, 1990). Often science knowledge is assumed to be absolute and students are viewed as passive recipients of information (Driver, 1987). In such instances, reading assignments are given, lessons are reviewed, and question-answering is equated with producing "right answers." Under these circumstances, knowledge construction is reduced to factual knowledge production with little regard for critical thinking, problem solving, or clarifying misconceptions.

Texts are often written to support acquisition of factual knowledge. The language of the textbook or laboratory manual is often vague with ill-defined concepts or with lists of facts that are not situated in a context that encourages students to relate new concepts to their prior knowledge. Seldom are these facts and ideas related to students' everyday experiences or to other disciplines (Donham, 1949; Erickson, 1984; Eylon & Linn, 1988; Sarason, 1990; Schwab, 1976). Further, Novak, Gowin, and Johansen (1983) show that students lack or misconstrue links between text concepts resulting in a failure to assimilate and accommodate new knowledge in their cognitive structure.

It seems that an important role of an elementary school teacher when teaching science is to aid students' ability to reflect upon what they know about a given topic and make available strategies that will enhance their conceptual understanding of text and science experiments. Developing metacognition, the ability to monitor one's own knowledge about a topic of study and to activate appropriate strategies, enhances students' learning when faced with reading, writing, and problem solving situations (see Baker & Brown, 1984). Metacognitive learning occurs whenever individuals are able to self-regulate and control their own learning when confronted with new knowledge. In order for metacognition to occur, one must have strategies for monitoring their understanding of a given topic. An instructional strategy that can aid students in developing metacognitive awareness is the Vee diagram (Gowin, 1981; Novak & Gowin, 1984).

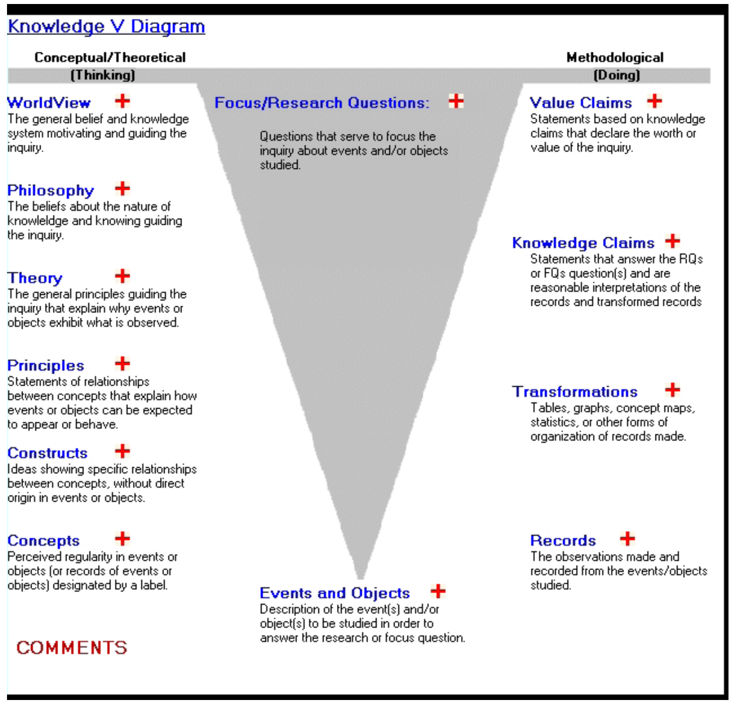
This article discusses the effectiveness of using a Vee diagram to aid students in comprehending and learning science concepts meaningfully. A lesson using a Vee diagram is explained in which the teacher guides students in understanding the concept of "seed germination". A Vee diagram, which is described below, is a structured, visual means of relating the methodological aspects of an activity (such as a science experiment) to the underlying conceptual aspects.

Theoretical Framework

Gowin's (1981) theory of educating, Ausubel's (1963, 1968) cognitive theory of meaningful reception learning, and a constructivist epistemology provide the philosophical and theoretical background upon which this lesson was designed and through which the results were interpreted. Gowin's theory of educating focuses on the educative event and its related concepts and facts. This theory is helpful in classifying the relevant aspects of the educative event. In an educative event, teachers and learners share meanings and feelings so as to bring about a change in the human experience. This theory stresses the centrality of the learner's experience in educating. Ausubel's learning theory places central emphasis on the influence of students' prior knowledge on subsequent meaningful learning. Epistemology is a philosophical term that deals with the nature of knowledge and how knowledge is produced. Philosophers such as Brown (1979), Gowin (1970, 1981), and Toulmin (1972) feel that knowledge is constructed from experience using concepts as stepping stones. Recently, strategies have been reported in which students are active in constructing their own concepts (e.g., Driver & Oldham, 1985; Fosnot, 1989; Pines & West, 1986).

The Vee heuristic was developed by Gowin (1981) to enable students to understand the structure of knowledge (e.g., relational networks, hierarchies, combinations) and to understand the process of knowledge construction. Gowin's fundamental assumption is that knowledge is not absolute, but rather it is dependent upon the concepts, theories, and methodologies by which we view the world. To learn meaningfully, individuals must choose to relate new knowledge to relevant concepts and propositions they already know. The Vee diagram aids students in this linking process by acting as a metacognitive tool that requires students to make explicit connections between previously learned and newly acquired information (see Figure 1).

Figure 1. Gowin's Vee Diagram.



SOURCE: D. Bob Gowin and Marino C. Alvarez. The Art of Educating with V Diagrams. New York and Cambridge UK: Cambridge University Press, p.36.

The Vee diagram separates theoretical/conceptual (thinking) on the left from the methodological (doing) elements of inquiry on the right. Both sides actively interact with each other through the use of the focus or telling question(s) that directly relates to events and/or objects. Epistemic elements are arrayed around the Vee diagram, and represent units that form the structure of some segment or portion of knowledge required to construct a new meaning or piece of knowledge.

The conceptual side includes philosophy, theory, principles/conceptual systems, and concepts all of which are related to each other and to the events and/or objects. On the methodological side of the Vee, records of these events/objects are transformed into graphs, charts, tables, transcriptions of audio or videotapes, and so forth and become the basis for making knowledge and value claims.

The need for instructional tools, such as the Vee diagram, to enhance conceptual learning has been stressed by Novak (1977, 1990). In a study with seventh and eighth graders, Novak, Gowin, and Johansen (1983) found that students could understand and use Vee diagrams in science classrooms, and that science teachers could use this strategy as a part of their everyday teaching/learning practice. The results of their findings, as well as others (e.g., Alvarez, 1987; Alvarez, Risko, Waddell, Drake, & Patterson, 1988; Chen, 1980; Gurley, 1982; Leahy, 1986; Taylor, 1985), suggest that Vee diagrams can aid students by focusing on the salient role of concepts in learning.

The purpose of this lesson was to determine if Vee diagrams could be taught, understood, and used meaningfully to help third grade students learn concepts in a science experiment. The focus question was "Can third-grade students learn science concepts meaningfully through the use of a Vee diagram?"

A Lesson on "Seed Germination"

Preparation

The teacher placed her twenty-eight students into six groups to observe the participation of each student during Vee activities. The teacher randomly interviewed eight students five days prior to the start of this investigation to assess the degree of prior knowledge with the concept to be studied. None of these students gave an accurate account of the designated concept "seed germination" (sprouting plants).

The teacher was knowledgeable on the purpose, terminology, and use of hierarchical concept maps and Vee diagrams. She used the following guidelines when introducing the steps of the Vee.

1. Students should first be familiar with, and be able to construct concept maps before using the Vee (see Novak & Gowin, 1984, pp. 23-34; Stice & Alvarez, 1987). Once students are acquainted with using concept maps, they are shown how concept maps supply most of the information on the "left side" of the Vee. Introducing the concept mapping procedure first also familiarized students with two elements of the Vee: concepts, and events and/or objects.

2. Explain and define the terms: (1) concepts, (2) events and objects, (3) records of events/objects (facts), and (4) focus question(s). (Descriptions of concepts, events, and objects are presented earlier in this article). *Records* are the facts that are gathered of the events/objects being observed. Focus question(s) guides the kind of records students are to make. The kinds and types of records we make are determined by the focus question(s) that we ask. Students are shown by demonstration and explanation how records are used to observe events or objects. Based on these observations of events or objects, records are made (e.g., field notes, interviews, measurements of time, length, weight, height, temperature, audio and videotapes, documents, and so forth).

3. After the records have been made of the facts, the information is *transformed* into a format that allows the student to construct answers to the focus question. This information is organized and put into a format (such as a table, graph, chart, diagram, and so forth).

4. Using the information from the *transformed* data, *knowledge claims* are constructed to answer the focus question(s). Students' thoughts as to why these *knowledge claims* are made are in accordance with their prior knowledge about the concepts and principles already known to them.

5. *Principles* and *theories* follow knowledge claims when introducing the Vee. *Principles* tell

how events or objects appear to behave. For example, in the experiment with sprouting seeds, a principle derived from the outcome is "Plants need air, water, soil, and light to grow." *Theories* show *why* events or objects appear to behave as they do.

6. *Value claims* are statements of self-worth. This involves the affective component. It is an expression of feelings about the findings of the inquiry.

In accordance with these guidelines, the teacher introduced examples of concept maps and Vee diagrams to her students. She then had them construct hierarchical concept maps for the corresponding reading assignments for this unit. For example, students constructed a concept map on the topic of energy. One student approached this topic by showing that energy can be demonstrated by moving water which he described as turning into snow, ice, and liquids which are forms of matter that can be solids, liquids, and gases. His concept map showed these hierarchical relationships with elaborations and examples.

Engagement

For this lesson, a science experiment investigating "sprouting plants" under four conditions was conducted. All four conditions contained lima beans that had been soaked overnight in water and then were placed in a jar suspended between paper toweling and the inner glass. The four conditions were: (1) an inch of water at the bottom of the jar with wet paper toweling surrounding the inner portion of the jar that supported the lima beans against the jar with the top opened; (2) an inch of water at the bottom of the jar with wet paper toweling supporting the lima beans against the jar with a plastic covering so that air could not get in; (3) an inch of water at the bottom of the jar with paper toweling with the top opened placed in a dark compartment without light; and, (4) no water in the jar with dry paper toweling with the top opened.

The teacher gave each student a skeletal Vee diagram that contained these headings: *focus question*, *event/object*, *concepts* to be investigated, *records*, *transformations*, *knowledge claims*, *value claims*, *theory*, and *principles*. She used Gowin's (1981) Q-5 Technique as a questioning strategy to guide students' notations on their Vee diagram. These questions comprised the Q-5 Technique: (1) What is the telling question? What does it tell *on,* or is about?; (2) What concepts are needed to ask the question?; (3) What methods/procedures are useful in answering the question(s)?; (4) What answers are produced?; and, (5) What value do these claims have? The purpose of these questions is to guide the learner's inquiry of a topic under study by focusing attention to the components arrayed around the Vee.

The teacher began by calling their attention to the seeds that had been soaked in water overnight. The teacher explained how the seeds had been arranged in four different jars. She asked, "What do you want to know about these seeds in the four jars?" "What do you suppose will happen in each of these four conditions?" The intent of these questions was to elicit reflective thinking from the students by guiding them in formulating their focus question. The students were then asked to describe the four conditions under events, and list those concepts that they believed were necessary to understand the target concept stated in the focus question. Twice daily, students individually recorded the time of day and what they observed was taking place in these four conditions in their journals.

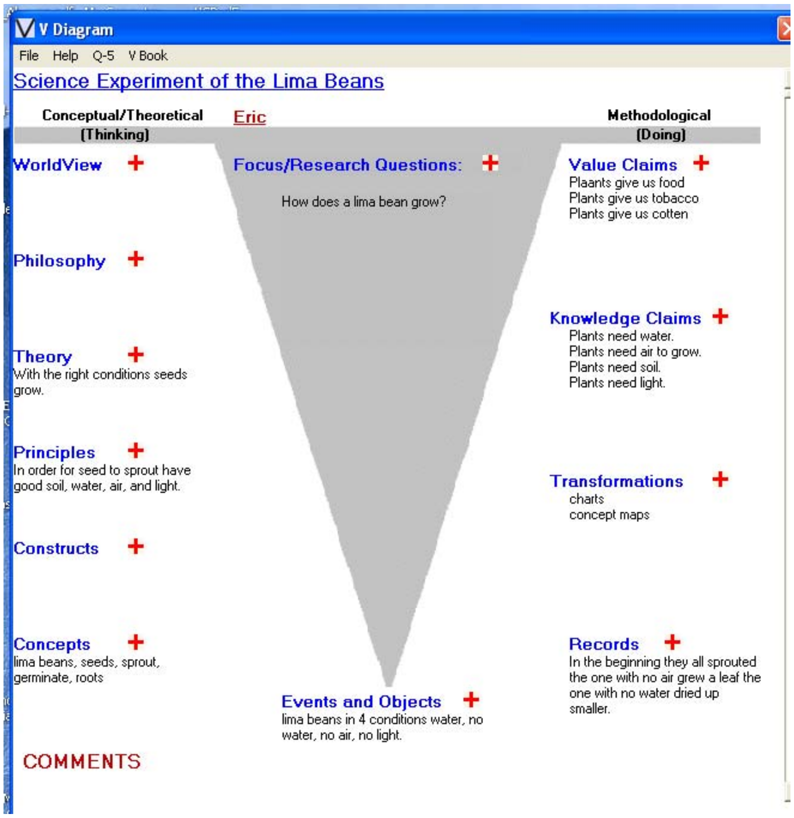
Students were encouraged to share their records of these events and ask questions of each other within their group and with the teacher during their data collection. After six days of observations, each group was asked to use their recorded data to construct a graph depicting their daily observations. Each student was then asked to develop a hierarchical concept map showing the results of their findings. Upon completion, students within groups shared their maps with each other. Students were informed that they could revise and reconstruct their maps resulting from these comparisons and discussions.

Using the transformed information derived from their graph and concept maps, the students began generating answers to their focus question. These answers served as the products of their inquiry and were listed under knowledge claims. From these knowledge claims, students constructed principles that stated how the events occurred during the experiment. These principles led them to devise a theory that attempted to explain why the events they observed appeared to act as they did. Students made judgments as to the worth of these findings by listing them under value claims.

Scoring procedures of student Vee diagrams followed the protocol suggested by Novak and Gowin (1984, see pp. 70-72 for details). Individual Vee diagrams were scored on a quality point scale (0-4) with a maximum score being 18 using the following criteria (point values in parentheses for each of the categories): focus question (0-3), objects/events (0-3), theory, principles, and concepts (0-4), records/transformations (0-4), and knowledge claims (0-4).

An example of a Vee diagram constructed by a third grade student is shown in Figure 2. A maximum score of 18 was possible; numbers represent points assigned to this Vee diagram werr as follows: Focus Question = 2; Theory = 3; Events = 3; Transformations = 4; Knowledge Claims = 2. Total point for this student’s Vee was 14.

Figure 2. Example of a scored Vee diagram prepared by a third grade student.



In this example, a score of 2 indicated that the focus question was identified and included the concept but did not adequately describe the event. A score of 3 indicated that the major events were identified and were consistent with the focus question, and suggested that records would be taken. Likewise, a score of 3 was awarded for the identification of a relevant theory, principle, and concepts that related to the focus question, knowledge claims, and events of the investigation. A score of 4 was given to records/transformations because records were identified for the major event; and, transformations were consistent with the focus question and the grade level and ability of the student. Items listed under knowledge claims were awarded a 2 because a generalization was made that was inconsistent with the records and transformations (i.e., "the one with no air grew a leaf" - later corrected).

Vee diagrams constructed by the students were collected for the designated science experiment and scored by independent raters (interrater reliability .96) using the scoring procedures described above. All scores were in a range of 11 to 16 (maximum score 18). The frequency distribution and percentage of raw scores are presented in Table 1.

Table 1. Frequency distribution and percentage of total individual raw scores.

Raw Score	f (n=28)	%
11	2	61
13	11	72
14	9	77
15	5	83
16	1	88

All students were able to complete the component parts of the Vee with success. Student interviews by the teacher indicated that Vee diagrams helped them to understand what was taking place in the experiment by keeping records of the events. These students indicated that they found making charts of the records and hierarchical concept maps of the results of the experiment helpful in understanding the idea of "sprouting seeds."

Analysis of the Vee diagrams showed that members within a group stated the same focus question and contained similar: (a) entries under each component (i.e., "How do seeds germinate?" How do seeds sprout, etc.), (b) words listed under the *concept* portion of the Vee, (c) notations of observed events under the *records* portion, and (d) responses to the *value claims*. This seems to suggest that social and communicative interaction during the educative event contributed to group specific constructions (see Table 2).

Table 2. Individual raw scores, percentages, and stanine scores by group. Mean and standard deviation of raw scores of each group are in parentheses.

Subjects (n=28)	Stanine Score	Raw Score	Percentage
Group 1 (M = 12.2) (SD = 0,98)			
1	*	11	61
2	7	13	72
3	7	13	72
4	5	13	72
5	6	11	61
Group 2 (M = 14.0) (SD = 0.00)			
6	8	14	77
7	5	14	77
8	9	14	77
9	9	14	77
10	5	14	77
Group 3 (M = 15.2) (SD = 0.40)			
11	9	15	83
12	5	15	83
13	5	15	83
14	5	16	88
15	8	15	83
Group 4 (M = 13.6) (SD = 0.49)			
16	9	14	77
17	7	14	77
18	7	13	72

19	8	14	77
20	4	13	72
Group 5 (M = 13.0) (SD = 0.00)			
21	9	13	72
22	9	13	72
23	4	13	72
24	5	13	72
Group 6 (M = 13.7)			
25 (SD = 0.82)	7	15	83
26	7	13	72
27	6	14	77
28	4	13	72

*No test records

The teacher reported that students became interested in the experiment and were able to discuss the knowledge claims in relation to their focus question and events. She found that the Vee diagram provided her with an evaluation instrument to determine how well students understood their focus question and were able to relate the four conditions comprising the events to their findings. This, in turn, enabled her to provide differentiated feedback according to their understanding of concepts (e.g., sprout, germinate), theory, principles, records, knowledge and value claims through a visual inspection of their Vee and verbal questions.

The valuative effects of the Vee for the teacher in helping students to clarify misconceptions is illustrated by the following circumstances. An inspection of the Vee diagrams showed that 57 percent of the students generated knowledge claims that related to their principles and not to their records (i.e., plants need air to grow, but they grew even when they didn't have air). On the surface there seemed to be a discrepancy between these two items. However, our interview with the teacher revealed that this discrepancy was made known to her when she reviewed the students Vee diagrams. When questioning these students, she discovered that the plastic covering on the jar was not air tight. In fact, it fitted loosely. She reported that this portion of the experiment was repeated and that these students then understood that air was needed for the seeds to sprout thereby clarifying their misconceptions and accounting for their notation under principles (refer to notations under records in Figure 2).

As a metacognitive tool the Vee diagram aided students in monitoring the concepts, events, and facts needed to answer their focus question concerning "germination." These elements, combined with the other components arrayed on the Vee, were revisited by these students during this experiment and enabled them to search their prior knowledge of the targeted concept under study and extend this knowledge through the formulation of graphs, hierarchical concept maps, knowledge and value claims, and by linking principles to a plausible theory. Conceptual understanding of the science concept was also enhanced by conversations emanating from other group members and the teacher as the experiment progressed.

These components, once completed, comprise the structure of knowledge of an event or object.   Structure, in Gowin's Vee, refers to the elements and their relation to each other. This structure of knowledge can be analyzed by answering the questions that comprise the Q-5 Technique stated earlier. These questions enable students to analyze a document or report. They also engage students in an inquiry to problem solve (e.g., mathematics, problems, science experiments, and so forth).

CONCLUSION

In this lesson, Vee diagrams were a viable tool in learning about the structure of knowledge and the processes of knowledge production. They enabled third-grade learners to examine a piece of knowledge and come away with a deeper understanding of how knowledge is constructed by showing how the concepts, events, and records of the events are formulated when attempting to create new knowledge.

These third graders were able to learn concepts associated with the science experiment. They were able to relate and complete the designated components of the Vee with success and understanding. Students were free to express their emotions and thoughts, make predictions, and raise questions in meaningful contexts with each other and with the teacher. They were able to make connections, structure their knowledge, and create their own meaning (i.e., to see how the elements on the Vee related to the focus question and events that they formulated).

Vees served as an evaluation instrument for both the teacher and the student in determining how well ideas were represented among the component parts of the Vee diagram. Students became self-empowered (a notion that one can cause his or her own learning while trusting others in the process) when they corrected their scientific misconceptions. Together, the teacher and the students, were able to resolve uncertainties or misunderstandings and make the educative event a meaningful learning experience. Responsibility for learning science concepts took on a new dimension through the use of Vee diagrams. Students realized that information contained in textbooks could be used to create new meaning by recombining facts into ideas.

Vee diagramming is a way to help students penetrate the structure of knowledge they seek to understand. Being able to get the right answer is sufficient in many school evaluations upon which grades are based, and too often only rote recall is needed to answer questions. Teachers when versed in Vee diagramming seem to be receptive to this learning strategy in order to achieve meaningful rather than rote verbatim learning, and see this strategy as an independent learning aid to be used by the student (Novak, 1990; Novak & Gowin, 1984; Novak, Gowin, & Johansen. 1983). A conceptual change approach to teaching should include explicit ways for students to become aware of their own beliefs and to come to understand the nature and construction of knowledge (Bransford & Nitsch, 1985; Brown, 1975; Fosnot, 1989; Siegel, 1988). Vee diagrams provide the learner with this type of a metacognitive tool by which facts and ideas can be learned meaningfully through reflective thought.

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