The Bridging Question Strategy

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Abstract

The authors describe a specific constructivist strategy called the Bridging Question Strategy, which they developed through years of study of the work of Lev Vygotsky while teaching secondary mathematics. The strategy seeks to help students activate prior knowledge and connect it to new concepts in math.

The Bridging Question Strategy and Prior Understanding

Like good pitching is to good baseball teams, activating prior knowledge is to the constructivist philosophy. Memory experts, philosophers, researchers and cognitive scientists have advocated the constructivist premise that connecting to, or modifying previous knowledge, creates new knowledge. Frederic Bartlett (1997), a specialist in memory, states the following concerning the act of remembering: "It is an imaginative reconstruction, or construction, built out of the relation of our attitude towards a whole active mass of organized past reactions or experience..." (p.213). The important phrase is "organized past experiences", the implication being that prior knowledge is a system of interconnections. The philosopher John Dewey (1991), in discussing the subjectivity of knowledge, states that knowledge "is a power of following up and linking together the specific suggestions that specific things arouse" (p.39). The phrase, "following up and linking together" infers the existence of knowledge that already existed. Marian Diamond and Janet Hopson examine a biological model. They envision neurons and cells migrating up vertical stems, and cells form different layers at different levels of the stem. The cells, in the migration process, hop off at the right point, form a layer, and "then the next group comes up and migrates right through this existing layer and forms a new one above it" (p. 44). Saxe (1985) studied Oksapmin children in Papua New Guinea with the purpose of examining the effect of Western schooling on their arithmetical understanding. Saxe endeavored to study how traditional children's indigenous numerical understandings would guide their arithmetical achievements as they participate in a formal school setting. Saxe concluded that the Oksapmin children not only used their indigenous understandings in a Western style curriculum, they created novel procedures that went beyond what they would do in their normal community life. Thus, Saxe's study confirms the preeminence of prior knowledge in the learning process.

While the activation of prior knowledge is key to creating new knowledge, it is a complex process. This is more than just reviewing a definition or problem from the day before. While these activities are somewhat beneficial, they do not always empower students to use concepts effectively or necessarily reach a deep enough level for making new conceptual distinctions and relating them to new information and new processes. Leinhardt (1992) echoes this view when she writes: "The impact of prior knowledge is not a matter of 'readiness,' component skills, or exhaustiveness; it is an issue of depth, interconnectedness, and access" (p. 22). One of the ways we propose for activating this type of prior understanding is what we will call the BQS (Bridging Question Strategy). As will be discussed later, BQS was initially suggested by Vygotsky's idea that spontaneous knowledge and scientific knowledge are continuously working their way toward each other. Although Vygotsky's ideas provided the trigger, Dr. Pelech created BQS thru continued research and his own experience. This present paper gives a glimpse of his work on BQS. The main example used here is a condensed version of one he has used a number of times. The strategy aligns with constructivist theory, and while the examples cited in this paper can help students to achieve state and national standards in secondary mathematics, the principles of the strategy could be applied to instruction in other subjects as well.

Creating and Understanding Mathematical Concepts

Anyone who has taught mathematics has heard comments like: "I am smart, but not math smart" or "I am a good student, except in math" or "My daughter is extremely smart, except in math class, and that is because math is hard for everyone." Another type of comment that I have heard is "My son has practical intelligence, not math intelligence." Such comments seem to indicate that mathematical thinking and ordinary thinking are radically different, that mathematical thinking and regular thinking are separated by a large gap. Of course there is a gap but researchers, educators, philosophers, and cognitive scientists, present another side of the coin. Their findings not only point to the fact that the gap between mathematical thinking and everyday thinking can be bridged, but also that both types of thinking are outgrowths of ordinary experience and that everyday experiences, and school experiences reinforce each other. The philosopher John Dewey (1991) supports this idea and expands on it. In his discussion concerning thinking, he supports the theorem that knowledge and logical thinking is actually a network of interdependencies:

> Reflection involves not simply a sequence of ideas, but a consequence—a consecutive ordering in such a way that each determines the next as its proper outcome, while each in turn leans back on its predecessors. The successive portions of the reflective thought grow out of one another and support one another, (p. 3)

As remarked earlier, BQS was initially suggested by Vygotsky's distinction between spontaneous knowledge and scientific knowledge (Vygotsky 1962). Spontaneous knowledge is knowledge that the student constructs in his everyday experience, while scientific knowledge is knowledge that the student constructs through direct, formal instruction. Vygotsky takes the stand that spontaneous knowledge and scientific knowledge are not different in their nature, construction, or development. Vygotsky criticized Piaget for keeping these two concepts separate: "he fails to see the interaction between the two kinds of concepts and the bonds that unite them into a total system of concepts in the course of the child's intellectual development." (p.84) Vygotsky views the two concepts as informing each other and working toward each other:

> We believe that the two processes, the development of spontaneous and of non-spontaneous concepts, are related and constantly influence each other. They are parts of a single process: the development of concept formation, which is affected by varying external and internal conditions but is essentially a unitary process... (p. 85)

Vygotsky presents a view in which the two types of knowledge work toward each other. In Vygotsky's view, once a concept is formed, it works it way toward another concept. Vygotsky is presenting a case for a dynamic equilibrium. This concept is consistent with Fischer's (1998) model in which knowledge is aligned as a network of thinking domains that intersect with each other and even cross into each other's domain. Fischer's concept of a complicated network of thinking strands that forms forks and intersections is in agreement with Vygotsky's view that the two types of knowledge work toward each other. Vygotsky's ideas have been supported by recent research. Mohamed Osman and Michael Hannafin (1994) discuss the concept of "orienting questions". Orienting questions can be thought of as questions or ideas that are *concept-related* to an upcoming topic, but are not necessarily *content-related.* As an example, they discuss how the tossing of a coin two times is related to the probability of inheriting genetic traits. This is parallel to the BQS. The research of Osman and Hannafin indicate that orienting questions are an effective method of activating prior knowledge.

The Bridging Question Strategy is based on these ideas, believing that different types of knowledge work toward each other in order to create equilibrium. More specifically, the BQS is a process that uses everyday knowledge to construct mathematical knowledge. BQS uses everyday knowledge that is not content-related to a math topic, but rather is *conceptually related.*

The General Bridging Question Strategy

Definition of the Bridging Question

The general bridging question asks, "What is going on here?" in reference to some activity. It is an open-ended question that calls for more than a simple description of the activity. It is knowledge of an everyday activity or concept that is not content-related to a mathematical topic, but rather is conceptually related. Wrapping and unwrapping a package can be used as a bridge to concepts used in solving equations. Deciding on what new car to buy can be related or bridged to classifying polygons. The activity of taking money from one account and putting it in another is analogous to the translation of a conic.

Implementing the Bridging Question

The Bridging Question Strategy consists of three phases.

(1) Present a bridging activity to bring the manifest concepts of interest into focus.

(2) Fully activate the bridging question. This can be done by:

- Breaking into groups and having groups compare responses to the bridging question
- Expressing responses to the bridging question in different modes, or words
- Having groups develop their own questions based on the above activities

(3) Bridge to the more remote mathematical concept. This can be done by:

- Having students predict how the bridging question is related to the more remote mathematical concepts
- If necessary, leading them to understand the connection between the bridging question and the more remote concepts
- Presenting the more remote concepts and then discussing with students how the bridging question and these are related.

These activities are presented in order for the student to actively construct the relationship between everyday manifest understanding and more remote understanding. These steps are not set in stone, but serve as general guidelines.

An Example of Using BQS: Let's look at how we can use BQS to help students learn the concept of reversing a mathematical process. We use the everyday experience of wrapping and unwrapping a package. This is analogous to one method used in solving equations, but it can be related to both simpler and more complex mathematical processes.

<u>(1) Present the bridging activity.</u>

In doing this we have a student volunteer to wrap the package and have another one write the steps on the board.

(a) Put the present inside the box. See photo A.

(b) Close the box. See photo B

(c) Put the box on the paper. See photo C

(d) Fold the paper and add nametag. See photo D

Photo A Photo B Photo C Photo D




Now we have that student or another student unwrap the package. Again, the steps are written on the board. The board should read as follows:

Wrapping the Package	Unwrapping the package
Put the present inside the box.	Take off the name tag and unfold paper
Close the box.	Take box out of paper
Put the box on the paper.	Open the box
Fold the paper and add nametag.	Take out present

We have activated the concept of ***undoing operations in reverse order.*** While some students may see this immediately, it is may be necessary to coach students to see that the two processes undo each other in reverse order. At this juncture some students may have already constructed the general scheme. If not, the next phase will. At this point it is important to recognize that the process of wrapping and unwrapping a package is an example of understanding a spontaneous concept which is analogous to solving equations. We now go to the next phase.

(2) Fully activate the bridging question.

Split the students into groups, and have each group discuss the relationship between the wrapping and unwrapping processes. Group members should discuss and write down their understandings. Each group may reword their findings. By rewording their original findings, students modify their prior understanding. This phase of the activity enables students to develop a deeper understanding of the concept of "undoing in the opposite order". Then each group publicly presents their findings.

Now each group must construct their own example of two activities that "undo each other in reverse order." In the Constructivist spirit, the process of putting the concept into words, we have the students put their ideas into words and then re-word them. Again, each group presents their findings. In the past my students have come up with concepts such as getting in the car and pulling out of the driveway (compared to the process of coming home in the evening), and coming into a classroom, getting out one's homework and opening the book. In both cases the students are activating and strengthening the concept of undoing an operation in reverse order. Now that the scheme of "undoing in reverse order" is fully activated, the teacher goes to the third phase.

(3) Bridge to the more remote mathematical concept.

For students who can correctly read an equation you can have them predict how the undoing processes in reverse order concept relates to solving equations. It is recommended that the teacher review the concept of the order of operations. Below is an example.

$3x^2 \cdot 5 = y$, letting x be 2 and computing y.

Let $x = 2$
Squaring gives $x^2 = 4$
Multiply by 3 gives $x^2 \cdot 3 = 12$
Adding 5 gives $x^2 \cdot 3+5 = 17$

In this example we have squared, multiplied, and then added. A few more examples of the order of operations will solidify this sequence. The teacher must then coach the students to apply the recently activated concept of undoing operations in reverse order. It is recommended that the teacher put the following on the board:

Order of Operations	**Solving Equations**
Exponents	Undo exponents
Multiplication/Division	Undo Multiplication/Division
Addition/subtraction	Undo Addition/Subtraction

We now apply the process of undoing in reverse order.

- *Begin with the equation:* $x^2 \cdot 3+5 = 17$
- *Since addition was done last, undo the addition of 5 giving:* $x^2 \cdot 3 = 12$
- *Since multiplication was done next to last, undo the multiplication by 3 giving:* $x^2 = 4$
- *Finally undo the squaring of x by taking the square root giving:* $x = 2$

After a couple of more examples, have each group compare and contrast the process of wrapping/unwrapping a package with that of solving equations. In doing so, it is important that each group construct the SIMILARITIES and the DIFFERENCES of the two processes.

A Second Example of the BQS: Let's look at how the BQS can be used to help students understand the importance and significance of classifying triangles. This was always a challenge to teach because students viewed this lesson as uninteresting. The BQS changed this by increasing student engagement, which in turn increased deeper understanding of the process of classifying triangles.

(1) Present the bridging activity.

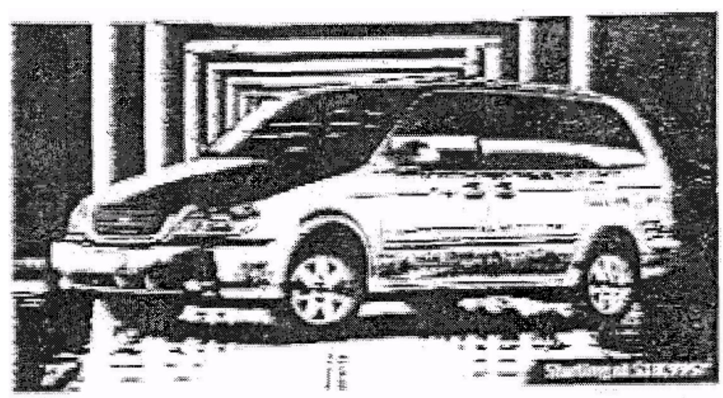
First, students were put in pairs, and the students were then passed out the two sheets shown in Figure 1.

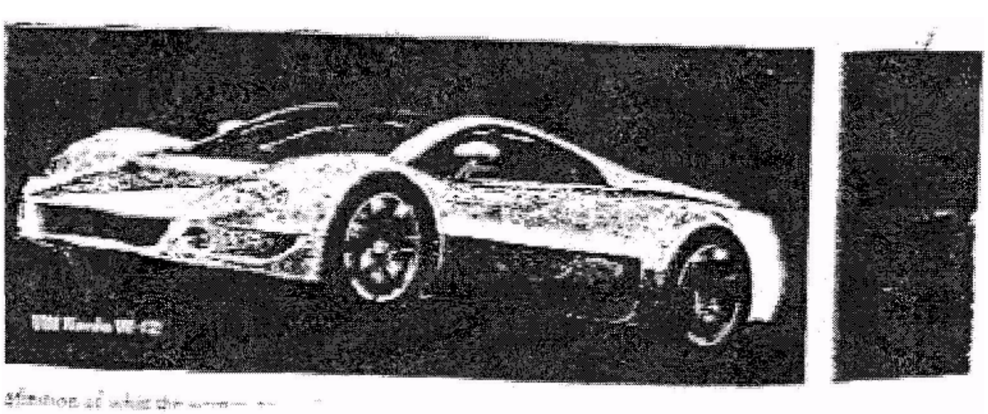
Figure 1.

Classification Activity

2OOO EXPLORER

1998 & 1999 Lincoln Town Car





We then had students rank the vehicles in order from most desirable to least desirable. Students were allowed time to discuss this with each other. By ranking these cars using the concept of desirability, we have activated the spontaneous knowledge concept of classifying cars.

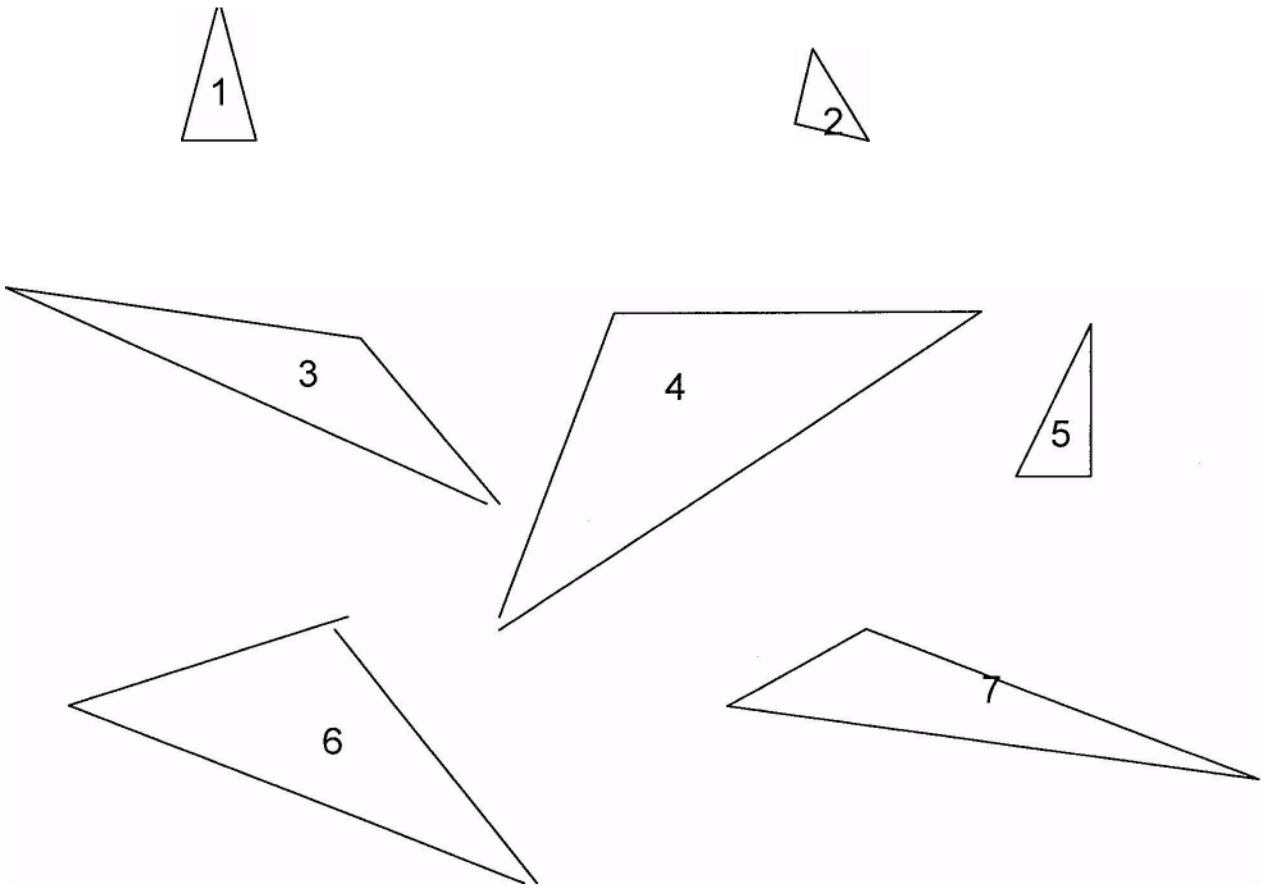
<u>(2 and 3) Fully activate the bridging question/ Bridge to the more remote mathematical concept.</u>

We fully activate this concept by having students come to the board and discuss and defend their rankings. During this time it is important for the teacher to coach students to create the following important classification concepts:

1. Classification (ranking) is an arbitrary concept
2. An object or idea may simultaneously be in two or more categories

We then continue with the activation by passing out the worksheet on the next page. We then have the students cut these triangles out (in some cases this is already done for them). While this example may have seven triangles, very often their sheet may have more. The students are then asked to put these triangles into two groups; then three groups, four groups etc. During this time the students are reminded that they are to use the two principles above. Now that the students understand and have created their own understanding of the classification of triangles, they are ready to bridge to the more abstract mathematical concept. They have done this by starting with the everyday concept of classification of cars and then bridged to the mathematical concept. After these activities the students have had no difficulty with the traditional classification of triangles.

Figure 2.
Classification of Triangles



Summary

Students bring all types of knowledge to the mathematical classroom. While some of this knowledge is not directly content-related, it may be concept related to the mathematical topic that the class will be studying. The BQS is a teaching strategy that uses everyday knowledge to bridge to a mathematical concept. The BQS is centered on the concept that the activation of prior knowledge involves the activation of an interconnected system, not just an isolated fact. A teacher applying the BQS starts with everyday concepts and then bridges to the abstract mathematical concept. It is a strategy that must be in the "bag of tricks" of every Constructivist teacher.

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