RMLE Online
Research in Middle Level Education

David Hough, Ph.D., Editor
Missouri State University
Springfield, Missouri

2004 • Volume 28 • Number 1 ISSN 1084-8959

# Promoting Critical-Thinking Dispositions by Using Problem Solving in Middle School Mathematics

Lars F. Leader
Valdosta State University
Valdosta, Georgia

James A. Middleton
Arizona State University
Tempe, Arizona

Citation: Leader, L. F., & Middleton, J. A. (2004). Promoting critical-thinking dispositions by using problem solving in middle school mathematics. *Research in Middle Level Education Online, 28*(1). Retrieved [date], from http://www.nmsa.org/Publications/RMLEOnline/tabid/101/Default.aspx

## Abstract

This review of research generates principles for the design of instructional programs that foster critical-thinking dispositions. The dispositional aspect of critical thinking may be considered part of attitudinal memory, readily activated if sufficiently strong. We describe evidence suggesting that ill-structured problem-solving can provide middle schoolers with motivating activities that strengthen critical-thinking dispositions, thus fostering sensitivity to occasions for thinking critically and the inclination for engaging in such practices. The Jasper Series and Decision Making are reviewed as cases of programs for middle level mathematics learning that afford opportunities for ill-structured problem-solving activities that incorporate five important attitude-strengthening elements. Fazio (1995) identified these elements as direct experience, sensory experience, emotional reaction, freely chosen behavior, and attitude rehearsal. We describe how the design of the two mathematics programs incorporates attitude-strengthening elements that can potentially foster critical-thinking dispositions. Based on this review, we present a set of design principles to promote those dispositions.

---

Thinking critically in problem situations is a skill that has received increasing attention as an educational goal. Critical thinking is often described as an ability. Yet, ability is only one aspect of critical thinking. People behave more or less intelligently governed not only by abilities but also by predilections or tendencies. This additional aspect of critical thinking has been termed *disposition* by a number of educational researchers and philosophers (Baron, 1985; Bereiter, 1995; Cacioppo & Petty, 1982; Ennis, 1986). As Norris (1985) points out, "One must have the disposition to think productively and critically about issues, or else no amount of skill in doing so will be helpful" (p. 40).

A number of taxonomies of critical-thinking dispositions have been developed (e.g., Ennis, 1986; Facione, Facione, & Giancarlo, 1996). They all go beyond analyzing ability to perform cognitive tasks to emphasis on attitude towards and awareness of opportunity for critical thinking. For instance, the dispositions that Taube (1997) identifies as characteristic of effective critical thinkers are open-mindedness, cognitive complexity,

need for cognition, tolerance of ambiguity, and reflectiveness. Perkins, Jay, and Tishman (1993) describe seven dispositions they view as central to good thinking. Those are the dispositions: to be broad and adventurous, toward sustained intellectual curiosity, to clarify and seek understanding, to be intellectually careful, to seek and evaluate reasons, and to be metacognitive.

As Perkins and Tishman (1998) point out, taxonomies of thinking dispositions are normative, reflecting the cultural orientation of the authors and their conceptions of how best to gain knowledge. In many cases, efforts to promote good thinking dispositions focus on learners and how to nurture the development of these dispositions in learners (e.g., Leshowitz, DiCerbo, & Symington, 1999; Ritchhart & Perkins, 2000). That is also the focus of the present paper. The purpose of this manuscript is to explain the importance of dispositions as an essential aspect of critical thinking and to suggest how instruction can be designed to promote learners' development of the dispositional side of critical thinking. We use examples from middle level education as situative aids to better illustrate our general model and also to show specifically how critical thinking dispositions can be built into middle level curriculum and technologies.

## The Dispositional Bottleneck: Sensitivity to Occasion

Most authors treat dispositions simply as tendencies, for example the tendency to consider counterarguments to one's own position on an issue. However, Perkins, Jay, and Tishman (1993) have demonstrated that a full account of intellectual behavior requires three components: sensitivity, inclination, and ability. *Sensitivity* concerns awareness of occasion; *inclination* concerns motivation or leaning; and *ability* involves the capacity to follow through appropriately. For example, to attend seriously to the other side of an argument in everyday circumstances, a student would need to be sensitive to the occasion to seek reasons supporting the other side, inclined to invest mental effort in examining the other side of the issue, and have the basic ability to do so.

Perkins and Tishman (1998) conducted studies to explore the validity of their three-component model. They had eighth-graders read short stories that contained thinking shortfalls. A series of three tasks were used to measure the relative primacy of sensitivity, inclination, and ability as determinants of critical thinking. In the first task, which was designed to reveal sensitivity, subjects were asked to underline parts of the story they thought reflected poor thinking. The second task presented the shortcoming and then asked the subjects whether they thought it was problematic, and, if so, what should be done about it. This second task was meant to determine inclination to think through the potential problem. In the third task, after being informed that there was a problem, the subjects were asked to list several options for dealing with it. This final task focused on the subjects' ability to generate alternative options, independent of their sensitivity or inclination to do so. Results indicated significantly greater performance on the ability task compared with the inclination task, and significantly greater performance on the inclination task compared with the sensitivity task. This result uncovered a construct that Perkins and Tishman termed the “disposition effect”: A substantial gap exists between what students can do (ability) and what they do do (behavior). Furthermore, the principal dispositional bottleneck between opportunity and action is sensitivity: Students do not detect shortfalls in thinking (i.e., potential problems that require critical thinking) in the first place.

## Attitudes and Spontaneous vs. Deliberative Processing

How do these findings pertain to learning and instruction? Our discussion focuses primarily on the aspect of dispositions that Perkins and Tishman found was the limiting factor for being disposed to think critically—sensitivity to occasion. With this in mind, we will address the question, “How can middle schoolers learn to identify occasions that call for thoughtful attention?”

We wish to frame our answer to this question by considering the similarities between dispositions and attitudes. A disposition such as the disposition to “seek and evaluate reasons” can be recognized in a person by that person's behavior. A strong, or well-developed, disposition to seek and evaluate reasons is manifested in situations where seeking and evaluating reasons is appropriate. This cause-effect relationship between disposi-

tion and action points out the similarity between dispositions and attitudes. Robert Gagné put it even more clearly, defining an attitude as "a disposition or readiness for some kind of action" (1977, p. 236).

Through investigations into the influence of attitude on action, Russell Fazio and his colleagues have demonstrated that a person's behavior is consistent with an attitude to the extent that the attitude is strong and therefore easily accessible from memory (Fazio, Blascovich, & Driscoll, 1992; Fazio, Herr, & Olney, 1984). These researchers conceive of an attitude as an association between an object (or issue, or event) and an individual's evaluation of the object. The strength of this association determines the likelihood that the attitude will be activated from memory when the individual again encounters the attitude-inducing object (Fazio, et al., 1992).

According to Fazio (1990), a person's judgments and actions can stem from either of two processing modes—a spontaneous process or a more effortful, deliberative process. The *spontaneous* process requires that one's attitude be activated from memory by an attitude-inducing object. The automatically activated attitude then serves as a filter, influencing subsequent object-relevant information processing, judgment, and action. In contrast, during *deliberative* processing, individuals carefully examine the available information, analyzing the likely consequences of options before deciding on an intention to act in a certain way. Fazio's model integrates spontaneous and deliberative processes by postulating *motivation* and *opportunity* as the two factors that determine which process will occur. To the extent that preexisting attitudes are capable of automatic activation, they will govern a person's attention, judgments, and actions—unless he or she is motivated to engage in deliberative processing and is given sufficient opportunity to do so.

In situations where there is low motivation to deliberate over decisions, preexisting attitudes are activated from memory. These attitudes, although often biased, free the individual from the processing effort required for critical thought. Fiske and Taylor (1991) use the term "cognitive misers" to describe people exhibiting this common tendency. In contrast, motivated individuals can overcome the potentially biasing influence of a strong, preexisting attitude—if they are given the opportunity to deliberately bring critical-thinking processes to a problem situation.

## Attitude Strength and Sensitivity to Occasion

The contrast between spontaneous processing and deliberative processing provides an explanation for Perkins and Tishman's conclusion that sensitivity to occasion is the bottleneck to critical thinking. When a student does not apply critical thinking in a situation that calls for it, this does not necessarily reflect a lack of ability or even a lack of inclination to do so. Rather, it may be the case that the student is a cognitive miser in this situation, exhibiting spontaneous behavior influenced by an automatically activated attitude. The attitude activated is one that identifies the situation as not requiring any particularly deliberate thought.

Recognition of an occasion that calls for thoughtful attention may occur in one of two ways. On the one hand, a student may not normally recognize a situation that calls for critical thinking. On a particular occasion, however, she may be motivated and have the opportunity to deliberate over the situation. Upon examining the options available, the student's inclination and ability to make thoughtful choices then come into play. On the other hand, a student may have already acquired a strong attitude of critical thinking in certain situations. In such situations, this attitude will be spontaneously activated and the person will recognize the need for thoughtful attention. She will then most likely be inclined to act thoughtfully and carry out her intentions.

Strong and accessible attitudes appear to have a functional value in that they serve to direct our attention to certain objects. Roskos-Ewoldsend and Fazio (1992), for example, conducted a series of experiments in which they demonstrated that an individual's attention is automatically drawn to attitude-activating objects, those objects toward which the individual has a strongly associated evaluation in memory. An attentional component of attitudinal memory was identified:

> Collectively, these findings demonstrate that the extent to which objects attract attention as they enter our visual field depends, at least in part, on the accessibility of our attitudes toward the objects. If a

> strongly associated evaluation of the object exists in memory, then that object attracts attention. Hence, we are likely to notice those objects that we have personally defined as likeable—those that can provide some reward or satisfaction—those that we wish to approach. Likewise, we are likely to notice those objects toward which we have a strongly associated negative evaluation—those that can hurt us—those that we wish to avoid. What we "see" appears to be influenced by accessible attitudes. By orienting our attention to objects that have the potential for hedonic consequences, accessible attitudes ready us to respond appropriately. (Fazio, 1995, p. 265)

Teachers and instructional designers can promote students' sensitivity to occasions that call for critical thinking. They can do this by providing sufficient opportunity for students to engage in motivating and deliberative activities that entail identifying occasions for critical thinking. Students may thereby develop good thinking dispositions that are strong and accessible. Through appropriate activities, these dispositions may become the default attitudes available during spontaneous processing (Middleton, Lesh, & Heger, 2002). In other words, students might learn to detect occasions for critical thinking as a natural habit of mind.

## Attitude Strength and Ill-Structured Problems

Development of strong attitudes, those that are readily activated from memory when an individual encounters a situation associated with the attitude, depends upon a number of factors. Researchers in a wide range of investigations have identified a variety of determinants of attitude strength. In a review of this research, Fazio (1995) suggested that five factors are major determinants of attitude strength and accessibility from memory: (1) direct experience, (2) sensory experience, (3) emotional reactions, (4) freely chosen behavior, and (5) attitude rehearsal.

Consideration of critical-thinking dispositions as attitudes that can be activated in certain situations suggests that to facilitate the learning of sensitivity to critical-thinking occasions, instruction should incorporate into motivating problem-solving activities the attitude-strengthening factors Fazio identified. Solving *ill-structured problems* can furnish students with activities that meet these conditions. Ill-structured problems are "the kinds of problems that are encountered in everyday practice" (Jonassen, 1997, p. 68). They are problems situated in the real world. Jonassen characterizes ill-structured problem solving as a design process in which "the problem solvers must frame the design problem, recognize the divergent perspectives, collect evidence to support or reject the alternative proposals and ultimately synthesize their own understanding of the situation" (p. 79). Ill-structured problem-solving activities can be seen to incorporate the above-mentioned five attitude-strengthening factors. They afford students opportunities to (1) directly experience occasions for critical thinking, (2) engage a number of senses in the richness of real-world problem situations, (3) react emotionally to those situations, (4) freely choose a path to solution, and (5) engage in a series of activities that provide repeated opportunities to rehearse critical-thinking dispositions (see also Middleton, Lesh, & Heger, 2002).

### *Direct experience in opportunities for critical thinking*

Attitudes based on direct experience are more likely to be activated and influence subsequent behavior than those based on indirect experience (Fazio & Zanna, 1981). In a direct experience, the individual interacts with an attitude object or commits himself or herself to an issue or event. This contrasts with an indirect experience, in which the person forms an attitude on the basis of nonbehavioral information such as reading about the attitude object. Solving ill-structured problems through authentic activities is one way to involve students in direct experiences that incorporate situations that call for critical thought. Brown, Collins, and Duguid (1989) describe authentic activities as "the ordinary practices of the culture" (p. 34). A problem solver involved in authentic activities addresses a problem within the framework of the context that created it. Authentic activities provide in-context learning similar to that available to people participating in craft apprenticeships. Solving ill-structured problems through authentic activities can facilitate the learning of sensitivity to critical-thinking occasions by providing situations in which the student directly experiences the context of a problem. By committing to the problem-solving activities inherent in such situations, a student can form strong associations between the situations and the need to think critically about problems manifested in those situations.

### *The role of sensory information*

Incorporating a rich variety of sensory experiences into problem-solving situations may also strengthen critical-thinking dispositions. Wu and Shaffer (1987) provide evidence that attitudes based on sensory reactions may be more accessible from memory than attitudes formed less directly. Sensory experience of a situation contributes to formation of strong attitudes towards the situation, attitudes that are then more likely to influence decision-making in similar situations. Again, authentic tasks that include the context for ill-structured problem solving can provide students with advantageous conditions. Visual, auditory, olfactory, tactile, and kinesthetic stimuli may all be part of the "peripheral features" of authentic tasks. Brown, Collins, and Duguid argue for the importance of such peripheral features:

> These features are often dismissed as "noise" from which salient features can be abstracted for the purpose of teaching. But the context of activity is an extraordinarily complex network from which practitioners draw essential support. The source of such support is often only tacitly recognized by practitioners, or even by teachers or designers of simulations. (1989, p. 34)

Granted, school tasks are by nature to some extent inauthentic because students are not practicing members of communities within which school tasks are embedded (e.g., Lave & Wenger, 1991). For example, in one of the curricular innovations reviewed in this paper, students are expected to take on the role of urban planners. While the task attempts to be as faithful to the real activity of urban planning as practicable, it cannot truly capture the complexity and structures of discourse that professional urban planners engage in. Technology may be a potential tool under such circumstances for increasing the authenticity of experience by providing sensory information (in the form of video, audio, and kinesthetic experiences) reflective of, or even recapitulating, real phenomena.

### *The role of emotions*

The emotional reactions that a student has to a task situation can greatly influence the student's attitude toward that task and its context. Stronger object-evaluation associations are formed when the emotional reaction to an attitude object, such as a task situation, is stronger. More so than other sources of information, people trust their emotional reactions as indicative of their attitudes (Fazio, 1995). From a number of studies, Schwarz and Clore (1988) provide evidence that individuals use their affective reactions as relevant information when making evaluative judgments. The emotional components of memory appear to play an important part in an individual's response to current emotion-inducing situations. The second author of this paper has remarked earlier on the significance of emotional memory to a student's evaluation of the value of involvement in a current situation:

> When a student faces an opportunity to engage in an activity, he or she may experience an emotion previously induced by a similar activity. Since her feelings *index* or *signify* a plethora of eliciting conditions from past experience, the emotion serves as a means for unpacking memory, revealing potentially important information about the value of participation. (Middleton & Toluk, 1999)

Not only are emotions used as evaluative criteria, they are also used as information in solving everyday ill-structured problems (Sinott, 1989). Emotions are often the impetus for determining what the nature of a problem is as well as for generating and choosing solutions. From its importance in relating past experience to current situations both contextually and cognitively, the emotional reactions of students to a situation can have a strong impact on forming and strengthening dispositions towards critical thinking.

### *Free choice*

People view their own freely chosen behavior to be a highly reliable and relevant indication of their attitudes or dispositions. One may come to rely on one's own behavior as an attitude indicator in the same way that observers would rely on how they see an individual act to infer the dispositions that the observed individual might possess (Bem, 1972). Behavior that an individual willingly chooses, that thus allows for self-perception, has been shown to promote formation of strong attitudes (Fazio, Herr, & Olney, 1984). Since ill-structured problems typically do not have a single solution, an important component of the process of solving such prob-

lems is to assess the viability of alternative solutions. To do this, a student needs to construct an argument for a preferred solution or against alternative solutions. To support or reject different perspectives, the student must gather evidence. He or she eventually develops a personal position about a preferred solution (Jonassen, 1997). Constructing arguments and articulating personal beliefs during this solution process engages the student in numerous situations during which choices are freely made and strengthens the interest level of chosen behavioral options (Middleton & Toluk, 1999). These activities thus provide occasions for forming and strengthening critical-thinking dispositions.

***Opportunity for rehearsal***

Any object, issue, or event that calls an individual's attention to the evaluation he or she has formed towards that class of objects, issues, or events serves as an additional instance of associative learning and strengthens the individual's attitude (Fazio, 1995). Repeated expression of an attitude in this manner has been shown to enhance the accessibility of the attitude from memory and thus increases the ease, speed, and quality of decision-making (Fazio, Blascovich, & Driscoll, 1992). As described earlier, in the process of solving ill-structured problems students have to weigh possible solutions. This involves them in constructing arguments and considering alternatives. Before reaching a solution, they often proceed through iterations of restricting the alternatives and refining their arguments (Jonassen, 1997). A student attempting to solve this kind of problem thus engages in a series of actions that provide successive opportunities with similar attitude objects for rehearsal of critical-thinking dispositions.

## A Comparison of Sorts...

A variety of instructional programs include ill-structured problem solving as the approach taken for instructional design and implementation. We focus on two of these programs: *The Jasper Woodbury Problem Solving Series* (Cognition and Technology Group at Vanderbilt, 1992a), and *Decision Making*, a unit on problem solving through algebra (Middleton & Roodhart, 1997). The design of these programs affords learners with opportunities to engage in activities that can be related to Fazio's attitude-strengthening factors. In addition, published descriptions of implementations of these programs provide examples of positive changes in learners' critical-thinking dispositions.

In the following sections we will describe these instructional units in relation to the attitude-strengthening factors described above and how those factors might relate to changes in learners' critical-thinking dispositions, especially in terms of sensitivity to occasions that call for critical thinking. Keep in mind that these instructional tools are examples used to illustrate aspects of design that are intended to foster deep mathematical content understanding as well as critical thinking dispositions in mathematics-related applications. As of yet, these are plausible models, untested, but showing significant promise.

***The Jasper Problem-Solving Series***

*The Jasper Woodbury Problem Solving Series* (Cognition and Technology Group at Vanderbilt, 1992a) is a set of video-based adventures, with each adventure presented as a 15- to 20-minute story on CD-ROM. At the end of each story, a challenge faces the main characters. Students are given the task of solving this challenge before they are allowed to see how the characters in the story solved it.

*Rescue at Boone's Meadow* is one of a pair of Jasper adventures that deals with issues of trip planning. This story involves an ultralight airplane pilot, one of his students, and their friend, Jasper Woodbury. During flying lessons the student pilot, Emily, as well as the viewers learn a lot about the ultralight, such as the plane's fuel capacity, speed, and payload limits. While on a fishing trip, Jasper finds a wounded bald eagle and radios Emily for help. The adventure ends with Emily posing this challenge to herself: What is the fastest way to rescue the eagle, and how long will that take? Students presented with this problem can go back and search through the video, which contains all the data needed to solve the problem. This challenge is a complex problem that requires the students to generate the kinds of subgoals Emily must consider to decide which is the best way to rescue the eagle.

*The Jasper Series* provides students with richly detailed ill-structured problems. In describing their series, the designers explained that their goal "was to create interesting, realistic contexts that encouraged the active construction of knowledge by learners" (CTGV, 1993, p. 52). Some of the instructional strategies used in *Rescue at Boone's Meadow* that may promote sensitivity to occasions for critical thinking are described in Figure 1. These strategies appear to incorporate the attitude-strengthening factors that Fazio (1995) described.

**FIGURE 1.** Critical-thinking strategies in "Rescue at Boone's Meadow"

| Attitude-Strengthening Factor | Strategies Promoting Sensitivity to Occasions for Critical Thinking |
|---|---|
| Direct Experience | Students become participants in the story as they assume Emily's role. To solve their problem, they must generate relevant sub-problems, argue their positions, and select among alternatives. They do this by working directly with the same information available to the character in the story. |
| Sensory Experience | The data needed to solve the problem are embedded in the video as a natural part of the story. The sights and sounds contextually integrated into the story provide rich sensory information. |
| Emotional Reactions | Students become emotionally engaged by their role in solving the challenge. Their arguments about how best to attempt saving the eagle are often emotion-laden. |
| Freely Chosen Behavior | After viewing the story, students must find and define the problems to be solved. They make choices among realistic alternatives when gathering evidence and reaching positions about the solution. |
| Attitude Rehearsal | The students need to consider a number of alternatives and proceed through a series of steps to solution of the problem. Opportunities for critical thinking occur at each of these steps. They can also work on another adventure in the series to get additional practice on the core schema of trip planning. |

Recall that Fazio's model of the influence of attitude on action identified both opportunity and motivation as necessary for the deliberative processing needed to establish a disposition towards critical thinking. Students using *Rescue at Boone's Meadow* receive extensive opportunity to identify occasions where critical thinking is appropriate. For example, to have a good shot at solving the story's challenge students must generate a series of subgoals based on the contextually embedded data.

As far as motivation is concerned, the *Jasper Series* provides the motivating conditions that Jonassen (1997) describes as an inherent component of instruction that incorporates ill-structured problem solving:

> Because they are situated in everyday practice, [ill-structured problems] are much more interesting and meaningful to learners, who are required to define the problem and determine what information and skills are needed to help solve it. (p. 68)

Evidence of the motivational effects of the Jasper programs comes from the developers' assessment of student attitudes and the comments provided by teachers (CTGV, 1992b). Fifth- and sixth-grade students in nine states were given a questionnaire at the beginning and the end of the school year during which they used at least three Jasper adventures, spending approximately one week on each adventure. Compared with students in control classrooms, the Jasper students were less anxious toward mathematics, more likely to view mathematics as relevant to everyday life, more likely to describe it as useful, and more likely to appreciate complex challenges. Teacher comments about the Jasper program included some impressions of its motivational effect on students. Typical is one teacher's comment:

> We wrote letters to the new fifth graders coming up—giving them tips so it will make their year better. In all of them, I was looking over them, they wrote about Jasper: "Just wait until you get to Jasper," "It's not just fun, you'll learn so much." (CTGV, 1992b, p. 308)

It should be noted that a recent study (Hickey, Moore, & Pellegrino, 2001) has provided evidence that the motivational advantages attributed to activities in the *Jasper Series* may actually result from the instructional orientation of the teachers who use those materials. In the study, teachers in 19 fifth-grade classrooms in a school district implementing a constructivist-inspired reform of its math curricula were paired in four closely matched schools. Reforms had been made over the previous six years in accordance with the 1989 standards of the National Council of Teachers of Mathematics. Based on results from a motivational beliefs survey, the researchers concluded that for those classrooms in which the learning environment was more consistent with the reforms the students became more confident in their own ability and learned to value mathematics.

Is the *Jasper Series* effective in making critical-thinking dispositions strong and accessible? The developers of the series (CTGV, 1992b) give examples of learning transfer in which students spontaneously made connections between classroom activities and activities in other classes or outside of school. Some project teachers reported that several parents noticed when they stopped at gas stations that their children began to ask questions about the fuel capacity and efficiency of their car. Teachers also described the way students came to label complex everyday problems as "Jasper problems." In one example of this kind of problem, students picked up on how a substitute lunchroom staff failed to anticipate the meals it needed to prepare. Though these reports are anecdotal, they indicate that far transfer of these dispositions may occur in a variety of situations.

***Decision Making***

*Decision Making* is a mathematics unit designed for use in Grade 7 or 8. The unit presents students with a dilemma. Two parties with competing points of view are negotiating on rezoning a reclaimed landfill to build new residences for the city center. One party wants to maximize the number of people who can live in the area, and so wants to build high-rise apartment houses. The other party wants to rezone the land to accommodate the need for new homebuyers, and therefore wants single-family houses. Students were encouraged to take the position of one of the parties and argue their position with their classmates. As the two parties negotiate, students are asked to develop feasible plans for making decisions on just how the land will be zoned and to make recommendations as to how these plans can be carried out. The major mathematical content of the unit centers on the graphical representation of linear inequalities—the basis for linear programming. However, the abstraction of the graphical information into systems of algebraic inequalities was not emphasized in the unit. Rather, the concepts of "fair exchange" and "trade-off" were used to help students understand the linear relationship between x and y values.

*Decision Making* involves students in the application of linear algebra to difficult real-world problems with multiple solutions. Through the process of designing and developing their zoning plans, as well as defending their recommendations, the students are clearly engaging in ill-structured problem solving. A number of instructional strategies used in the unit appear to promote sensitivity to occasions for critical thinking. Figure 2 describes some of these strategies and the attitude-strengthening factors they incorporate.

**FIGURE 2.** Critical thinking strategies in "Decision Making"

| Attitude-Strengthening Factor | Strategies Promoting Sensitivity to Occasions for Critical Thinking |
|---|---|
| Direct Experience | Students take on the role of architects and urban planners. To design and develop plans, they must apply mathematics to a realistic situation. In negotiating with the opposing party, they explore the feasibility of different plans and engage in trade-offs to reach a workable solution. |
| Sensory Experience | Students apply the mathematical concepts by graphing data and creating scale models of their housing proposal. This kinesthetic experience authentically reflects the work of architects and urban planners. |
| Emotional Reactions | In the process of defining and presenting their position on how the land should be zoned, students become stakeholders with an emotional investment in their plan. Emotions become heightened as students on one side work through the negotiations process with the other party. |
| Freely Chosen Behavior | While engaged in planning, making recommendations for, and negotiating over the zoning change, students frequently must make choices and develop personal positions. Multiple models embodying the underlying mathematical concepts in the unit allow students to choose a preferred mode of representation for solving each problem at hand. |
| Attitude Rehearsal | During the four weeks typically spent on the unit, students encounter many occasions where critical thinking is desirable. These occasions occur in the context of a real-world problem that motivates students to continue to engage in applying good thinking. |

Opportunities for deliberative processing occur at many points in *Decision Making*. Through engaging in the real-world problem solving in their roles as urban planners making fair-exchange decisions, students repeatedly encounter occasions that require critical thinking.

The motivation necessary to bring about and maintain deliberative processing is also evidenced in the activities of students using this unit. Middleton and Roodhart (1997) studied the implementation of *Decision Making* by 17 middle-school teachers and their students in four Midwestern school districts. They observed that students were willing to work beyond their teachers' expectations for the sake of creating quality projects. In most of the classes, the students were not allowed class time to construct their choice of final projects—models of their rezoning plans. Yet, they met after school and on weekends to develop high-quality, mathematically correct scale models.

When asked what they thought of the unit, most students agreed that it was hard, but not too hard to do. They felt it was interesting because it dealt with real-life issues that they had heard about before. They understood the application of the context to the fields of architecture and urban design, and several students expressed a desire to learn more about these professions. The students also expressed a desire for more mathematics of this type.

Although the novelty of the situation certainly added to their enjoyment, the sustained effort students demonstrated over four to six weeks of work would suggest that the unit structure and content tapped into the structure of students' intrinsic motivations. That is, the unit provided them with a level of stimulation by the tasks and a level of control over those tasks that kept them intrinsically engaged (Middleton & Toluk, 1999).

The authentic tasks provided by *Decision Making* appear to be effective in developing critical thinking. Examples of near transfer were reported by the observers (Middleton & Roodhardt, 1997). When students were questioned with regard to their problem-solving strategies, they often referred back to the context of the rezoning conflict and said, “Oh, it's just like...,” and used their previous strategies as analogies to communicate their present thinking. When the observers asked the students what the mathematical constraints to the systems of inequalities meant, the students used the relationships in the rezoning context to come up with a general solution. As for the dispositional side of critical thinking, observations did not disclose evidence of transfer to other contexts. Although this unit provides the conditions needed for development of strong and accessible dispositions, the implementation study did not reveal any instances supporting far transfer.

## Conclusion

The *Jasper Series* and *Decision Making* are just two empirically supported cases of a number of instructional programs that incorporate ill-structured problem solving into their design (e.g., Leshowitz, DiCerbo, & Symington, 1999). As the cases suggest, through the use of activities focused on solving ill-structured problems, teachers and instructional designers may promote positive changes in students' thinking dispositions. With involvement in authentic activities, students can more directly experience problems within real-world contexts. Appropriate use of video and multimedia technology can also add realistic richness to the context. Moreover, instruction incorporating ill-structured problem solving also encourages students to invest emotionally and choose freely as they construct arguments and articulate a personal position on a problem. In addition, this kind of instructional design promotes repeated expression of critical-thinking dispositions through the give and take of considering possible alternatives and developing support for arguments.

From our examination of these two prototypical instructional innovations, we can abstract a number of design principles that pertain specifically to the nurturance of dispositions for critical thinking and to the stimulation of subsequent achievement:

1. *Development of attitude strength takes time*. Just as development of the ability to think critically in a domain takes considerable experience solving problems in that domain, so does the development of attitude strength. Both of the programs take two to four weeks to complete, revisiting common mathematical and contextual themes over the course of instruction, as opposed to traditional approaches to mathematics instruction in middle schools, which allow fewer experiences with concepts and contexts, and less time to go in-depth. In instructional design, familiarity does not breed contempt. In our cases, it appears to breed strong positive attitudes to learn.

2. *Students need to have a stake in their learning*. Both innovations provide consistent and coherent experiences that attempt to enculturate the student into the ways of thinking and acting, as authentically as possible in a school mathematics environment, of actual communities of practice. In *Rescue at Boone's Meadow*, students have a stake in the outcome of the rescue. In *Decision Making*, students must choose a perspective on urban planning that potentially would have real consequences for the ultimate design of the new development. In each of the experiences students encounter, the perspective they have chosen impacts on the learning activities they engage in.

3. *Multiple perspectives on problem solving are built into the design*. In both innovations, students are able to develop their own ways of solving the problems. Multiple perspectives on how to approach and work through the problems are fostered. A visually oriented student can utilize graphical analysis, a symbolically oriented student may use algebraic notation and operations, while a numeric thinker might employ number patterns in a table. These multiple methods are encouraged and fostered as bringing unique information to the endeavor of solving the ill-structured problem. Diversity of modes of thought is not an afterthought. Instead, it is an integral part of the design of the activities.

While just a terse list, these three principles run counter to most current approaches to curriculum design in the middle school. Considerable renegotiation of the conditions of learning is required for environments such as these to be integrated into the everyday practice of education that currently does not allow enough time, personalization of activity, or integration of multiple ways of knowing to really amount to much in terms of critical thinking or dispositions to think critically. Moreover, though these principles embody the research literature in each of their areas, they are still somewhat untested empirically as a set. Just what is the time scale for developing attitude strength for a field such as mathematics? We suspect it is on the scale of several years of consistent and coherent instruction. Two- to four-week units are only important if they are embedded in a larger curriculum that paints a consistent picture of attitude development.

To what degree do students' investments in their own learning in a contextualized program narrow the potential for transfer to alternative situations? Perkins and Tishman (1998) suggest that expertise in an area is key to sensitivity to the occasion to think critically. It may also be that being overly narrow may prevent broader sensitivity to develop. As Bereiter (1995) points out, when learners are given an analogous problem—a problem in a different situation that can be solved in the same way—they typically do not put to use what they learned in the first situation unless they are prompted in some way. This may be true for transfer of attitudes in general and critical-thinking dispositions in particular. One avenue of future research, then, could address aspects of the transfer of learned dispositions. Perhaps critical-thinking dispositions are activated by rather broad classes of attitude-inducing situations. If that were the case, dispositions might transfer more readily among contexts than some other kinds of learning (such as the conceptual or procedural knowledge needed to solve a problem).

Lastly, diverse modes of thinking are acknowledged but not articulated clearly in much of the literature. We suspect that diversity is an ultimate advantage. Yet, exactly what ways of thinking complement each other in instructional situations and how can they be maximized? These and other questions are crucial for more widespread application of the three principles to instructional design.

We conclude that there is tremendous potential for curriculum design for critical-thinking dispositions in even as intractable a subject-matter as mathematics. This review, then, constitutes a plausibility argument—a hypothesis—that articulates key areas of the psychology of dispositions and its implication for instructional design in the middle grades. In it we stress that in every learning situation (or other context where critical thinking is important), a student's ability is not sufficient to predict how he or she will act. Teachers and instructional designers should keep in mind that students are also more or less disposed to good thinking. Our efforts need to address this attitudinal aspect of critical thinking as well and result in tools and principles that inculcate critical thinking dispositions into the fabric of students' activity. Years ago, Gordon Allport (1935) expressed in simple terms the importance of such attitudes: “Attitudes determine for each individual what he will see and hear, what he will think and what he will do” (p. 806).

## References

Allport, G. W. (1935). Attitudes. In C. Murchison (Ed.), *Handbook of social psychology*. Worcester, MA: Clark University Press.

Baron, J. (1985). *Rationality and intelligence*. New York: Cambridge University Press.

Bem, D. J. (1972). Self-perception theory. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 6, pp. 1-62). New York: Academic.

Bereiter, C. (1995). A dispositional view of transfer. In A. McKeough, J. Lupart, & A. Marini (Eds.), *Teaching for mastery: Fostering generalization in learning* (pp. 21-34). Mahwah, NJ: Lawrence Erlbaum.

Brown, J. S., Collins, A., & Duguid, P. (1989). Situated cognition and the culture of learning. *Educational Researcher, 18*(1), 32-42.

Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. *Journal of Personality and Social Psychology, 42,* 116-131.

Cognition and Technology Group at Vanderbilt. (1992a). The Jasper experiment: An exploration of issues in learning and instructional design. *Educational Technology Research and Development, 40*(1), 65-80.

Cognition and Technology Group at Vanderbilt. (1992b). The Jasper series as an example of anchored instruction: Theory, program description, and assessment data. *Educational Psychologist, 27*(3), 291-315.

Cognition and Technology Group at Vanderbilt. (1993). Anchored instruction and situated cognition revisited. *Educational Technology, 33*(3), 52-70.

Ennis, R. H. (1986). A taxonomy of critical thinking dispositions and abilities. In J. B. Baron & R. S. Sternberg (Eds.), *Teaching thinking skills: Theory and practice* (pp. 9-26). New York: W. H. Freeman.

Facione, P. A., Facione, N. C., & Giancarlo, C. A. (1996). The motivation to think in working and learning. *New Directions for Higher Education, 96,* 67-79.

Fazio, R. H. (1990). Multiple processes by which attitudes guide behavior: The MODE model as an integrative framework. In M. P. Zanna (Ed.), *Advances in experimental social psychology* (Vol. 23, pp. 75-109). New York: Academic Press.

Fazio, R. H. (1995). Attitudes as object-evaluation associations: Determinants, consequences, and correlates of attitude accessibility. In R. E. Petty & J. A. Krosnick (Eds.), *Attitude strength: Antecedents and consequences* (pp. 247-282). Mahwah, NJ: Lawrence Erlbaum.

Fazio, R. H., Blascovich, J., & Driscoll, D. M. (1992). On the functional value of attitudes: The influence of accessible attitudes on the ease and quality of decision making. *Personality and Social Psychology Bulletin, 18*(4), 388-401.

Fazio, R. H., Herr, P. M., & Olney, T. J. (1984). Attitude accessibility following a self-perception process. *Journal of Personality and Social Psychology*, 47, 277-286.

Fazio, R. H., & Zanna, M. P. (1981). Direct experience and attitude-behavior consistency. In L. Berkowitz (Ed.), *Advances in experimental social psychology* (Vol. 14, pp. 162-202). New York: Academic Press.

Fiske, S. T., & Taylor, S. E. (1991). *Social cognition*. New York: McGraw-Hill.

Gagné, R. M. (1977). *The conditions of learning, 3rd ed*. New York: Holt, Rinehart, and Winston.

Hickey, D. T., Moore, A. L., & Pellegrino, J. W. (2001). The motivational and academic consequences of elementary mathematics environments: Do constructivist innovations and reforms make a difference? *American Educational Research Journal, 38*, 611-652.

Jonassen, D. H. (1997). Instructional design models for well-structured and ill-structured problem-solving learning outcomes. *Educational Technology Research and Development, 45*(1), 65-94.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, UK: Cambridge University Press.

Leshowitz, B., DiCerbo, K. E., & Symington, S. (1999). Effective thinking: An active-learning course in critical thinking. *Current Issues in Education, 2*(5). Retrieved April 22, 2004 from Arizona State University Web site: http://cie.ed.asu.edu/volume2/number5/

Middleton, J. A., Lesh, R., & Heger, M. (2002). Interest, identity, and social functioning: Central features of modeling activity. To appear in Doerr, H. & Lesh, R. (Eds.), *Beyond constructivism: A models and modeling perspective on mathematics problem solving, learning and teaching*. Mahwah, NJ: Lawrence Erlbaum Associates, Inc.

Middleton, J. A., & Roodhardt, A. (1997). Using knowledge of story schemas to structure mathematical activity. *Current Issues in Middle Level Education, 6*(1), 40-55.

Middleton, J. A., & Toluk, Z. (1999). First steps in the development of an adaptive theory of motivation. *Educational Psychologist, 32*(2), 99-112.

Norris, S. P. (1985). Synthesis of research on critical thinking. *Educational Leadership, 42,* 40-45.

Perkins, D. N., Jay, E., & Tishman, S. (1993). *Beyond abilities: A dispositional theory of thinking*. Merrill-Palmer Quarterly, 39(1), 1-21.

Perkins, D. N., & Tishman, S. (1998, March). *Dispositional aspects of intelligence*. Paper presented at the 1998 Winter Symposium of the College of Education, Arizona State University, Tempe.

Ritchhart, R., & Perkins, D. N. (2000). Life in the mindful classroom: Nurturing the disposition of mindfulness. *Journal of Social Issues, 56,* 27-47.

Roskos-Ewoldsen, D. R., & Fazio, R. H. (1992). On the orienting value of attitudes: Attitude accessibility as a determinant of an object's attraction of visual attention. *Journal of Personality and Social Psychology, 63,* 198-211.

Schwarz, N., & Clore, G. L. (1988). How do I feel about it? The informative function of affective states. In K. Fiedler & J. Forgas (Eds.), Affect, *Cognition and Social Behavior* (pp. 44-62). Toronto: C. J. Hogrefe.

Sinnott, J. D. (1989). A model for solution of ill-structured problems: Implications for everyday and abstract problem solving. In J. D. Sinnott (Ed.), *Everyday problem solving: Theory and applications* (pp. 72-99). New York: Praeger.

Taube, K. T. (1997). Critical thinking ability and disposition as factors of performance on a written critical thinking test. *Journal of General Education, 46*(2), 129-164.

Wu, C., & Shaffer, D. R. (1987). Susceptibility to persuasive appeals as a function of source credibility and prior experience with the attitude object. *Journal of Personality and Social Psychology, 52*, 677-688.