

Running Head: METACOGNITION IN THE COMPOSITION CLASSROOM

Just Don't Make Me Think:

Metacognition in the Composition Classroom

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Abstract

Many college writing students don't know how to write and don't want to think about improving their skills. If our students know how, when, and why to do academic writing, they will be able to use both cognition and metacognition to good effect. College composition teachers can use metacognition to help students learn to analyze and adapt their thinking, learning, and writing processes. Drawing on personal observation and a survey of published literature, this paper explores the history and definition of the term metacognition, discusses how to distinguish between cognition and metacognition, describes methods for assessing students' metacognitive skills, investigates how to build metacognitive experiences into writing courses, and recommends that teachers also practice metacognitive thinking.

Just Don't Make Me Think:

Metacognition in the Composition Classroom

Early in October, I held conferences with my second-semester composition students. These one-on-one meetings turned out as they usually do: some students were eager to work with me on the outline for their next paper, others were somewhat anxious about meeting with a professor, and a third group – those who believe homework is optional – hadn't completed the required outline assignment. Many college writing students don't know how to write and don't want to think about improving their skills. If our students know how, when, and why to do academic writing, they will be able to use both cognition and metacognition to good effect. College composition teachers can use metacognition to help students learn to analyze and adapt their thinking, learning, and writing processes. Drawing on personal observation and a survey of published literature, this paper explores the history and definition of the term metacognition, discusses how to distinguish between cognition and metacognition, describes methods for assessing students' metacognitive skills, investigates how to build metacognitive experiences into writing courses, and recommends that teachers also practice metacognitive thinking.

This paper came about because I wanted to go to Hawaii for Christmas break.¹ It's true. But I had been working on metacognition in my classes. Last year I used Elbow and Belanoff's (2000) A Community of Writers for English 101, with great success, I think. So I wanted to apply some of these ideas to English 102 this semester. I was working on a paper about difficult students and how they bring out the worst in teachers, but that paper wasn't going anywhere in my imagination. Then one night, in

¹ In this paper I will alternate between the text proper (cognition, formal tone, regular font) and telling the story of how I wrote this paper (demonstrating metacognition, informal tone, italic font).

the middle of my 2 a.m. insomnia, I thought about metacognition as a topic. I got out of bed, went to my computer, logged into the Idaho State University mainframe, and began a professional journal search for articles about metacognition. Might as well put that insomnia to use. That's how the paper started.

History and Definition of the Term

Metacognition became a buzzword in education in the mid-1970s, especially for teachers of reading and special education. Metacognition can be loosely defined as “thinking about thinking,” but it is important not to be superficial about this complex form of higher-order thought. Metacognition involves not only the ability to think about one’s cognitions, but also knowing how to analyze, to draw conclusions, to learn from, and to put into practice what has been learned.

Metacognitive theory draws on the work of Plato, Aristotle, Confucius, Lao Tzu, Solomon, and Buddha. In 1690, John Locke observed that most children gradually develop the ability to reflect on their own thinking processes, although some children never do. Strategies for assessing and teaching metacognitive skills were in use long before the term became popular. Reading was an early focus of research on reflective thinking. In 1909, Baldwin used a questionnaire to learn about students’ reading , and a year later Dewey introduced “reflective reading.” For Dewey, reflection was a special kind of thinking involving the ordering and linking of ideas. By 1917, Thorndike was using reflection, asking students to problem-solve by answering questions on texts they had read (Brown 1987, Hatton & Smith 1995). Flavell published The Developmental Psychology of Jean Piaget in 1963, and planning as a distinct form of higher order thinking once again caught the interest of researchers. In 1971, Flavell introduced

“metamemory” and conducted the first study of children’s metamemory. By 1975, the word “metacognition” had come into common use.

Over the next several days, I downloaded about a foot and a half of articles from databases. (We are lucky to have a wonderful library computer system at Idaho State University which lets us search for full-text articles from any computer, on campus or at home.) I went to the library to get journal articles and about ten books, five of which turned out to be helpful.

Distinguishing Between Cognition and Metacognition

Hacker (1998) mentions that Kluwe refined the concept of metacognition by noting two characteristics: the thinker knows something about his or her own and others’ thought processes, and the thinker can notice and change his or her thinking. Kluwe calls this second type of metacognition “executive processes.” Pointing out the difference between cognitive tasks (remembering things learned earlier that might help with this task or problem) and metacognition (monitoring and regulating the process of problem solving), Hacker stresses the importance of learning more about thinking. An additional point is made by Cornoldi (1998), who emphasizes the role of learners’ beliefs about thinking. If students feel confident that they can solve problems, they do better work.

In 1987, Weinert wrote about the apparent ease of separating the two types of thinking, defining metacognition as simply “thinking about thinking” or “second-order cognition” (p. 8). However, he acknowledges that use, conscious understanding, ability to talk or write about tasks, and generalizability to other tasks are important factors in determining whether or not a given task is metacognitive. Brown (1987) agrees that metacognition requires the thinker to use and describe the process of an activity. Allen

and Armour-Thomas (1991) include both knowledge about and control over thinking processes in defining metacognition, while Vadhan and Stander (1993) separate ordinary thinking from awareness and understanding of thinking. Hacker (1998) separates metacognitive thinking into three types: metacognitive knowledge (what one knows about knowing), metacognitive skill (what one is currently doing), and metacognitive experience (one's current cognitive or affective state).

While cognition focuses on solving the problem, metacognition focuses on the process of solving the problem. According to Marchant (2001), "Metacognitive skills involve knowing what to do, and how and when to do it" (p. 488). In the 1987 film No Way Out (Donaldson), a young woman of shady character who is later murdered uses, "You know what to do, and you know how to do it, so . . . let's do it!" as the message on her answering machine. Writers must learn how to plan the writing process; to organize, draft, revise and copyedit; and to consider audience, purpose, and genre.

The next step was to read all this stuff. I went to the books first, starting with the most general and theoretical books, moving toward more specific information. Because it's not polite to mark up library books, I cut paper into strips to use as bookmarks and wrote the page numbers and what I wanted to remember about that page on the strips. After several days, the books sat in a stack on my desk with many little white strips protruding from their tops like strange growths.

Then, focusing on even more specific information, I read all the articles, one after the other, as fast as I could go. This took two weeks of reading every afternoon and evening and most of the day on weekends. While reading, I highlighted important ideas and turned passages into my own words by summarizing them in the margins and on the

backs of pages. When I finished each article, I wrote one or more key words on the top right corner of the first page to allow me to sort the articles: definitions, strategies, for teachers, etc. Most of the articles had nothing I could use, but a few were gold.

Factors Which Affect Metacognition

Although much of what we know about metacognition grew out of the work of specialists in reading and learning disabilities, this information also can be applied to college writing classes. Flavell (1987) points out the importance of knowing how three variables interact. Person variables involve the learner's beliefs about how he or she and others think and learn. Task variables include how difficult a problem is and how that affects the process the learner uses. Strategy variables are also important. Cognitive strategy may involve knowing how to do a particular task, but higher-order metacognitive strategy involves checking to see that the solution to the problem is correct and that the goal has been reached. Learners have metacognitive experiences often, especially in new situations, where correctness is important, and when difficulty develops.

Going a step further, Kluwe (1987) separates executive decisions from other types of metacognition. Executive decisions focus on how to solve a problem rather than just the actual solution, develop from the need to avoid failure, and may not be needed when completing some tasks. Brown (1987) points out that one weakness of executive decision theory is its source in theories of synthetic intelligence. Although marvelous thinking machines have been developed, for instance, IBM's Deep Blue, which beat world champion Garry Kasparov at chess ("Deep Blue Wins Match"), synthetic intelligence differs from human intelligence in important ways.²

² For an interesting experience with synthetic intelligence, read about and talk with Richard Wallace's chatbot A.L.I.C.E. at www.alicebot.com.

Then I put my quick outline on the computer and began to fill in the blanks with information, putting in the paraphrases, some pithy quotations, and correct citations as I went along, so that I wouldn't have to do it later. The outline grew to 25 pages, but it's better to have too much than not enough.

Now I am looking for several methods of incorporating metacognition into teaching composition. Once that's done, I plan to print the outline, scissor and paste if necessary, and then revise the outline into a draft paper.

What about the learning process, thinking process, my own metacognition about this task? I know metacognition works, that both students and teachers are reluctant to use higher-order thinking if it adds more work to their already busy schedules. I know that students' confidence in their ability to learn makes all the difference, and that part of my role as a teacher is to set up situations in which learning, however difficult, can take place.

Assessing Metacognitive Skills

Writing teachers look for certain skills in their students. The table below combines descriptions of characteristics supplied by Collins (1994), Sitko (1998), Gourgey (1999)³, Paris and Paris (2001), and this author. It is easy to spot writers who may have trouble by comparing this list of behaviors with the skills of individual students. However, more formal methods can also be used to assess metacognitive thinking in students.⁴

³ This material is about readers, but works well for considering the skill level of college writers, too.

⁴ Rules for human subjects research may limit your ability to use these assessment methods. At Idaho State University, teachers are allowed to pursue research that is used only for improving their own classes without a formal proposal to the Human Subjects Committee. However, if it is possible that the results of the research will be shared with others, then it is better to consult the governing committee for advice before proceeding.

Table 1. Differences Between Skilled and Less-Experienced Writers	
Skilled writers	Less experienced writers
Write more Active Feel confident of skills Have repertoire of strategies Ask questions, take notes Consider rhetorical goals such as purpose, audience, genre Understand conventions of genre Figure things out for themselves	Write less Passive Insecure, worried about skills Lack repertoire of strategies Overlook important ideas because they do not engage in self-questioning and self-testing Forget to consider purpose and audience Lack knowledge about genres Rely on others for clarification May have mistaken notions of how writers work Frustrated, give up easily Daydream, forget assignments
Divide process into parts Use subgoals as motivation Allocate time and resources judiciously Relate information to previous knowledge	Tend to organize ideas by using a list Don't use memory or environment to generate content Don't understand how to manage a task Fail to relate the present task to previous knowledge
Better at revision Can detect, diagnose, and fix problems in their own texts and those of others	Often decide to leave problems in the text untouched Seek help with sentence-level errors from older people
Complete assignments in a timely manner Talk to professor, arrange conferences	Complete assignments at the last minute May fail to finish or hand in assignments Avoid professor, fail to show up for conferences

One simple test for abstract thinking is “The Frog Puzzle”⁵ (1975), which this author received as a handout from the Nebraska Writing Project in the summer of 1982.

The puzzle tells the story of a professor who caught, banded, and released frogs in a pond, and then on a second trip, caught a number of frogs and counted how many had bands. From the information given, students are asked to compute the total number of frogs in the pond and write down the method they used to come up with the answer.

Answers and reasoning tends to fall into three categories. The first type of student thinks

⁵ See Appendix A.

concretely and writes that the problem cannot be solved with the available data. The second type of student, on the verge of making the breakthrough into abstract thinking, gets the number of frogs wrong but understands that there is some method which can be used to calculate the total number of frogs in the pond. Able to easily move from the data provided to the abstract thought required to construct the equation that solves the puzzle, the third type of student comes up with the correct answer and has no trouble explaining how it was done.

I remember solving the Frog Puzzle for the first time in the Nebraska Writing Project. It was just presented to us without explanation, and I looked at it, realized it required an equation, and got the correct answer. Then I wrote down the process I used to solve the problem. I felt amazed when several members of our class of twenty writing teachers answered the question incorrectly. Later, I used this test with my students, in a general sort of way, to determine where a class stood in relation to abstract thinking. Just like the test answers show, my students all wrote in one of the three styles. How can something so simple reveal information about something as complex as human thought?

Another instrument for measuring higher-order thinking is the “Components of Metacognition Questionnaire”⁶ adapted a bit from the work of Allen and Armour-Thomas (1991). This questionnaire asks people to rate themselves using a five-point scale on a series of tasks that may be approached cognitively or metacognitively. Each section focuses on one aspect of metacognition, including defining the nature of a problem, options for problem-solving, using strategy, selecting a representation for information, allocating resources, and evaluating how well a solution worked.

⁶ See Appendix B.

The “Vividness of Visual Imagery Questionnaire”⁷ developed by Marks (1991) takes a different approach, equating metacognition with the ability to “form mental pictures, or to ‘see in the mind’s eye’” (p. 11). Marks argues that, “Mental practice which employs subjectively experienced images of future events – and explores how these events might be influenced by behavioral intervention – enables the experiencer’s future actions towards his/her goals.” (p. 2). The questionnaire asks students to visualize four different images, first with eyes open and then with eyes closed, and rate them on a five –point scale ranging from “clear and vivid as normal vision” (1) to “no image at all” (5) (p. 11). Marks concludes that the ability to form mental images is an important part of goal directed thinking and action. The ability to imagine doing something is one step in the process of solving a problem or completing a task.

The “Holistic Critical Thinking Scoring Rubric”⁸ developed by Facione and Facione (1994) can help teachers evaluate students’ ability in critical thinking, a skill closely allied to metacognition. The rubric can help to evaluate critical thinking in papers or other projects. Since critical thinking involves understanding the assignment, focusing on relevant rather than irrelevant information, storing information, and trying out new strategies, this scoring system may give a teacher some insight into metacognitive ability. Graham and Wong (1993) developed a questionnaire for assessing metacognition in readers that this author adapted for writers as the “Metacognitive Writing Skills Questionnaire”⁹. This simple questionnaire asks students to describe their feelings about and experiences with writing, looking for strengths, weaknesses, and what needs to be learned in the future. Another easy way to estimate metacognitive ability is suggested by

⁷ See Appendix C.

⁸ See Appendix D.

⁹ See Appendix E.

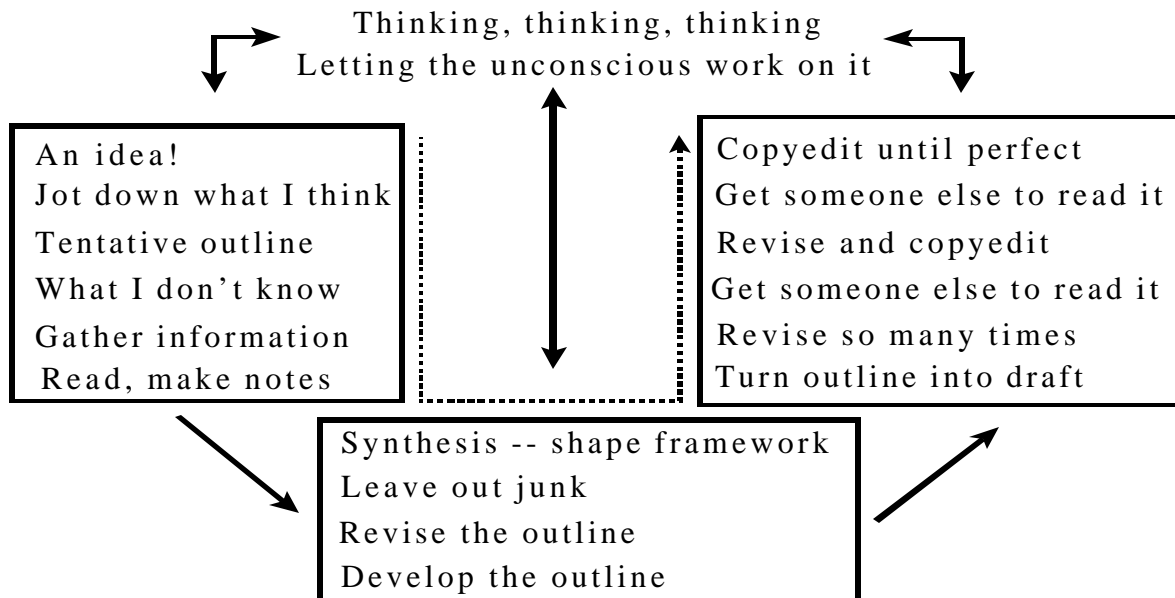
Vadhan and Stander (1993). They asked students to estimate what grade they would receive. The actual grade measures cognitive ability, but looking at how close the student's estimate came to the actual grade measures metacognition, in particular the individual student's ability to predict how well he or she will do on an assignment.

I want to take a nap. I want to go out and get the mail. I want to take the dogs for a walk in the beautiful fall weather. Anything but work on this paper. If difficulty and frustration are any measure of success, then this process is going well.

Using the Writing Process to Teach Metacognitive Skills

The writing process can be organized in many ways. Ask students to draw a picture or diagram of the steps they go through when writing a paper. You will learn a great deal about how they perceive the writing process. For instance, when this author drew a picture of her writing process, the diagram took the shape shown in Figure 1. The form of the diagram emphasizes the reflexive nature of the process, with each stage of writing moving back and forth between conscious thought, using the unconscious, and actual work on the project. The dotted arrow stresses the smooth movement of the process from the initial idea and information gathering stage, to synthesis and outlining, and finally through drafting, multiple sessions of revising, and copyediting. The sixteen-part process has been simplified by organizing it into three task blocks. It also may be useful to think of the writing process in four steps: planning, drafting, revising, and copyediting. Experienced writers find it easy to construct a sequence, but those who are fearful or simply haven't done enough writing to know how it works may need skills in forming a strategy for attacking the writing task.

Figure 1. The Author's Writing Process



Ha, ha, ha. There I was describing my “smooth movement of the writing process” with such pride when disaster struck. Word stinks. It’s 11 p.m., and Word just had to close itself and lose all the writing I did tonight. Six hours of work. Ugh. No one’s writing process is smooth. It’s always bumpy and difficult. We have to expect that it will be difficult. Making mistakes is part of the process. When you feel stuck, it’s the moment before the breakthrough. We can hope so, anyway.

Sitko (1998) recommends that teachers develop “. . . explicit guides to reduce the strain on working memory and encourage a range of activities such as goal setting and problem identification . . . facilitations in the form of cards, verbal cues, or computer-generated prompts” (p. 102). Prompts designed to elicit metacognition can be used at any stage in the writing process, although college writers may need help in many areas, including coming up with an idea, setting goals and planning how to reach those goals,

synthesizing research materials, drafting, global revision, sentence-level revision, and careful copyediting. Sitko notes that students who received instruction in global and rhetorical revision strategies were able to improve their writing more than those who did not receive such instruction.

When planning a specific writing lesson that will also teach metacognition, teachers can follow guidelines created by Paris and Paris (2001) and Bereiter and Scadamalia (Sitko, 1998). Writing about self-regulated learning, a classroom technique which uses metacognition, Paris and Paris describe tasks which help students develop higher order thinking with the following terms: interesting, collaborative, difficult rather than easy, providing opportunities to succeed. Choose a specific task that novices don't do – based on your assessment of the metacognitive skills of students – and develop an explicit description of the mental operations involved in the task. Create a plan to let students know how and when to begin and end the process, and then develop cards, mnemonics, and routines to help students remember what to do (Sitko, 1998). It is not enough to teach the strategies. You must also teach how, when, and why to use each strategy. Students should recognize the cause-and-effect results of applying strategies and becoming better writers.

For instance, Gourgey (1999) designed two exercises to help students develop metacognitive skills. The first assignment, "Vocabulary in Context," asks students to analyze Lewis Carroll's "Jabberwocky," which "is composed largely of nonsense words, yet . . . tells an understandable story" (p. 2). Working collaboratively in small groups, the students read the poem and figure out definitions for as many words as possible. Beyond the surface exercise, students are asked to think metacognitively by

focusing attention on the process they use to solve the problem of words that seem to have no meaning.

Gourgey's second exercise focuses on "Metacognitive Reading Strategies." Students presented with a newspaper article that contains an undefined term must generate questions and predictions about the article. Then students read the article, find answers to their questions, see how accurate their predictions are, generate new questions and answer them, and note when they feel confused and how they resolve this feeling. The students then report their experiences with the task, and afterward review how to write summaries, then decide what to include in their own summaries. The students are enthusiastic about the exercise, but Gourgey notes that, "When I repeated this procedure using progressively lengthier and more technical passages, students still struggled to master the metacognitive skills, and needed to review them again and again . . . only by struggling with these skills over time did they begin to develop the confidence that they could figure out meaning for themselves" (p. 6).

Elbow and Belanoff (2000) divide revision into three stages or levels: changing the bones, changing the muscles, and copyediting. An exercise on changing the muscles – a type of global revision – asks students to print drafts of their papers with three inch right margins. In the first part of the exercise, each writer creates a paragraph " . . . which states briefly your purpose for writing the paper and the reasons why you chose to accomplish your purpose in the way you did" (p. 157). Then each writer goes through the draft paper paragraph by paragraph and writes in the wide margin, "a *summary* of what the paragraph says and does (its purpose), and how it fits in where it is." Group members write margin notes on each other's papers and also jot down their emotional

responses to each paragraph. Using the information generated by this exercise, the writers can then restructure, rewrite, or add to their papers.

It's the next morning, and I'm recovering a bit from last night's disaster. Now saving all sections of this new version of the paper on diskette, CD-Rom, and c:, even though it takes a few minutes every time. I never want to go through last night's horror again. Thank goodness I printed 14 pages of the draft, which I'm going back through and retyping now. Ghost of Ernest Hemingway, who lost all his writing when a suitcase was stolen from his wife in a train station. He thought his work was better for having been rewritten from memory.

Peer group analysis and discussion is particularly useful. Students have fun sharing their writing, but they also see how others in the class take on and accomplish tasks, thus enabling them to generalize about strategies as well as learn and try out specific techniques. The strategies learned in a writing course can also be applied to other opportunities to learn, think, manage work, and solve problems. Of course, metacognition should always be practiced within actual assignments, not in isolation (Paris & Paris, 2001). Overall strategies should be planned to encompass the separate parts of a project, perhaps by requiring that research materials, an outline, or a draft paper be brought to class to share in peer groups. This allows students to adjust their plans as the project proceeds. Throughout an assignment, students should have opportunities for self-assessment to make sure they are on the right track and to help them correct problems.

Assessing Performance in Writing Classes Using Metacognition

One valuable method of grading involves both student and teacher: portfolio-based assessment. Writing students – perhaps during conferences with the teacher – go through their work and select examples that show the progress they have made. A letter or essay accompanying the portfolio discusses what the student found difficult, which writing samples show his or her best writing, how the examples show progress, his or her feelings about writing and how those feelings may have changed, and how he or she responded to evaluation by the teacher (Paris & Paris, 2001). In addition, students should be asked to assess what they learned from didactic instruction, practice in using writing strategies, what they didn't understand, and what they still need to learn about writing in the future.

Process letters or journals and portfolio assessment are wonderful tools. The process letters get students thinking about each assignment. At the end of the semester, we have conferences and they choose samples of their work. Then during the final exam, they write about their learning and how it is revealed by the work in the portfolio. They reflect on their learning, and I really like understanding how they think about writing.

Murray (1990) describes how commentaries on writing teach both students and instructor. He and his students wrote about their writing and shared their work. They found that this helped define what they did well and find solutions to problems. The tone for these letters is “. . . that of a letter to a friend who is also writing” (p. 20). Murray asks students to focus on the emotions they feel when writing, the techniques they use when writing goes well, how problems are solved, the connections between reading and

writing, and the overall process they use. He notes that this type of writing enables writers to learn from themselves and each other.

Elbow and Belanoff (2000) point out that metacognition gives students power and control over their learning and writing. Improving as a writer means looking at what, how, and why people write the way they do. These authors point out Vygotsky's conclusion that higher learning depends on what you already know. Today's college students tend to not know much about writing. If students have trouble writing, they should analyze the problem to figure out what works and what doesn't work. Marchant (2001) suggests a more direct approach to metacognition. She points to Woolfolk's recommendation that students be actively taught strategies, when to use them, and what the positive effects of using writing strategies will be.

One way to get college writers thinking metacognitively is demonstrated by Giancarlo and Facione's (2002) one page "The Reflective Log" handout for a senior capstone course in liberal studies. They point out that metacognition is a skill exhibited by good thinkers, whether or not these people are highly educated. The assignment asks students to keep a log for nine weeks. Students make daily entries in their logbooks, writing about and perhaps diagramming their thoughts. At the end of each week, students write a final paragraph that relates an important learning experience and evaluates the quality of thinking they did. Weekly questions help students gradually develop the ability to "analyze, interpret, explain, and evaluate one's thinking by the standards of good reasoning."

My back is really sore now from sitting in this chair. Even the tips of my fingers are sore. But I'm starting to feel more confident about this paper. The body of the paper

is nearly finished, the references and appendices in place, the cover page and abstract page on, but still no intro or conclusion. I want to insert some of these metacognitive writings, too. What did I learn from last night's disaster? Save, save, save, everywhere, on every medium. And stick with it. Never give up. I saw a T-shirt that said, "Pain is the body's way of telling you it needs more exercise." I guess anguish over writing is the mind's way of telling you it needs more writing.

Metacognition for Teachers, Too

Borkowski (1992) points out that, "Teachers desperately need explicit examples of how to teach children to carry out task analyses, how to scan past experiences for a range of viable strategies, how to match task demands to the strategy set in order to select the best strategy, and how to monitor and revise the initial strategy selection" (p. 256). But where do teachers find such models? One way is to develop working models based on experience and interaction with others. The use of "critical friend" dyads is recommended by Hatton and Smith (1995). This pattern of reflection with a peer who can be trusted to be honest, questioning, and thoughtful enables teachers to think aloud and explore new ideas which they might not think of when working alone. This technique works well with Marchant's (2001) method for the reflective practitioner who wants to create knowledge. In this model, the teacher asks critical questions about how students can learn metacognitive skills, conducts an "experiment" – an exercise which combines knowledge, practice, and self-analysis – to solve the problem, and then learns from how the experiment did and did not succeed, developing another exercise in the process.

College is difficult for many students. The younger ones may be focused on “the college experience” of hanging out with friends, and thirtyish students have jobs, children, and mortgages. One way composition teachers can help many types of students learn and grow in their ability to deal with the complex demands of life is by teaching them metacognitive skills. If our students can evaluate problems and develop plans to solve them, carry out strategies for solutions by checking and adjusting their behavior so that the results are positive, and evaluate their successes and failures so that they learn what to do next time, they will have a good start on a lifetime of successful thinking.

Now I am going to evaluate my successes and frustrations. Okay, so I got the paper more-or-less done – that’s a big success. I still have to read, revise, and edit in the morning, but it’s essentially in place. I would like to work on the conclusion a little, too. I’ll see how it reads tomorrow.

Frustrations were many. First, I had too much information, most of it not on target, and it took many weeks to do the reading and decide what to use. Second, I spent too much time on drafting. Well, maybe not. It seems like there’s never enough time to write a good draft of an entire paper. Third, I had trouble at the end writing the introduction and conclusion. I just couldn’t think of anything to write.

What will I do next time? What did I learn from this paper about the writing process and how to do it more effectively? Hmm. I will select an easier topic. No, seriously, I can winnow the material somehow before I do all that unnecessary research and reading. Perhaps I could set up some sort of way to screen books and articles – If it doesn’t mention X, then I won’t look further. Second, the problem with drafting. I was too focused on the research material and not what I wanted to say. So I would stick with

my outline, write a short draft of the paper first, and then insert the research material. On the other hand, I do think it was good that I read and synthesized so much material. One thing that really helped with this was making tables. Several tables are not included in the paper, but helped me get organized.

I will also try to start big projects earlier to allow more time, maybe writing the paper and then finding a conference for it, instead of the other way around. Of course, I will always, always save my files in three places from now on to avoid losing hours of work.

Finally, I learned that writing can be fun. The experience of diving into this topic and learning more about metacognition was wonderful. I especially enjoyed the afternoons of writing, just sitting here and letting the ideas flow – and , of course, I do like having written.

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Appendix A. **The Frog Puzzle** (Copyright Regents of the University of California, 1975)



Professor Thistlebush, an ecologist, conducted an experiment to determine the number of frogs that live in a pond near the field station. Since he could not catch all the frogs, he caught as many as he could, put a white band around their left hind legs, and then put them back in the pond. A week later he returned to the pond and again caught as many frogs as he could. Here is the professor's data.

First trip to the pond: 55 frogs caught and banded.

Second trip to the pond: 72 frogs caught, of those 72, 12 were banded.

The professor assumed that the banded frogs had mixed thoroughly with the unbanded frogs, and from his data he was able to approximate the number of frogs that live in the pond. If you can compute this number, please do so. Write it in the blank below, and then below that explain in words how you calculated your result.

Total number of frogs in the pond: _____





Responses to Frog Puzzle

1. (a) “I do not feel that I can come up with the number of frogs in the pond due to lack of conclusive data. However, I may not be aware of specific statistical means in which the actual number can be determined.”

(b) “The professor doesn’t have enough data to compute the answer. He should give up.”

(c) “115. I can only assume that he would total the banded frogs (55) with the unbanded frogs caught the second time (60) and add them together – unless he had some other way.”

(d) “115+ frogs that week. The Prof. Should know that populations don’t remain stable. He found at least 115 frogs but he will have a hard time keeping up 2/ the population growth of frogs, and two spot checks of a pond would hardly constitute conclusive evidence.

2. (a) “270. If the professor’s assumption was correct that the frogs would mix and he got twelve banded out of 72 and he started w/55 you would get 270 actually, I don’t believe it is possible to calculate this experiment.”

(b) “115 frogs/385 frogs

72 frogs – 12 frogs = 60 frogs

60 frogs + 55 frogs = 155 frogs or

1 out of every 7 frogs was banded so you could say $55 \times 7 = 385$ frogs maybe.”

3. (a) 330. On the second trip to the pond he caught 72 frogs, of which one-sixth were marked. If he assumed that this would be the proportion of marked frogs in any

sample, then he could also assume that he had originally marked $\frac{1}{6}$ of the frogs. 6×55
= 330 frogs.”

b) “330 frogs. If the frogs had mixed evenly, then the ratio of banded frogs in the
2nd catching to number caught would be the same as the ratio of all caught the first time,
to the whole.”

Appendix B. **Components of Metacognition Questionnaire** (Adapted from Allen and Armour-Thomas, 1991)

Circle the number in each section which best reflects what you would do.

Defining the nature of the problem	<p>If you saw your neighbor's house on fire, what would you do first? Help your neighbor rather than call the fire station?</p> <p>Help your neighbor Call 911</p> <p style="text-align: center;">1 2 3 4 5</p>
Selecting options	<p>If you had to solve a problem on a test, how often would you first consider many approaches to solving the problem before you begin rather than selecting the first approach you think of?</p> <p>Select first approach Consider many options</p> <p style="text-align: center;">1 2 3 4 5</p>
Selecting a strategy	<p>If you wanted to plan a trip to the amusement park, how often would you organize the things that had to be done, rather than do the many tasks without any particular order?</p> <p>No particular order Organize the tasks</p> <p style="text-align: center;">1 2 3 4 5</p>
Selecting a representation for information	<p>If you were giving a party, how often would you first make a mental note of all the things you had to do before you set out, rather than run each errand as it occurred to you?</p> <p>As they occur to me Make mental note</p> <p style="text-align: center;">1 2 3 4 5</p>
Allocating resources	<p>If you were taking a test, how often would you consider the amount of time you would spend on each question, rather than completing as many questions as time allows?</p> <p>As time allows Consider time to spend on each</p> <p style="text-align: center;">1 2 3 4 5</p>
Solution monitoring	<p>If you were taking care of several children, how often would you make sure the children were safe and leave them to play, rather than check on the children as the day went along?</p> <p>As day goes along At set intervals</p> <p style="text-align: center;">1 2 3 4 5</p>

Appendix C. **Vividness of Visual Imagery Questionnaire** (Marks, 1991)

Name _____ Age _____ M or F _____

Major _____ Year in College _____ Occupation _____

Visual imagery refers to the ability to visualize; that is, the ability to form mental pictures, or to ‘see in the mind’s eye.’ Marked individual differences have been found in the strength and clarity of reported visual imagery, and these differences are of considerable psychological interest.

The aim of this test is to determine the vividness of your visual imagery. The items of the test will possibly bring certain images to your mind. You are asked to rate the vividness of each image by reference to the five-point scale given below. For example, if your image is ‘vague and dim,’ then give it a rating of 4. After each item, write the rating in the box provided. The box on the left is for an image obtained with your eyes open, and the box on the right is for an image obtained with your eyes closed. Before you turn to the items on the next page, familiarize yourself with the different categories on the rating scale. Throughout the test, refer to the rating scale when judging the vividness of each image. Try to do each item separately, independent of how you may have done other items.

Five-point Rating Scale

Complete all items for images with eyes open, and then return to the beginning of the questionnaire and rate the image obtained for each item with your eyes closed. Try and give your “eyes closed” rating independently of the “eyes open” rating. The two ratings for a given item may not in all cases be the same. The image aroused by an item might be:

Image	Rating
Perfectly clear and as vivid as normal vision	1
Clear and reasonably vivid	2
Moderately clear and vivid	3
Vague and dim	4
No image at all; you only ‘know’ that you are thinking of an object	5

Rate 1-5 Eyes Open	Images	Rate 1-5 Eyes Closed
	In answering items 1 to 4, think of some relative or friend whom you frequently see (but who is not with you at present) and consider carefully the picture that comes before your mind's eye.	
	1. The exact contour of face, head, shoulders, and body.	
	2. Characteristic poses of head, attitudes of body, etc.	
	3. The precise carriage, length of step, etc., in walking	
	4. The different colors worn in some familiar clothes	
	Visualize the rising sun. Consider carefully what comes before your mind's eye.	
	5. The sun rises above the horizon into a hazy sky.	
	6. The sky clears and surrounds the sun with blueness.	
	7. Clouds. A storm blows up, with flashes of lightning.	
	8. A rainbow appears.	
	Think of the front of a store that you often go to. Consider the picture that comes before your mind's eye.	
	9. The overall appearance of the store from the opposite side of the road.	
	10. A window display including colors, shapes, and details of individual items for sale.	
	11. You are near the entrance. The color, shape, and details of the door.	
	12. You enter the shop and go to the counter. The counter assistant serves you. Money changes hands.	
	Finally, think of a country scene which involves trees, mountains, and a lake. Consider the picture that comes before your mind's eye.	
	13. The contours of the landscape.	
	14. The color and shape of the trees.	
	15. The color and shape of the lake.	
	16. A strong wind blows on the trees and causes waves.	

Appendix D. **Holistic Critical Thinking Scoring Rubric** (Facione & Facione, 1994)

<p>4 Consistently does all or almost all of the following:</p> <ul style="list-style-type: none"> Accurately interprets evidence, statements, graphics, questions, etc. Identifies the salient arguments (reasons and claims) pro and con. Thoughtfully analyzes and evaluates major alternative points of view. Draws warranted, judicious, non-fallacious conclusions. Justifies key results and procedures, explains assumptions and reasons. Fair-mindedly follows where evidence and reasons lead.
<p>3 Does most or many of the following:</p> <ul style="list-style-type: none"> Accurately interprets evidence, statements, graphics, questions, etc. Identifies relevant arguments (reasons and claims) pro and con. Offers analyses and evaluations of obvious alternative points of view. Draws warranted, non-fallacious conclusions. Justifies some results or procedures, explains reasons. Fair-mindedly follows where evidence and reasons lead.
<p>2 Does most or many of the following:</p> <ul style="list-style-type: none"> Misinterprets evidence, statements, graphics, questions, etc. Fails to identify strong, relevant counter-arguments. Ignores or superficially evaluates obvious alternative points of view. Draws unwarranted or fallacious conclusions. Justifies few results or procedures, seldom explains reasons. Regardless of the evidence or reasons, maintains or defends views based on self-interest or preconceptions.
<p>1 Consistently does all or almost all of the following:</p> <ul style="list-style-type: none"> Offers biased interpretations of evidence, statements, graphics, questions, information, or the points of view of others. Fails to identify or hastily dismisses strong, relevant counter-arguments. Ignores or superficially evaluates obvious alternative points of view. Argues using fallacious or irrelevant reasons, and unwarranted claims. Does not justify results or procedures, nor explain reasons. Regardless of the evidence or reasons, maintains or defends views based on self-interest or preconceptions. Exhibits close-mindedness or hostility to reason.

Appendix E. Metacognitive Writing Questionnaire (Adapted from Graham & Wong, 1993)

1. Suppose you have a friend who is going to start college. What would you tell your friend about the skills necessary for writing in college?
2. Do you think writing is important? Why?
3. When you don't do well at writing, what do you think are the reasons?
4. What things does a person need to learn to be a good writer?
5. What things does a person need to do to be a good writer?
6. When a person is writing papers as a freshman in college, is that person doing the same things a graduate student does when writing?
7. What things do you need to do to be a better writer than you are right now?