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AUTHOR	Goldberg, Pat
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ABSTRACT

A teacher involved in Kentucky's statewide systemic reform began a personal effort to change her classroom through action research, especially in the area of higher order thinking. This action research gathered data about the aspects of metacognition that might develop naturally in 8- and 9-year-olds and then translated the data into classroom practices. The investigator's class of 26 third graders was compared with the school's other third grade class. In the investigator's class, a culture of thinking was created throughout the school day by using several instructional strategies focusing on student self-awareness and planning, monitoring, and evaluating within the subject domains of mathematics, science, and visual arts. Videotapes of students performing developed tasks in pretest and posttest situations were analyzed. Results indicate that a child of 8 is not likely to use metacognitive categories of planning, monitoring, or evaluating during problem solving, although some students who have just turned 9 are more likely to monitor their problem solving activities by reviewing their work. The study also found that the behavior of monitoring review is responsive to instruction and related to improved understanding of mathematics and visual arts problems. The implications of these findings for determining the appropriate age for instruction in metacognitive strategies are discussed. Seven attachments contain supplemental information, including scoring guides for the developed tasks. (Contains 22 references.) (SLD)

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Increasing Problem Solving through the Metacognitive Skills of Planning, Monitoring, and Evaluating

Pat Goldberg, Ph.D.

Campbellsburg Elementary School

Henry County Public Schools, Kentucky

Final Report
The Spencer Foundation
August 1999

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Final Report to The Spencer Foundation, August 1999

Pat Goldberg, Ph.D.
Campbellsburg Elementary School
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Focus of the Research

In 1990 Kentucky created a statewide, systemic reform initiative in education which involved fundamental changes in assessment, curriculum and instruction. This teacher researcher began a personal effort to change her classroom through action research, particularly in the area of higher order thinking. Two of the reform goals relate to teaching of thinking: 1) develop abilities to think and solve problems, and 2) develop abilities to connect and integrate experiences. Metacognition, thinking about one's own knowledge and thinking processes, offers promise in reaching these goals (Costa, 1991; Perkins, 1992 and 1995; Forgarty, 1994; Swartz and Parks, 1994; Tishman, Perkins, and Jay, 1995; Marzano, 1997).

The primary purposes of this action research were 1) to gather data about what aspects of metacognition might develop naturally in the 8-9 year old, 2) to translate the research and literature on metacognition into applied classroom practices teachers can use with 8-9 year olds, and 3) to examine the effects of the instruction of metacognitive strategies on problem solving in different subject areas.

Overview of the Research

Sample. The subjects were the entire third grade population, two classes of 8-9 year olds, at a rural school in Kentucky. Each class had 26 students. The experimental class was the investigator's class. The control class was taught by the other third grade teacher in the building. Art, music, and physical education are taught by itinerant special teachers, and all other subjects are taught by the classroom teacher. The school also has a part-time teacher of the gifted/talented program. A stratified random assignment of students was made by teachers from the previous year to insure a balance in gender, achievement, behavior problems, and special education students.

Method. *Tasks.* Tasks of comparable difficulty were developed in mathematics, science, and visual arts with the assistance of four faculty from the University of Kentucky who served as content experts and research advisors. This group decided to develop tasks which fall into the category of synthesis in Bloom's Taxonomy of Educational Objectives for the cognitive domain (1956). According to Bloom, synthesis is defined as "the putting together of elements and parts so as to form a whole"(p. 162, 1956). Two tasks were developed for each subject which served as pretest and posttest. Table 1 briefly presents the tasks. Scoring guides were also developed with the guidance of the content specialists. (See Attachments for a more complete description of the tasks and the scoring guides.)

Table 1

Content	Pretest	Posttest
Mathematics	Using any arrangement of four different Unifix cubes, create all possible towers that can be made.	Using any arrangement of the colored tiles, create all the possible room arrangements that you can make with the 5 tiles.
Science	What shape structure of aluminum foil would float and hold the most pennies?	What shape structure of plastic clay would float and hold the most pennies?
Visual Arts	Build a structure which shows the idea of friendship.	Create a collage which shows the feeling of happiness.

The investigator trained college education students to serve as proctors who administered the tasks. The procedure for data gathering using a think aloud protocol was as follows: The student was reminded of a classroom lesson on "thinking aloud" which was conducted in both classes. The proctor presented a task to the student and asked the student to think out loud as she completes the task. The proctor listened and reminded the student to continue to speak using specific verbal cues. The student's work was video taped. The pretest tasks were administered during October and the posttest tasks were administered during May.

Experimental method. In the investigator's class, a culture of thinking (Tishman, Perkins, and Jay, 1994) was created throughout the day using several different instructional strategies. Instructional strategies were composed of a two-pronged approach: 1) strategies which focused on raising student self-awareness, especially of their own thinking and 2) strategies which focused on planning, monitoring, and evaluating within the subject domains of mathematics, science, and visual arts.

Both the experimental and the control classes received six weekly lessons provided by the teacher of the gifted and talented program during September and October. These lessons, a regular part of the gifted and talented program, presented de Bono's ideas about the six thinking hats (Six Thinking Hats for Schools, 1991). Each lesson introduced a type of thinking mode with a picture of a colored hat, and students practiced that particular type of thinking during the half-hour lesson. As presented in de Bono's lessons, metacognition, or "thinking about thinking" was the subject of the last lesson. Based on analysis of teacher plan books, the thinking hat lessons were the only instruction which occurred on thinking skills in the control class.

Building on the thinking hat lessons in the experimental class, the investigator initiated a series of lessons on self-awareness during November and December. A program called Second Step was used to build better understanding of one's emotional self. This weekly program was continued throughout the year. Students learned the technique of mind-mapping (Margulies, 1991) during lessons encouraging them to explore ideas about themselves, their private hopes and dreams, and their understanding of subject areas they were studying. Two lessons on the anatomy of the brain explained the effect of "flight or fight" response of the amygdala and how several parts of the brain were used during thinking, learning, and problem solving.

During the last week of November, the investigator introduced the idea of a language of thinking (Tishman et al, 1994). As Tishman suggests, students were told that there were many different kinds of thinking and that words help us talk about specific kinds of thinking. The students and investigator generated a chart of thinking words like create, hypothesize, question, guess, opinion, evidence, and investigate. Blanks were left on the chart, and other words were added throughout the year as the class learned about them, i.e. plan, monitor, and evaluate.

After Christmas break, instruction in metacognition strategies began. Though direct instruction was offered on planning, monitoring, and evaluation, the primary emphasis of the instruction was within the subject areas. The investigator varied instructional strategies as well, such as modeling, explanation, group interaction, feedback and practice.

Data Sources. *Analyzing the tapes.* The video tapes from the student pre- and posttest sessions were transcribed. Each statement was coded using a metacognitive category system, METACATS (see Attachments). The categories are Planning Clarify, Planning Strategy, Monitoring Review, Monitoring Self-regulate, Evaluating Self, Evaluating Action/Product. The category system provided the metacognitive scores. The video tapes were also scored using rubrics in mathematics, science, and visual arts. For each subject area, the content rubrics yielded scores in Problem Understanding, Problem Strategies, and Problem Solutions. The

Wilcoxon signed-rank test was applied to test for differences between the pre- and posttest scores for both experimental and control groups. This statistic allowed examination of the natural development of metacognition. The Mann-Whitney test was applied to the scores of the experimental and control groups on the posttests to test for differences which might be a result of instruction.

Reliability studies. Two raters were used to analyze the transcriptions for the metacognitive scores. After rater training on the metacognition category system, the Pearson correlation coefficient was applied to the scores. The reliability of the content raters was also tested using the Pearson correlation coefficient after raters had been trained. The correlations ranged from .75 -- .99. This investigator would have liked correlations at .80 or above. Since only two of the correlations were below this figure and the majority were above .90, the scores were considered acceptable.

Summary of Findings

What types of metacognitive thinking do students demonstrate naturally? During the pretest task, both experimental and control groups made very few statements which could be categorized as Planning, Monitoring, or Evaluating. During the mathematics and visual arts posttest, however, both groups made statements more frequently in the category of Monitoring Review compared to the pretest. An example of a Monitoring Review statement is "Now I found out four or five ways how to do it" and student begins writing on paper to record ways. For the mathematics task, the control group's scores showed a significant difference ($p = .019$). For the visual arts task, the control's group's scores did not demonstrate a significant difference ($p = .056$); however, the score suggests a relationship and warrants further research. A possible interpretation for this result is that monitoring one's problem solving during mathematics and visual art tasks can develop without instruction in metacognition. No significant differences in metacognition between the pre- and posttest in the science scores were found for the control group.

Some researchers have raised the question about whether metacognitive skills are domain specific (in math or reading) or generalized (Perkins and Salomon, 1989; Schraw et al, 1995) Tishman (1995) presents the position that metacognition is a thinking disposition of an individual. In the current study, the Pearson correlation coefficient was applied to the total group of 51 students. All correlations between the Monitoring Review categories of math, science, and the visual arts were significant (p = . 01). Therefore, Monitoring Review, at least, appears to behave like a disposition in a 8-9 year old because the child is likely to exhibit this metacognitive behavior across subject areas.

Is there a relationship between direct instruction in metacognition and problem solving in 8-9 year olds within the context of the classroom setting? Before examining the relationship between instruction in metacognition and problem solving, the investigator looked at a preliminary question: Does direct instruction increase metacognition? Though both groups showed a significant difference between the pretest and the posttest in the Monitoring Review category, the experimental group made a significantly higher number of statements in this category than the control group on the posttest in mathematics (p = .022), science (p = .002), and visual arts (p = .001). Another monitoring category also seemed to respond more to instruction – Monitoring Self-Regulating. The category of Monitoring Self-Regulating requires the student to make a change in the direction of the problem solving. An example of a statement would be "This isn't working, so I'm going to have to turn up the sides (of clay) so the water won't come in." The experimental group made a significantly higher number of statements in this category during the visual arts task (p = .038). In mathematics, the results of the Mann-Whitney test (p = .057) justify further research. Thus, the results would seem to indicate that monitoring in problem solving (both Monitoring Review and Monitoring Self-Regulating) is more likely to respond to direct instruction at this age than planning or evaluation. In addition, though the category of Monitor Review may develop without instruction in some children, the Monitor Review category is the most responsive to instruction.

To examine the relationship between instruction in metacognition and problem solving in the three content areas, the Mann-Whitney test was applied to the experimental and control posttest scores of the mathematics, science, and visual arts tasks. The three content categories were Problem Understanding, Problem Strategies, Problem Solutions. In mathematics, the experimental group showed a significant difference from the control on the content score of Problem Understanding (p = .009). In visual arts, though both groups showed a significant difference between the pretest and the posttest in the content score of Problem Understanding, the experimental group scored significantly higher when the posttest scores were compared (p = .038). A possible interpretation is that direct instruction in metacognition increases the likelihood of a young child understanding a mathematics or visual arts problem.

Neither group showed significant differences between the pretest and the posttest on the science content scores. The control group, however, scored significantly higher in the category of Problem Solutions. ($p = .008$) on the posttest. The control group was able to float the clay more often than the experimental group, and floating the clay was the primary criteria for the Problem Solutions category.

No differences between the experimental and control groups were found in the content categories of Problem Strategies and Problem Solutions; however, one statistical difference indicates a possible relationship. In the visual arts, the difference between the experimental and control was $p = .071$ for the Problem Strategies category. This category reflects the variety and number of appropriate art strategies used for the particular art medium.

Importance of the study.

Why might metacognition be important? As adults, we see some evidence of children planning, monitoring, and evaluating. Parents listen to their children say what candy they will get at the movie theatre. Teachers hear children stop what they are doing in a group and tell another child he isn't doing the assignment correctly. A grandparent may hear the grandchild comment confidently about the quality of a drawing he insists be displayed on the refrigerator. When given a novel task, however, children are very likely to jump into the problem with one strategy, continue the strategy without "looking back," and to finish without reexamining the solution. Often, the result can be a misunderstood problem, or an ineffective strategy, and/or a solution which doesn't work. According to Perkins (1995), reflective intelligence "particularly supports coping with novelty" (p. 112). Perkins also suggests that reflective intelligence "supports thinking contrary to certain natural trends" (p. 113), thus, contributing to breaking mental set and exploring new ideas.

This investigation has provided new knowledge about the development of metacognition. Based on the results, the child of 8 is not likely to use the metacognitive categories of planning, monitoring, or evaluating during problem solving; however, some newly-turned 9 year olds are significantly more likely to monitor their problem solving activities by reviewing their work. The study also found that the behavior of Monitoring Review is responsive to instruction and related to improved understanding of mathematics problems and visual arts problems. The educational importance of these two findings could be the location of the beginning age during childhood where instruction in some metacognitive strategies would be developmentally appropriate.

According to Flavell (1994), children of 7 to 8 show a better understanding of introspection than the younger child. Perhaps children of 8 to 9 not only improve their understanding and use of introspection, but also respond more to outside influences, such as classroom instruction.

Teachers are hard pressed to add anything new to an already full curriculum; however, if an instructional strategy can improve a child's understanding of a mathematics or visual arts problem, a teacher can find time within the instruction of that subject. The opposite is also true. Teachers sometimes include instruction which may not be developmentally appropriate and would be grateful for the opportunity to reexamine a particular practice in light of new research.

Connections to previous and anticipated research.

For three years this investigator conducted preliminary work on a methodology and instrument which could be used to study metacognition in the classroom (Goldberg, 1996, 1997). The results have been 1) a successful use of a "think aloud" protocol in which students talk out loud about what they are thinking during an assigned task, and 2) a category system which is used to categorize student statements. This early effort was fueled by the investigator's belief that metacognition plays a crucial role in both learning and problem solving across subject domains. The writings of David Perkins (1992, 1995), Shari Tishman (1995), and Robert Swartz (1994) were particularly influential in presenting the theoretical understanding and instructional possibilities.

The conceptual framework of academic self-regulation presented by Zimmerman (1994) offers a larger context for the direction and interpretation of this investigator's research. He states that the "construct of *self-regulation* refers to the degree that individuals are metacognitively, motivationally, and behaviorally active participants in their own learning process." (Zimmerman, p. 3) The current study fits into two components of the conceptual framework: 1) "students' methods for self-regulating their learning and performance" (1994, p.7) and 2) "students' efforts to self-regulate their academic performance outcomes" (p.8).

This study offers promise for several lines of inquiry. If Monitor Review helps students understand mathematics and visual arts problems, what instructional strategies are most successful with children? Is there a relationship between the categories of both Monitor Review/ Monitor Self-Regulating and mathematics and visual arts problem solving? What instructional strategies would affect the child's growth in planning and evaluating? When would those strategies be developmentally appropriate? What type of instruction on metacognition would be helpful in science investigations, if any? What is the developmental profile of metacognition in the school age child? Does instruction in metacognition transfer to other self-regulatory behaviors?

This teacher researcher continues to believe that metacognitive instruction influences the learning of science. During the 1999-2000 school year, data will be gathered regarding this question: What is the effect of instruction of metacognitive strategies on science problem solving? New tasks will be developed, an additional search of the literature will be conducted, and metacognitive strategies will be revised. The University of Kentucky faculty member who served as the science content specialist has agreed to serve as a consultant.

Several findings from this investigation indicate that metacognitive instruction may influence science problem solving. Some of the findings were significant and some were not. For instance, the experimental group increased significantly in the science metacognitive score of Monitoring Review ($p = .022$). The science content scores for the experimental group showed a statistic worth continued investigation: the improvement of the Problem Solutions score was $p = .07$ on a two-tailed test. In addition, the experimental group performed significantly more trials during the posttest than the pretest ($p = .001$). A trial was defined as the action of placing the foil or clay into the water to check results of floating/non-floating. The control group did not show a significant increase in the number of trials between the pretest and the posttest. The two groups did not significantly differ on the number of trials on the posttest; however, the direction was towards a significant difference ($p = .072$) on a two-tailed test. The trial results might be interpreted as an increase in volition, a self-regulating behavior. According to Corno (1994), volition is "the tendency to maintain focus and effort towards goals despite potential distractions."

<u>Changes in Plans</u>.

Two changes were made in this study. One, the three original subject areas were mathematics, visual arts, and writing. The area of science was substituted for writing. Second, at the recommendation of the content specialists, video tapes were used instead of audio tapes.

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Attachments

1. Metacognition Category System (METACATS) with science examples
2. Tasks
3. Proctor Sequence for Science Task 2, Clay Boats
4. METACATS Tally Sheet
5. Mathematics Scoring Guides
6. Science Scoring Guides
7. Visual Arts Scoring Guides

Metacognition Category System (METACATS)
SCIENCE EXAMPLES

Planning/Clarify– This category of statements demonstrate the child is preparing to do something and is thinking about the task before tackling it. For this category, the child could be restating the problem, attempting to understand the problem, or rereading the problem.

Example: So that I can see if it can hold the most pennies, 'cause that's what we gotta do.

Planning/Strategy – This category of statements demonstrate the child is preparing to do something and thinking abut the task before tackling it. For this category of statements, the child could be planning a strategy, attempting to identify a strategy, or announcing the application of a particular problem solving strategy.

Example: I'm gonna take one of these pieces of clay, and I'm gonna try and make it into a square.

Monitoring/Review: This category of responses would demonstrate that the child is engaged in a task and notices the success of her idea, or lack of it, towards the task.
She might check her work for errors, simply look over the work again, or notice a repetition.

Example: (1) I already made that shape. (2) That shape held more pennies than this one.

Monitoring/Self-Regulate – This category of responses would demonstrate that the child is engaged in a task. The child regulates herself by adjusting her activity. This category involves a change in behavior.

Example: (1) Maybe I could get another piece and put the sides up. (does what she says)
(2) Maybe I could try it again, but make it ... (inaudible as child begins a different shape).

Evaluating/Self: This category of responses would demonstrate that the child has completed the task and is passing judgment on herself. The comments imply knowledge of one's own abilities and limitations.

Example: (1) I can't think of anything. (2) I think I figured it out.

Evaluating/Action or product – This category of responses would demonstrate that the child has completed the tasks and is passing judgment on actions or products just produced.

Example: So maybe this one, 'cause this one holds nine pennies, which is the most that [any held].

Mathematics Task 1 – Towering Towers
Materials: 4 red Unifix cubes, 4 blue Unifix cubes, pencil, unlined paper
Directions: On the table in front of you are Unifix cubes of two different colors. Each cube represents a different floor of a Unifix cube tower. Using any arrangement of four different cubes, find out how many possible towers can be made. You may use the paper and pencil if you would like.

Mathematics Task 2 – Building Houses
Materials: 5 colored tiles, pencil, unlined paper
Directions: On the table in front of you are 5 colored tiles. Each tile represents a room in a house. Using any arrangement of the tiles, create all the possible room arrangements that you can make with the 5 tiles. You may use the paper and pencil if you would like.

Science Task 1 – Aluminum Boats
Materials: 6 4 ½ X 4 inch sheets of regular aluminum foil, pennies, 6 X 6 inch container holding 2 inches of water, pencil, unlined paper, and paper towels
Directions: On the table in front of you are sheets of aluminum foil, pennies, a container with water, pencil and paper, and paper towels. A sheet of aluminum foil can be shaped so that it will float and hold some pennies without sinking. What shape of aluminum foil will hold the most pennies without sinking? Use only one piece of aluminum for each shape.

Science Task 2 – Clay Boats
Materials: several flat pieces of plasticine which are 3 inches in diameter, a 6 X 6 inch container of water holding 2 inches of water, pencil, unlined paper
Directions: On the table in front of you are pieces of a plastic clay, a container with water, pennies, pencil and paper. A piece of plastic clay can be shaped so that it will float and hold some pennies without sinking. What shape of the plastic clay would float and hold the most pennies? Use only one piece of plastic clay for each shape.

Visual Arts Task 1 – Create a Structure
Materials: a 8 X 11 inch tray, glue, scraps of material, 1-2 Styrofoam balls, sand paper, cardboard, colored tagboard and construction paper, cotton balls, yarn, "sticky wick", packing material, tooth picks, popsicle sticks, buttons, and lace. The colors of all materials are neutrals: brown, tan, gray, white, rust, or black.
Directions: On the table in front of you are a tray, glue, and many different kinds of materials. Build a structure which shows the idea of friendship. You may use any of the materials on the table in any way that you want.

Visual Arts Task 2 – Create a Collage
Materials: a 8 ½ X 11 inch piece of tagboard, glue, scraps of materials, sand paper, cardboard, tagboard, cotton balls, string, yarn, "sticky wick," packing material, tooth picks, popsicle sticks, buttons, lace, markers, crayons. The colors of materials, except markers and crayons, are neutrals: brown, tan, gray, white, rust or black.
Directions: On the table in front of you is a piece of tagboard, glue, and many different kinds of materials. Create a collage which shows the feeling of happiness. You may use any of the materials on the table in any way that you want.

Session with Proctor -- SCIENCE

Part I

Developing rapport with child

- Talk to child about being on video
- Set up camera to record
- Return to sit by child
- Ask child to tell you what she/he did this morning
- Rewind and play for child to see in viewer

Reviewing/demonstrating think aloud method

Use example: you are checking to make sure you have everything on the table and talking out loud about what you are doing and thinking.

Part II

Science Task 2 – Clay "Boats"

Materials on table at beginning of task: several flat pieces of plasticine which are 3 inches in diameter, a 6 X 6 inch container of water holding 2 inches of water, pencil, unlined paper

Proctor reads with student.

Written task: On the table in front of you are pieces of a plastic clay, a container with water, pennies, pencil and paper. A piece of plastic clay can be shaped so that it will float and hold some pennies without sinking. What shape of the plastic clay would float and hold the <u>most</u> pennies? Use only one piece of plastic clay for each shape.

Proctor says: I will be making marks on this paper whenever I say something. As you are working, make sure you talk to me about what you are doing and thinking.

<u>When student indicates that she is finished, Proctor says, "Are you finished?"</u>

<u>Task stops</u>.

Proctor says: What do you think the shape you chose is the best?
What have you learned from making the shapes?

METACATS Tally Sheet

Rater ________________
Student ID ____________
Gender: M F
Task: Math Science Art
Pretest Posttest

Planning/Clarify	
Planning/Strategy	
Monitoring/Review	
Monitoring/Self-regulate	
Evaluating/Self	
Evaluating/Action or Product	
Doing the Task	
Other	
Inaudible	
Questions	

MATHEMATICS SCORING GUIDE
Mathematics Task 1: Towering Towers

Rater ____________________
Student ID ________________
Gender: M F

	0	1	2	3
Understanding	Little or no understanding; makes towers which have more or less than 4 cubes	Focuses on number; Makes several correct towers but takes no notice of duplications OR Focuses on examples; makes 1-2 correct towers and stops	Demonstrates understanding of task with both number and examples; Notices less than/equal to half of duplications AND Makes several correct examples	Demonstrates understanding of task with both number and examples; Notices more than half of duplications AND Makes several correct examples
Strategies	Does not use a discernible strategy; Sequence of towers is random	Uses a consistent single, clear strategy for generating correct towers	Uses multiple strategies for generating correct towers	
Solutions	Creates fewer than 8 correct and different towers	Creates 8 – 11 correct and different towers	Creates 12 – 15 correct and different towers	Creates 16 correct and different towers

R	B	B	B	B	R	R	R
R	R	B	B	B	B	R	R
R	R	R	B	B	B	B	R
R	R	R	R	B	B	B	B

R	B	R	B	R	B	B	R
B	R	B	R	B	R	B	R
R	B	B	R	R	B	R	B
B	R	R	B	R	B	B	R

_____OTHER (towers which are incorrect, such as towers built with more or less than 4 blocks)

Scores
Understanding Problem ________
Strategies ________
Solutions ________
TOTAL ________

MATHEMATICS SCORING GUIDE
Mathematics Task 2: Building Houses

Rater ____________________
Student ID ________________
Gender: M F

	0	1	2	3
Understanding	Little or no understanding; consistently makes houses which are incorrect	Focuses on number; Makes several correct houses but takes no notice of duplications OR Focuses on examples; makes 1-2 correct houses and stops	Demonstrates understanding of task with both number and examples; Notices less than/equal to half of duplications AND Makes several correct examples	Demonstrates understanding of task with both number and examples; Notices more than half of duplications AND Makes several correct examples
Strategies	Does not use a discernible strategy; Sequence of houses is random	Uses a consistent single, clear strategy for generating correct houses	Uses multiple strategies for generating correct houses	
Solutions	Creates fewer than 9 correct and different houses	Creates 9 – 13 correct and different houses	Creates 14 – 17 correct and different houses	Creates 18-19 correct and different houses

_______ OTHER (variations of arrangement which uses all tiles, but one or more tile edge is not lined up with other tile edges.)

Scores
Understanding Problem ________
Strategies ________
Solutions ________
TOTAL ________

SCIENCE SCORING GUIDE
Science Task 1: Aluminum Boats

Rater ____________________
Student ID ________________
Gender: M F

	0	1	2	3
Understanding of problem	Little or no understanding	Focuses on shape OR number of pennies but does not do both	Demonstrates understanding of task with both shape and number of pennies	
Strategies				
• weight	Little or no attempt to use pennies	No attempt to float before adding pennies;	Attempts to float before adding pennies; add pennies singly	Attempts to float before adding pennies; add pennies singly
• shape	Little or no attempt to shape foil	Folds flat shapes or pockets	Attempts 1-2 shapes with turned-up sides	Attempts 2+ shapes with turned-up sides
	and/or does not attempt to float foil	Tries to float shapes made	Tries to float shapes made; makes few if any changes	Alters shape based on observations and/or makes different shapes based on observations from attempts to float
Solutions	Does not produce a shape that floats	Produces one shape to float; shape holds 0 – 4 pennies	Produces 2 or more shapes that float; produces a shape which holds 5 – 9 pennies	Produces a barge shape w/sides; shape holds 10 + pennies

Scores
Understanding Problem ________
Strategies ________
Solutions ________
TOTAL ________

SCIENCE SCORING GUIDE
Science Task 2: Clay Boats

Rater ________________
Student ID ________________
Gender: M F

	0	1	2	3
Understanding of problem	Little or no understanding	Focuses on shape OR number of pennies but does not do both	Demonstrates understanding of task with both shape and number of pennies	
Strategies				
• weight	Little or no attempt to use pennies	No attempt to float before adding pennies;	Attempts to float before adding pennies; add pennies singly	Attempts to float before adding pennies; add pennies singly
• shape	Little or no attempt to shape foil	Folds flat shapes or pockets	Attempts 1-2 shapes with turned-up sides	Attempts 2+ shapes with turned-up sides
	and/or does not attempt to float foil	Tries to float shapes made	Tries to float shapes made; makes few if any changes	Alters shape based on observations and/or makes different shapes based on observations from attempts to float
Solutions	Does not produce a shape that floats	Produces one shape to float; shape holds 0 – 4 pennies	Produces 2 or more shapes that float; produces a shape which holds 5 – 9 pennies	Produces a bowl shape; shape holds 10 + pennies

Scores
Understanding Problem ________
Strategies ________
Solutions ________
TOTAL ________

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VISUAL ARTS SCORING GUIDES
Visual Arts Task 1: Creating a Structure

Rater ____________________
Student ID _______________
Gender M F

	0	1	2	3
Understanding Of problem	Explanation (of product) does not relate to the concept of friendship	Includes 1 reference to the concept of friendship	Includes 2 references to the concept of friendship	Includes 3+ references to the concept of friendship and/or a single in-depth explanation
Strategies • Structure Processes	Includes no application of 3-D structure processes	Includes 1-2 applications of 3-D structure processes	Includes 3-4 applications of 3-D structure processes	Includes 5+ applications of 3-D structure processes AND/OR complex application of few structure processes
• Deliberate Application	Structure processes show no careful deliberation in creating the project	Structure processes show 1-2 careful deliberations in creating the project	Structure processes show 3-4 careful deliberations in creating the project	Structure processes show 5+ careful deliberations in creating the project AND/OR deliberation throughout project
Solution (art work)	No art work; Art work is incomplete	Little correlation between verbal explanation and art work	Clear correlation between verbal explanation and art work	Strong correlation between verbal explanation and art work

***PROCESSES** are ways of building up the structure, i.e. by adding materials onto other materials, breaking parts a larger material, standing materials up, folding, wadding, crushing, cutting, slotting, and other creative applications

Scores
Understanding Problem ______
Strategies ______
Solution ______
Total ______

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VISUAL ARTS SCORING GUIDE
Visual Arts Task 2: Creating a Collage

Rater ____________________ Student ID ________________ Gender: M F

Understanding Of problem	Explanation (of product) does not relate to the concept of happiness	Includes 1 reference to the concept of happiness	Includes 2 references to the concept of happiness	Includes 3+ references to the concept of happiness and/or a single in-depth explanation
Strategies • Collage Processes	Includes no application of Collage processes	Includes 1-2 applications of Collage processes	Includes 3-4 applications of Collage processes	Includes 5+ applications of Collage Processes AND/OR Complex application of collage processes
• Variety of materials	Little or no use of collage processes	Includes application of 2-3 materials	Includes application of 4-6 materials	Includes application of 6+ materials AND/OR Complex use of materials
• Deliberate Application	Structure processes show no observable deliberation applied to creating the project	Structure processes shows little deliberation applied to creating the project	Structure processes shows focused deliberation applied to creating the project	Structure processes shows concentrated/ Intense deliberation applied to creating the project AND/OR Deliberation throughout project
Solution (art work)	No art piece; Art work is incomplete	Little correlation between verbal explanation and art work	Clear correlation between verbal explanation and art work	Strong correlation between verbal explanation and art work

***PROCESSES** are ways of creating a collage and include cutting, tearing, overlapping, building up, drawing/coloring onto materials, gluing, and other creative applications

Scores
Understanding Problem ______
Strategies ______
Solution ______
Total ______

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Organization/Address: Hanover College 3024 Freys Hill Road Louisville, KY 40241	Telephone: 502-425-1543	Fax:
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