**Supplemental Materials**

**Example Puzzle Problems**

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| **Type of Problem** | **Example Problem** |
| **Spatial Insight Problem** | **The Nine Dot Problem**  Draw four straight lines without lifting your pencil from the paper so that each of the nine dots is crossed by a line. This is meant to be a hard problem, so it is okay if you are wrong. Try your best. |
| **Riddles** | **The Letter Z Problem**  Can you figure out where the letter Z belongs? Does it belong on the top or bottom line? Why?  **\***Where should the letter Z go (top or bottom line)? Why should it go there?  A EF HI KLMN T VWXY ------------------------- BCD G J OPQRS U |
| **Simple Math Problem** | **The Cat Problem**  Peter has four cats, an orange one, a black one, a white one, and a gray one. Jenny has twice as many as Peter.  \*How many cats do they have all together? |

**Example Packet Quiz**

Short-Answer Question

1. What are important steps to take when solving problems?

Multiple-Choice Questions

1. When solving a problem it's good to \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_. (circle **only one**)
   1. Plan, use strategies, monitor progress
   2. Have a reason for taking the steps you take to solve the problem
   3. Give your best effort
   4. Get the correct answer
   5. Plan, check to see if you are making progress, and evaluate your solution
2. Understanding the \_\_\_\_\_\_\_\_\_\_ is critical to solve problems. (circle **all that apply**)
   1. Tools
   2. Steps
   3. Goals
   4. Logic
   5. Words
3. Katie (a student at another school) was given this problem:

*A toymaker made 3 batches of rocking horses and 1 batch of jack-in-the-boxes. A batch is 12 items. The toymaker’s daughter accidentally broke* 1/3 *of the toys in each batch. How many toys did she accidentally break?*

She came up with the following solution:

My goal is to figure out how many toys the daughter broke.

My plan is to use arithmetic to solve the problem.

12• 2/3 =8 toys left in each batch

8 x 4 = 32 toys

The toymaker’s daughter broke 32 toys.

She thought she had the right answer, but when the teacher looked at her solution he said that it was not correct. What was Katie’s major difficulty in trying to solve the problem correctly? (circle **all that apply**)

* 1. Planning
  2. Using the right strategies
  3. Monitoring progress
  4. Evaluating the solution
  5. Understanding the problem

**Planning Definition and Prompting Questions**

**Beginning the Problem**

Sometimes when we read a problem, we automatically jump right in to solve it without thinking about a plan. Although this sometimes leads us to a solution, you should ALWAYS create a plan to make sure you understand what is being asked of you. This will allow you to know whether you have the best answer for the problem or if you need to reread the problem to get a better understanding of the task. Even in cases when we think we understand, we should ask ourselves: What is the problem? What are the goals? What are some strategies I can use?

**What is a Plan?**

**MC900024492[1]**One way we can show that we understand a problem is to come up with a **plan**. A plan is like a blueprint to a house. It takes all the given information, interprets it, and then organizes it into a proposal for achieving a goal. In relation to the pig pen problem, the given information is:

* The # of pigs
* The # of preexisting pens
* The # of added pens
* The shape of the pens
* That the pigs must be in their own enclosures

The interpretation of this problem requires you:

* To think about what it means to have a square pen
* To determine the orientation of each square.

The plan would be to place the pens in different orientations in order to put each pig in its own space. Thus, a plan requires you to do three things. It requires you to:

* **Understand the problem**
* **Interpret the goal of the problem**
* **Analyze which strategies to use**

Easier said than done, right? Here are some suggestions to help you meet these three aspects of planning.

**Monitoring Definition and Prompting Questions**

**Monitoring Progress**

Last week we learned how to make a plan before attempting to solve a problem. Today, we are going to learn how to monitor our progress to make sure we are on the right track and that our plan is working. When solving difficult problems like the candle problem, it is important to make sure you know how and why you are making progress toward the correct solution. Our focus will be on learning how to monitor the steps we take toward a solution.



**How do we Monitor Progress?**

One way we know that we are on the right path to solving a problem is to **monitor the steps we take that we outlined in our plan**. We monitor progress toward a solution by thinking about where we are in solving the problem. Are we close to the solution? Are we moving toward the solution or are we stumbling in circles? Do we have several more steps to take? Should we start over? We are on the right track when we understand every step we take and are able to say where we are headed.

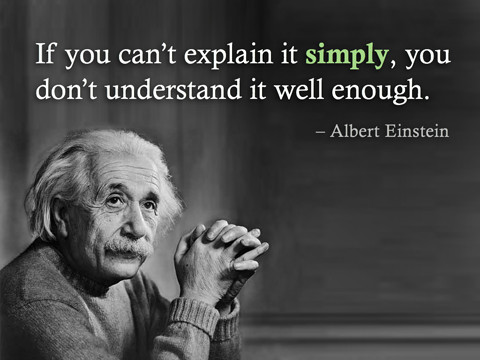
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When monitoring progress, you should be able to do three things:

**Understand** why you are completing a step

Provide good **reasons** for completing that step

* Explain why each step is **bringing you closer to your goal**

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**KEEPING TRACK of where you are**

When solving the problem it is necessary to make sure you are crystal clear about what you are doing. In order to do this you need to ***keep track*** of what step you are on at any given point in problem solving. Where are you in regards to your problem-solving **plan**? Sometimes when solving complicated problems we make mistakes by forgetting or skipping steps, so it is very important to think about each one carefully. Some questions that will help you keep track of the steps are:

* What step am I on?
* Where is this step in the plan?

**Giving REASONS for taking each step**

For every problem-solving step you take, you should be able to give a ***reason*** for taking it. For example, sometimes when we solve a problem we think of a prior problem that required a *similar step* to get the answer, so we use that same step to solve the problem we are working on. Other times we remember important scientific principles and facts that help us to determine what step comes next. When you are solving a problem, make sure your steps have **reasons** too and, if you are stuck on which step to take next, choose the one with the best reasons supporting it. Ask yourself:

* Why am I taking this step?
* Are there any reasons that I can use to help me determine what step to take?

**CHECKING to see if you are getting closer to the goal**

Have you checked to see if you are making progress toward your goal? While solving a problem it is important to check and see if we are getting closer to the goal. One way to do this is by thinking about the current step in relation to our **plan** and the resulting **goal**. In addition, by **checking** our **reasons** along the way we canwe can trace how and why this step is moving us in the right direction**.** To help you see if you are getting closer to the goal, ask yourself:

* By taking this step, am I getting closer to the solution?
* Are my reasons for taking each step moving me closer to the goal?

**Evaluation Definition and Prompting Questions**

**After Solving the Problem**

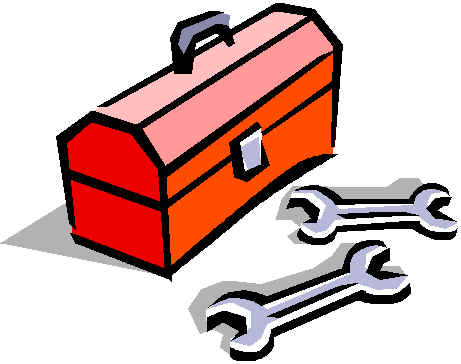
Sometimes when we finish solving a problem we go with our first solution and move on to the next problem. Although this can lead us to the right solution, you should ALWAYS evaluate your solution. This will allow you to know whether you have the best answer for the problem or whether there might be a better solution. Additionally, this helps us to figure out what strategies worked and what strategies didn’t work, which can help us when we solve future problems that require similar solutions.

**How do you evaluate your solution?**

One way you can show that your solution is the best answer is to **evaluate whether the solution makes sense**. Evaluating your answer means that you compare your answer to your goals. Do they match? If they don’t match then you should go back and try the problem again, but if they do, then you should think about why it makes sense. After solving a problem, try asking yourself: Does my solution reach the problem’s goal? Does my solution make sense? Why does it make sense?

**What worked and what didn’t work?**

Looking to see what strategies you used to solve your problem helps you better understand the problem you solved and helps you solve future problems. It allows you to see what types of strategies work for certain types of problems. For example, after solving the Nine Dot Problem, you now know that lines can be drawn past the dots to allow you to approach the dots from a different angle. When facing a similar problem, you can try using that strategy.

Checking to see what strategies work also allows you to add strategies to your toolbox. That way, when you are facing a problem that you have never seen before, you can look through the strategies you have used in the past to see if they would help you solve the problem. Some questions that will help you evaluate which strategies to use are: Which strategies helped me reach my goal? Which didn’t? Could I have used other strategies? How can these strategies be useful in solving other problems?

**How can evaluating lead to prediction?**

Evaluating your solution and checking to see which strategies worked gives you the opportunity to make predictions about the future. This allows you to say statements like “Next time when I see a recipe that needs to be tripled I think that changing my fractions from complex to simple will allow me to have an easier time solving the problem with a solution that makes sense.”

Making predictions is very common in science. In fact, it is what allows new medicines and technology to exist. At one point the scientist or inventor thought, “I think that if I do this, that will happen.” To test a prediction or hypothesis, scientists have to conduct experiments, which are similar to solving a problem. You have to come up with a plan, use strategies or methods to complete that plan, and then evaluate to see if your prediction was right.

Evaluating requires you to do three things. It requires you to:

* **Check to see if your answer matches your goal**
* **Think about what worked and what didn’t work**
* **Think about how this can help you in the future**

**Integration of Planning, Monitoring, and Evaluation Definition and Prompting Questions**

**Planning, Monitoring & Evaluating**

Over the past week and a half we have learned about planning, monitoring progress, and evaluating solutions when solving a problem. These three skills are very important to have, especially when solving tough problems. Let’s take a look at these skills to refresh our memories.

**Planning**

**Requires you to understand the problem, identify the goal, and strategize to create a plan.** A plan is like a blueprint to a house. It takes all the given information, interprets it, and then organizes it into a proposal for achieving a goal. Remember we don’t guess, we use GUS (goals, understanding & strategies).

**Goals**

**GUS**

**Understanding**

**Strategies**

* Does the problem make sense?
* If asked to repeat what the problem is, could you summarize it?
* What does the problem want you to accomplish?
* Are there similar problems you have encountered that can help you decide which strategies to use?

**Monitoring Progress**

**Requires you to think about where you are on the path to solving the problem in order to monitor your progress toward the goal.** We monitor progress toward a solution by thinking about where we are in solving the problem.

* Are we close to the solution?
* Are we moving toward the solution or are we stumbling in circles?
* Do we have several more steps to take?
* Should we start over?

**Evaluating your Solution**

**Requires you to compare your answer to the problem’s goal, and look to see which strategies worked to best evaluate your solution.**

* Does my solution reach the problem’s goal(s)?
* Does my solution make sense?
* Which strategies helped me reach my goal(s)?
* Could I have used other strategies?
* How can these strategies be useful in solving other problems?

Each of these skills can be used separately to help solve problems. Planning, monitoring, and evaluating are **each** important in their own right, **BUT they are even MORE powerful when they work together**. For example, sometimes when we are monitoring our progress towards a solution we might realize our strategy is not working or we might ‘discover’ a new strategy and then want to go back and change our plan writing out the new steps. An important aspect of science is discovering new ways to solve problems. Another example comes from when we evaluate we might realize that our solution does not make sense, so we need to revisit our plan, strategies, and goals. The important thing to remember is that these different problem-solving activities are interactive and help you to solve the problem.

**For the next two problems, use these skills to help you find the correct solution.**

**Timing for the Instructional Materials and Comparisons of Conditions**

Planning

|  |  |  |
| --- | --- | --- |
| Time | Experimental | Control |
| ½ min | Introduction – script read by teacher | Introduction – script read by teacher |
| 1 ½ min | Initial problem | Initial problem |
| 3 min | Hint with opportunity to continue solving the problem | Hint with opportunity to continue solving the problem |
| ½ min | Solution to the initial problem | Solution to the initial problem |
| ~20 min | Direct instruction, worked examples, and prompting questions of planning through the use of the initial problem | Puzzle/Physics problems |
| 3 min | Practice using planning with another problem | Solutions shown |
| 3 min | Transfer problem | Transfer problem |
| 3 min | Hint with opportunity to continue solving the transfer problem | Hint with opportunity to continue solving the transfer problem |
| 5 min | Packet quiz | Packet quiz |

Monitoring

|  |  |  |
| --- | --- | --- |
| Time | Experimental | Control |
| ½ min | Introduction – script read by teacher | Introduction – script read by teacher |
| 1 ½ min | Initial problem | Initial problem |
| 3 min | Progress check and then a hint with opportunity to continue solving the problem | Hint with opportunity to continue solving the problem |
| 10 min | Direct instruction of monitoring. Practice monitoring on a second problem. | Solution to the initial problem  & four additional puzzle/physics problems |
| 2 min | Practice monitoring with a progress check (a series of questions) for the second problem | Two more puzzle/physics problems |
| 2 min | Continue solving the second problem | Two more puzzle/physics problems |
| 2 min | The solution for the second problem | The solutions (to the above problems) |
| 10 min | Analyzed two worked examples of monitoring | Four more puzzle/physics problems |
| 1 min | Concise summary of monitoring | Solutions to the problems |
| 3 min | Transfer problem | Transfer problem |
| 3 min | Hint with opportunity to continue solving the transfer problem | Hint with opportunity to continue solving the transfer problem |
| 5 min | Packet quiz | Packet quiz |

Evaluating

|  |  |  |
| --- | --- | --- |
| Time | Experimental | Control |
| ½ min | Introduction – script read by teacher | Introduction – script read by teacher |
| 1 ½ min | Initial problem | Initial problem |
| 3 min | Hint with opportunity to continue solving the problem | Hint with opportunity to continue solving the problem |
| 2 min | Evaluation check | Solution for the initial problem and a puzzle/physics problem |
| ½ min | Solution for the initial problem | Solution to the puzzle/physics problem |
| 7 min | Practiced evaluating by solving another problem and evaluation check | Three puzzle/physics problems |
| ½ min | The solution for the second problem (metacognitive solution) | The solutions (to the above problems) |
| 7 min | Direct instruction and prompting questions of evaluating | Series of puzzle/physics problems |
| 6 min | Practiced evaluating by solving a third problem and evaluation check | Solutions and then a series of puzzle/physics problems |
| 1 min | The solution for the third problem | The solutions (to the above problems) |
| 3 min | Transfer problem | Transfer problem |
| 3 min | Hint with opportunity to continue solving the transfer problem | Hint with opportunity to continue solving the transfer problem |
| 5 min | Packet quiz | Packet quiz |

Integration

|  |  |  |
| --- | --- | --- |
| Time | Experimental | Control |
| ½ min | Introduction – script read by teacher | Introduction – script read by teacher |
| 1 ½ min | Initial problem. Asked to create a plan | Initial problem |
| 3 min | Progress check | Hint with opportunity to continue solving the problem |
| 4 min | Hint with opportunity to continue solving the problem | Solution for the initial problem and puzzle/physics problems |
| Evaluation check |
| ½ min | Solution for the initial problem | Solution to the puzzle/physics problems |
| 6 min | Planning, monitoring and evaluating definitions and integration | Work on puzzle/physics problems |
| 3 min | Transfer problem | The solutions (to the above problems) |
| Transfer problem |
| 3 min | Hint with opportunity to continue solving the transfer problem | Hint with opportunity to continue solving the transfer problem |
| 3 min | Transfer problem | Transfer problem |
| 3 min | Hint with opportunity to continue solving the transfer problem | Hint with opportunity to continue solving the transfer problem |
| 5 min | Packet quiz | Packet quiz |

**Example PFL CVS Questions**

Example Pretest and Posttest Items



Evaluative Example Problem



Evaluative Example Problem

