Combining Problem Identification with Problem Solving: A Strategy for Formulating Solutions To Scientific Problems

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Introduction

The strategies I discuss in this chapter came about, or better yet evolved, as possible solutions to problems students were experiencing in my Biology and Chemistry Regent’s classroom in Springville, a small community in Western New York. The reason I equate these strategies with evolution is that I realize they are not perfect specimens. They are a project in the works, which can always be improved upon or modified with new ideas and discoveries. My hope in printing these is that people will build upon them, that they will give someone who finds themselves with the same dilemmas a place to start, or a model to follow, that they can modify to fit their own teaching style, perhaps in the process creating something new and interesting that adds to it. Every teacher’s goal throughout his career should be to constantly improve and update his or her methods of teaching. I feel the best way to do that is to be open to new ideas and techniques, be willing to change my own ideas, and borrow anything from peers that may work for me.

Step 1: Identifying the Strategies

The first skill I wanted to address was that the students often seem to have difficulties pairing the two cognitive functions (mental operations) of identifying a problem and then going to the next step of solving the problem.
Each involves its own set of mental skills. The first is identifying what is being asked of the reader, or what approach they need to take to accomplish the desired outcome. The second is having the ability to pick and separate the pertinent information from the extra information I like to call "fillers," and apply this to the approach previously chosen to get the desired results.

The second skill I’ve been working on came as a strategy to get the students to write better conclusions for their lab write-ups. I found that students were stuck on the idea that all the information for the conclusion must come directly from the lab. What I expect from them is pretty much the opposite. I want the conclusions to be written from multiple sources that tie what is being done in the laboratory to what is being learned outside the lab. This could be from their text, class notes, the encyclopedia, internet, or any material of their choice, as long as it relates to the task at hand, in this case the completed lab.

Step 2: Modeling the Strategies

In the first case, of combining problem identification with problem solving I find it best to start them off with a simple word problem, one that has little to no misleading information and an easy reading level. For example, in chemistry I sometimes use a problem that determines how much acid it takes to neutralize a base or vice-versa. This problem is solved by an equation in which the variables are easy to manipulate \((M_aV_a=M_bV_b)\). \(M\) = molarity \(V\) = volume, and the subscripts a and b are acid and base. I give them three of the four variables and then this can be solved with simple algebra using multiplication and division. (For anyone who is reading this and is a science teacher, yes, I keep the ratio of coefficients 1:1 all the way through the balanced equation to not throw any twist in at this point). This allows them to focus on the skill and not be distracted by the complexity of the content. Once the students have a handle on the skill, and show an ability to apply it to new problems, then I can move on to more in depth, multi-level questions.

I begin by having the students read through the question twice. I find the first reading introduces them to the problem, and the second reading allows them to absorb the information. Next I have a discussion on what is being asked of them. I find it best to start with determining what is the goal. What type of answer does the question want: number, word, phase, etc... or what is being asked for. From there we make a plan of attack. How do we achieve this goal? Do we use equations, steps, a template, or a flow chart for example? Once we’ve brainstormed all of our ideas and have what we feel is a course of action we put it down on paper. I’ll refer back to my sample problem in the previous paragraph. In this problem we may have now determined that the
missing variable that needs to be solved for is $M_b$ (molarity of the acid). In order to solve for this we need to manipulate the equation to isolate this variable on one side. This we determine using algebra is accomplished by divided both sides by $V_b$. This cancels out the volume on the left hand side of the equation, but divides the product of the base’s volume and molarity by the volume of the acid, in the end giving us the answer to our missing variable. All that is left now is to plug in the actual numbers and do the calculations. (My sample thinksheet at the end of this chapter shows this whole example on paper as what a finished product may look like).

In this stage we are not solving the problem, but writing how to solve the problem. Basically it will be a series of steps that will give us the correct solution when we apply the correct information. When I give the students the problem, it is at the top of a page of which the remainder is blank. I now have them draw a line down the middle of the blank portion from top to bottom. To the left of this line they are going to write their steps of how to solve the problem. To the right they are going to solve the problem. At this point I have them fill in the left hand side.

Now we return to the problem. Using our left hand column as a reference, we reread the question and decide what data will fit into our solution. On the right hand side we apply this data, for example, replacing variables with numbers. Once we’ve applied all the pertinent information we can now do the things, such as calculations or referring to a key necessary to solve the problem.

The last stage is to double-check our work. Does our answer make sense? That is the most important question here. Many students are happy that they have just filled in the blanks, and never check to see if they should have come up with apples and their answer is oranges. If the answer looks logical, then they are probably in good shape.

The second strategy deals with getting the students to write multi-source conclusions to their laboratory experiments. My experience has shown me that the students often are looking for the easiest and quickest way out of doing work. There is a constant struggle to get them to do activities such as research that may cut into their “free-time.” Time and time again I get labs turned in for which the conclusion is the purpose and procedure restated to me. This is unacceptable, because if that is what I wanted I would simply have them return the sheets I gave them to complete the lab. To overcome this, I require them to come up with four sources of information that is relevant to what was performed in the lab. This can be anything except the materials I handed out for the lab, such as: their textbook, class notes, scientific journals, the Internet, or a type of media program. From this material they pull any pertinent information and make an outline of a conclusion. Now they can refer back to
their lab, specifically their data and results. They need to incorporate the lab material into the outline, but cannot delete any of the original information. If the outline shows a logical progression of information and incorporates the outside sources with the purpose of the lab, then they can go ahead and convert the outline to a conclusion.

This may seem lengthy or tedious, however our lab cycle gives them eight days between lab periods (this includes weekends). This is more than enough time to complete all the stages.

To change it a little, but still accomplish basically the same thing I have another approach. In this case, I give them copies of articles that I have selected on the material being covered in the lab. I allow them to read the articles. Then they must put them down and write about the topic without looking at the articles again. This accomplishes two things: it eliminates plagiarism since they are writing in their own words, and it makes them combine the articles into one. As they recall the information a natural blend occurs. They generally cannot tell me which article the information came from, but that they know that they just read it. Most of the time more information comes from one article more than the other, but this is usually a result of one article being more interesting than the other, or more readable. This “free-writing” now works as their rough draft. The students then take the articles out and to this draft add details that they may not have been able to recall before that supports the draft. Examples could be numbers, names, or places. This is also when they incorporate the data from the lab. Once again, the transition of information must be smooth and their articles must be proof read. The final copy is what now serves as their final conclusion.

Step 3: Providing Additional Practice

For additional practice I use thinksheets to gradually work them into doing these processes on their own. I do this for both the problem solving and the conclusions. After initially introducing them to these processes as explained previously, I give them a partially completed situation. For example, if it is the problem solving the left (step side) may already be completed. What they need to do is fill in the right side with the proper information and solve for the solution. If it is the conclusion writing, this initial thinksheet is usually an outline of main terms along with the articles the terms came from. From the articles, they fill in the outline with pertinent information and from this write the conclusion.

Each successive worksheet from this point on will give them less and less information. This makes them come up with more and more on their own. The
transition, however, is gradual so that they learn the "routine" and become accustomed to what needs to be included or accomplished each time.

Conclusion

As is the case with human nature, many students are not very receptive to this at first. Humans have a tendency to resist change. They like to stay with what is familiar and safe to them. Writing in science is not very familiar to them, so they moan and groan the first time through this. This is when I found I should to be the most persistent. This first time through, instead of making the completed problem due at the end of the lab cycle or class, I make individual steps due at different points. This is to make sure they are on the right track and on task. Many will get frustrated and try to give up or act as if they don’t care, but a little encouragement and direction usually overcomes this. I have found that after a couple times through they begin to adjust. Complaints become fewer, and they begin to ask each other for help, instead of all coming to the teacher. I see their writing gradually improve. They begin to worry less about the format as they become accustomed to it, and start concentrating more on their writing. Once they begin doing this it is very easy to help them by teaching them to critique themselves. I recommend having students read their writing to themselves aloud. By reading it aloud they can hear what doesn’t make sense or doesn’t flow smoothly. If they read it to themselves, people sometimes have a tendency to read over their own mistakes and not catch them. I also encourage students to have a friend proofread.

As I said in the beginning of this chapter it is merely a suggestion of how to approach these common problems among students. It is not set in stone. I actually encourage modifications. Every classroom is different as is every student. This whole model might work for some, while maybe only bits and parts will work for others. Writing and problem solving are very important skills that not only will get students good grades in school, but also will increase their communication skills at both the social level and in the job market. For this reason I think that all grade levels and subject matters should encourage an increased use of these skills.

Thinksheet

Copy is attached.
Example of solving word problems

Sample Word Problem: Chemistry

How much 2.0M hydrochloric acid would it take to completely neutralize 225ml of 3.5M sodium hydroxide?

\[ \text{HCl} + \text{NaOH} \rightarrow \text{HOH} + \text{NaCl} \]

Set up how to solve the problem:

1. Identify the type of method to be used to solve this problem.
   
   A: The problem uses variables so it may be solved with an equation.

2. Identify the equation to be used.
   
   A: \( M_aV_a = M_bV_b \)

3. Identify the individual variables.

   A:
   
   \( M_a = 2.0 \text{M} \)
   \( M_b = 3.5 \text{M} \)
   \( V_b = .225 \text{L} \) (ml were converted to L)
   \( V_a \) = unknown to be solved for

4. Manipulate the equation to solve for the missing variable.

   \[ \frac{V_aM_a}{M_a} = \frac{M_bV_b}{M_b} \]
   
   A: \[ \frac{V_a}{M_a} = \frac{M_bV_b}{M_b} \]

Plug in information and solve:

\[ V_a = \frac{M_bV_b}{M_a} \]

\[ V_a = \frac{(3.5 \text{M})(.225 \text{L})}{(2.0 \text{M})} \]

Perform Calculations:

\[ .7875 \text{ M L} \]

\[ V_a = \frac{.7875 \text{ M L}}{2.0 \text{ M}} \]

\[ V_a = .39275 \text{ L} \]

Significant Figures and check to see if units match the variable:

\[ V_a = .39 \text{ L} \]

If needed convert back to ml.

\[ .39 \text{ L} = 390 \text{ml} \]