Problem – Solving as part of the Learn-to-Learn Process

Gary Cardinale
DeVry Institute at North Brunswick, New Jersey

An electronics instructor, while teaching a class, puts a basic series resistive circuit on the board. This individual, being very conscientious, makes sure that the resistor values and supply voltage are given and what needs to be found – voltage drops – is clearly indicated. The instructor then asks the students to take out their calculators and, together, work out the problem. Sound familiar?

This situation could represent a typical classroom scenario – the instructor is doing a good job teaching students how to solve a problem. What's wrong with this picture?

First – an assumption has to be made that the students understand voltage, current, resistance, and power.

Second – an assumption had to be made that the students understand what a circuit is.

Third – an assumption had to be made that the students understand Ohm's law, Kirchhoff's voltage law, and the rules for series circuits.

That's a lot of assumptions!

Assume now that the students do not have the necessary background to follow the instructor. What is the end result? The instructor is doing all the work while the students are number crunching. This is called passive learning, a process that allows little to no real student participation.

This paper concerns itself with a process that enables students not only to become good problem solvers but also enables them to "learn-to-learn". This process consists of six steps. The first five deal with the learning process – active learning – where students become involved in classroom and lab activities. The sixth step is the actual "learn-to-learn" step. This is where students use what they have learned and apply that knowledge. The process, in detail, now follows.

FIRST STEP – teach the concepts! From this develop graphs, circuits, etc. to illustrate these concepts. Then, use the appropriate mathematics to relate the concepts to the illustrations.

SECOND STEP – apply the following heuristic (a procedure that provides direction in the solution of a problem) to step one. This will help the students develop the necessary skills for problem solving and critical thinking.

A. Define the problem.
   You must be able to recognize the real problem from the perceived problem. (What seems to be the problem but is not.) The real or actual

problem can be looked at as the objective – What is needed to be found.

For example: A student asked to solve a series circuit might stop at finding total resistance or current. In this case, resistance and/or current would be considered the perceived problem. The voltage drops – or objective – would be the real problem.

B. Generate solutions.
Brainstorming is an excellent method for enhancing creativity and generating solutions to problems. During this time, all possible solutions to a problem are presented. Individuals, as well as teams, can find this method to be quite effective. With this in mind, use the given information (of the problem), what is needed to be found (objective) and develop the appropriate equations.

C. Decision.
Once the appropriate equations have been developed, determine – with the objective in mind – which equation should be solved first, second, etc.

D. Implementation.
At this point, the order of equations has been resolved. Now it's simply a matter of solving the equations which – in turn – solves the problem.

E. Evaluate – go back through the process and make sure that everything has been accomplished.[1]

THIRD STEP – New concepts can now be built from the previous concepts by using step one and step two as the basis for step three.

FOURTH STEP – Relate courses together. Students will get a better understanding of electronics (overall) when the core courses (DC, AC, devices and digital) are related together. This will also establish a strong foundation for the advanced study of electronics.

FIFTH STEP – Relate courses to labs. What is taught in class should be done in lab. This means not only the circuit concepts but also the exact circuit. As is known, the lecture and lab concepts may be identical, but the way it is represented in lab may be different and therefore difficult for the student to understand. This could have an impact on the learning process that, in turn, might affect their ability to design their own circuits.

SIXTH STEP – Develop your own lab based on the learned concepts and use your own circuit designs for the experiment.

What follows now is an actual classroom project AND/OR logic which illustrates this process. The first step in the development of this project was to teach the concepts of the AND/OR functions using DC Series and Parallel circuits as models. From this the actual AND/OR gates are introduced with the basic truth tables. By comparing truth tables, a need for inversion, the NOT gate, becomes apparent.

The second step is needed to accomplish step one as it introduces the process of Problem Solving:

A. The objective was to develop basic logic gates(and how to analyze them) from simple DC circuits.

   For example: A series circuit consisting of two single pole – single throw (On – Off) switches, a five volt power supply, and a volt meter can be used to demonstrate the AND function. To illustrate this, switch one *and* switch two must be closed in order to measure five volts. (Switches closed produces five volts which equals a logic one; switches open produces zero volts which equals a logic zero.)

   For example: A parallel circuit consisting of the same two switches, power supply, and volt meter can be used to demonstrate the OR function. Switch one *or* switch two *or* both switches must be closed in order to measure five volts.

   The AND function is best represented by an AND gate and the OR function by an OR gate.

   A circuit is now made from two AND gates and an OR gate. The OR gate has two inputs. The output of each of the two input AND gates are connected to each input of the OR gate. If **00** is placed on the inputs of the AND gates, then the output of the OR gate would be zero. If **11** is placed on the input of the AND gates, then the output of the OR gate would be one. Suppose, however, a logic one (output) is needed when 00 is placed on the AND inputs and a logic zero (output) is needed when 11 is placed on the same inputs. The need for inversion now becomes apparent. Hence, the NOT gate or inverter.

B. Brainstorming is used to develop the appropriate Boolean equations and the proper format for the AND – OR – Inverter truth tables. Each team has a leader who facilitates the group's activities as they explore different possible solutions. The leader then delegates project development responsibilities to each member.

C. A decision is then made regarding which gate is first. The team leader makes sure that the decision being made is a direct result of understanding the problem and has the final decision-making responsibility for the team.
   1. Series circuits are taught first, logically then, AND gates would be taught first.
   2. Parallel circuits follow series circuits, therefore, OR gates would be taught next.
   3. Since an understanding of AND gates and OR gates is needed for inversion, the inverter or NOT gate would be taught last.

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D. The solving of the Boolean equations was established with the proper order of the gates. The objective has now been met.

E. The results are evaluated to see if the objective was met.[1] The team leader would reexamine the process that was utilized to arrive at the final result to make sure that each step was processed correctly and that the entire process logically concludes with the result given.

Step three introduces how new concepts can be built from the previous ones: AND/NOT functions produce a NAND gate. OR/NOT functions produce a NOR gate. Also, NAND gates are used to form NAND logic and NOR gates are used to form NOR logic. De Morgan's Theorem (which can also be used to simplify certain NAND/ NOR logic circuits) becomes a good introduction to AND/OR logic (an OR gate with AND gates and inverters).

Step four is used to relate the core courses (DC, AC, Devices, Digital) together. As seen, DC concepts of series, parallel circuits as well as magnetism and inductance are needed to understand generators and transformers (AC concepts). These two concepts are needed to understand diodes and transistors (Devices concepts). All three of these core courses are needed to understand Digital concepts.

Step five now relates the core courses to labs. The two, three, and four input AND/OR logic circuits taught in lecture were the circuits the students did in lab.

Step six – Students (in teams of four) had to design and build a three input AND/OR logic circuit that would turn on an LED (load) using a set binary sequence. Each team would choose three different possibilities from **000** to **111**, write out the Boolean equations, and then design the circuits.

Students were taking the AC and devices courses with their digital course. (The DC course was taught the semester before.) The courses that were needed to understand their digital course also allowed them to design and build their own five volt regulated power supply needed for the circuit's operation.

The final part of the project involved each team developing their own lab using their circuit designs. The lab had to be six to eight pages in length, word processed, and double-spaced with one inch margins. The following format was used for the lab write-up: Title, parts list, objective, discussion (theory on AND/OR logic and regulated power supplies), procedure (includes graphs, circuits, calculations, etc.) and ten original questions with answers. They were given a month to complete this project. All teams finished on time.

The students found this project to be exciting and thought provoking for the following reasons:
1. They were developing into good problem solvers.
2. They were becoming good independent thinkers.
3. They were able to share this newly found knowledge, through collaborative learning, by working in teams.

This was a one-time project selected by the author for this paper.

From the instructor's perspective, as each team project was finalized, the project was observed in the lab and the instructor's observations were provided to the team. The team's final report was then submitted for evaluation and more specific critical commentary by the instructor.

Overall, a positive observation on the part of the instructor was seeing how well the students worked together in a team environment and the synergies that were created to help bring the project to a successful conclusion. There were no real negative observations.

Bibliography

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GARY CARDINALE

Gary Cardinale is a Professor of Electronics at Devry Institute at North Brunswick, New Jersey. His most recent accomplishments include being listed in Who's Who Among America's Teachers(1998, 2000) and being inducted into the International Who's Who of Professional Educators(2000). Professor Cardinale received a B.S. degree in Physics from Charleston Southern University in 1971.

Proceedings of the 2001 American Society for Engineering Education Annual Conference & Exposition