Experiential Learning of Students through Prescriptive Laboratory Experiments Versus Open-ended Laboratory Assignments

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EXPERIENTIAL LEARNING OF STUDENTS THROUGH PRESCRIPTIVE LABORATORY EXPERIMENTS VERSUS OPEN-ENDED LABORATORY ASSIGNMENTS

Abstract:

Traditionally, at undergraduate level courses, experiential learning is performed through prescriptive laboratory experiments. Usually, there will be a laboratory manual having twelve to fifteen experiments written either by textbook author or by others. The laboratory manual will typically have the following format: Experiment Title, Objectives, Parts necessary to perform the experiment, Step by Step Procedure, and Tables for writing collected data, Graph paper for plotting collected data, and Related Questions to answer by student in the final report. The process has been working for students for centuries, and not always without hiccups. Those hiccups mostly have been generated from differences in laboratory equipment, types of parts used, changes in software tools and their versions, and a few other unforeseen laboratory issues.

To improve creativity and critical thinking of students, authors of this paper have created a little variation to the above process. Instead of providing students with all they need, students are only provided with an experiment/assignment title and the objectives of the experimentation. Students are also provided help with available software and hardware tools that they need to perform any specific assignment. These helps do not include any step by step procedure, what data to collect, or even how to present them in the report. This process emulates a real world environment that a graduate would encounter in industry.

This paper will show and discuss how such laboratory process has provided several benefits for students, how students have come up with innovative solutions and approaches to the same problem, and how those solutions have been quite different from the authors' own solution of

the assignment. In addition, students with innovative solution were asked to present their solution to other students in the laboratory. The paper discusses how this later effort created a competitive environment that facilitates enhanced learning without pressure.

The paper also discusses how to improve student experiential learning by innovating solutions to problems such as limitation caused by number of hardware stations and variation in speed and skills of students while performing experiments. Finally, data is presented that proves the benefits of open ended and non-prescriptive assignments over the traditional approach.

INTRODUCTION

Experiential learning through open ended laboratory assignments is the main subject matter of this paper. We strongly believe and observed in laboratory environment that a student group or a single student is able to express their innovative side of a solution more in oppose to when they are limited by a prescribed procedure to a laboratory experiment. Because of these prescribed step by step procedure to laboratory experiment, in many cases students are limited or even do not care to bring out their intrinsic talent towards the solution of the laboratory problem. Even if someone out of extreme curiosity do find an innovative solution to a laboratory problem, he/she is either afraid to express of simply do not know value of the solution.

We are not suggesting or discounting merits of prescribed step by step process of a problem solution. However, there should be a free path to students to express their innovation without being embarrasses for going away from the norm. The verbal encouragement does not always work as good as a definite free path of expression. The students with limited knowledge are generally **not** locked in a paradigm like a professor having extensive knowledge about the subject matter. This is just one of the methods where the process provides a platform in which a student can express his/her talent towards a laboratory problem. Thus often in today's world one can find that apparently an unusual solution becomes the most valuable one.

Induction from one student to another works well in this process also. When a student is asked to present his/her solution in an informal way to others trying to solve the same laboratory problem, provided a soft competitive environment without undue pressure. It was observed many times that these kinds of activities bring out hidden aptitude of an apparently non performing student to become an active participant.

Since authors have made available almost all the assignments except group class projects at the beginning of the semester coupled with a tentative schedule about their due dates, students have the freedom of doing the assignments at their own pace. This caters to both high paced and low paced students and allows both types of students completing their assignments on time and succeed in their endeavor. This specifically helps instructor and students having limited number of available hardware setups in a laboratory. One laboratory period sometime is not enough for an innovative solution to an assignment and also that laboratory period may be not fully functional due to unforeseen laboratory hardware and software issues.

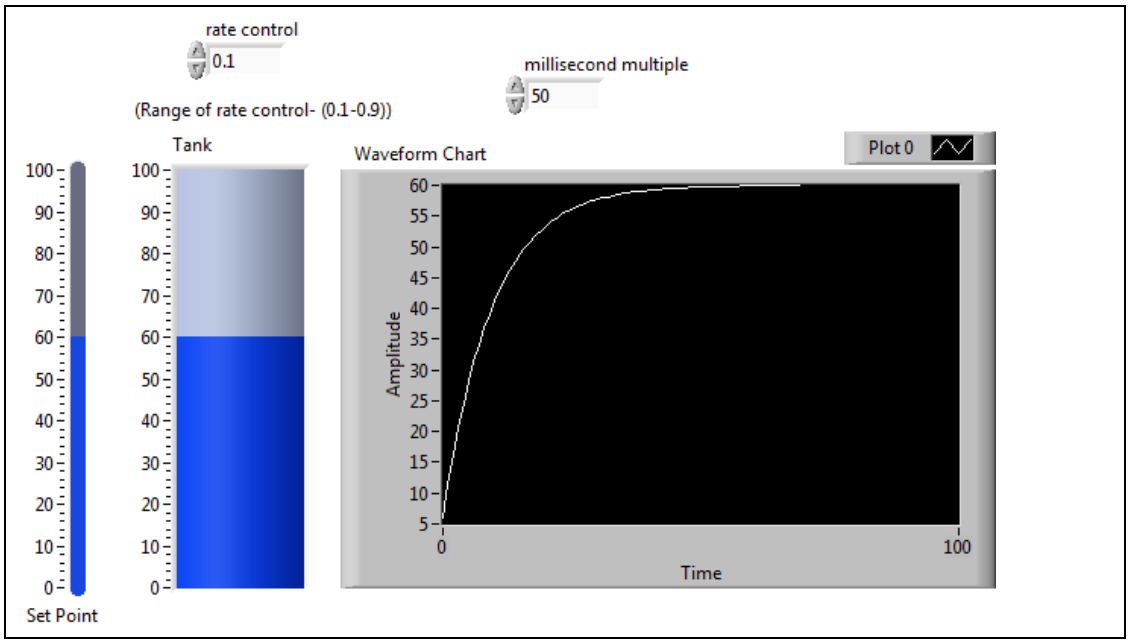
We also observed that due to these open ended and non-prescriptive assignments at least forty percent of students completed their assignment before their due date, and another fifty percent completed their assignments on time, and only ten percent needed extra time to complete an assignment. This is notably different from the prescriptive laboratory assignments in which students generally finish one assignment and often fall behind due to unforeseen laboratory hardware, software issues, and issues associated with low paced students.

AN EXAMPLE OF ASSIGNMENTS AND ITS SOLUTION BY STUDENTS

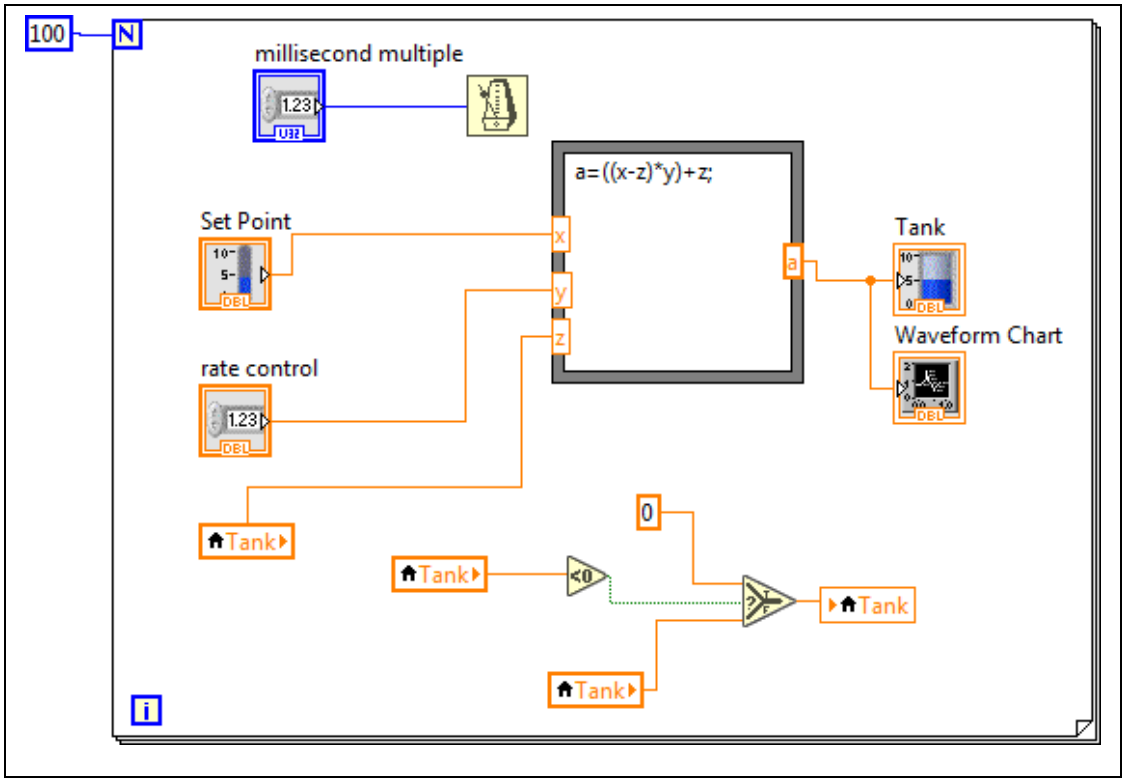
Assignment #4:

Develop a LabVIEW program (Front Panel and Block Diagram) using “FOR Loop”, Equation Node, and Local Variables where a tank will fill to a desired level at a desired rate. As the desired level is changed to either higher or lower value, the level will adjust to that level at the specified rate. Plot the actual level in a time scale.

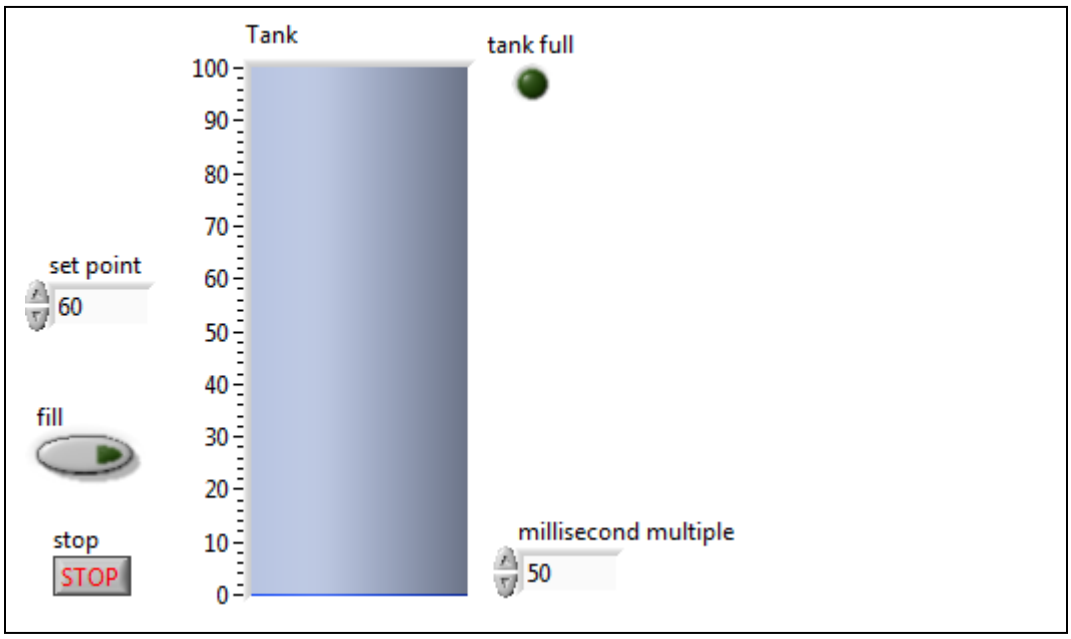
Solution of Student #1:
FRONT PANEL



BLOCK DIAGRAM



Solution of Student #2:
FRONT PANEL



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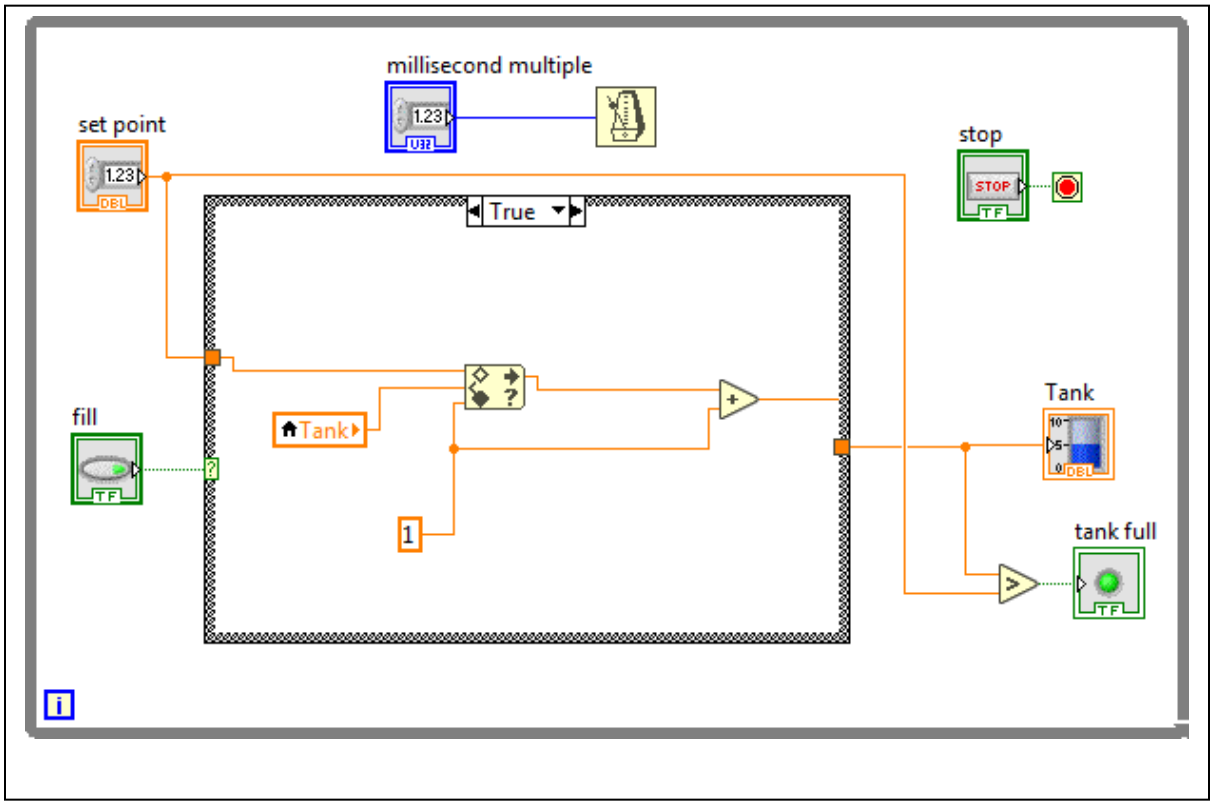
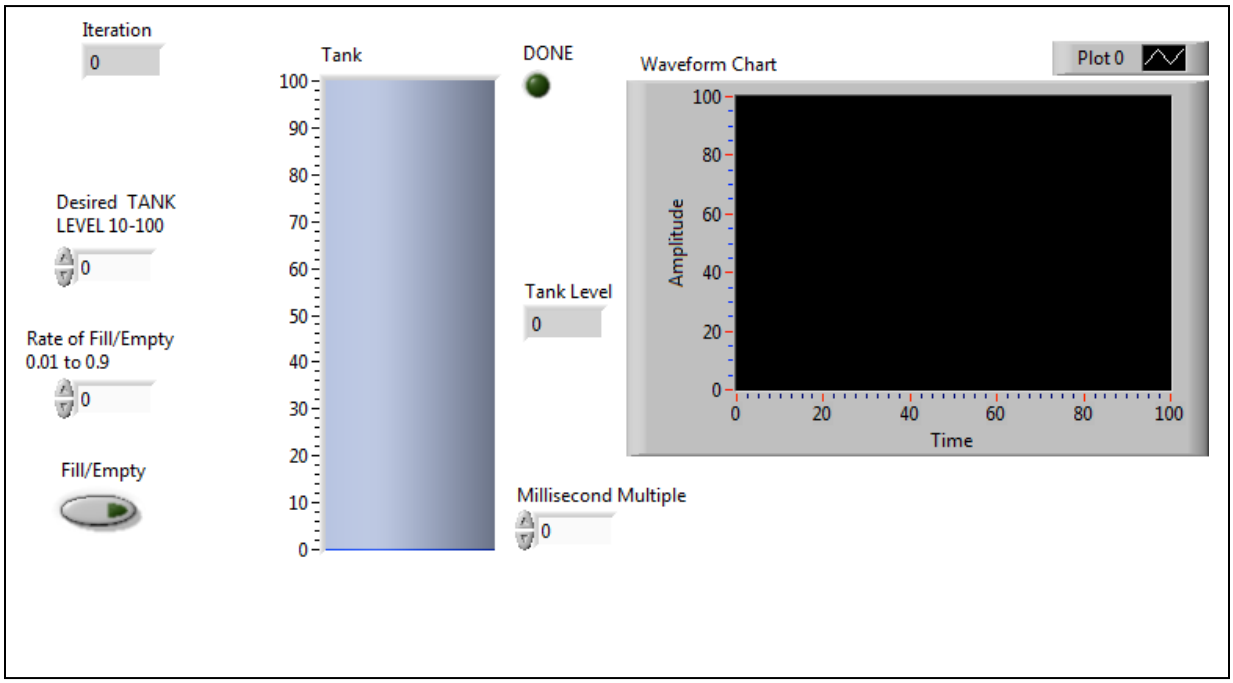


Solution of Student #3:
FRONT PANEL



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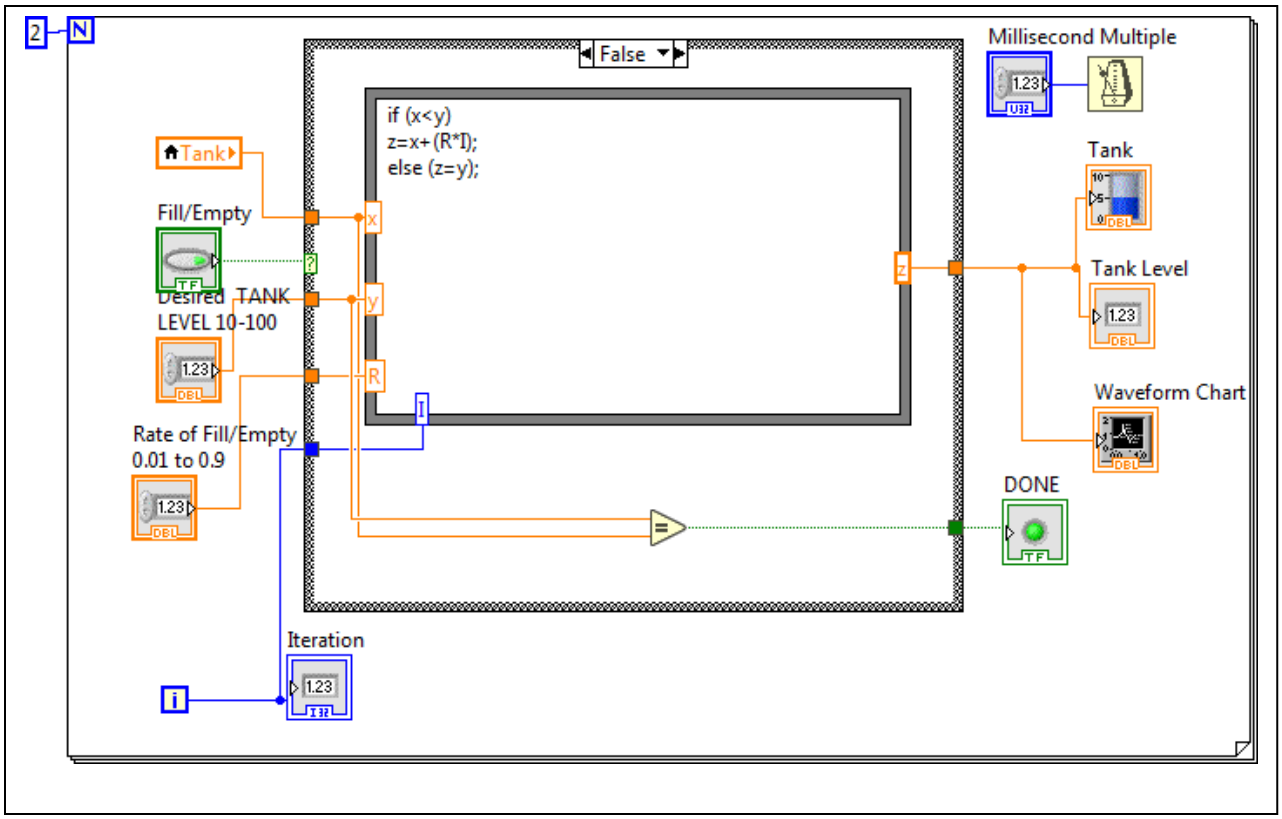
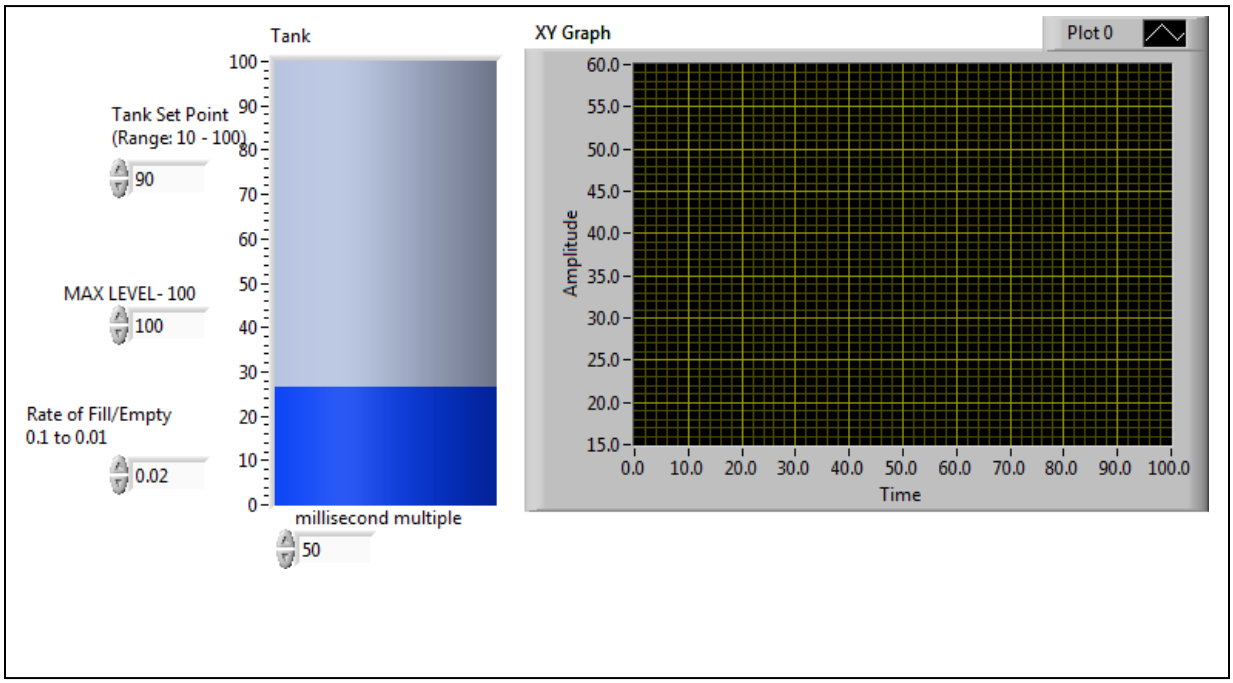


Solution of Student #4:
FRONT PANEL



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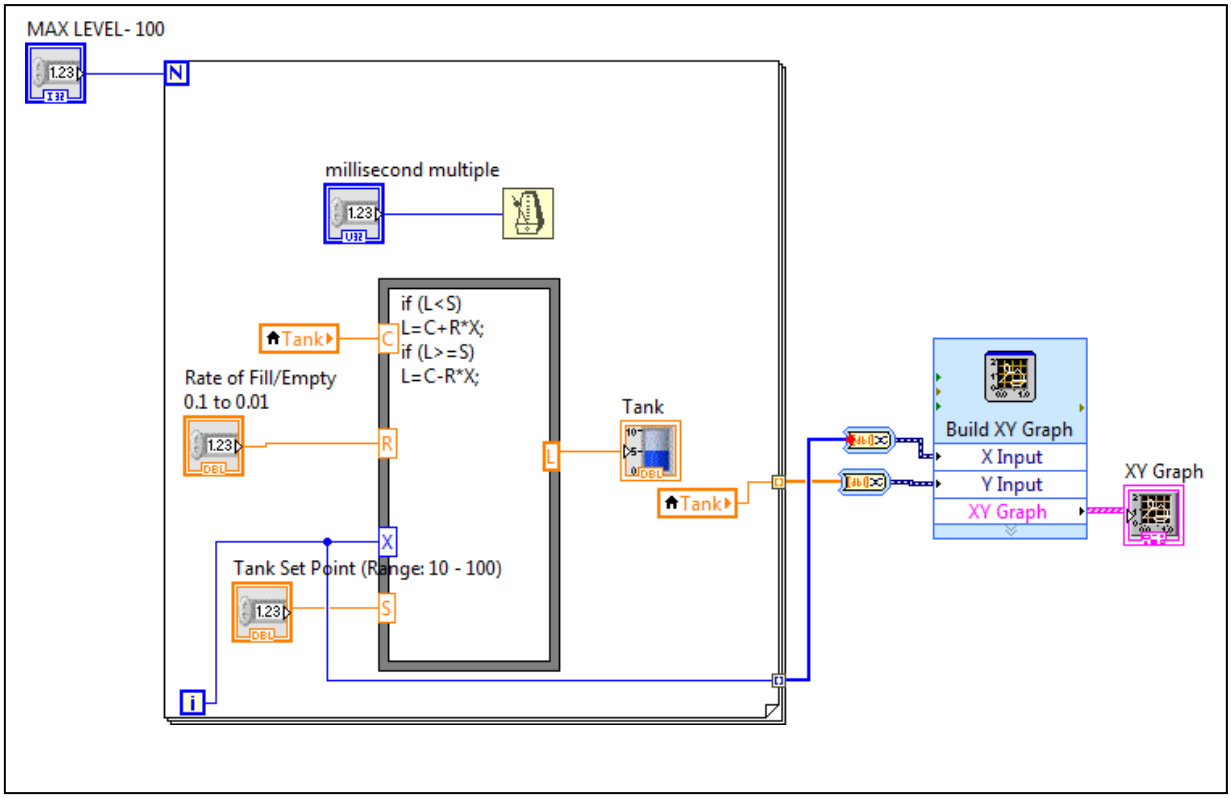
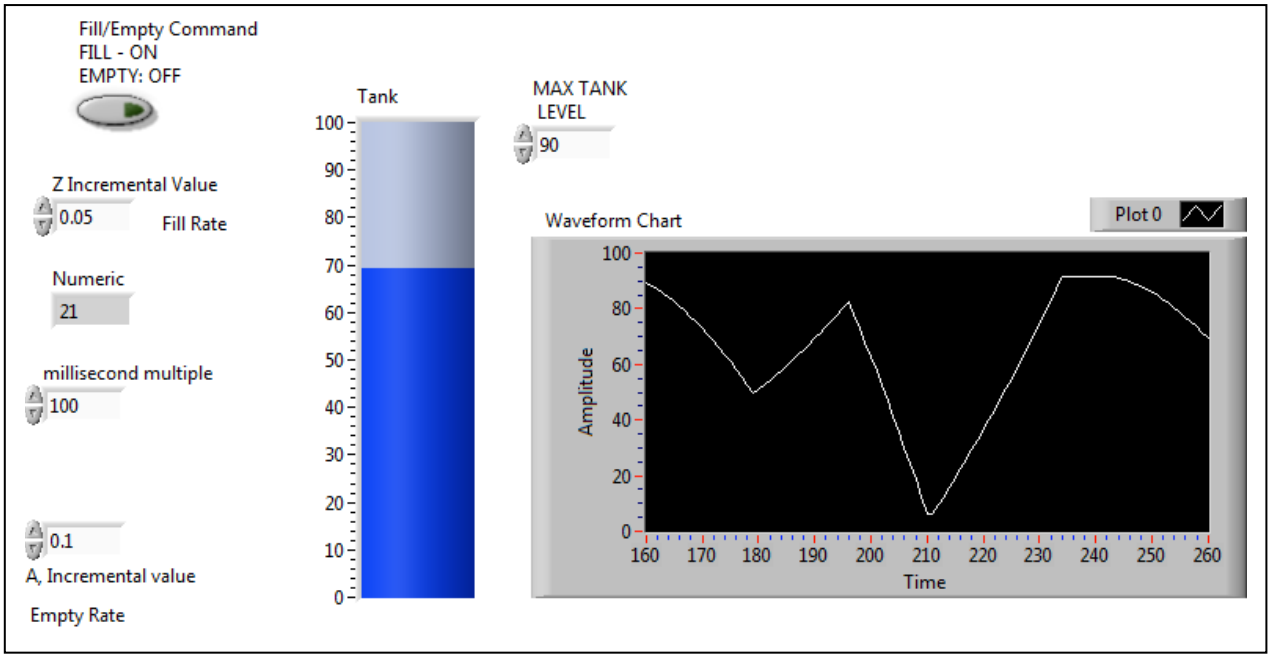


Instructor's Solution:
FRONT PANEL



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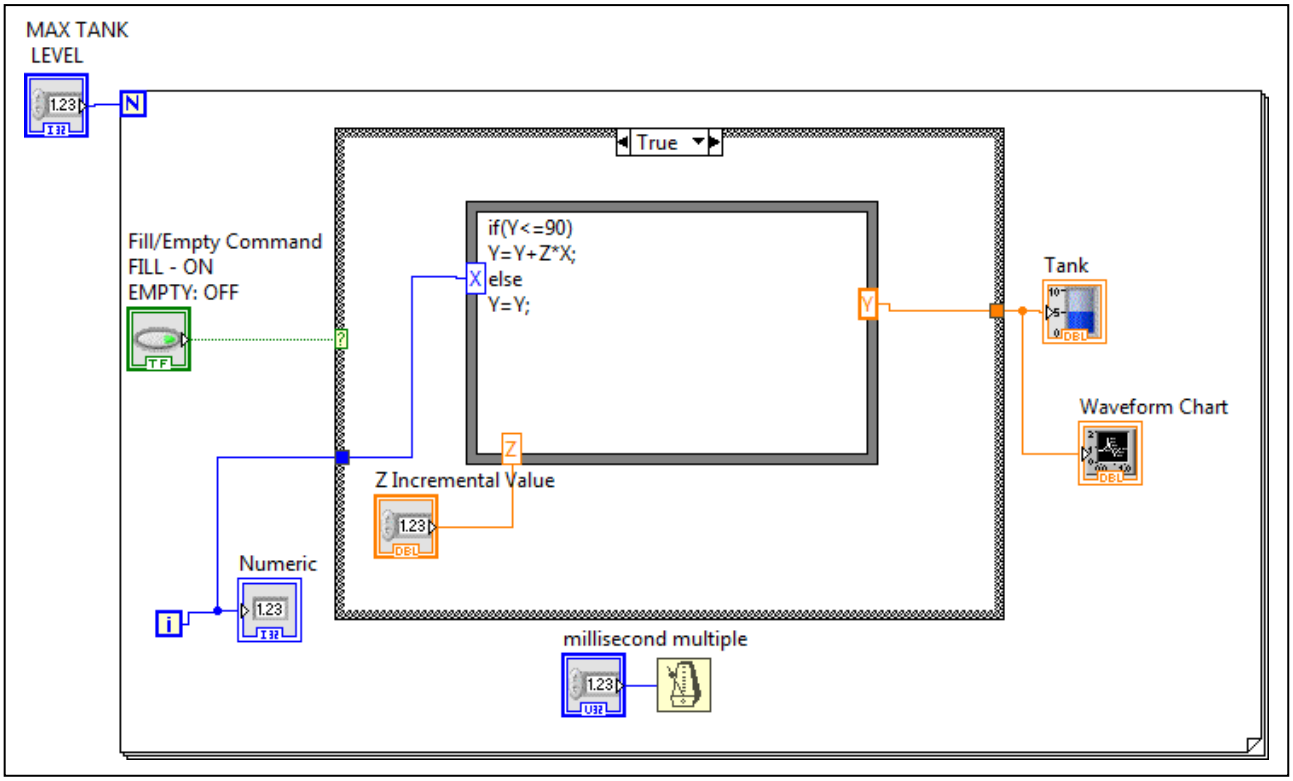

DISCUSSION OF RESULTS

Student #1 implemented the solution using simple proportional control algorithm. Student #2 used “In Range Coerce” block available in LabVIEW. Student #3 solved the problem using “if then else” statement. Student #4 also used “if then else” statement. However, all used “FOR Loop” and “Equation Node” because Assignment #4 requires them to use those function blocks. Instructor’s solution that was not revealed to the students until they (students) tried to solve or solved the problem on their own. The instructor solution is close to the solution provided by Students #3, that used “if then else” statement. If we notice carefully in their solutions, we will find that each of them used different type of algorithm, types of variables, little bit different Front Panel diagram, different way of plotting the rise and fall of tank level.

It is also very important to know what information students were given other than description of the laboratory problem. They had a handout on Front Panel and Block Diagram that include “FOR Loop”, “While Loop”, “Case Structure”, and “Formula Node” Structures and their fundamental functionality. In addition laboratory instructor explained LabVIEW software tool and functionality of these above structures in the laboratory.

We also asked students for anonymous comment regarding their experience in the laboratory having such a type of assignments where step by step procedure is not provided for the laboratory experiments. We find that overall the comments are positive. In addition, laboratory grades indicate successful completion of all laboratory assignments.

The authors also experimented similar methods in both a sophomore and two freshmen level courses. The results show an improvement in all courses as the new method is compared with traditional approach in Table 1.

Table 1 lists the overall GPA of students in four classes before and after the implementation of the new methodology. As evidenced, overall GPA increased in all three courses by an average of 17.48 percentages. This shows that the students are learning and understanding the material

better using the new methodology. The total sample size (students) in this comparison is 195 with an average of 21 students per class.

	MCET 46200	MCET 21700	MCET 10000	ECET 15200
Class GPA before implementation	2.61	3.30	3.11	2.33
Class GPA after implementation	3.01	3.42	3.56	3.18
Increase in GPA (%)	15.33	3.64	14.47	36.48

Table 1. Comparison of course GPA before and after implementation of the new methodology

ANNONOMOUS COMMENTS OF STUDENTS REGARDING THE PROCESS

Following are some comments from students after implementation of this new approach. These are direct quotations of student response and therefore may have some grammar issues:

Student #1: Problem solving in the laboratory helped me in developing my skills. It has been a good platform where one can express his own idea and solve the problems in own approach. Projects and assignments exposed me to real life scenarios. Using LabVIEW trainer is one more interesting aspect. I had a really great experience of controlling the processes with computer.

Student #2: The way the class was developed was useful. I found that there are more than one way to solve a problem and rather than having the instructor showing how to do it, we were able to find a variety of methods to reach our goal. I was also forced to explore the LabVIEW computer program allowing me to learn more than a structured lab would teach me. Out of the box thinking is well taught in this class. I know from my experience that this is how it is when you are at work and have to solve a problem on the fly.

Student #3: This unconventional laboratory instructional method is when the instructor gives the students a small demonstration on how to do certain labs, and allow students to attempt to

find a solution on how to solve a problem given to them in the lab. The advantage of implementing this method are that it allows the student to use their creativity to come up with a solution of their own, rather than having the instructor give them a predetermined sequence on how to solve certain problems. The advantage of the unconventional method is that it allows diversity of different solutions that are unique to a student.

Student #4: Both types of labs have merits. When a student has an opportunity to find a solution on their own the level of learning is generally higher, with the drawback of assignments taking little bit longer. Structured procedure help student accomplish more but for me those kinds of labs are not challenging.

CONCLUSION

In conclusion, as shown through both quantitative data and qualitative survey, this method has several advantages over the traditional prescriptive laboratory experiments:

1. It promotes the creativity of students as they have to think about their approach rather than following a written procedure by the professor;
2. Once they see that their solution is unique and came from their thoughts, students are encouraged and become more interested in the subject matter;
3. As shown in comparison GPA, Table 1, the students, due to an increased level of enthusiasm, tend to perform better in the course. The study was performed on four courses before and after implementation of the proposed methodology. The overall GPA of class increased by 17.48% after the implementation.

However, the most important effect of this research paper is that the methodology creates a lasting experience for students and provides them with an environment where they are challenged with a task. In this environment they can express themselves in a creative way to solve a given problem without the conventional step by step laboratory procedure. This challenging experience provides students a taste (flavor) of real life engineering environment

and thus better prepares them for professional activities, while increasing their learning and creativity.

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