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Induced Collaborative Engagement for a ”Solution-to-Question” Model using Remote Experimental Laboratories as a Tool

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Induced Collaborative Engagement for a "Solution-to-Question" Model using Remote Experimental Laboratories as a Tool
(Work In Progress)

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Abstract

Since the introduction of remote experimentation laboratories for learning, lots of research has been done to determine the most suitable paradigm for remote laboratory implementation. Of all the models proposed, the collaborative model for remote experimentation labs which involves a means of group communication between students performing experiments has been found quite effective. Despite this discovery, feedback questionnaires still record a high percentage of dissatisfaction from students performing experiments in remote labs. Hence, there is the need for an effective learning approach which includes fun in other to sustain the interest of the student. Learning is made easier when fun or play is included in the process.

This paper tries to answer two questions: how can engagement be induced amidst a group of students collaborating together to perform an experiment on a remote lab; and how can this induced engagement create fun and hence improve the learning process?

To achieve this aim, the "Solution-to-Question" Model was conceived, created from the approach which is adopted in computer games. About 50% of the most played computer games have two major components in common which are; there's a target or a goal to achieve and there's also a tool or multiple tools to achieve that goal. Computer games give the player the freedom to determine the right approach to achieve the goal using the tools provided. This creates suspense and hence inducing engagement in the user. Other things like graphic designs contribute little to the engagement.

The "Solution-to-Question" Model is divided into the solution, which serves as the goal or target, and the question, which is the random path adopted by the user in achieving the goal. Starting from a given goal (solution), numerous approaches to achieving the goal are explored by the student using the tools provided. The approaches adopted satisfy the question part of the model. In the quest to attain the solution, the student learns and engagement is induced by the desire to solve the problem using the tools provided.

This model was used by the Remote-labs research group at the authors' university in the design and implementation of a Remote lab platform. This paper focuses on two experiments conducted on a LabVIEW platform, and involves students experimenting on parallel and series resistances.

Keywords: Solution-to-Question, Collaboration, Engagement, Remote-Labs

1 Introduction

Laboratories are essential to education. Laboratories afford students the opportunity to experience the concepts they have been taught in class. Traditional labs require direct contact between the students and the laboratory setup in a physical location called a laboratory. This system however poses some limitations well captured by a number of questions put forward by National Instruments[1]. Remote labs emerged as an answer to these questions. Hence, remote labs make it possible to do lab work at any time of any day, from the comfort of one's bedroom or during a live lecture in class. They also make it possible to share laboratories across students and researchers at great distances from each other. This means that remote labs inherently have the capacity to foster collaboration between students and researchers of different demographics, across great distances.

A sketch of a typical remote lab model is shown in figure 1.

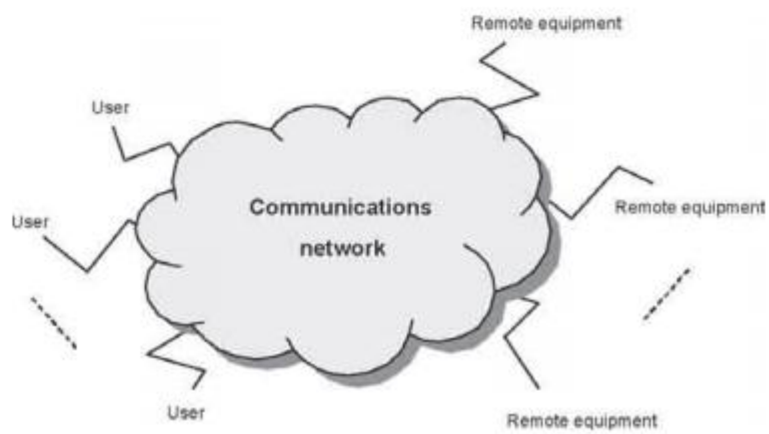


Figure 1: Typical Remote Lab Structure [2]

1.1 Issues of Remote Labs

Several advances in laboratory education have been credited to remote labs[3]. Remote labs have been found to be successful in teaching and research in several different areas such as digital process control[4, 5, 6], aerospace applications[5] , PID control[7, 8] , digital electronics[9], robotics[10, 11] predictive control, embedded communication systems[12] and real-time video and voice applications. Despite the successes of remote labs, they face a number of challenges. In our experience, one of the most prominent challenges to remote labs is the rapid loss of interest by the students when performing experiments in the remote labs. This problem leads to a decline in the rate of learning by students.

Interest has been defined as "*something we care about, is important to us or that we have (mostly) positive feelings towards*" [13]. Interest can been divided into two; individual interest and situational interest[14, 15]. When an assignment is given to a student to perform an experiment on a remote lab, the interest may be individual i.e the student cares about learning, or situational i.e the student cares about just completing the assignment. The level of interest of the student depends on the design architecture of the remote lab. Loss of interest in these labs however reduces the utility which students find for the labs and hence reduce gains from the remote labs. Interest, it has been shown, is a necessary ingredient to learning[16]. Since quick loss of interest in performing experiments on remote labs poses as a major problem, a solution is required. In attempting to solve this problem of loss of interest, the "Solution-to-Question" model was used. Research carried out at the Remote-Labs unit at the authors' university led to the design and implementation of a platform which used this model (Solution-to-Question) as its design architecture. The goal was to increase and sustain the interest level of the students in the remote lab. It was hoped that the Solution-to-Question model would help spur "engagement" in the remote lab just as computer games do.

2 Theoretical Development

Some fundamental concepts used in this research work are first presented.

2.1 Choice of Remote Lab Case Study

The remote lab used as a case study for this research is a "Resistance Lab". A lab based on resistor networks was chosen because the analysis of resistor networks is fundamental to electric circuit theory. Several practical circuits comprise a network of resistors and other electric components which can be represented by their impedances and then analyzed as "resistors" in circuit. For example, the analysis of a network of resistors, inductors and capacitors can be easily analyzed using techniques used for purely resistive networks.

2.2 "Question-to-Solution" and the "Solution-to-Question" Models

The conventional "Question-to-Solution" model is the usual approach to traditional remote labs design, which requires a procedure in arriving at a given solution. Students who use this type of labs constantly have one major question in mind, which is, "what is the next step or procedure?" By a repeated process of following the procedures or steps provided by the lab manual, a solution can be obtained. In the drafting of lab manuals using this model, more effort is put into creating procedures for individual experiments.

The "Solution-to-Question" model is an ongoing research in the authors' university for the right approach to the design of remote labs. This model uses the approach similar to that of computer games. In the modeling of computer games, there are two main blocks: the goal block and the tools block. The goal block contains the aim of the game which the player tries to achieve. The tools block contains the instruments / equipments provided to achieve the goal. Most computer games have their story board directed after this model. Figure 2 shows an example of this model for a game called Angry Birds. The goal is to hit the blue birds (goal block) by using the red birds (tools block), and the player is rewarded with points for this. From this design the player is not provided with a definite procedure to hitting the blue birds. This leaves the player with multiple options of hitting the blue birds. Figure 3 shows the parallel between the architecture of remote labs adopted and the game model. A final output voltage is given and a student is required to find a series-parallel resistor configuration that can result in that voltage.

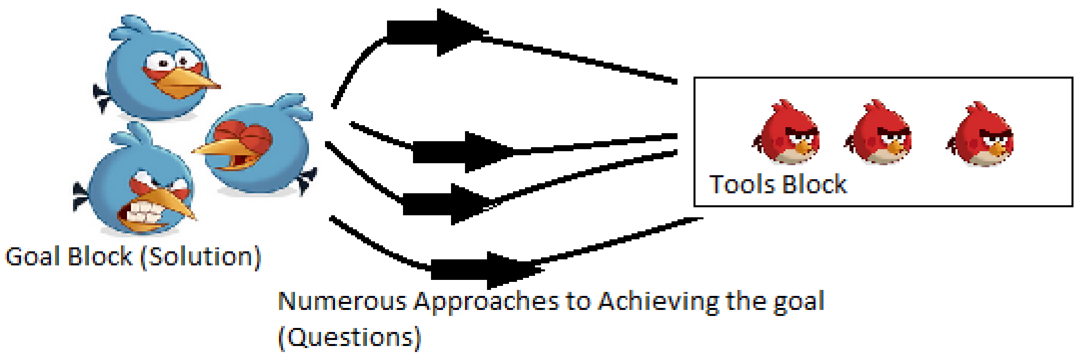


Figure 2: Model for Angry Birds

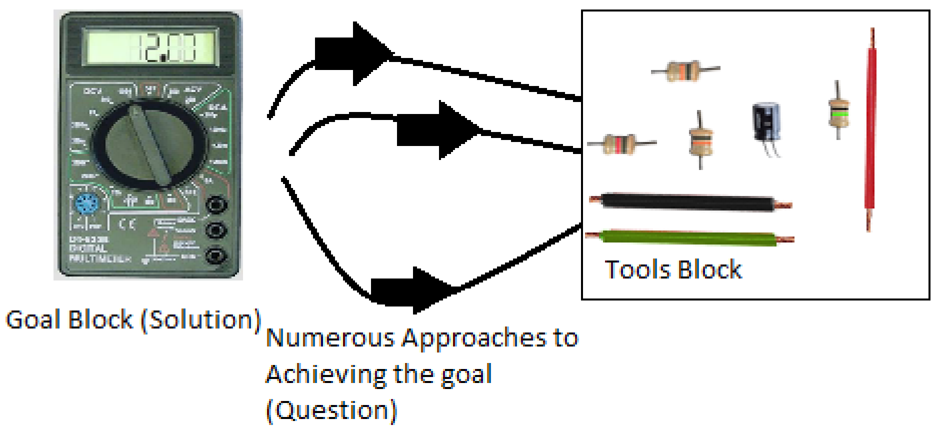


Figure 3: Solution-to Question Model

With this model the goal is the solution (i.e. the experiment set up connected such that it correctly gives the output voltage specified and the appropriate readings taken). The numerous approaches to achieving the goal are the questions, which are made possible by using the tools (lab instructions and components provided).

To explain our model further, a student may be given components of the circuit of figure 4 and asked to set the circuit up in the lab and measure the voltages across certain resistors. This approach is the “Question-to-Solution” approach.

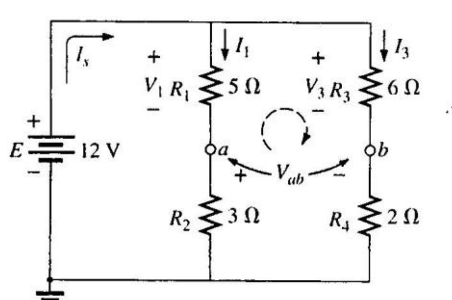


Figure 4: A resistor circuit

In the “Solution-to-Question” model, a student may be given just the values of voltages across R3 and R4 and the voltages across each of them. He will then be asked to use circuit theory to find possible values for R1, R2 and the supply voltage E that would satisfy the given data.

The major differences between the Question-to-Solution model and the Solution-to-Question model are shown in Table 1.

Table 1: Differences between the “Question-to-Solution” and The “Solution-to-Question” Model.

Question-to-Solution Model	Solution-to-Question Model
1. The model starts with a procedure which is driven by a question. For example, procedures or steps to set-up a voltage division circuit.	1. The model starts with a goal or rather a solution. For example getting a 5volts output from a 9volts input.
2. The model ends with a final solution. For example, an output voltage from a voltage division circuit.	2. The model ends with one of multiple possible procedures or steps which are adopted in obtaining the solution. These procedures are created by self generated questions asked by students. For example, questions may be generated which will involve the theory of voltage division.
3. The questions to be answered by the students are in the lab manual.	3. The questions generated by students are answered by the students.

2.3 Collaborative Learning And Engagement

Collaborative learning is the process whereby two or more people learn together. It is sometimes also jointly defined in terms of joint problem solving [17]. The power of collaboration is displayed in the fact that collaboration, when done well, does not just additively combine the strengths of the individuals collaborating. Their strengths are combined exponentially. With the advent of the social era, collaboration has been made easier through the use of social network platforms such as Skype, Watsapp, Facebook, etc. With this new trend, the adoption of these platforms in learning will improve the collaboration of students. In this research work, the platform being adopted is the Skype chat and an interective real time sketch pad. It is used in creating a means of collaboration between students performing experiments on the remote lab.

Uncontrolled Engagement or addiction is basically viewed as a bad thing. It has been defined as a "*chronic, relapsing disease that is characterized by compulsion*" [18]. The addict compulsively seeks the object of his engagement even when it is harmful to him health-wise or otherwise. According to Brian and Wiemer-Hastings[19] email, chat and the web in general are inately addictive and everyone is susceptible. Young[20] added that interactive real-time services are the most engaging. The two prominent interactive services are internet relay chat (IRC) and multi-user domains (MUDs). With this in mind, this research study aims at inducing engagement in the process of performing experiments on remote labs. With engagement, concentration is induced and hence learning and innovation are promoted.

3 Description of Experimentation

The analysis of resistor networks is often done based on two simple rules: the rule governing the connection of resistors in series and that governing the connection of resistors in parallel. These are the platforms used in the design cases for our experiments as explained following. Case 1 experiments are those which make use of the Solution-to-Question model (i.e. the “traditional” remote lab). Case 2 experiments are those which make use of the Question-to-Solution model.

a. The Traditional Remote Lab for Series Parallel Circuits (Case 1)

This lab was designed using the traditional model i.e. the “Question-to-Solution” model. The students were provided with a circuit as shown in figure 5. The component specifications for this experiment were specified in the lab manual. The task for the experiment was to input the components’ specification values as gotten from the lab manual, and to record the outputs from the individual indicators. The procedure was included in the lab manual.

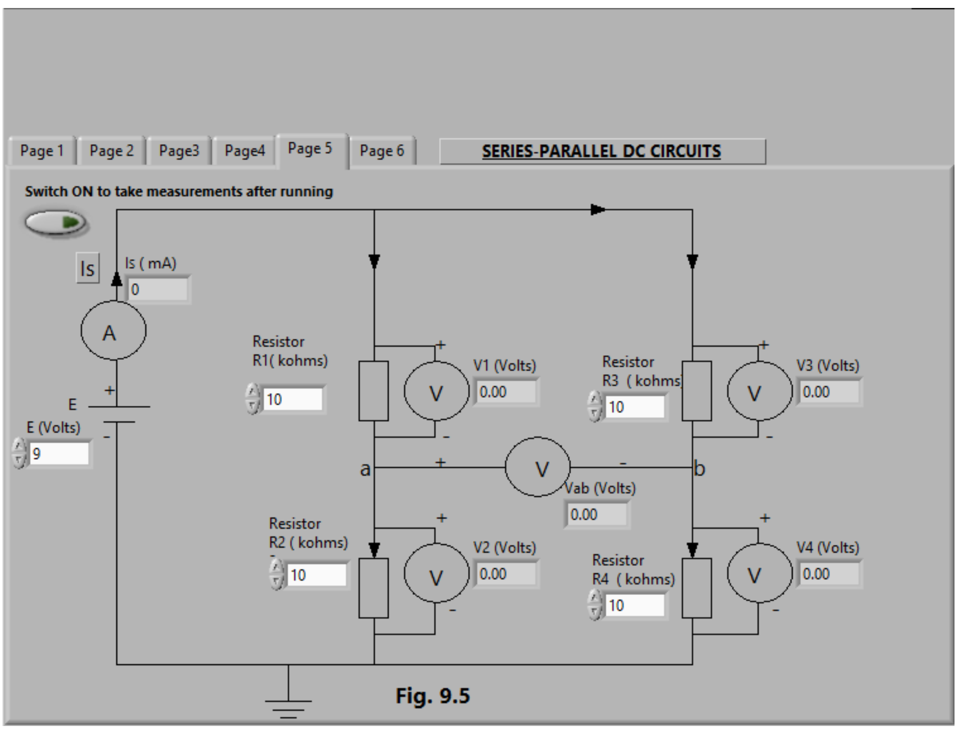


Figure 5: LabVIEW screen shot for traditional series-parallel experiment

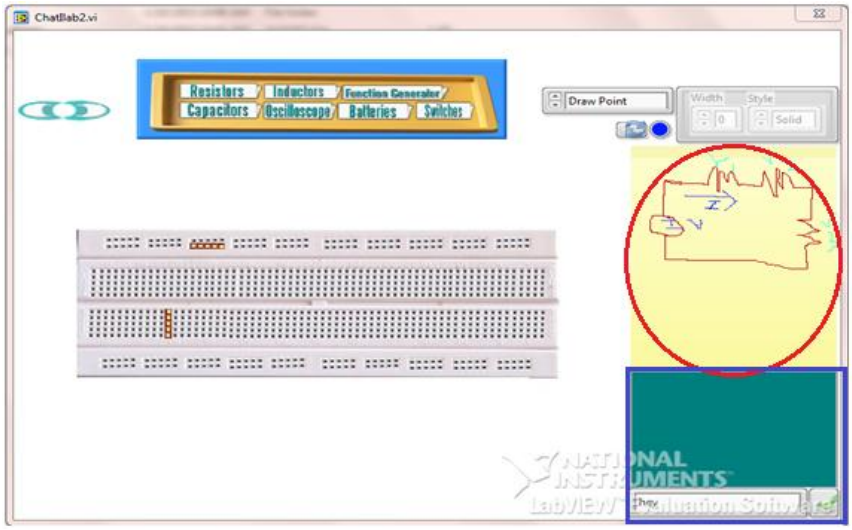
In the design of traditional remote labs, a procedural or stepwise method is laid out for achieving a solution. This type of remote labs adopts the use of experimental procedures in executing tasks or in obtaining a solution. The students performing experiments on this type of labs are often interested in a major question which is “what is the next step or procedure”. With the stepwise execution of these procedures a solution is obtained. This kind of model can be referred to as a “Question-to-Solution” model. Figure 5 shows a LabVIEW-based traditional remote lab that was designed using the “Question-to-Solution” model for a resistive series-parallel circuit. The online experimental procedure given to a student is as follows:

1. Connect the circuit as shown in “fig. 9.5”.
2. Use an input of 9 Volts
3. Set resistor R1 to 10 ohms
4. Set resistor R2 to 10 ohms
5. Set resistor R3 to 10 ohms
6. Set resistor R4 to 10 ohms
7. Flip the mechanical switch on to take measurements.
8. Record the readings for V1, V2, V3 and V4. and determine V3+V4

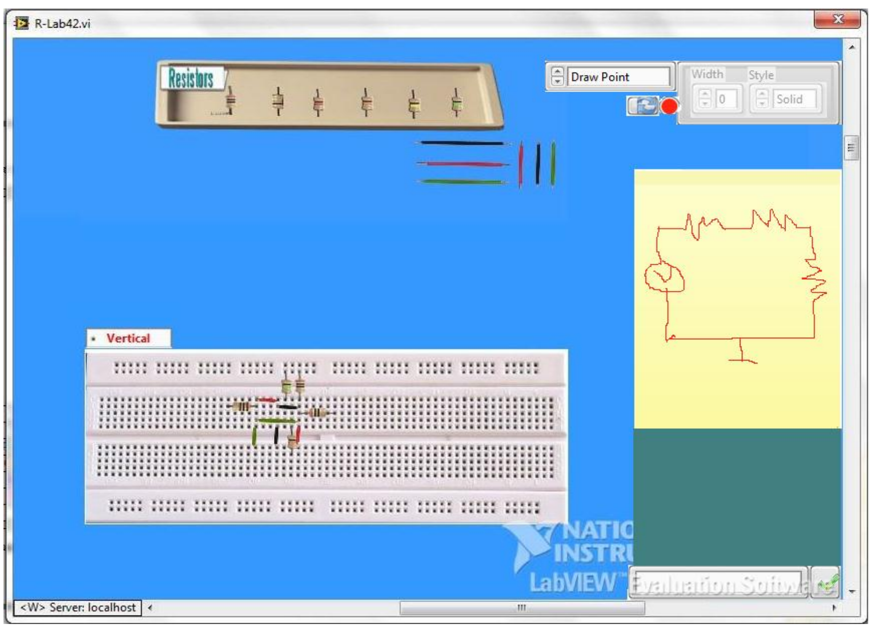
Finally fill the form at http://goo.gl/forms/YBbJ67PE5I

b. The “Solution-to-Question” Model for Series-Parallel Circuit (Case 2)

The second lab developed was developed using the “Solution-to-Question” model. The students were not provided with a circuit, but rather with tools such as resistors of specific values, a multimeter, wires, a bread board and a power supply unit. The virtual interface for this remote lab is shown in figure 6. Students could pick components from a box and place them on the virtual breadboard. This platform for the Solution-to-Question model is a suite of remote laboratories designed with the LabVIEW G-language. It contains a chat platform which uses the Skype third party Application Programming Interface (API) provided for LabVIEW. The students can share and discuss real time updates of experimental set-ups done on the virtual breadboard (Figure 6). This platform, which is still in further development, adopts the Solution-to-Question model as its design approach. The red circle in figure 6(a) shows a real time sketch pad which enables students to share draft circuit sketches online. The blue rectangular box shows a real time chat box. The main interface page for the resistor Lab is shown in figure 6b.



(a)



(b)

Figure 6: (a) Main page including chat and sketch pad for drafting circuits
(b) Main page for a resistor lab

The task for this experiment was that the student should construct a voltage division circuit using the tools provided and hence obtain an output voltage specified by the lab manual. The input voltage to the circuit was also included in the lab manual. No resistor values or circuit configurations were provided to the student in the manual as were provided in the traditional case. The experimental procedure given to a students in this case was.

1. By the use of the tools provided i.e. resistors, multimeter, wires, breadboard and a power supply, set-up a circuit that outputs 5 Volts when an input voltage of 9 Volts is applied.

2. The circuit should be a combination of series-parallel resistances and a voltage source only.

Finally fill the form at http://goo.gl/forms/YBbJ67PE5I.

c. The Traditional Remote Lab for Thevenin's Theorem Circuit (Case 1)

The experimental procedure for this experiment was (the experiment setup is shown in figure 7):

1. Connect the circuit as shown in Figure 7.
2. Calculate the Thevenin's voltage and resistance to the left of the load resistor
3. Set up the Thevenin's circuit using the values earlier calculated
4. Measure the voltages and currents across the Thevenin's and load resistors.
5. Record all readings.
6. Finally fill the form at http://goo.gl/forms/YBbJ67PE5I

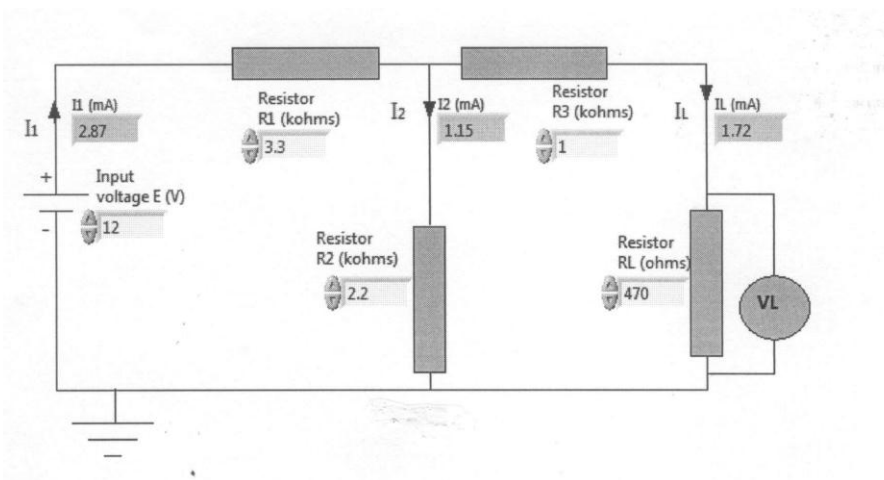


Figure 7: Circuit for which the Thevenin's equivalent is required.

d. The "Solution-to-Question" Model for Thevenin's Theorem Circuit (Case 2)

1. You are given the Thevenin's circuit of Figure 8. E_{TH} = 4.8V , R_{TH}= 2.32 kohms and R_L=470 ohms
2. Using Thevenin's theory develop a T-type 3-resistor circuit to replace R_{TH} and evaluate an input voltage E such that your final circuit and the given Thevenin's circuit are equivalent
3. From the resistors given, connect up a new circuit with the calculated resistors and voltage E obtained in 2
4. Measure and record the voltages and currents across the load resistor and other resistors.

Finally fill the form at http://goo.gl/forms/YBbJ67PE5I

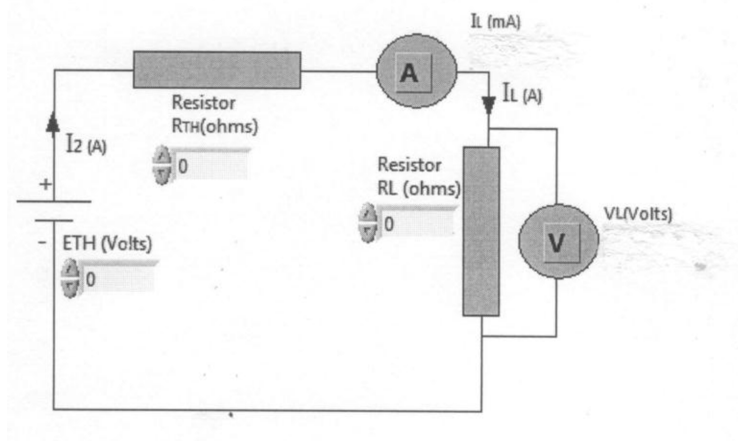
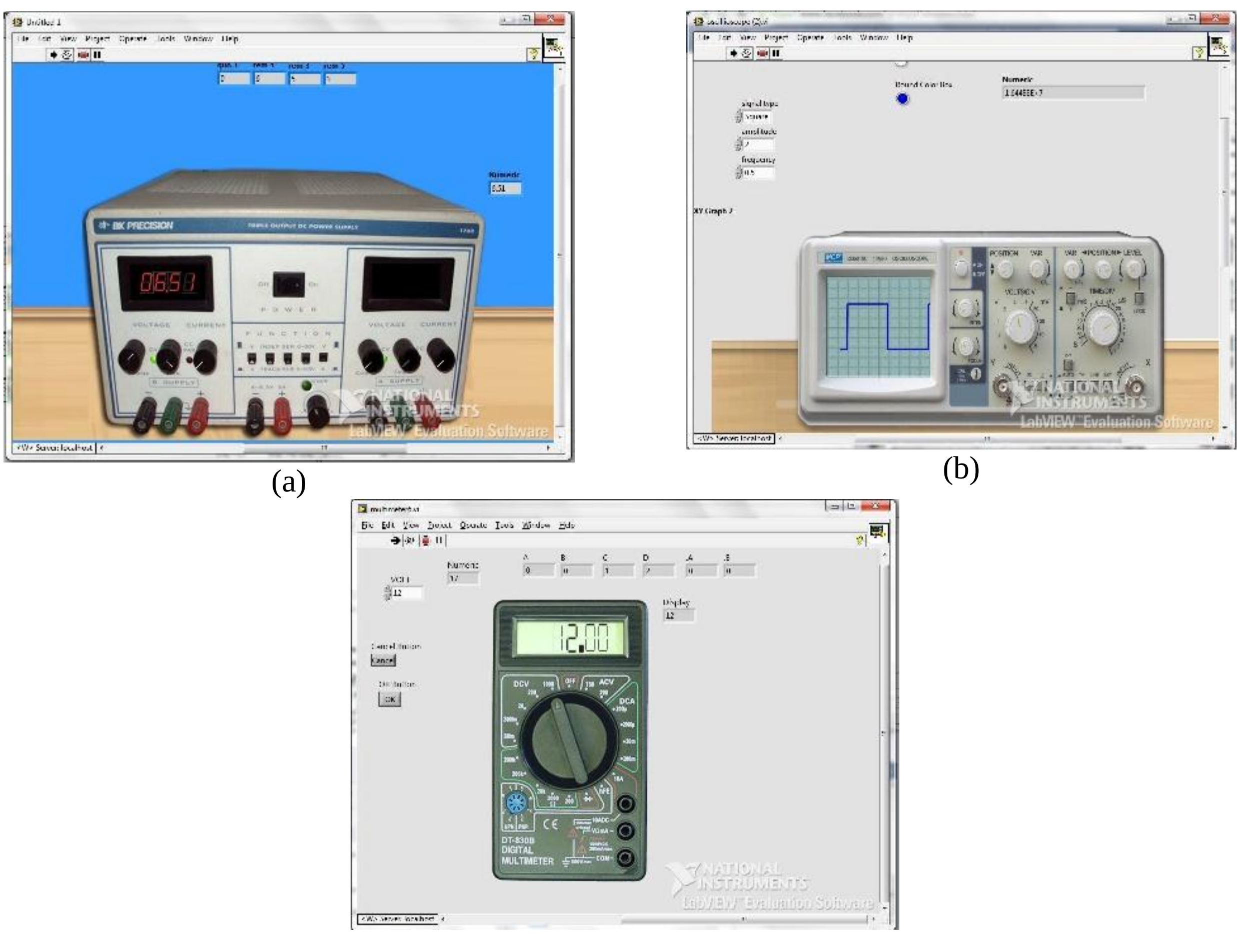


Figure 8: A Thevenin's equivalent circuit

In this example, students can arrive at different combinations of resistors and voltages. The important thing is that the current and voltage across the load resistor RL, in the final circuit they end up with, is the same as the one on the Thevenin's equivalent circuit.

Figure 9 shows some of the virtual tools provided in the Case 2 Remote-Lab platform.

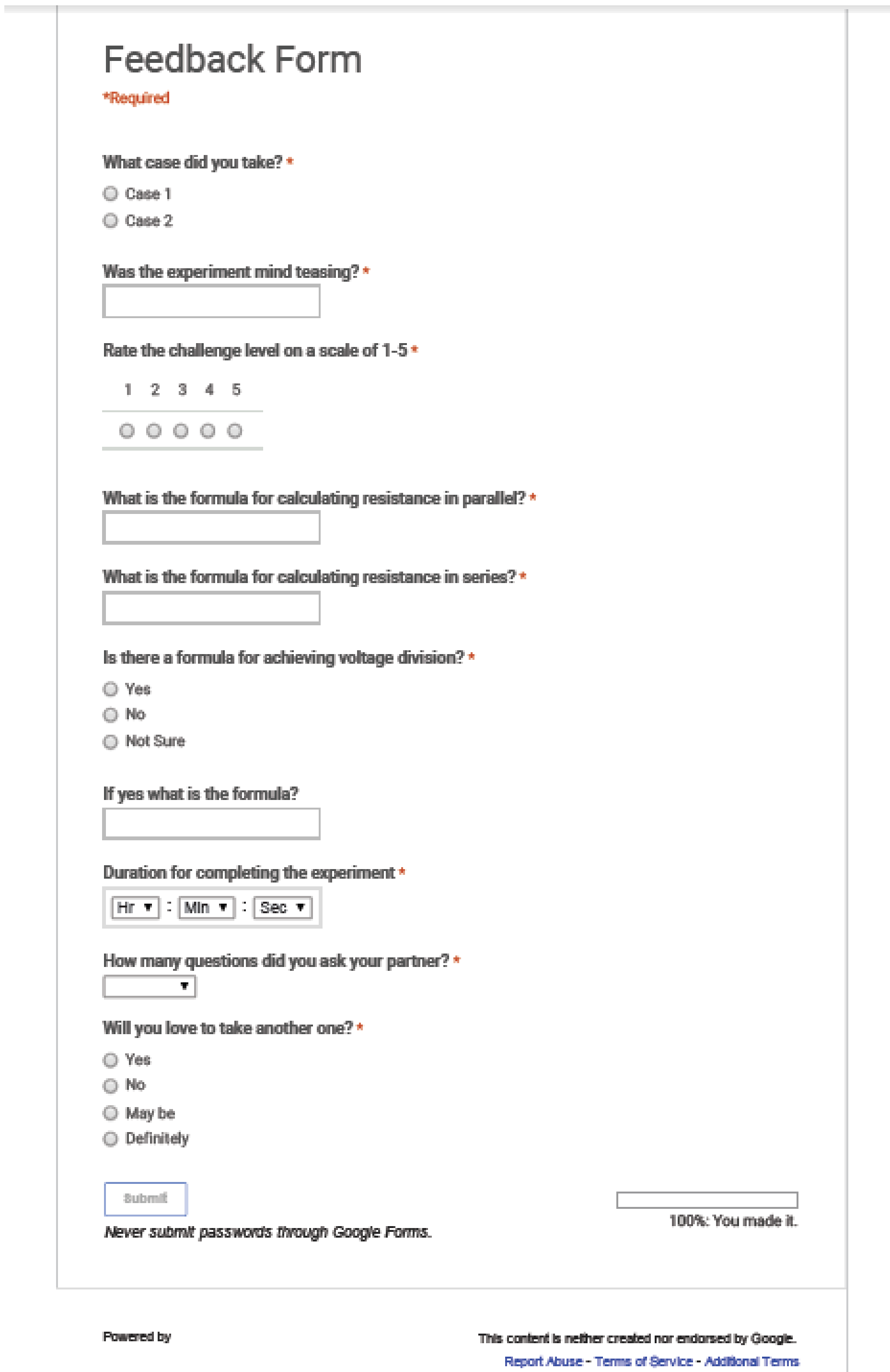


(a) (b) (c)

Figure 9: (a) Power Supply Unit (b) Oscilloscope (c) Digital Multimeter

4 Performing the Experiments

As mentioned earlier, each experiment was set up using LabVIEW. We will discuss the series-parallel experiment. Students were divided into groups in order to compare the two approaches to remote lab design above. Sixty students were used for the tests. The students were randomly grouped into two sets of thirty and then each set of thirty was randomly grouped into groups of threes. Hence, the sixty students were grouped into two sets of ten groups with three students in each group. The students were placed under the same conditions but in different remote locations. The start time for the study on the individual groups was the same. For the two case studies, two manuals were provided: one manual for the platform designed with the traditional approach (Question-to-Solution model) and is called case 1 and the other for the platform designed with the Solution-to-Question model which is called case 2. At the completion of the experiments by the individual groups, a feedback form was filled. The form filled by the students is shown in figure 10. The question asked in the feedback form, “Is there a formula for achieving voltage division?” tried to assess the basic understanding of the students when performing the experiments for the different cases.


Feedback Form
*Required

What case did you take? *
Case 1
Case 2

Was the experiment mind teasing? *

Rate the challenge level on a scale of 1-5 *
1 2 3 4 5

What is the formula for calculating resistance in parallel? *

What is the formula for calculating resistance in series? *

Is there a formula for achieving voltage division? *
Yes
No
Not Sure

If yes what is the formula?

Duration for completing the experiment *
Hr : Min : Sec

How many questions did you ask your partner? *

Will you love to take another one? *
Yes
No
May be
Definitely

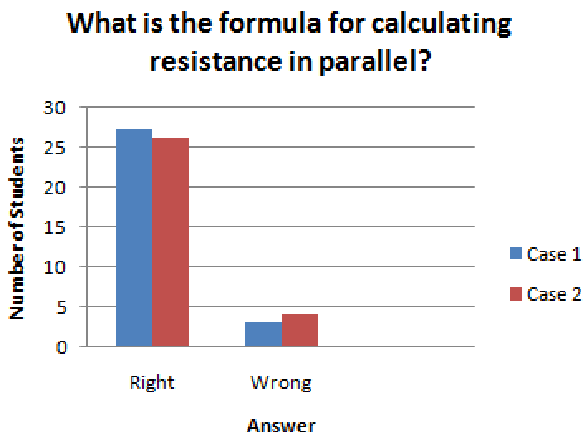
Submit
Never submit passwords through Google Forms.
100%: You made it.

Powered by
This content is neither created nor endorsed by Google.
Report Abuse - Terms of Service - Additional Terms

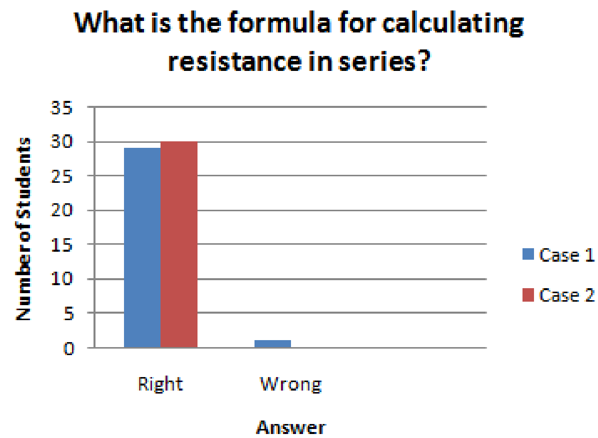
Figure 10: Feedback Form

5 Discussions

The results gathered by analysis of the students' responses on the feedback forms are presented in Figure 11. Figure 11(a) and 11(b) show that, relatively, all students had a basic knowledge base of both series and parallel resistance. Figure 11(c) indicates that students who took case 2 found the experiment more mind teasing. The challenge level from Figure 11(d) shows that students found case 1 less challenging than case 2. Figures 11(f) and 11(g) show that the groups who took the second experiment (case 2) collaborated more but also spent more time in completing the experiment.



(a)



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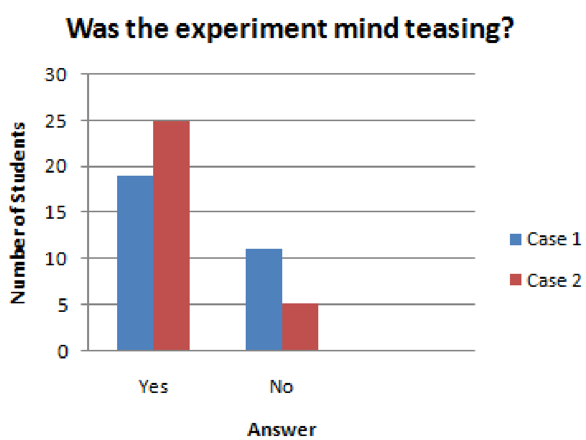
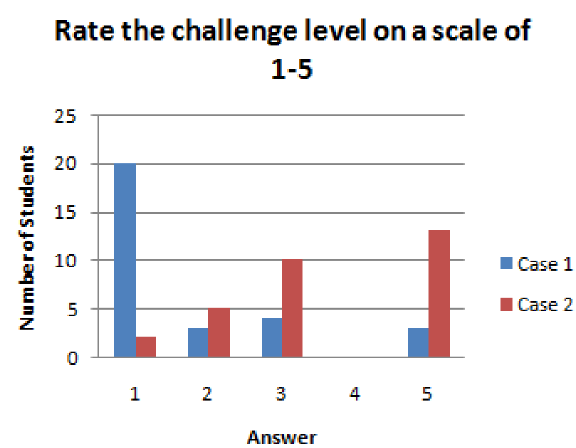
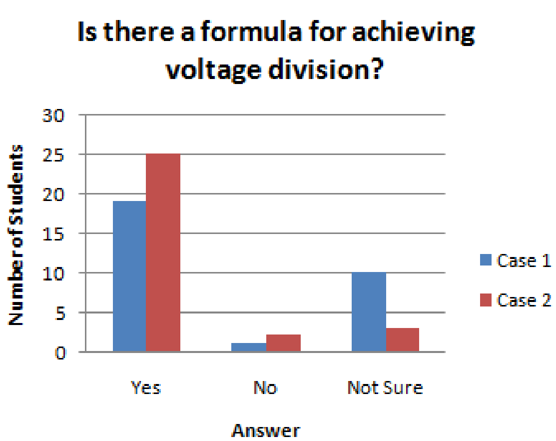


(c)

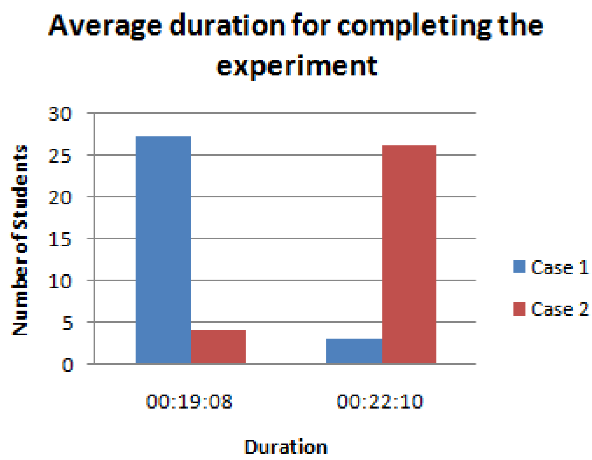


(d)



(e)

(f)



(g)

Figure 11: Students' responses for case 1 and case 2

6. Findings

From the results of this study, it can be seen from figure 11(g) that engagement can be induced by using the Solution-to-Question model. Figure 12 shows that students who took case 2 (Solution-to-Question model) experiments certainly wanted to have more. From this study it is discovered that students who performed the case 1 experiment (Question-to-Solution model) spent less time and easily got tired. But in contrast, those who performed the case 2 (Solution-to-Question model) experiments, spent more time and retained a high level of motivation, concentration and interest throughout the experiment period.

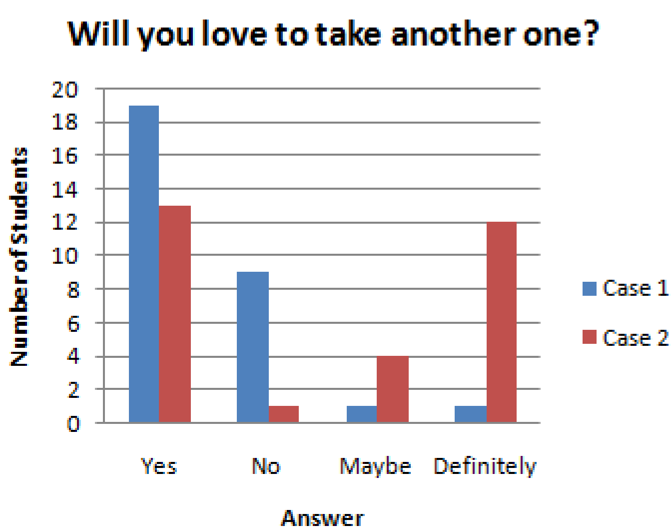


Figure 12: Statistics showing induced engagement level

7 Conclusions

The outcome of this study shows that the adoption of the “Solution-to-Question” model in the design of remote labs will result in an increase in interest level, mild increase in engagement to the platform and an increase in collaboration. From the findings, it shows that the major factor that may affect the positive results of using the “Solution-to-Question” model is if undue large amounts of experimental procedures are included in the drafting of its lab manual, whereby the student is not given the challenge and opportunity to reason out the backward steps required to get back to the “question” from the “solution”. In summary the “Solution-to-Question” model induces engagement and interest at a sufficient rate, thereby providing a better approach or paradigm for the design of remote experimental laboratories. In conclusion, as circuit complexity increases, it may be necessary to give a bit more known data to the students. This helps to prevent the student being stuck when working backwards using the “Solution-to-Question” model. Finally, remote laboratory developers should bear in mind that engagement and interest enhances learning.

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