NEA

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# Analysis

## Introducing the problem

### Background

Exeter College is a general further education college that offers a wide range of courses, there most popular of which is A levels for post 16 students. They are an award-winning college with many on site facilities located in the city centre of Exeter. Students from all across Devon enrol at Exeter College, subsequently Exeter College educates 10000+ students for any academic year.

The physics department at Exeter College is comprised of three teaches and has roughly 200 As level physics students and 150 A level physics students at any given time. Typically, a topic that has been notoriously difficult for students has been electricity.

Pino is one of the A Level physics teachers at Exeter College and wants a visually interactive tool to help make teaching the electricity topic more intuitive for her students.

In order to make the electricity topic more digestible I will be making a DC circuit simulator in the form of a website. Where the user can drag and drop different components onto lines of a grid. The website will then be able to provide feedback where the users will then be able to see the amps voltage and resistance at various points throughout the circuit. The goal is through getting the students to visually interact creating the circuits they should better understand more intuitively the different physics concepts that go along with it. For example, how amps are proportional to the resistances in different areas in parallel circuits.

### Problem

There are two main problems that the new system will attempt to solve. One, making the electricity topic for AS level physics more intuitive to understand. Two, improve the limited functionality that the current system provides.

The first problem I hope to address through the various tools and functionality of the new system. The new system will be able to perform useful calculations as well as displaying different IV characteristics for the components. The teacher will also be able to create a classroom where they can invite their students. This will be done to increase the tools usefulness within classrooms and when lesson planning. This virtual classroom will allow for the teacher to example circuits, that shows off concepts relevant to the lesson, around to the students in the classroom. Then the students will have the opportunity to play around with the circuit changing specific aspects and hopefully build the intuitive understanding through getting hands on experience seeing how the circuits responds to variations.

The second problem will again be solved by adding new tools and functionality to the new system that the old one lacks. At the moment the old system only contains a very limited number of components not all of which are obvious what components they are. Limited components means that the overall usefulness of the system is low as there is not that much that can be learned from it. My new system will not only contain more components with hopefully a more intuitive way of using the system, but also be able to perform various calculations on the circuits where appropriate such as calculating the emf of a cell or a voltage of a component.

### Research

Checklist: Look at various websites decide on the one youre using for current system and write about the website and all the other stuff it does not just the simulator. Evaluate the best way to create the new system whether in the form of a website or a c# form etc.

In order to solve these problems, I have decided that the new system will most benefit from the form of a website.

Due to the specific nature of the project research easiest and most efficient ways to produce a solution has been difficult. I have iterated through multiple designs

## Users and their needs

### End users

The new system will be a website accessible by anyone and can be used without making an account. However certain features will only be accessible by those who have an account. When making an account you will need to select if you want to make a teacher or a student account. The teacher and student accounts will have the same functionality when it comes to the circuit simulator. However, the teacher account will be able to create a classroom to which they can invite students to. They will then be able to send circuits to the students for them to view and play around with. If there is time, I’d like to make a system that allows the teacher to make problems using circuits that the students will then need to solve. These problems would take the form of having limited access to a set number of components and then must arrange the components in such a way that it meets some criteria such as the voltmeter giving a specific output for example.

### Interview

Q: Would you use the current system to assist in teaching the electricity topic?

A: Yes

Q: What features do you like about the current system or what does the current system do well?

A: I like the value of electrical potential at each junction and after each element. Also, the positive direction of conventional current. I also like the voltmeter and how they can be placed.

Q: What features do you not like or problems with the current system?

A: It is not clear how to place the ammeter in series and lots of students will probably put it in parallel and get a wrong value.

Q: What are the most important features that you would like to see in the new system?

A: More components such as diodes, thermistors and LDRs.

Q: Are there any processes or calculations you would like done by the new system?

(for example, showing the iv characteristic of a filament lamp or calculating the voltage at different parts of the circuit)

A: No, I think those should be done by hand with the data collected.

Q: What is the most difficult part of the electricity topic for students usually?

A: Understanding the concept of potential difference. Potential dividers. Internal resistance.

Q: Do you have any ideas on how the new system could help the students understand these parts of the topic?

(for example, some visual way of showing current flowing or resistance increasing as current increases)

A: Visual way of showing how much energy per coulomb the charge has on each part of the circuit (relates to potential and potential difference) and how much energy per unit charge is transferred to the circuit elements.

Q: Are there any other comments or ideas about the new system?

A: No.

### User requirements

The new system should be able to provide a grid-based circuit simulator. This simulator should provide the ability to place components along the lines of the grid. At each junction on the grid there should be the ability to see the potential difference and current. At each component there should be the ability to see the resistance. The user will need to be able to sign into an account to save different circuit pre-sets however, it should not be a requirement to login to an account to use the simulator.

## SMART Objectives

1. The new system should be in the form of a website.
   1. The backend should be handled through C# and a database.
   2. The front end should be HTML, CSS and JavaScript.
2. The website should not require an account to use.
3. Website should have a sign in and sign-up page.
   1. Requires a unique username.
   2. Requires a strong password.
      1. At least 8 characters.
      2. At least one special character.
      3. At least one number.
   3. Requires an email.
      1. That email should be verified.
   4. Select whether the user a teacher or a student.
4. Once signed in the user should be able to save favourite circuits to their account to be accessed at a later date.
5. The circuit simulator should be grid based.
   1. The components of the circuit should be able to snap onto the lines of the grid.
   2. There should be a list of components in a toolbar to be used on the grid.
6. There should be minimum components for the simulator.
   1. There should be a component wire.
   2. There should be a component filament lightbulb.
   3. There should be a component cell.
   4. There should be a component battery.
   5. There should be a component voltmeter.
   6. There should be a component ammeter.
   7. There should be a component switch.
   8. There should be a component variable resistor that can be set by the user.
7. Teacher accounts should be able to create and manage multiple classrooms.
   1. Teacher accounts should be able to invite students to that classroom.
   2. Teacher accounts should be able to send example circuits to the students in the classroom.
   3. \*The teacher account should be able to create and send circuit based problems to students.\*
8. \*If there’s time advanced components to be added:\*
   1. Thermistor.
      1. The user will need to be able to change the environment of the circuit by being able to adjust the ambient temperature of the simulation.
      2. The simulator will need to be able to simulate the temperature of the circuit depending on variables such as ambient temperature, amps, voltage, and resistance of the circuit.
   2. Capacitor.
   3. Diode.
   4. LED.
   5. Fuse.
   6. LDR.
      1. The user will need to be able to change the environment of the circuit by being able to adjust the ambient light of the simulation.
      2. The simulator will also need to be able to simulate the light given off by the LED or filament lightbulb.
   7. Inductor

## Modelling the problem

The current system that the new system will be improving upon is from the website:

<https://www.physicsclassroom.com/Physics-Interactives/Electric-Circuits/Circuit-Builder/Circuit-Builder-Interactive>

A picture containing chart

Description automatically generatedThe current system has a basic interface where you can select the different components to be placed on the lines of the grid. The current system provides the following components: wire, resistor, filament lightbulb, and ammeter. As you can see in the image on the left, none of the of the components have any labels. This makes it difficult to know what each component is and potentially search it up and learn more about it, unless you already know what it is. For example, I did not know what the component on the right was until I randomly stumbled across a tool that identifies what each component is. However, this tool is in my opinion unintuitive to use and was hidden under an unrelated menu.

Diagram

Description automatically generated with medium confidenceChart

Description automatically generated with medium confidenceThe next menu initially, I thought was simply a menu to change the voltage of the battery. However, after some messing around I’ve realised that it is a menu to adjust the variables at each component. As you can see in the images on the left. I believe that this is unitivitive and a poor design but could be easily fixed with good form design and labelling which I hope to address in my new system.

A picture containing diagram

Description automatically generatedThe last menu provides a voltmeter and ammeter that can be placed at the junctions of the grid to provide a reading. However, as mentioned in the interview the ammeter in this menu is easy to accidentally place in parallel to the circuit which can provide the wrong values for circuit. This may end up confusing students using the current system.

One thing that the current system does well is that at each junction is states the potential difference at that junction. There is also animations of charge flowing around the circuit which can provide an intuitive understanding of the conventional way to imagine current flowing around a circuit. As well as this, the filament light bulbs provide a light when current is flowing through them. The light also increases and decreases depending on the amount of the current flowing through the lamp.

In the new system it may not be possible to include all these niceties and animations due to time constraints and the other functionality that I hope to include. If there is time these additional animations may be attempted to be added as they are a good way to make the electricity topic more visually intuitive for the students.

# Design

## Overall System Design

### Front End

The new system will be made up of a frontend and a backend. The frontend will be the part of the system that the end user actually interacts with. The frontend will be a website that can be accessed by anyone with an internet connection. The new system will have a list of components on the left-hand side of the screen as well as a sign-up button. There will be a grid in the centre of that takes up most of the screen this will be the sandbox area for the circuits to be built.

front end html css or jquery reactjs

web api bridge between front end and back end

backend python or nodejs

database mysql

css tricks

The front end will be a HTML page styled using bootstrap CSS and consist of moveable components powered by Jquerey

<https://www.itsolutionstuff.com/post/node-js-express-form-submission-exampleexample.html>

<https://www.digitalocean.com/community/tutorials/how-to-use-web-forms-in-a-flask-application>

https://css-tricks.com/snippets/css/complete-guide-grid/

### Back End

The backend will be made up of various different components. These will include the C# algorithms that actually handles the simulation and a database to store details on the users that sign up to the website.

The back end will be made using the express framework for node.js server which is then connected to a MongoDB database. This database will be interfaced using the Mongoose framework which will simplify and ease database integration. The node.js server will be responsible for circuit manipulation and simulation calculations.

## Data Dictionary

## Database Design

## Pseudocode

## Class Definitions

## User Interface Design

## Security and Integrity

# Solution

## Attempt one

## Attempt two

## Attempt three

# Testing

# Evaluation

I do not think that I have managed to produce an MVP over the course of the project. I believe the over ambitiousness along with the lack of knowledge and experience hindered me from completing the project to the best of my ability. One month was dedicated just to research in the best solution to the problem, however due to the specific nature of the problem and lack of experience knowing the correct buzzwords to use to effectively search for the information I needed in order to complete the project was extremely difficult. Another month was lost to the original design I had finally settled on attempting relying on solely front end which not only would have been inefficient and messy but also lack any database at all. It was extremely difficult to know how much time to dedicate to attempting one solution and calling it quits. If I were to have stuck with one solution I always run the risk of hitting a dead end and not finishing the project, on the other hand if I attempted a new solution I then have to start a new with less time. Finally I had settled on a more ambitious more efficient solution that uses many practices from industry level software developers such as the jasmine testing environment I used throughout the development of the solution. Unfortunately, I came across a difficult logical problem to solve that to my disappointment took my two months to finally come up with a viable solution at which point I was left with very little time to complete the rest of the project. In hindsight it would have been smart to divert my efforts into developing the frontend or database while I had hit that snag in the backend. However in the moment it felt as though without that problem overcome I could not continue on to the rest of the project. I believe that if I had not had these setbacks than the project would have been a lot more complete and impressive due to the extra time I would have had to continue development. I would argue that the project or at least the solution I chose to implement for my the project was way above A level standard and had it been completed would have scored top marks.