Project Report: Interactive Web Content for STEM

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Introduction

Background

STEM is the umbrella term for Science, Technology, Engineering and Mathematics. When coupled with “education”, it is a reference to school curricula that focus primarily on training students to apply concepts derived from the aforementioned fields to tackle practical real-world challenges. In line with this phenomenon, there are several websites that attempt to involve youngsters in engaging academic discourse. Examples include Code.org: a non-profit organisation aiming to teach the disparaged of the world about Computer Science [1]; the National Aeronautics and Space Administration (NASA): an agency of the United States government that provides lessons on the many facets of space travel [2]; and “Playground.tensorflow.org”: an interactive simulation showcasing the capabilities of Neural Networks [3].

However, in the provided examples, either the notion of education is secondary to effective interaction, or the topics covered are too niche and specialized to be considered an encompassment or celebration of STEM. As a response to this, I propose the following project: a web application that thoroughly educates its users on a single topic through the use of interactive media and a sandbox environment.

Objective

The primary objective of this project is to create a product that would serve potential users as a guide as they explore everything from the fundamentals to the specialized aspects of a particular topic. This way, the user would have a more complete experience than what is offered on the discussed web platforms. The topic to be discussed will be the computer processor: users would start from an abstract overview of how data is processed within one, and will gradually progress to building their own programs within a provided sandbox environment. Concurrently, the platform would encourage teenagers and young adults to pursue a career in STEM-centric fields.

In line with this, the proposed web application would be targeted towards higher secondary school students, and all materials will be designed to cater to the aforementioned group.
Additional Information

The topic discussed on the proposed web application will be the history and evolution of computer processors. To accomplish this, the work of key historical figures (such as John von Neumann and Alan Turing) will be recreated as interactive and digestible simulations.

One significant simulation would be that of the Turing Machine [4]: a hypothetical device proposed by Alan Turing in 1936 that is capable of solving any conceivable problem, granted that the problem is expressed using binary digits, and running any algorithm. In many ways, the Turing Machine is the ideal computer processor, and will be discussed for this very reason.

Another concept to be discussed would be that of the von Neumann Model [5]: the architectural model that is employed within most modern computers. Conceived in 1945, this model allows for a processor comprised of an arithmetic component, a processing component, and some memory space dedicated to the aforementioned components (now called registers). A simulation of this model would attempt to explain to users what role(s) each component has within the model.

Quantum computing, being the subject of another simulation, is a computing model that deviates from the current binary systems [6]. In binary systems, a bit of data is encoded as either a 1 or a 0, but the quantum computing model allows for the bit to be 1 and 0 simultaneously, as an example. This allows for the creation of more complex computer systems than what is available, and represents the future of computing. For this reason, simulations on this model will be included in the web application.

To supplement these simulations, a sandbox environment will be provided. It can be used by users to test concepts demonstrated by the simulations, which would then enable them to grasp the concepts better.
Deliverables

The completion of this project will, firstly, produce a web application will allow users to interact using both the standard array of peripherals (keyboards and mice) and touch-based actions (to cater to mobile platform users). This application will be able to respond asynchronously to any input provided by the user, thus allowing for a more seamless user experience.

Moreover, in terms of the content of the web application, a sandbox environment coupled with educative simulations that can be interacted with will be produced. The concept of a computer processor will be studied from the most abstract level down to the hardware level, after which users would be provided access to a sandbox environment. Within it, they could test and consolidate their knowledge, and the idea behind this is to provide a more holistic learning experience than that provided on other platforms, and therefore promote the viability of a STEM-oriented career.

Furthermore, the adherence to the Progressive Web Application user experience will allow the product to exhibit native mobile application-like behavior: this would grant the application access to features such as offline access and push notifications on mobile devices. This would allow the product to demonstrate cross-platform capabilities, and therefore be available for a larger user base.
Technologies Employed

The implementation of the proposed web application will be accomplished using the MERN stack: this software stack is comprised of MongoDB, Express, React and Node.js. A point to note is that the entirety of the MERN stack is built upon JavaScript, thereby making it a fundamental technology for this project. To facilitate the creation of the interactive materials and sandbox, Java will be used. With regard to Progressive Web Applications, Lighthouse will be used.

The MERN Stack

MongoDB is a NoSQL database [7], and it will be used in this application. It was chosen over SQL-based databases for its greater flexibility with regard to storing data. Using SQL databases, data can be stored only in tables, whereas NoSQL databases allow for document-based storage and key-value based storage, among other flavours, in addition to tables [7]. Their lack of strongly-defined schema would allow for more flexibility with regard to design, and should permit better database scalability.

React is a JavaScript-based library specifically used to create fast and lightweight user interfaces [8]. It embodies the “View” aspect of the Model-View-Controller model: a web design approach that compartmentalises aspects of a web application into the 3 aforementioned aspects. It was chosen over Angular (with which the stack would have been called the MEAN stack) due to its less steep learning curve and its use of the so-called “Virtual Document Object Model (DOM)”: a significantly-abtracted version of the structure of an HTML document [9].

Node.js is the JavaScript-based asynchronous runtime environment that will be used to handle the back-end of the proposed web application [10]. Express will run on top of this environment: it is a robust framework for the development of web and mobile applications [11].

Java

Java is a powerful general-purpose programming language that is supported by a large community of libraries and extensions [12]. It supports object-oriented programming, which will be the language model employed for this project. Moreover, it can be used to produce relatively high-performance, due to its use of a Just-In-Time (JIT) compiler (source): a runtime compiler [13].
Lighthouse

Lighthouse is an open-source tool developed by Google. Among other things, it is used to gauge the viability of a web application as a Progressive Web Application [14]. It will be used towards the end of the project development cycle.

Risks and Mitigation

The most significant risk involved in this project is whether it would be possible to optimize the assets in accordance with Lighthouse standards. A key requirement for a web application to be deemed a PWA is the quality of its performance on low-specification mobile devices [14]. The simulations are expected to employ a large volume of visual media assets, which may adversely affect the application’s performance on the aforementioned devices. This can be mitigated by arranging for means of data compression within the application, and this workaround will be applied during the testing stage of the process. As an extension of this, the process of optimising the application to meet PWA standards will be fairly time-consuming, and it can only be mitigated by remaining on or ahead of schedule.

Another point to consider involves the hosting of the web application online. A solution that does not involve employing the virtual budget provided by the faculty is the use of web hosting services such as GitHub and GitLab. For the time being, GitHub will remain the solution of choice, for its free web hosting and extensive support community.
## Tentative Schedule

<table>
<thead>
<tr>
<th>Proposed Deadline</th>
<th>Corresponding Deliverables</th>
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</thead>
<tbody>
<tr>
<td>October 20, 2018</td>
<td>• Front-end user interface</td>
</tr>
<tr>
<td></td>
<td>• Solution for hosting of web application</td>
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<tr>
<td>October 31, 2018</td>
<td>• Back-end development of required database</td>
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<tr>
<td>November 30, 2018</td>
<td>• Streamlining of web application</td>
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<tr>
<td></td>
<td>• Robust implementation of proposed Sandbox environment</td>
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<tr>
<td>February 14, 2019</td>
<td>• Testing of Sandbox environment</td>
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<tr>
<td></td>
<td>• Robust implementation of proposed simulations</td>
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<tr>
<td>March 15, 2019</td>
<td>• Fully-functional web application</td>
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<td></td>
<td>• Progressive Web Application optimization</td>
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<tr>
<td>April 5, 2019</td>
<td>• Final testing &amp; debugging</td>
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<tr>
<td>April 14, 2019</td>
<td>• Delivery of final product</td>
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References


