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Enhancing Online Teaching-Learning Environment in Schools Through the Use of a Website

Introduction

Numerous institutions in many countries have embraced a very useful application of technology – online education. This includes taking online courses outside the course curriculum and teaching students via online web applications. Countries like America, UK, etc. where most of the people are lucky to have access to the internet and computing devices, have used websites as a tool to enhance their teaching-learning experience. Sadly, for developing countries like Nepal, the major issue is the lack of proper use of technology. Born and raised in Nepal, I had to struggle to have access to a stable internet connection and online tools to expand my knowledge beyond the scope of our course material. There are no such things as online classes. We still rely heavily on face-to-face classes, which made it very difficult for schools to manage their classes during the pandemic situation in Nepal in 2020. Being in America for a couple of years now, I have realized how much technology can impact and ease the teaching-learning experience if we could use it to build online web application tools.

US universities, like Kent State, have made great use of online platforms like Blackboard that allow for a seamless teaching-learning environment, especially during times like the COVID pandemic. Seeing such effective and wise use of technology to advance the learning experience made me think about building a free and open-source web application which will allow schools in developing countries to significantly improve their online teaching system. Being free, the

only payment schools would need to make is the hosting bills from a provider of their own choice and being open-source, people can manipulate the code in order to add extra functionalities if they desire to do so. This makes it incredibly useful and flexible, which will help manage online classes for schools that cannot afford to buy already existing platforms.

Rise of Online Education System

With the rise in technological advancements, schools and colleges have adopted teaching-learning using internet and various software that allow for video conferencing. “Statistics from 2003 showed that over 75 percent of colleges and universities offered online learning. Recent studies show that the number has increased to roughly 86 percent” (Kubo). According to NCES (National Center for Education Statistics), “In fall 2018, there were 6,932,074 students enrolled in any distance education courses at degree-granting postsecondary institutions” (NCES). While developed countries like US, UK have facilitated the use of ICT (Information and Communication Technologies), there are several developing countries that are facing obstacles while trying to integrate ICT with education.

The rise of the digital era has significantly increased the number of online education platforms and services. On one hand, there are online platforms that teach skills and knowledge in certain criteria. Sites like Udemy, Coursera, Udacity, Skillshare, etc. teach students certain skillsets. Websites like these are helping students learn something more than what their classes might teach them. While the paid courses in these platforms are not accessible to every student in the world, there is however a significant increase in the number of students enrolled in these platforms. On the other hand, there are free sites like YouTube where students can find valuable information concerning a lot of educational topics. Free or paid, there are students learning

through different websites all over the world. The online education business model has been on the rise too. “Even before the pandemic, Research and Markets forecasts the online education market as $350 Billion by 2025, so the numbers might be updated after analyzing the growth impacts of COVID-19 on the online learning market” (Koksal). Online education has skyrocketed with aspiring developers, engineers, etc. buying courses online to master skills of their choice ranging from introductory knowledge to advanced concepts in programming, cybersecurity, designs, photography, etc.

Online Learning in Developing Countries

A survey was conducted by the UN “covering multiple aspects of the online presence of all 193 Member States. The survey assesses the technical features of national websites, as well as e-government policies and strategies applied in general and by special sectors in delivering services” (2020). This survey calculates OSI (Online Services Index) of member countries. Developing countries like Nepal, Jamaica, Ethiopia scored OSI score of 0.400, 0.3882, and 0.3647, respectively (2020). In comparison, countries like the US, UK, and Denmark had OSI scores of 0.9471, 0.9588, and 0.9706, respectively (2020). This lack of online services is also one of the reasons why there is a lack of online platforms for e-based learning. While the lack of online communication services including a stable internet connection is a wider and more difficult issue to be solved by an undergraduate student, the lack of web application platforms is, however, not as difficult.

The ability to teach and learn online can be very beneficial both to the tutor and the learner. “A survey of 387 students in their final undergraduate year at the Virtual University of Pakistan (established in 2002) concluded that the majority of students (over 90%) found learning over the Internet and via satellite TV beneficial” (Gulati). Online teaching-

learning can help schools especially in situations like the pandemic. Online learning can also help students access course materials even if they were not able to join the class for any other reasons including medical reasons. Teachers or professors can record their classes and upload a link on the web application along with some other resources including presentations, articles, quizzes, etc.

Inconvenience During the COVID-19 Pandemic

Schools had to shift to online platforms during the COVID-19 pandemic but not every school could afford it or go through that process as easily as others. Talking to my friends in Nepal, I found that schools were forced to use the non-paid version of Zoom, Facebook groups and other non-efficient ways of teaching-learning. Students were asked to send a photo of their assignments through Facebook Messenger. Except for the very few rich schools in the capital city, every other school in the country either had to completely cancel classes or was forced to use inefficient ways of communicating to students for academic purposes. Safal Adhikari, a senior at SOS Hermann Gmeiner School, a high school in Chitwan, Nepal, expressed his concerns in an email exchange. He writes, “Those learning from government-run distant learning programs via Television could only listen to the tutor without the ability to ask questions or interact in any way if they had any doubts…” While some schools had to close because of lack of internet access, others had to either close or limit their teaching-learning activity due to the lack of an efficient web platform. This is exactly why a web application can significantly improve the online education experience for both teachers and students.

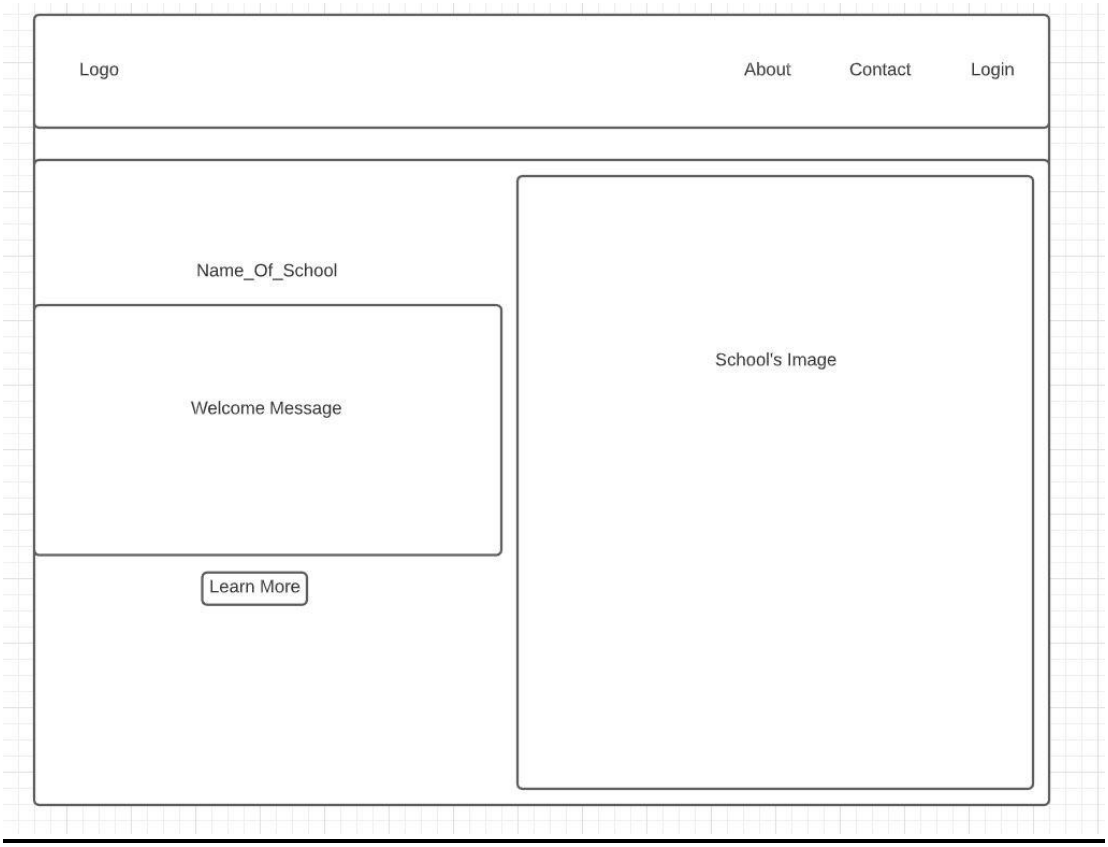
The web application to be built as a part of this research will provide an online platform for educators and students in schools thus eliminating the need for disorganized Facebook groups and use of social media as a tool of education. Such use of social media is not wrong but rather

extremely disorganized and inefficient. Having a website would help create a seamless experience where teachers will not have to use numerous tools for different purposes. The site will have all the basic functionalities that would be required for an online student portal system like Blackboard.com or ecn.walsh.edu. Teachers can assign tests, quizzes, assignments, course materials, etc. to the students. Students can then download or view the assignments and submit them via the same portal site. Teachers will also be able to grade their students' work and release the grade through the site itself. Such website (or web-application) would provide an easy-to-use online platform thereby improving the teaching learning experience.

Technologies Used:

This web application will be built using the following technologies:

UX/UI Design:



LucidChart will be used to build the wireframe for the website. A sample wireframe for the web application is shown above.

Vue.js will be used to build UI (User Interface) faster and with less code. I will be using https://vuematerial.io/, which is material UI design for Vue.js based projects. By using vuematerial, the CSS code I will need to write for my project will be reduced significantly because of pre-applied styles and responsiveness. Using multiple UI framework will also help style different pages differently according to what the content is. This project will also use components from other UI frameworks like Element and Veutify. Using a framework makes it incredibly easier and faster to build UI components with much less code as compared to coding every component by the developer. Here is an example of setting up and creating a login form using Veutify.js's material design. First, the developer can start a vue app with the command: **vue create [name]**. Once created, move to the directory created by the cli and use the command **vue add vuetify**. Using <v-card> and wrapping the whole body of the login form inside the <v-card> will create a login form with a few lines of codes.

```
<v-card>
    <v-card-title> <h1> Login </h1> </v-card-title>
    <v-card-text>
        <v-form>
            <v-text-field label= "Username" />
            <v-text-field type= "password" label= "password" />
        </v-form>
    <v-card-text>
    <v-card-actions>
```

```
            <v-btn>Register</v-btn>
            <v-btn> Login </v-btn>
        </v-card-actions>
    </v-card>
```

With a few lines of code as shown above, a simple login form will be generated with pre-applied CSS and behaviors. Developing a dynamic web application is challenging on its own and coding the CSS and JS for each component to make it look and work better takes a lot of time, code and debugging. With UI design frameworks built for Vue.js like Vuetify, Element, VueMaterial, etc. the time and code required for styling the components is significantly decreased thus increasing productivity.

Front-End Technologies:

HTML will be used to build all the elements like buttons, navigation bars, links, tables, etc. HTML "defines the meaning and structure of web content" (MDN 2020). The 'Hyper Text' in HTML "refers to links that connect web pages to one another, either within single website or between websites" (MDN 2020). HTML uses tags like <head>, <title>, <body> , etc. to build up elements. HTML and HTML5 have added new 'semantic' tags like <article>, <nav>, <form>, <video>, etc. that tell exactly what the content would be inside the tags. My website will be built using both semantic, like <section>, and non-semantic tags, like .

CSS is "a declarative language that controls how the webpages look in the browser" (CSS). I will be using CSS3 features like transitions, styles, pseudo-classes, and gradients for my web application. CSS is used for providing styles to different elements like how big a text should

be? Or how should an element behave when the mouse hovers over it? Or how should an element behave when clicked?

Sass is "the most mature, stable, and powerful professional grade CSS extension language"(Sass). Sass allows the use of variables, mixins, functions, etc. that significantly improves CSS programming and adds more power to it. A sass file will have the extension .scss which won't be understood by the browser. To solve this, programmers would have to compile the sass code back to css. By adding a dictionary pair of "compile:sass" : "node-sass sass/main.scss css/style.css" to the package.json file, programmers can then run the command: **npm run compile:sass**. This will automatically compile the scss code into a css code that will be easily understood by the browser. In order to compile scss into css every time a change has been made, developers can simply add the '-w' parameter at the end of the command. This will "watch" for any changes and automatically compile to css code once it detects any changes in the scss code.

JavaScript (JS) is a "lightweight, interpreted, or just-in-time compiled programming language with first-class functions" (JavaScript). JS will be used to control the behavior of the websites. For example, JS would control how elements and pages would behave when an event occurs. An event would be anything from a click, double-click, to key presses, mouse hover, etc. Any interaction by the user with the webpages and its elements will be controlled by JS.

Responsiveness:

Responsiveness of a website or web application is very important as there are various screen sizes on which the user could possibly visit the website. Mobile phones, tablets, laptops, computers, monitors, etc. are of different sizes and resolution. This means the web app needs to adjust its content according to the size of the screen it is being viewed on. This includes adjusting

the pictures' resolution, size of tables, size of components and even the text itself. This can be done in two ways, specifically for my project: a) using media queries and b) using pre-styles APIs that are responsive by default. This web app will use both these ways to achieve responsiveness. The components this website builds from vuematerial.io will be responsive by default. And for all the other components and pictures, media queries will be used to achieve responsiveness. The following code snippet provides a good idea of how media queries will be integrated with Vue.js to build a responsive web app:

```scss
@mixin respond($breakpoint){
    @if ($breakpoint == phone) {
        @media (max-width: 37.5em) {@content}
        ;  // 600px
    }

    @if ($breakpoint == tab-port) {
        @media (max-width: 56.25em) {@content}
        ;   // 900px
    }

    @if ($breakpoint == tab-land) {
        @media (max-width: 75em) {@content};  /
        / 1200px
    }

    @if ($breakpoint == desktop) {
        @media (min-width: 112.5em) {@content}
        ;  // 1800px
    }

}
```

Figure 1

```scss
html{
    // this defines what 1 rem is
    // 1 rem = 10px

    font-size: 62.5%;

    // responsive design. Using Sass mixins

    //we dont need this beacuse tap-port has
    50%
    // @include respond(phone){
    //     font-size: 50%;
    // }


    @include respond(tab-land){
        font-size: 56.25%;          // make 1
        rem = 9px, so 9px/16px = 56.25%
    }

    @include respond(tab-port){
        font-size: 50%;          // make 1 rem
        = 8px, so 8px/16px = 50%
    }


    @include respond(desktop){
        font-size: 75%;          // 1 rem = 12
        px, 12/16 = 75%
    }


}
```

Figure 2

Figure 1 shows the code for a SaSS mixin that accepts size as parameter and changes width accordingly and Figure 2 shows the respond() function called with different screen sizes to adjust content accordingly.

Back-End Technologies:

The website will be built using the MEVN Stack. The MEVN stands for MongoDB, Express.js, Vue.js and Node.js.

MongoDB "is a general purpose, document-based, distributed database built for modern application developers and for the cloud era" (Mongodb). The web application will store all the data for the website and the data generated within the website through student's information, assignments, profile data, resources, etc. using MongoDB. MongoDB is a non-SQL based database. Relational databases have been and still are widely used from small individual projects to relatively big projects, but they come with a downside. "To handle a huge volume of data like internet, multimedia and social media the use of traditional relational databases is inefficient. To overcome this problem the "NO SQL" term was introduced" (GYŐRÖDI et al.) . MongoDB works on the principle of "NO SQL." MongoDB is based on a document model unlike the relational databases that are used with MySQL, PhpMyAdmin, etc. With a relational database, data is generally represented graphically with excel-like tables but with MongoDB data is stored in key-value pairs as a BSON document. A sample data could look like:

```
{
    "id" : "1",
    "first_name" : "sagar",
    "last_name" : "subedi",
    "year" : "junor",
}
```

The few lines of code above creates an object with ‘id’ of 1, ‘first_name’ as sagar, ‘last_name’ as subedi and ‘year’ as junior. In comparison, storing the same piece of data in a SQL based database like MySQL will look like:

INSERT INTO `table_name` (`id`, `first_name`, `last_name`, `year`) VALUES (1, ‘sagar’, ‘subedi’, ‘junior’)

Express.js is a “minimal and flexible Node.js web application framework that provides a robust set of features for web and mobile applications” (Express). Express.js can be installed using the Node Package Manage (NPM) with the following code : **npm install express -- save**. According to developer.mozzila.org:

“It (Express.js) provides mechanisms to:

- ***Write handlers for requests with different HTTP verbs at different URL paths (routes).***
- ***Integrate with "view" rendering engines in order to generate responses by inserting data into templates.***
- ***Set common web application settings like the port to use for connecting, and the location of templates that are used for rendering the response.***
- ***Add additional request processing "middleware" at any point within the request handling pipeline.”***

Node.js is a “JavaScript runtime built on Chrome's V8 JavaScript engine” (NodeJS). Node.js will handle back-end API services, and event-based servers for building fast and scalable web apps. Node is a cross-platform runtime environment. Node can be used to build API (Application Programming Interface) to build scalable web application. As a developer, using Node for back-end services makes the code more consistent and cleaner. Generally,

developers use technologies like HTML, CSS, JS with additional libraries for the front-end and then use php, python or ruby on rails. These technologies are completely different languages which force developers to use different naming conventions, programming styles, and syntaxes which results in confusion and increases chances of errors. Since Node is completely JavaScript based, developers can use JavaScript (JS) for both front- and back-end services. This means consistent naming conventions, programming styles and language syntax. The existence of a large ecosystem of open-source libraries make Node.js more attractive to developers. Node is an emerging server-side JavaScript framework and when used with other JavaScript frameworks for UI designs like Vue.js and web frameworks like Express.js, it makes the whole web development experience smooth.

Security:

With the rise of security threats and exploits, security is the most important aspect of any project. Using my knowledge of cybersecurity and penetration testing, I will check my website against the OWASP Top Ten Web Application Security Risks. If any vulnerabilities are found, those will be fixed in order to comply to more secure coding practices as suggested by OWASP. The web app will be tested for numerous vulnerabilities, some of which are explained below:

1. Injection: If a website is not coded securely then it will very likely be vulnerable to an injection attack. Even web apps that do not use SQL can be affected using No SQL injections. Injection occurs when "when untrusted data is sent to an interpreter as part of a command or query. The attacker's hostile data can trick the interpreter into executing unintended commands or accessing data without proper authorization" (OWASP).

2. Cross-Site Scripting (XSS): “XSS flaws occur whenever an application includes untrusted data in a new web page without proper validation or escaping, or updates an existing web page with user-supplied data using a browser API that can create HTML or JavaScript” (OWASP Top 10). A simple example would be sending a <script> </script> tag with JavaScript code that will be interpreted by the server as a valid input. This malicious <script> tag will then be executed and run, thus making the server perform tasks that the server was not intended to do.
3. Insecure Direct Object Reference: “Insecure Direct Object References (IDOR) occur when an application provides direct access to objects based on user-supplied input” (WSTG). During some research for one of my CS classes, I found a website where just changing the number after “logic_” will take me to different pages. This website https://www.electronics-tutorials.ws/logic/logic_1.html can redirect users to different pages/files simply by changing the number in the URL. While this is not a security threat for this specific website because of no user-login or sensitive information, this vulnerability can allow one user to access information of another user just by changing some parameters in the URL, if sessions are not checked properly.
4. Using Components with Known Vulnerabilities: Rather than coding literally everything, it is easier and more efficient to use already existing libraries, modules, frameworks, APIs, etc. to build an application. With the use of numerous freely available tools like those mentioned above, programmers could use some tools that have a known vulnerability and risk the security of the whole project. According to owasp.org, “if a vulnerable component is exploited, such an attack can facilitate serious data loss or server takeover.”

5. Security Misconfiguration: According to owasp.org, this is “one of the most seen issues.” For example, if Apache is used as a web server in a web application, improper configurations of the defaults could lead to a security risk. Apache also has numerous known vulnerabilities ranging from 4.0 to 9.3 on the CVE Score. HTTP headers, if not configured properly, would also lead to a vulnerable web application. Developers should make sure to change the default credentials like admin – admin, root – root, admin – password, etc.
6. Broken Authentication: As the web application built as a part of this project will have authentication features to allow students, teachers/professors, and the admin to log in, it is crucial that the website is as safe as possible from weak passwords, unauthenticated user sessions and vulnerable security questions. According to owasp.org, “Application functions related to authentication and session management are often implemented incorrectly, allowing attackers to compromise passwords, keys, or session tokens, or to exploit other implementation flaws to assume other users’ identities temporarily or permanently.”

   Penetration tests like those mentioned above can significantly help improve the security of any web application. Since the website built for this research will have user-login credentials and sensitive information stored, security is of utmost importance.

Hosting:

For most of my project development cycle, I will be hosting my project locally in my machine to build and debug the web application. Since the web app will be built using the MEVN stack, npm (Node Package Manger) will be used to control the application through the

command line. The command **npm start** will run the server.js file by default (if no other parameter is given after the 'start'), which will start a local server in the machine of the developer. The address "localhost" will host the web application locally. This will result in a very fast response time and make it much easier to debug. Projects like these should be checked constantly for errors as simple as misspelled file names to complex debugs.

Once completed, I would need to host my website on an online hosting provider like Amazon's AWS, Hostgator, etc. Hosting services will be chosen based on the features they provide and the fees for the services. Any school or individual that wishes to use this project can clone the git repository and make a few changes, if desired. After making a few configuration changes, users can then upload this to any hosting provider of their choice and availability.

Conclusion

Schools in many developing countries are facing difficulties during the COVID pandemic to smoothly transfer to online classes, in part, due to the lack of web platforms. To solve this issue, this research focuses on building a web application. The web application will serve as a student portal site where professors can assign tests, quizzes, assignments, etc. to students and the students can work on their assignments accordingly. This web application will also track student's grades and have other functionalities that are critical to any e-learning site. Being open-source and free, this web application can be modified to add or remove functionalities depending on the need of the school. The only payment required would be the hosting fees from a provider of the school's choice.

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