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Web-based Virtual Reality development in classroom: From learner's perspectives

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***Abstract*—Content development tools for Virtual Reality (VR) are in continuous use by both enthusiastic researchers and software development companies to create new and exciting VR environments. And so, computer science students may benefit from participating in this development, not only for learning vital programming skills, but also to develop their creativity through peer-to-peer collaboration. Web-based VR (WebVR) has emerged as a platform-independent framework that permits individuals (with little to no prior programming experience) to create immersive and interactive VR applications. Yet, the success of WebVR relies on students' technological acceptance, the intersectionality of a user's perceived utility of and ease of use with said technology. In order to determine the effectiveness of the emerging WebVR tool for computer science students of varied experience levels, this paper presents a case study of 38 students tasked with developing their dream house using WebVR. Results showed that students exhibited technological acceptance by not only learning and implementing WebVR in a short time (one month), but were also capable of demonstrating creativity and problem-solving skills with classroom supports (i.e., pre-project presentations, online discussions, exemplary projects, and TA support). Results as well as recommendations, lessons learned, and further research are addressed.**

***Index Terms*—Web-based virtual reality, technology acceptance model, course design, student creativity, A-frame**

I. Introduction

Virtual Reality (VR) and Augmented Reality (AR) have become two internationally known technologies used across a variety of domains, from medicine, education, business, art, architecture to the military. According to the International Data Corporation [1], VR and AR hardware sales grew 25.5% in the second quarter of 2017, reaching a total of 2.1 million units sold. Further, VR hardware accounted for 98% of shipments in the combined AR/VR market and is expected to reach $26 billion by the end of 2020 [2], indicating it has become the large market among these two emergent technologies. Apart from industry, the K-12 education sector has too increased using VR experiences in the classroom. A recent study [3] suggested that a majority of teachers (93%) reported that their students would be motivated by using VR technology in the classroom and 83% said VR could improve students' learning outcomes. Other research [4] suggests VR technology has unique affordances in engaging students, preferring VR technologies over traditional learning (e.g., lecture, textbooks, videos, etc.) by enhancing both students' interest and content understanding. In this emerging environment, VR software (content) plays a vital role in providing engaging and meaningful classroom activities. Several companies are dedicated to creating K-12 content to facilitate global expeditions, enhance medical training, explore cell biology and the like. Creating this content is expensive and time-consuming, especially in making them work on multiple devices (e.g., smartphones, laptops) and within a single user hardware interface (e.g., Head Mounted Displays or HMDs).

As demand for VR content increases, VR content-developers should too move quickly to create and share their software on a variety of platforms and devices, especially ubiquitous platforms to enhance access for teachers and students, both domestically and internationally. This demand has paved the way for the expansion of VR onto the web, or Web-based VR (WebVR). This open specification platform supports VR environments with the use of an HMD and a web browser, including smartphones, tablets, laptops, desktop computers, and entire room displays. With several WebVR frameworks on the internet such as A-Frame, React VR, Three.js, Vizor, Babylon.js, and PlayCanvas, each offers a different level of abstraction, varied by user experience and preference. These continuously developing frameworks not only allow users to enjoy available VR contents but also enable users to create their own content with panorama pictures or 360 videos with a smartphone camera. Although these preset models and functions have greatly influenced the way users interact with the world, the content of these aforementioned frameworks are limited and creating a barrier for users' usability and creativity.

From a learning perspective, coupling the affordances of VR technologies and student agency and ownership through their creation of classroom activities [5] may be transformative in K-12 education teaching and learning. Therefore, there is a clear need to identify aspects of frameworks that not only allows users to create their own VR content but also enables them to experience and share their work with other learners across the world. Such a framework should meet users' needs of utility and ease of use, to facilitate their acceptance as per the Technological Acceptance Model (TAM) [6]. When ease of use and utility mesh within a framework, that framework may be acceptable to a broad audience of students and learners, regardless of their experience and expertise such as

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engineers, developers, designers, educators, markers, artists, and hobbyists.

From a teaching perspective, there is also a need to have guidelines for selecting a suitable framework for students to use when creating VR content in the classroom. Existing work [7]–[9] focused on the use of 3D professional software, such as CAD drawing and Unity 3D, that require prior knowledge and some mastery of programming and design. Because of this, the bulk of educative user programming is with advanced engineering students. Yet, research suggests younger learners benefit from experiences with software development and programming in enhancing their cognitive understandings of content and creative skills [10], [11]

Considering both learning and teaching perspectives, the theoretical underpinnings of TAM, and expanding the use of WebVR, this provides some avenues for inquiry, which have yet to be addressed in the extant research literature: Which WebVR framework is preferred by students for first-hand VR development? And, to what extent do these frameworks meet students' expectations in creating VR content? What is the prior or prerequisite knowledge before using these frameworks? Last, what are the drawbacks and challenges of students' using these frameworks?

This paper seeks to address the previous research questions by evaluating libraries for WebVR. The main contributions of this paper are:

- providing feasibility in using WebVR frameworks in education in terms of learning and creating WebVR contents
- evaluating the chosen frameworks to fulfill students' needs (i.e. ease of use)
- and demonstrating the usefulness of the chosen framework through a case study

The following paper is organized as follows: summarizing related research in Section II; presenting the study design in Section III; Section IV analyzes the results from students' perspectives; lessons learned and challenges are described in Section V; recommendations are provided in Section VI and finally, conclusion and future research direction are concluded in Section VII.

II. Related Work

The VR concept was introduced in the early nineteenth century when a French general painter Louis-Francois Lejeune created a panoramic painting of *The Battle of Borodino* [12], whose purpose was to extend the vision of the entire battlefield for the viewer. Since then, technologically-enhanced hardware and software have been developed for VR-based entertainment, training, and learning. This paper does not intend to survey all existing VR work, rather focusing solely on educational approaches.

In education, Nguyen and Dang [9] have presented a model as a structural guideline for educators building applications using VR and AR. This model suggested the use of both technologies (i.e., VR and AR) to engage students in the programming process (using Unity3D), to create vivid, realistic environments. The authors suggested using the Unity3D engine to create the application then exports to smartphone devices; so VR content can be created manually or obtained from free online providers. This approach is novel in significantly reducing the amount of time needed to create 3D models, yet still required a heavy demand for users' programming skills.

Another education-focused approach is the study of Miyata et al. [13] where students collaboratively (via group-work) designed a VR application. In engaging students in creating VR application cooperatively, students reported feeling creative and knowledgeable, developing as learners both individually and as a group, throughout the shared activity. However, it is difficult to replicate this model, provided the variability in time on task, students' efforts, the complexity of VR content, and various supporting devices. Taking a further step, Häfner et al. [14] engaged students in the creation of a 3-year industrial VR project, similarly resulting that task specification and group formation played the central role for the success of the VR product. Takala et al. [15] conducted a similar, yet more in-depth study, where they shared their experience of teaching VR development courses over a span of five years. Several efforts have been made to bring VR into classroom, from concepts [16], content [17], [18], and hands-on learning experiences [13], [19]. The challenges and difficulties found in most studies are the availability of HMDs, a standard hardware platform for VR, as well as the multifaceted needs for programming knowledge and specialized software tools in VR development. Many reasons cause these difficulties, like those reviewed here, due to the cost of the VR headset for testing; the compatibility of the application on the target devices, and the professional skills required for creating 3D, VR content.

This paper attempts to elaborate on these existing problems when helping students develop VR content in the classroom. Specifically, this paper provides an insight into these issues with a novel pedagogical approach which will be presented in Section III-B.

III. Methodology

This study seeks to answer the following research questions:

- **R1**: Is it feasible to learn and create WebVR applications in a limited time frame? Or, in other words, is WebVR development accessible for everyone? In answering this question, the gap between learners' knowledge and technical abilities will be reduced. In reducing the complexity of learning the application (framework), the remaining time may motivate students in creating new knowledge (content).
- **R2**: From the learners' perspective, what are their approaches in learning how to develop WebVR content? How much effort is used to create a WebVR application?
- **R3**: What are the challenges when learning WebVR content development?
- **R4**: Is there any correlation between the chosen library with the project expectation?

A. Goal and objectives

Based on the previous research questions, the goal of this study was to evaluate the feasibility of learning, and then developing a WebVR application with undergraduate students in inter-disciplinary fields. To meet this goal, our research approach held four objectives:

- to help students actively engage in the learning process when developing WebVR content;
- to understand students preferences on current WebVR libraries;
- and to collect and analyze students' experiences when developing a Web VR application .

B. Study design

In order to meet these objectives, this study was designed such that students can complete their project within a given time frame to meet their performance objective (developing a webVR application). Students worked either as a group or individually on their project. In order to have enough prior knowledge to complete the project, lecture-based and project-based learning activities carried out before and during project development. The lecture-based interaction provided fundamental knowledge for students and access to external resources, whereas the project-based learning activities provided them with the examination of other resources.

1) Introduction to VR and WebVR: At the beginning of the course, and one week prior to the project, a basic VR concept was introduced with a tutorial on WebVR [20], [21].

2) Short student presentations: Each student was required to present a 5-minute in-class talk on a given VR topic. The topics for presentation were suggested by the instructor or by student's choice. The purpose of this short talk was for all students to individually familiarize themselves with VR-based emergent technologies and sharing this new information with the group. The content of the discussions provided short and specific information about a given VR topic which included the following:

- Overview: What is it? History of the technique/device? Where is it used? What are best suited applications?
- Basic: How does it work? Why is it a good use of VR? Why is it unique? What is cool about it?
- Evaluate: Critique on strengths and weaknesses/issues. Can this lead to varying degrees of simulator sickness including nausea, fatigue, headache, eyestrain, vertigo, and dizziness

3) Sample project: The purpose of sample project was to grow skills for students with few prior experiences in programming, especially HTML and JavaScript. Within this sample project, students were given opportunities to learn some basic skills such as how to import a required library, how to set up VR environment, how objects are constructed, and how objects are put together regarding position, scale, and rotation.

4) Online discussion forum: As the lecture component only provided fundamental knowledge for WebVR development and the sample project could not cover all available functions in webVR libraries, additional communication channels are necessary for students to acquire and share advanced features in their project. Therefore, an online discussion forum was created where students could pose questions to each other as well as answers, sharing their solutions to advanced programming queries. When students were unable to find an answer (approximately 4 hours), a Teaching Assistant (TA) provided suggestions or direction to help solve the posted problem. When students found an interesting resource, they can share it in the online discussion forum. Students were incentivized to participate in discussions on the forum, receiving credit for their accumulated score for each useful (e.g., receiving a Thanks response, like, or when the instructor and TA found it useful for other students) post.

5) Teaching assistant appointment: In addition to providing suggestions and help on the online forum, students were able to make an appointment with TA so that the TA can help students solve the problem directly.

C. Project assessment

The project was developed in one month and students presented their work in the classroom. A report of how they carried out their tasks, created models or sourced models (obtained from the open sources) was also submitted for evaluation. To evaluate students' projects, three criteria/requirements were used, where each level gradually increased in difficulty. The purpose of categorizing the requirements into three levels was to evaluate the completeness of the tasks within a short time. Overall, the levels are summarized as follows:

- **Level 1:** The ability to create a house model from scratch or customize an existing model; make a 3D simple object or use at least 10 free 3D models, and light up the house.
- **Level 2:** The ability to add more 5, 3D models to the house without affecting the performance of the application, control the light of the house (for example turn on/off, increase/decrease the intensity of the light, or switch to different color themes), and navigate around the house.
- **Level 3:** The ability to interact with a certain object (e.g. drag/move/scale, run animation, or close/open doors), or display dynamic/movable objects in the house.

D. Survey

To answer the research questions, a post-activity survey was conducted to ask students their opinions of creating a WebVR application. The questions were informed by the two constructs of the Technology Acceptance Model: perceived ease of use and perceived usefulness. The survey consisted of 10 items which are as follows:

- **Q1**: Which library or framework did you use to do your project? (e.g., ThreeJS, A-Frame, Unity,...). *Open-ended question* (regarding the research questions **R2**)

- **Q2**: How did you find your framework? *Single answer choice* (regarding the research questions **R2**)
- **Q3**: To what extent did you find your library to use on the scale from 1 (easy) to 10 (very difficult)? *Likert scale* (regarding the research questions **R2, R4**)
- **Q4**: Did you find your chosen library meet your expectation to finish the project on the scale from 1 (No) to 10 (fully met the expectation)? *Likert scale* (regarding **R1** and **R2,R4**)
- **Q5**: To what minimum required level of programming (you think) to learn and use your chosen library? *Single choice* (regarding **R1**)
- **Q6**: How did you get the models for your Project? *Multiple choice(s)* (regarding **R2**)
- **Q7**: How did you learn about the library that you used for Project? *Multiple choice(s)* (regarding **R2**)
- **Q8**: How many days that you spent for your Project (including time to study your library and programming languages)? *Open-ended question* (regarding **R1**)
- **Q9**: How do you rate the difficulty of Project on the scale from 1 (easy) to 10 (very difficult)? *Likert scale* (regarding **R1, R3** and **R4**)
- **Q10**: How do you rate the usefulness (for your learning of building Web VR) of Project on the scale from 1 (useless) to 10 (very useful)? *Likert scale* (regarding **R3**)

Validity: The face validity of the questionnaire was evaluated and revised by the instructor and the TA, to ensure that all questions were easy to understand and inclusive of students' current knowledge of VR development. Questions are based upon perceived utility and ease of use of using technology, which are the major constructs of the validated TAM theory.

Reliability: This process was performed by both the instructor and the TA to maintain all responses are within the range of possible answers.

E. Case study

1) Participants: This study was conducted in an VR development course, where students worked on a project as an individual or in a team. This computer science course was comprised of university students who held general programming skills as a prerequisite for enrolling in the class. This course also encouraged students in other majors other than computer science, so sampled students represented interdisciplinary subjects. There was a total of 38 students in this study (33 undergraduates, 5 graduates including 32 males and 6 females).

2) Project description: This project focused on creating a *dream* human-scale house, experienced from the "inside out," in which the user can interact with specific objects. Students had the freedom to implement any type of interaction using the WebVR framework to create a house in VR. A requirement of the application was that the VR could run on any smart phone device, such that students could enjoy, run, or test the work of one another. This requirement directed students to utilize the WebVR platform. Since this was students' first VR course, it was helpful to examine how students resolved their problems from a learning perspective within a single tool (platform). The result of their performance would be a useful guide for new learners, instructors, or researchers conducting similar studies.

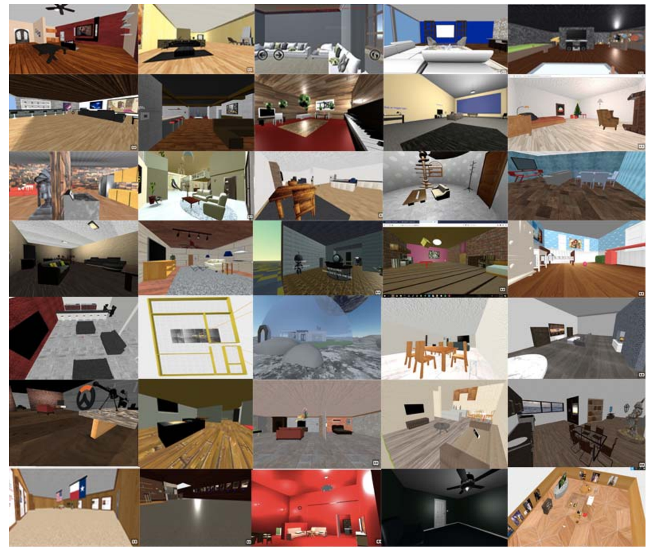

Fig. 1. A collage of WebVR applications created by sampled students.

3) Project delivery: Completed VR applications were presented in the classroom. Students presented their VR dream house projects using a desktop computer connecting to a projector and WebVR. Interactions in the scene were performed by using a mouse and keyboard. Students could also view the VR house with their laptops, tablets, smartphones, or immerse into the virtual world with an HMD (i.e. Google Cardboard headset). When users were immersed in VR environment, moving around was controlled by pressing the button at the top right of the Google Cardboard, whereas other interactions (e.g. turning on/off lights) were triggered by gazing at the objects within a certain amount of time (i.e. 3 seconds). Fig. 1 provides a snapshot of 35 WebVR applications created by students.

We found this approach was the most feasible in the classroom since all students possessed a smart phone or a tablet/laptop. To study user's technological acceptance regarding software-based perceived usefulness and ease of use, a standardized hardware interface was employed. Google Cardboard was selected as it is inexpensive and accessible, easy to carry, intuitive to use, and required no installation.

Along with presenting the projects in the classroom, students are required to submit a report describing their WebVR applications, including sources of references (for downloaded assets), challenges, lessons learned. We summarize all students' reports in the Section V.

4) Project results: At the end of the one month of project implementation period, 37 total houses were created. Due to the space constraint of this paper, we only provided a few examples of students projects. We show an example of a WebVR house on the moon in Figure 2(a), a tidy and

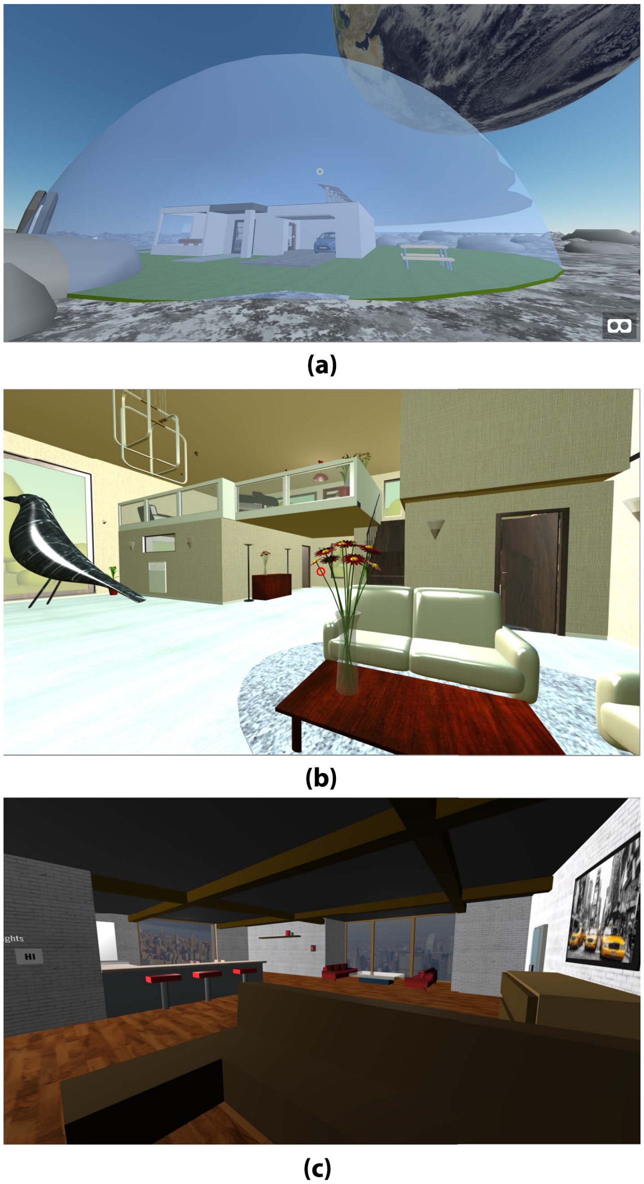

Fig. 2. Sampled Students' WebVR project examples: (a) A moon dream house (b) A 2-level dream house (c) A Newyork skyline dream condo

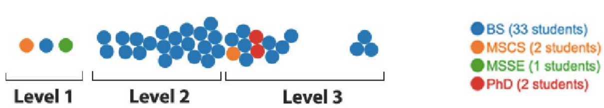

Fig. 3. Students' grade distribution of the WebVR dream house project: Level 1 is equivalent to a C while Level 3 is equivalent to a A.

complex VR house in Figure 2(b), and a VR house on top of a building in New York City which supports requesting Uber flight through the balcony in Figure 2(c).

The performance results (grades) of each student is illustrated in Figure 3; the majority of students finished their projects were awarded a Level 2 and 3. Further analysis on the result of grades is provided in the next section.

5) Ethical concerns in survey data collection:: Before taking the survey, students were informed about the research and assured that their private information would remain confidential in both data collection and analysis. After students submitted their surveys, the data were copied to Excel for analysis. Data was de-identified and encoded by converting categorical text data to number as well as shortening open-ended answers.

IV. Results

This study used descriptive and correlational analysis to garner a deeper understanding of students' reported experiences from the TAM-based post-project survey. In all, there were 36 completed survey responses.

Descriptive Analysis. As depicted in Fig. 4(Q1), majority (91.67%) of students chose *A-frame* as their WebVR library to complete their project; two students used both *A-frame* and *Three.js*, whereas only one student used *Unity3D*. Reasons included suggestions provided by this instructor Fig. 4(Q2), accounting for 77.78%. Although *A-Frame* claims to be one of the easiest libraries to create WebVR for any user [20], 9% of students reported it difficult to use (only 3 students rate *A-Frame* difficulty from 8 to 10). Anecdotally, a part of this problem may have stemmed from the fact that some students had no experience with web development (when asked in the classroom and short TA interviews). In general, the chosen library (largely *A-Frame*) was considered by students to be of moderate difficulty regarding ease of use ($mean = 5.09$). Overall, students' expectation of the chosen library was highly acceptable in terms of utility (overall mean score is greater than 7.0) as in Fig. 4(Q4). In terms of programming skills required to learn the library, a majority of students (97.22%) felt that they do not need an advanced level to complete their project, only 2.78% reported that they needed to learn more coding. This may be explained by the students' reports that, students spent most of their time in the project customizing objects (e.g. shape, size, color, position, rotation) rather than creating new objects. These results suggest that students with a moderate level of programming skills could creatively design and execute (accept the use of) a WebVR project within a short time.

Students also reported that the most time consuming part of the project was regarding content creation. Creating 3D models can be a painful task, especially to users who are new to designing 3D models. Consequently, 25% of students decided to use (download) existing models from the internet as depicted in Fig. 4 (Q6). In evaluating students' projects, researchers found that students often made 3D models from the basic shapes (e.g., a cube, a sphere and plane as indicated in the report); and these low poly models increased the performance (rendering and interactivity) of the application significantly compared to those downloaded from the internet. Only a few students challenged themselves by using third party software to create models (5.56%). Although, an sample

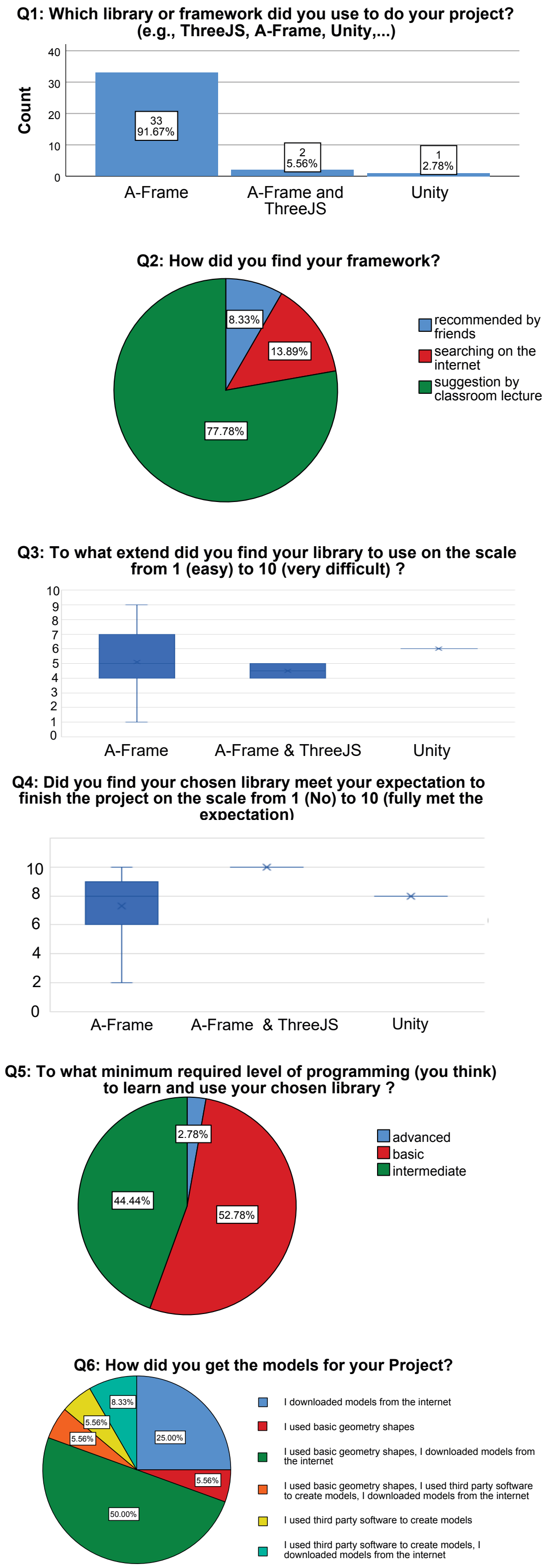

Fig. 4. Survey results for questions 1-6.

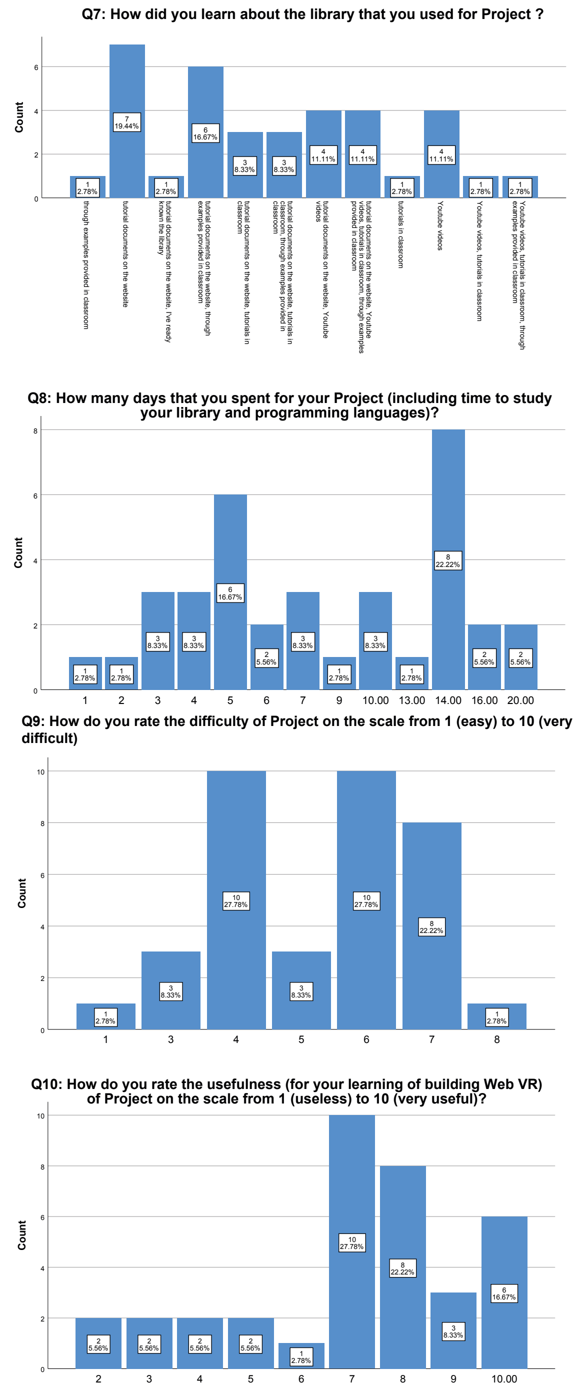

Fig. 5. Survey results for questions 7-10.

project was provided to students at the beginning of their project to provide context to the learning activity, students' feedback in Figure 5 (Q7) showed that they actively referenced tutorial documents on the chosen library website (19.44%). On average, it took more than one week (mean = 9) to finish the project as shown in Figure 5 (Q8). This estimation would

		Q3	Q4	Q9	Q10
Library ease of use (Q3)	Pearson Correlation	1	-.441	.620	.06
	Sig. (2-tailed)		.007	.000	.713
Library expectation (Q4)	Pearson Correlation	-.441	1	-.401	.272
	Sig. (2-tailed)	.007		.015	.108
Project difficulty (Q9)	Pearson Correlation	.620	-.401	1	-.109
	Sig. (2-tailed)	.000	.015		.526
Project Usefulness (Q10)	Pearson Correlation	.064	.272	-.109	1
	Sig. (2-tailed)	.713	.108	.526	

Correlation is significant at the 0.01 level (2-tailed)
Correlation is significant at the 0.05 level (2-tailed)

Fig. 6. Pearson correlation test scores produced by SPSS software.

have been more precise if we had measured students hourly as some students spent whole class days working on their project, while others allocated project time on multiple class days. We found that this duration was reasonable for the majority of the students who wanted to experience VR before getting bored.

Fig. 5 (Q9) illustrates students' feedback in terms of the difficulty of the project. Students felt that this project was neither too easy nor too difficult ($mean = 5.25$ and $Std.Deviation = 1.57$). This is what we expected when introducing a WebVR project for students from various disciplines. On the other hand, the usefulness of the Project toward learning VR did not yield expected results ($mean = 7.08$ and $Std.Deviation = 2.28$) as seen in Fig. 5 (Q10). Yet, this result may be a good indicator to help instructors for preparing similar classes using a student learning-centered model [22].

Correlation analysis. To assess whether there is a correlation between the chosen library with the project expectation (research question **R4**), the SPSS software was used for data analysis, the Pearson correlation is used as a metric for evaluation. Fig. 6 shows the correlation values among questions Q3, Q4, Q9, Q10. It can be seen that there is a moderate negative correlation (r =-.401, p = 0.015) between Q4 (library expectation) and Q9 (project difficulty), indicating a relationship between high library expectation and lower difficulty of the project (and vice versa). While exploring the correlation between the ease of use of the chosen library with library expectation to finish the project, the Pearson correlation (r =-.441) was only moderately negative and significant only at 0.01 confidence level. A weak correlation can also be found between library ease of use and perceived project difficulty (r = .620 and p =.000).

V. Lessons learned and challenges

The results of this project provides unique insights in using WebVR for individual and collaborative development of VR content among learners of various programming skill levels. Although *Three.js* library was introduced first and highly recommended to students for its utility, or ability to understand the basic idea of how WebGL works, only two students used this library for their project due to the complexity of the code, time to set up the basic VR environment, and interactions. An important reason for this was likely due to the effort (knowledge) needed by the user to maintain the program from breaking when a new interaction was added. The second library (*A-frame*), on the other hand, was more attractive to students because of the ease of use, namely its simplicity and easy VR setup compared to *Three.js*. In addition, instead of spending time on programming efforts, students focused on logical design and performance of the application. For example, while working with the high fidelity 3D models (obj or fbx), the size of these models are very big, so it heavily affects the performance of the application. Students overcame these problems by (1) creating a similar low poly model, and (2) converting these heavy models to another format (gltf - GL Transmission Format [23]). Therefore, students' perceptions of ease of use became paramount with equivalent platforms in utility, mediating their technological acceptance and overall use.

Of note, there were many helpful tricks made by students, one trick was with 3D object interactions. While some libraries did not allow direct interaction with 3D models (meaning only interact with some primitives such as cube, rectangle, cylinder, torus with pre-defined Box Collider), one student created an invisible big cube that cover the whole 3D models in the same position, functioning as a Box Collider, although was is not. From the user's perspective, it appeared to interact with the 3D model, but in fact, only interacts with the invisible cube. Another interesting trick was in creating scroll blinds on house windows, an animation made by merely creating two cubes on top of the windows and moving to the bottom windows, once the user clicked on the switch. When the cubes moved down, they blocked the light from entering into the house, creating an illusion of window blinds.

Although all students had some prior experience with programming, not all of them had troubleshooting skills, or ability to find out the reasons why application encountered an error. Such errors are unavoidable, especially when the size of the project gets bigger with complex VR applications. For example, it is easy to fix a mistake if there is an indicator of an error, however, what happens if the application shows no error? Several students faced this problem and one common strategy was to remove/comment parts of the application (*leave-one-out* approach) until it runs successfully. Then, students added back the codes incrementally to locate errors.

Besides the advantages of WebVR framework, there are some difficulties in developing WebVR applications. The first challenge is how to handle complex 3D models. Although these models can be converted to another format to reduce their size, they lost their fidelity, which reduces the apparent realism unique to WebVR environments. The second challenge was to reduce latency when users change their orientations suddenly which often causes dizziness or nausea, otherwise known as VR sickness. These challenges are common, yet important in maintaining virtual presence in 3D, VR environments [24].

VI. Recommendations

Based on this research, we present four recommendations for educators, instructors, and course designers when teaching WebVR in the classroom:

1) Before project development, short presentations for WebVR applications should be introduced by students.

First, it engages students in the process by researching contents and securing materials for self-guided learning. Second, it motivates and inspires other students by listening to peers showcasing the diversity of extant VR assets. And third, it provides a snapshot of this knowledge within a various content interests. Each presentation should only take around 5 to 7 minutes as longer presentations may lead to information overload.
2) To increase motivation for students in doing a project, a basic, sample project should be provided. It can work as a "skeleton" project as a baseline from where students can start, especially for those who are new to programming. By having a sample project, students can see an exemplar of the WebVR project expectation.
3) For agile project development, use of an online discussion forum and TA moderation can play an essential role in helping students throughout the development process. Any question comes out during project development can be posted, receiving feedback quickly without having to wait until next class. Interesting findings can also be shared among students, providing an opportunity to co-construct meaning of the process.
4) Regarding technological approaches, *A-frame* is a good starting point for undergraduate students. From the survey responses and project deliveries, students preferred *A-frame* as a skeleton structure and gradually develop the project based upon utility and ease of use, as per the TAM. Complex codes can be embedded later on, through careful scaffolding of information and guiding students through advanced programming.

VII. Conclusion and Future Work

This paper presents the feasibility of using the WebVR application in teaching students how to create VR content. While WebVR is still in the early stages of development, its usability and ease of use are undeniable because it supports a wide range of hardware devices and is independent of any operating system, facilitating technological acceptance among even the most novice of users. Access to hardware is an ongoing challenge for classrooms across the world (i.e ineffective or obsolete hardware, restrictions to third-party software, and so on), therefore WebVR has broad appeal due to the ubiquitous presence of web-based technologies. The result of the case study showed that students were able to create their WebVR application within a limited amount of time and with basic programming knowledge, thanks to *A-Frame* library. In the future work, we plan to extend this work with employing more classrooms/cases using WebVR, one use case is to have students uses any software/library to solve a problem, and the other one is the freedom of creating any application they want. Ongoing research will not only provide feedback for instructors teaching this course content but also serve as a guide for educators when they begin to use WebVR in their classrooms.

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