Envisioning the Future of Literature Learning: A Feasibility Study Exploring the Use of Virtual Reality to Help Students Better Understand Literature

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Background

In England, a child in care (or a "looked after child") is defined as one who is either subject to a care order granted by a court or who has been under a local authority's care for more than 24 hours (Children Act, 1989). According to the Department for Education (2021), on 31 March 2020 there were 80,080 children in care in the UK, an increase of 2% from the previous year. Children in care tend to have lower academic attainment than their peers starting at a young age, a gap which widens as children progress through school years (Berridge et al., 2020; Brännström et al., 2017). Children in care are often faced with many factors shown to have an impact on their educational success including: instability in their home and educational environments; lack of continuity of care; social, emotional, and mental health difficulties; difficulties with peer relations; and schools' responses to addressing the needs of children in care (Berridge et al., 2020).

The lockdown conditions imposed as a response to the COVID-19 pandemic have only served to widen the education gap between privileged and deprived pupils across the UK. A survey of teachers in the UK conducted by Teacher Tapp reported that 43% of secondary school teachers in deprived areas said their pupils studied for less than an hour a day under lockdown (2020). That compares to just 4% of private school teachers, and 14% in state schools in more affluent areas. Further, online learning assumes some devices are available to children along with appropriate supervision, yet 700,000 pupils in the UK lack access (BBC, 2020). Addressing educational underachievement amongst children in care must, therefore, also address their lack of access to appropriate educational technology and research into ways to improve academic outcomes for this group is paramount.

Almost 90% of adults in the UK own a smartphone (Deloitte, 2019), making it one of the most viable options for students to access educational technology. Further, virtual reality (VR) technology has demonstrated promise as an effective modality for delivering educational content. VR allows learners to experience an immersive interactive environment, visualize and reify presented material, learn in contexts that might be difficult or impossible in real life, enhance motivation, eliminate distractions, and adapt to individual learners' needs (Mantovani, 2003). With advances in technology, the availability of low-cost VR headsets which utilize smartphones with VR-compatible

apps, such as Google Cardboard, make leveraging this technology for educational purposes an even more cost-effective and convenient option. The EdTech in the Cloud project was created to explore the possibility of exploiting this technology in educational contexts.

Methodology

Virtual Reality Device

The goal of the development team was to deliver the VR application without the need of expensive specialist hardware. Having this low barrier to entry would enable us to scale this project up, and with minimal cost involved. It was quite clear that Google Cardboards , as seen in Figure 1, would be the most ideal device to use. The Google Cardboards are cheap, brandable and easy to use as the app can be deployed to Android and iOS devices via their app stores. However, with the low cost means we sacrifice visual quality to optimize performance for older devices.

Figure 1

EdTech in the Cloud Branded Google Cardboards

Development Platform

There is a wide range of development platforms we explored as part of the discovery phase, these included Amazon Sumerian, WebXR , Unity and a few more. Due to the funding coming from AWS, we wanted to try and get the project working on Amazon Sumerian, not only that but it looked very user friendly to build VR apps in the web. After some testing, we unfortunately couldn't get it to work reliably on android & iOS using a cardboard.

After the Sumerian experimentation we knew that we would have to use Unity in some capacity to get the project to work for WebXR or be deployed on Android & iOS. At this stage we started working with GeoSpark to help with the web deployment option using WebXR as this would make

the app easier for the students to use, as it didn't require a download. One of the main advantages of using Unity, given our project timeline, would give us the flexibility to switch platforms from WebXR to Android/iOS app deployment if one failed. We decided to target WebXR first as this would make the app more accessible but had the safe fall back of an app which we all had experience with in past projects.

Development Scope

Due to the very strict time constraints the development options were very limited and the team needed to find as many ways as possible to save time and to make sure if the WebXR route failed, we could as seamlessly as possible transition to Android & iOS app deployment. Using Unity would help us save a lot of time if a platform switch was needed. Even though this was time limited we also wanted to use this project as a chance explore new technologies with WebXR.

Time saving techniques:

- Use Unity as its familiar, and allows for easy platform switches
- Purchases as many 3D assets as possible to limit the amount of custom-made 3D assets
- Static scenes, as animation is very time consuming
- Clear roles for each member of the development team
- Using Git to allow for parallel work on the project development

Development Tools & Process

Tools being used:

Unity Game Engine

C# Programming Language

WebXR

Google Cardboard VR

Amazon Web Services

Autodesk Maya

Substance Painter

Adobe Photoshop

The development process was spilt into three parallel workflows that could be 'merged' together after major updates but allowed work to continue without having to wait for other tasks to be completed. This allowed us to speed up the development process for the short time frame we had.

The three parallels were spilt into ‘Asset creation and level design’, ‘Interaction engine’ and ‘Deployment’. Everything built in the ‘Asset and Level’ and ‘Interaction engine’ were also build with the idea they would work whatever the ‘deployment’ option would be, thus giving us some flexibly to change the deployment if necessary

Asset Creation

Figure 2

Purchased Assets

Figure 3

Custom Made Assets

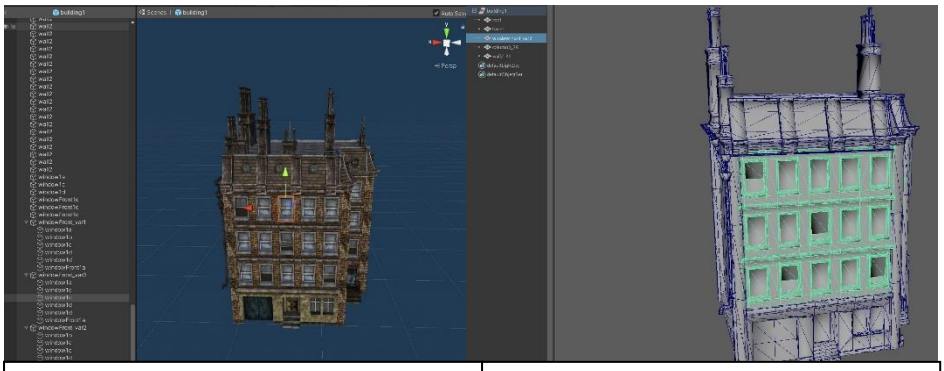
Asset Optimisation

Paying for assets online can be a great time saver but they are never perfect. As we were targeting mobile devices, we needed to optimise the 3D assets as much as possible to squeeze every bit of performance as possible. Using the pre-made assets, seen in Figure 2, populated our scene with 10,000s of objects, which caused the app to run very slowly on mobile phones making it un-usable. Additional assets specific to the *Oliver Twist* excerpt, see Figure 3, were also created.

The first stage was stripping back as much as possible, therefore we deleted a lot of unnecessary objects from the scene, but we still had over 10,000 objects. To make more improvements we would have to edit the assets in 3D modelling software Maya, as seen in Figure 4.

Figure 4

Editing of Assets



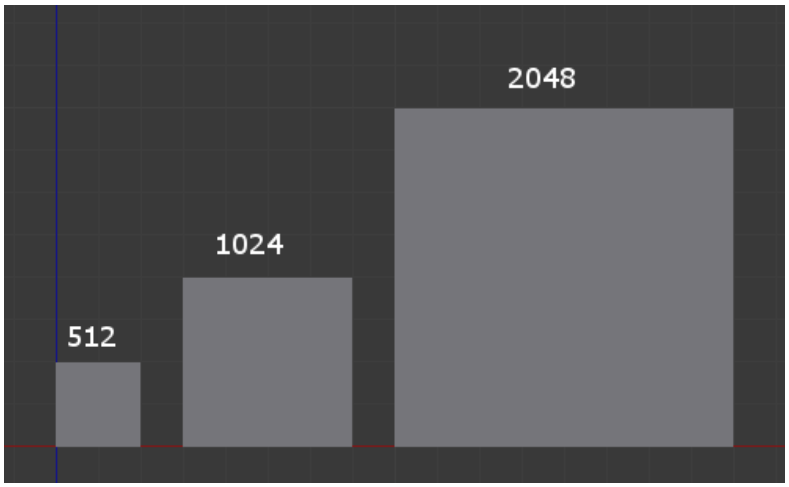
Building Pre-fab is made up of over 500 objects	Combing meshes with the same textures down to only 4 objects

Doing this took the number of objects in our scene from over 10,000 to under 100. This drastically increased performance to a more workable level on mobile but still required some more optimisations with assets but also with Unity itself.

Reducing the texture file sizes was also another effective way of optimising, as this reduces the file sizes, but we also take a hit on the visual quality, so we had to find a happy medium. Textures that were used on intractable objects were set to a higher resolution than objects that are in the background and aren't the main focus of the story, as seen in Figure 5.

Figure 5

Optimisation of Resolution of Assets



Interaction Engine

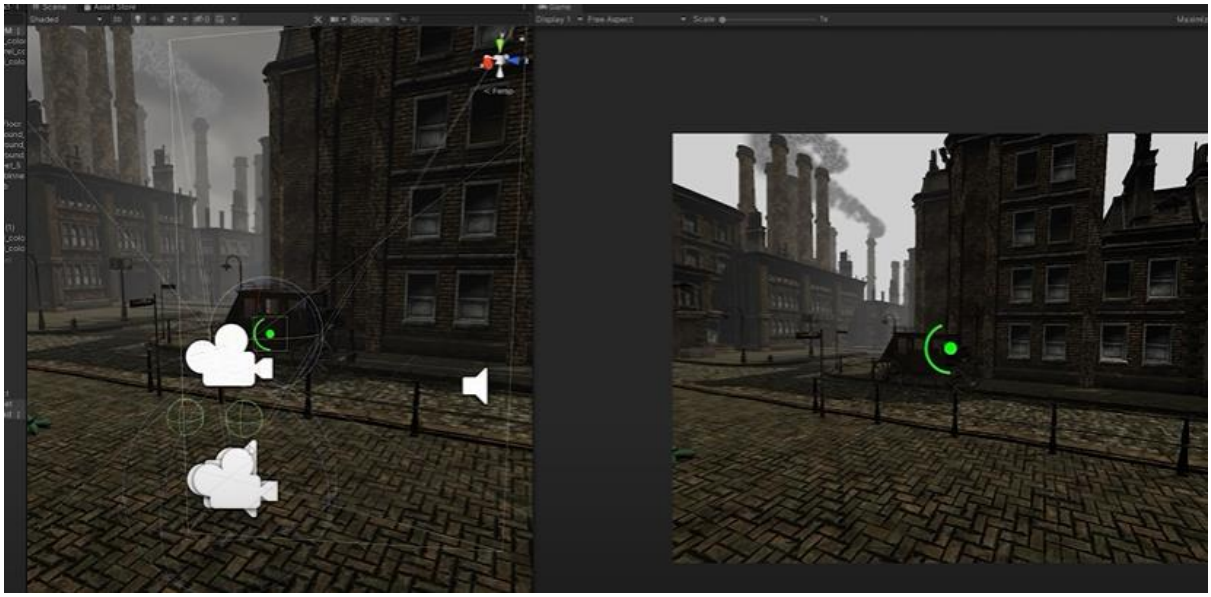
The Interaction Engine can be used to trigger something such as audio, enabling another scenario, playing a timeline cutscene, or loading another level.

A Scenario Manager was incorporated that signals when all compulsory scenarios have been completed. Scenarios can be optional, in which case they don't count towards whether all scenarios

have been completed. Again, events can be triggered on completion, so this could consist of either loading a new level, showing a score card etc., as shown in Figure 6.

Figure 6

Interaction engine/scenario manager



App Deployment

The original aim was to deploy the project using WebXR through a web browser. The original test we ran looked promising using Android and Firefox (an example can be seen herehttps://mixedreality.mozilla.org/hello-webxr/) but once we started doing more testing on other devices, including iOS we ran into a lot more performance issues that weren't easily solvable.

The way we developed the app allowed us to very quickly shift platforms from WebXR to native Android & iOS apps, so with this in mind we decided to set a deadline for WebXR which we unfortunately didn't meet, so in the end we decided to switch over to Android & iOS. We managed to do this in a weekend without it impacting any of the other work that was done in the other two workflows.

Participants

The participants in this study were all children in care in Oxfordshire, UK and attended state Oxfordshire secondary schools. Of the 41 participants who completed all phases of the study, 25 identified as male and 16 as female. There were 12 participants in the Year 8 group, 19 participants in Year 9, 7 participants in Year 10, and 3 participants in Year 11.

Participant recruitment

All participants were enrolled in the Oxfordshire Virtual School, an agency which works in conjunction with the Oxfordshire County Council to support the academic achievement of children in care within the county. Administrators from the Virtual School contacted a total of 150 caregivers, including 110 caregivers for students in Years 8 and 9 and an additional 40 caregivers for students in Year 10. Two recruitment videos were created and sent to potential participants, one video aimed at the caregivers and one video aimed at the students, to explain the research project further. Of the 150 caregivers contacted, 79 students agreed to participate and 41 completed all three phases of the study (pre-assessment, app usage, and post-assessment). Recruitment of participants in the younger age group, Years 8 and 9, proved more successful, with Year 10 and 11 students citing exam pressures and general disengagement with educational activities, among other explanations, as reasons for not participating. Participants who completed all three phases of the study and their caregivers were each offered a £10 Amazon gift card for their participation.

ID allocation

In this single blind study, each student was assigned a 4-digit unique ID number that they used to login to both the assessments and the app. The research team randomly generated the ID numbers, which were given to the Virtual School administrators to distribute to the student participants. The research team was unaware of the identity of the students.

Educational content development and design

As the purpose of this research was to create a virtual reality app to help bridge educational attainment gaps experienced by children in care, it was paramount to first decide on an academic subject on which to focus. In order to ascertain the subject where our research might have the most impact, the educational content development team met with teachers and administrators from the Oxfordshire Virtual School. As the staff of the Virtual School work closely with the children in care and their caregivers, they were able to relay that their students tended to show the largest achievement gaps in literature when compared to children who are not in care, as they tended to have deficits in the cultural capital that would allow them to connect with it. Specifically, these attainment gaps begin to appear in KS3 (Years 7-9), become more prominent by KS4 (Years 10 and 11), and performance is significantly lower on the GCSE English Literature exams than their peers not in care.

Once the academic subject and the age of the population to be included in the study had been determined, a specific genre of literature to focus on needed to be established. The staff of the

Virtual School identified Victorian-era literature as one genre that their students had the hardest time connecting with. A list of books that were commonly studied in KS3 and KS4 classrooms was consulted and extracts from some of these books were found. At this point, the Lead App Developer was consulted as to which of these extracts might provide the most visually rich in-app experience for the students. The decision was made to proceed with an extract from Charles Dickens' *Oliver Twist* in which a meal is taking place in the workhouse and Oliver Twist asks for more food.

As the purpose of the app was to give the students not only a visual representation of the extract they would read, but also some cultural capital which might help them understand and connect with it better, it was decided to have two scenes within the app – one which would depict a street scene to show what Victorian London was generally like and another to connect more specifically with the workhouse setting from the extract. With the assistance of the Virtual School staff, items were identified that could be used to give cultural and historical context in the Victorian London street scene and vocabulary words from the extract were identified that could be visually depicted within the workhouse scene for context and clarity.

Throughout the scriptwriting process, a PGCE-certified teacher of secondary-level History was consulted to ensure historical accuracy. Within the Victorian London street scene, the following elements were chosen to provide cultural and historical context (See Appendix A):

- Factory smokestacks – to depict the Industrial Revolution
- Cramped housing – to depict overcrowding in cities caused by the industrial Revolution
- Carriage and cobblestones – to depict what roads looked like at that time
- Wheelbarrow full of manure – to depict hygiene and sanitation conditions
- Pile of empty bottles – to depict the problems that came with the increase in both alcohol production and consumption during that era
- Façade of a prison – to depict the rise in crime and the difficult prison conditions
- Façade of a workhouse – to depict poverty and introduce the concept of Victorian workhouses.

Within the workhouse scene modelled after the *Oliver Twist* extract, items were chosen that would not only provide a visual representation of potentially difficult vocabulary words that appeared within the extract, but which could also be used to introduce historical and cultural knowledge specific to the era. The following vocabulary items were chosen to provide clarity and context:

- Porringers (wooden bowls) –to depict the amount of food workers were given

- Ladle – to introduce “gruel” and depict how workers were fed
- Copper – to provide a visual representation
- Aprons – to depict how workers would assist the master in serving meals
- High table – to show where workhouse administrators and officials sat and to depict class distinctions
- Cross – to depict the role religion played in workhouses
- Rats - to depict unsanitary conditions
- Puddles – to depict unsafe working conditions

In order to make the in-app experience more appealing to the students, an element of gamification was added by integrating a storyline to the experience. Students were given a pre-intervention assessment and then asked to use the app. The app started in the Victorian London street scene with a narrator providing a voiceover that told students they had the superpower of “book jumping” – having the ability to teleport into books and experience the stories from the point of view of someone in that time. It was further explained that they were still learning how to use their powers and couldn’t always control them, so the narrator would act as their guide to help them figure out which book they were in.

Due to time constraints, both scenes were created as static scenes. That is, no moving objects or animations were incorporated. Additionally, as the VR app was created for use with Google Cardboard viewers, there were limits on interactions with the objects within the scenes due to Cardboard’s capabilities. Students would interact with objects within the scenes by gazing at them to select them. Once selected, the narrator’s voiceover would explain what the item was and give some information as to how it related to the scene. A further element of gamification was added through a tally that was kept at the bottom of the screen so students knew how many objects they needed to find to interact with within the scene. This not only helped guide them but ensured that students interacted with all objects before being able to continue to the next scene. Upon completion of the first scene, students were informed by the narrator that the objects within the scene helped to identify the setting as Victorian London, but as there are many books that take place during that time, it was not yet possible to tell which book they were in. Students were then allowed to enter the workhouse and see the second scene, which depicted an empty workhouse dining hall in which a meal had recently been served. After completion of the second scene, students were informed the book was *Oliver Twist* and were given the option to either go back and interact with the objects in either scene to hear the information about them again or to quit the app and complete the post-intervention assessment.

Assessment

A repeated measures design was used. Care was taken to ensure that assessment questions would be similar to those that students would encounter in their usual English Literature classrooms and on exams. Working in conjunction with the educators from the Virtual School, the team devised a simple two-part assessment comprised of both multiple-choice and short answer questions. Additionally, consideration was given to devise questions that would assess both their comprehension of the literature and their knowledge of the Victorian era. An effort was made to present assessment materials in a format that would be familiar to participants. The experienced teaching staff at the Virtual School advised that it is common classroom procedure to give a pre-test followed by the presentation of content, followed by the same test given as a post-test. Both the pre- and post-assessments, therefore, consisted of the same format and questions.

In the first section of the assessment, students were first asked to read the extract from *Oliver Twist* (See Appendix B). They then answered two multiple choice questions regarding the extract to both serve as a baseline of their comprehension and to build their confidence before moving on to the short answer questions. The short answer questions were focused on the students' understanding of the setting and plot of the extract. Each short answer question was followed by an additional question asking students to explain why they gave the previous answer. This was done in order for the research team to be able to gauge the students' current understanding and impact the VR app might have on their understanding during the post-assessment. In the second section, students were asked to look at a photo of Victorian-era London. They first answered a multiple-choice question regarding the content of the photo. This was followed by several short answer questions regarding the setting of the photo and the experiences of the people in the photo. Each of the short answer questions was again followed by a question asking the students to explain their reasoning for the answer they gave.

As students were completing all phases of the study at home in their own time, they were able to access the assessments online through the study's website home page. Consent to participate was obtained from both caregivers and students. After receiving consent forms, a Google Cardboard was mailed to each participant. Administrators from the Virtual School emailed participants with instructions and to let them know that the pre-assessment was accessible and they were able to login and complete them. Approximately one and a half to two weeks following the initial assessment (times varied due to students completing the study at home), students were able to download the VR app from either the Apple Store or Google Play Store and complete their VR experience. Following their use of the app, students were asked to complete the post-assessment.

While some students did complete their post-assessments immediately following their use of the app, the post-assessment remained accessible online for two weeks following their initial accessibility.

Test scoring

Both pre- and post-tests consisted of two parts, described above in the Methodology section. Each question was valued as one point, for a total of eight points. Short answer questions relating specifically to the excerpt or photo were given one point for correct answers, half a point for answers that were partially correct, and zero points for incorrect answers. Short answer questions that asked participants to explain their reasoning for giving the previous answer were not included in the scoring.

Qualitative feedback

After data collection of the post-tests had concluded, a link to a voluntary qualitative feedback questionnaire was emailed to all participants. The questionnaire consisted of three questions that ascertained whether participants had used VR before and, if so, how often and in what contexts. These were followed by eight 5-point Likert scale questions (Likert, 1974) which asked students to rank their level of agreement with statements regarding their understanding of the extract, confidence in their test answers, and ability to visualize the extract setting before and after using the VR app. Additionally, they were asked to rate their enjoyment of the app, and whether they would like to use educational VR apps in the future and in what contexts. The questionnaire concluded with an open-ended question asking what students did or did not like about the VR app used in the study.

Results

Overall Pre- and Post-Test Results

All statistical analyses were carried out using SPSS Statistics (IBM Corporation, 2020). Table 1 shows the results of the pre- and post-test. The descriptive statistics show the average pre-test score for the group was 5.98 (*SD* = 1.18), with a minimum score of 4 and a maximum score of 8. The post-test showed an increase in the mean score to 6.68 (*SD* = 1.35), with a minimum score of 3 and a maximum score of 8.

The majority of the students (63.41%, *n* = 26) demonstrated an increase in their scores on the post-test, as shown in Table 2, with an average increase of 1.39 points. Decreased post-test scores were shown by 5 participants (12.20%) and 10 participants (24.39%) showed no change in their score. It is

worth noting that of the students that showed no change in their scores, 3 (30%) had scored a perfect score of 8 points on their pre-tests, leaving no opportunity to improve their scores.

Table 1

Descriptive Statistics (Pre- and Post-Test Results)

	N	Minimum	Maximum	Mean		Std. Deviation
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
PreTest	41	4.00	8.00	5.98	.185	1.18
PostTest	41	3.00	8.00	6.68	.211	1.35
Valid N (listwise)	41					

Table 2

Direction of Score Changes

Direction of Score Change	Average Score Change	Number of Participants	Percentage of Participants
Increased	1.39	26	63.41%
Decreased	-1.4	5	12.20%
No Change	0	10	24.39%
Total		41	100.00%

A paired samples t-test was conducted to compare the participants' test results prior to and after using the VR app. Table 3 shows the results of the paired t-test. On average, participants performed better on the post-test following use of the VR app (M = 6.68, SD = 1.18) than they did on the pre-test prior to using the VR app (M = 5.98, SD = 1.35). This difference, -0.71, was significant $t(40)$ = -3.45, p = .001 and represented a medium-sized effect, d = .54, as shown in Table 4. The improvement of test scores and VR app usage were moderately positively correlated, $r(39)$ = .54, p = .002, as shown in Table 5. These results suggest that use of the VR app increased participants' understanding of both the literature excerpt and the setting in which it takes place.

Table 3

Paired t-test Results

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	PreTest - PostTest	-.707	1.31	.205	-1.12	-.29	-3.45	40	.001

Table 4

Paired Samples Effect Sizes

					95% Confidence Interval	
			Standardizer[a]	Point Estimate	Lower	Upper
Pair 1	PreTest - PostTest	Cohen's d	1.31328	-.539	-.864	-.208
		Hedges' correction	1.32575	-.534	-.855	-.206

a. The denominator used in estimating the effect sizes.

Cohen's d uses the sample standard deviation of the mean difference.

Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.

Table 5

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	PreTest & PostTest	41	.469	.002

Short Answer Questions Analysis

Participants' answers to the short answer questions were further analysed through word clouds, shown in Figure 7, using Pro World Cloud (Orpheus Technology Ltd., 2020). Common words such as free functional morphemes, e.g., prepositions, pronouns, conjunctions, auxiliary verbs, and free negative morphemes, e.g., *no, not*, were automatically filtered out by the software. The remaining words were compiled into word clouds in order to demonstrate the differences in the frequency of the words used by participants when answering the short answer questions on the pre- and post-tests. The size of the words in each cloud corresponds to the frequency with which they were used; the larger a word is, the more frequently it appeared.

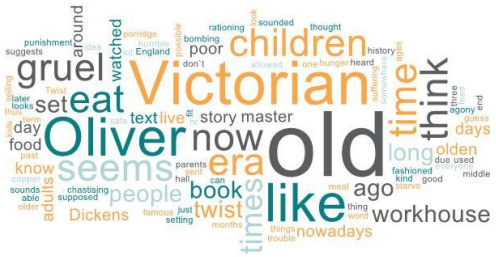
Figure 7

Word Clouds Depicting Frequency of Words Used on Pre- and Post-Test Short Answer Questions

A

Part 1 Q4: Why do you think (the story is set in the time the student indicated)?

Pre-Test



Post-Test

B

Part 1 Q6 – Why do you think the story took place in (the setting specified by the student)?

Pre-Test

Post-Test

C

Part 1 Q8 – Why do you think (activity specified by the student) is taking place in the passage?

Pre-Test

Post-Test

D

Part 1 Q9 - What do you think life was like for a child in this setting?

Pre-Test

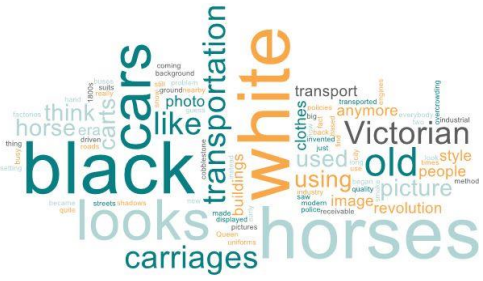
Post-Test

E

Part 2 Q3 – Why do you think the picture was taken in (time specified by the student)?

Pre-Test

Post-Test



F

Part 2 Q5 – Why do you think the photo was taken in (place specified by student)?

Pre-Test

Post-Test

For the questions pertaining directly to the participants' comprehension of the *Oliver Twist* excerpt, while also requiring them to rely on their cultural capital (Figures 7A, B, C, and D), there tended to be less variety in the words used by the participants' during the post-test as compared to the pre-test. Though the post-test answers for those questions were less varied, the participants tended to use words more frequently that directly related to the excerpt and which were mentioned several times through the narration in the VR experience, e.g., *workhouse, gruel, hungry, eating, Industrial Revolution.* The question immediately preceding the question depicted in Figure 6A asked participants when they thought the excerpt took place. Some responded with a specific year or date ranges, while others specified an era. While the word *Victorian* appeared slightly less frequently in the post-test answers shown in Figure 7A, the participants were able to use more descriptive language and point out more appropriate, specific reasons as to why they thought the excerpt took place during the time they specified. Of note, during the post-test, participants frequently mentioned they learned specific information through the VR app. Of the 16 mentions of information seen in the VR app, 37.5% (*n* = 6) of the participants increased their score on that particular question on the post-test, as shown in Table 6. Additionally, 31.25% (*n* = 5) of the participants answered the question they specified they had seen information for in the VR app correctly on both the pre- and post-test, so there was no opportunity to increase their score. Of the remaining participants who mentioned the VR app, 25% (*n* = 4) either answered somewhat correctly or incorrectly on the pre-tests and answered similarly on the post-tests, demonstrating no change in their scores for those particular questions, and one participant (12.5%) answered correctly on the pre-test, but incorrectly on the post-test, decreasing their score for that question.

Table 6

Responses Specifically Mentioning VR

Direction of Score Change	Number of students (*n* =16)	Percentage of VR Mentions
Improved score	6	37.50%
No change (correct)	5	31.25%
No change (somewhat)	2	12.50%
No change (incorrect)	2	12.50%
Decreased score	1	6.25%
Total	16	100%

The remaining questions (Figures 7E, F, and G) required participants to draw heavily on their cultural capital, as they required knowledge of the Victorian era to answer questions about the photo correctly but were not scaffolded by the literature excerpt. In answering these questions, participants tended to use a wider variety of words in their responses. Responses on the post-test were more descriptive than on the pre-test and used a greater number of words specifically mentioned by the narrator in the VR app, e.g., *poverty, pollution, carriages, Victorian,* and *Industrial Revolution*.

Qualitative feedback questionnaire analysis

Of the 41 participants who completed all three phases of the study, 13 returned the voluntary qualitative feedback form. Table 7 shows the results of the questions pertaining to participants' previous experience with VR. The majority of the participants (*n* = 10, 76.92%) had never used VR before, while 3 of the participants (23.08%) had, though not often and mostly for gaming purposes.

Table 7

Responses to Qualitative Survey Questions Pertaining to Previous VR Experience

Survey Question	Yes	No
Before using the EdTech app, had you ever used VR before?	3	10
Of those who answered *Yes*		
When else have you used VR?	Tried it at a friend's house. This year, last year and the year before Videogames	
How often do you use VR?	Got a Quest 2 for Christmas so now use it every day. Not very often Never	
Why have you used VR in the past (gaming, education, etc.)?	Gaming, work I have used it for gaming purposes Gaming	

A Wilcoxon Signed Rank test, the results of which can be seen in Table 8, was used to compare the participants' responses to questions relating to their understanding of the extract, confidence in their test answers, and ability to visualize the extract setting before and after using the VR app using a 5-point Likert scale. While there was an increase in the both the median rating given to participants understanding of the extract before and after using the app and their self-assessed ability to visualize the setting of the extract before and after app usage, the increases were not significant (z = 0.378, p = .705 and z = 0.962, p = .336, respectively). The results did show a significant difference in the participants' ratings of both their confidence in their answers to questions regarding the extract (z = 2.264, p = .024) and their confidence in their answers regarding the photo (z = 2.719, p = .007).

Table 8

Wilcoxon Signed Rank Test Comparing Participants' Responses to Before and After Questions Regarding the App's Usefulness and Effectiveness

Related-Samples Wilcoxon Signed Rank Test Summary

	Understanding of the Extract Before and After	Confidence in Answers Regarding Extract Before and After	Confidence in Answers Regarding Photo Before and After	Ability to Visualize the Extract Setting Before and After
Total N	13	13	13	13
Test Statistic	6.000	21	45	11
Standard Error	2.646	4.637	8.276	3.64
Standardized Test Statistic	0.378	2.264	2.719	0.962
Asymptotic Sig.(2-sided test)	0.705	0.024	0.007	0.336

Table 9 shows the participants' responses to the survey questions regarding their enjoyment of the VR app and their opinions on future educational VR apps. The majority of the participants who responded to the survey either felt neutral about (n = 6, 46.2%) or enjoyed (Agree: n = 4, 30.8%; Strongly Agree: n = 1, 7.7%) using the VR app. The majority of the respondents (n = 7, 53.8%) agreed that VR apps like the one developed for the purposes of this study could help them understand literature more. Most of the survey respondents either agreed (n = 5, 38.5%) or strongly agreed (n = 2, 15.4%) that they would like to use more VR apps to learn literature. A total of 69.3% of the respondents agreed (n = 6, 46.2%) on strongly agreed (n = 3, 23.1%)

Table 9

Responses to Survey Questions Regarding Participants' Enjoyment of the VR App and Their Opinions on Future Educational VR Apps

	I enjoyed using this app.		I feel apps like this could help me understand literature more.		I would like to use more apps like this to learn literature.		I would like to use apps like this for other subjects (maths, science, history, etc.).	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Strongly Disagree	1	7.7	1	7.7	0	0	0	0
Disagree	1	7.7	0	0	1	7.7	1	7.7
Neither Agree nor Disagree	6	46.2	3	23.1	5	38.5	3	23.1
Agree	4	30.8	7	53.8	5	38.5	6	46.2
Strongly Agree	1	7.7	2	15.4	2	15.4	3	23.1
Total	13	100.0	13	100.0	13	100.0	13	100.0

Additionally, respondents were asked to provide any additional comments or feedback on what they did or did not like about the app. Of the 10 participants (76.92%) who left additional feedback, the following responses were submitted:

"It was a good experience. Some of the questions were a bit odd though and I had to repeat my answers."

"Hurt my eyes when I looked around."

"I didn't like how if you scanned the area/object before you still had to wait until the narrator stopped talking to scan another object/area."

"It helped it told you information about each picture and it was all clear."

"Being in a virtual reality for a long period of time gives you eye aches and headaches."

"It did not work on certain types of phones."

"It was hard to get on but once on it was ok."

"It was difficult to get on the app using my pin."

"I really enjoyed using the VR, I would enjoy using it more."

"It made me go dizzy if I looked through it too long."

Discussion

The purpose of this study was to investigate whether using a VR app could help secondary school aged children in care gain a better understanding of literature by increasing their cultural capital through visual representations of what they have read. The results described above suggest that there are benefits for literature comprehension to this population of students after using a VR app. The majority of students increased their post-test scores and their writing became more focused and descriptive. With respect to the qualitative feedback, while the results showed a significant difference in the participants' confidence in their post-test answers regarding both the extract and the photograph as compared to their confidence in their pre-test answers, it did not, however, demonstrate a significant difference in their self-assessed understanding of the extract or ability to visualize the setting of the extract, though the ratings for both did increase. The majority of the participants enjoyed using the app and would like to use more educational VR apps in the future. It should be taken into consideration, however, that fewer than half of the participants - only 13 of 41 total participants - participated in the qualitative feedback survey and the results might not necessarily be representative of the sample population for this study.

To date, there is a paucity of research on the use of VR to better understand literature. In a broad sense, this study supports constructivist learning theory's principles of contextual learning, active learning processes, meaningful connection with presented materials, and building upon learners' prior knowledge to generate new meaning (Cronje, 2020). Further, the results support Mayer's (2020) Modality Principle, which states that better learning takes place through pictures and spoken words than through pictures and written words. It appears that while further research is needed on the use of VR in this specific capacity, VR might provide an ideal environment for presenting contextual information that can lead to deeper connection to literature.

It is useful to note that this was a small-scale feasibility study, conducted within a short timeframe of approximately 4 months from the start of the development of the app to the completion of post-tests, and with a limited number of participants. All testing and app usage was done in the privacy of participants' own homes rather than a controlled setting and, though caregivers were asked not to assist participants or explain the excerpt or photo to them, with the exception of participants who had reading difficulties and needed the excerpt read out loud to them, there was no way to ascertain that these conditions were adhered to. Staff from the Virtual School reported that there was some confusion from participants regarding the post-test, as it contained the same content as the pre-test. This may have had some effect on the responses submitted. Further, as both the pre- and post-tests contained the same material, there is potential that some degree of priming may

have resulted. However, as many of the participants were known to the Virtual School to experience learning difficulties, it was important to adhere to an assessment process that was familiar to them, as discussed above in the Methodology section.

The app was designed in a very short period of time - approximately 3 months from concept design to delivery of the app - and, while the graphics were of a good resolution, it was relatively low tech compared to video games that participants may have been used to playing. It was comprised of static scenes and contained no animation. Engagement during usage may have been affected by the lack of high-tech elements. Due to both time constraints and anonymity/safeguarding concerns for the population of children in the study, we could not conduct face-to-face interviews in order to better pinpoint any affective or engagement issues which may have led to either no change or a decrease in test scores.

While further empirical investigation is needed, the results of this study are promising for the further development of VR for literature learning. In particular, ways in which greater interactivity can be meaningfully integrated into such apps should be explored. Investigation into ways to expand the app experience to encompass more information that would be generalisable to from one specific book or excerpt to literature from that period as a whole should also be considered. Furthermore, expanding to other subject areas such as mathematics, history, etc. is also warranted.

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Appendix A

App Script

VICTORIAN LONDON STREET SCENE

[Victorian London street scene – dilapidated buildings, factories, smog blocking the sun, soot, street vendors, cobblestone streets, a horse-drawn carriages, wheelbarrow full of manure, a pile of empty gin/alcohol bottles, a prison, a workhouse, tenement housing]

Observer： By wearing these glasses, you have been given the supernatural power to teleport into books, interacting with the world inside. But you are young and haven't quite mastered your powers yet, often not able to control which book you end up in. Luckily, as a young Book Jumper you are paired with me, your Observer, a guide only you can see and hear, who will help you to use your surroundings to figure out which story you are in. During this Jump you find yourself in a city that seems strangely familiar…

[Observer appears in upper corner of screen – possibly just a glowing orb or something along those lines?]

Observer: Wow! You've done it again! Good job – you've made it into another book! But which book? I have no idea. Let's see if we can figure this one out…you're definitely in a city…it looks a lot like London - a bit grim, though. Let's try this – you have some powers that I haven't told you about yet. You have something sort of like telepathy - if you stare long enough at the objects around you, some of them will relay information that we can use to try to figure out where you are. An indicator will appear if it's something we can get some information from. Give it a try! Have a look around and let's see what we can find out!

<u>Things that are interactive</u>

Factory chimneys (in background)

Observer: Looks like the Industrial Revolution is in full swing! So much soot it's made the air smoggy and dirty! This was a time of great change for the economy and for people's way of life. Before this time, people made things like fabric, furniture, and iron goods in small amounts and sold them from their homes or small shops. Rapid advancements in technology meant that production of these goods changed from being hand made to using factories and machines.

Tenement housing

Observer: The fact that factories could produce cheaper goods, meant many people had to leave their homes in the countryside to look for jobs at the factories in the cities. So many people moving to the city meant lots of problems. The cities were far too full of people and there wasn't enough housing. Many people had to live in overcrowded slums.

Horse-drawn carriage/cobblestones

Observer: Ah! Cobblestones! Because there were no cars, only horse-drawn carriages, streets were paved with small, round stones called cobbles. These stones made the roads easier for the horses to walk on and kept the roads from getting muddy because the water could drain away more easily.

Wheelbarrow full of manure

Observer: Whoa! That must be from the horses! There were no sewer systems in Victorian times, so all the waste – animal and human - was thrown into the streets and washed into the rivers. That doesn't sound very hygienic, does it? Can you imagine what the cities must have smelled like?!

Pile of empty alcohol bottles on street

Observer: Judging from this pile of empty bottles, it looks like gin was quite popular! That's not surprising – industrialisation also affected alcohol production. They were able to make much more of it and people took full advantage of that, which ended up causing a lot of problems in society.

Prison facade

Observer: This is a rather grim-looking building. Perhaps it's a prison? Prisons at this time were often in old buildings, such as castles They tended to be damp, unhealthy, unsanitary, and over-crowded. All kinds of prisoners were mixed in together - men, women, children, the insane, serious criminals, people who committed small crimes, people awaiting trial, people who owed money. Inefficient police, overcrowding, and millions of people living in poverty and hunger led to desperate times and a high crime rate. Even very minor offenses could land you in prison for years.

Workhouse

Observer: Well this building looks a bit different from the prison, but it doesn't look any less grim. I wonder if it's a workhouse. Workhouses were used in Victorian times to provide shelter and food to the poor in exchange for work. Even children were put to work in workhouses! The work was usually very hard, and people worked very long hours. Usually the shelter and food they were offered were barely enough. Workhouses were *not* nice places!

Observer: [A*fter student has interacted with all objects in the scene]* Well done! I think you've given me enough information to guess that you're in Victorian London, which was between 1837 and 1901 during the reign of Queen Victoria. Gosh! There are tons of books that take place then! Right! We're going to need some more information. Maybe taking a look around inside somewhere will help. It looks like you might be able to go inside here [*indicates door to workhouse is interactive*] I haven't got the slightest clue which book you're in! Have you?

DINING HALL SCENE

[Interior of a workhouse dining hall]

The dining hall sits empty, though it appears as though a meal has just finished. Empty wooden bowls (porringers) with wooden spoons, empty cups, a high table where the workhouse officials would have sat, a cross/crucifix hanging on the wall behind the high table, a copper in the corner (similar to this, with a large copper cauldron inside), with some gruel leftover inside?, a few used, dirty apron hanging over a chair/lying on a table, a used ladle lying on a table which has bit of gruel left on it, items at the high table might look a bit nicer than the items on the children's tables – ceramic bowls, metal spoons, etc. Rats?, damp walls (maybe with mold/mildew?), puddles on the floor… Sounds: Dripping water, muffled factory-type sounds (e.g., thumping, voices, steam whistling in pipes?), creaking floors, rats squeaking and scuttling around, possibly muffled street sounds from outside?]

Observer: What is this room? A dining hall of some sort? It looks like we've arrived a bit late… there are some things left behind that might give us some clues. Find an indicator and we'll see if we can piece together where we are.

Things to interact with: (After they select something, is it possible to zoom in on it or have a pop-up box to show the item in more detail or a photo of the item? No biggie if not!)

Wooden bowl/porringer

Observer: I think this a porringer, which a small, shallow wooden bowl. They've obviously just had a meal and this bowl has been scraped clean! Judging by the size of this bowl, they were probably served "short commons," which means "not enough food."

Ladle

Observer: This looks like a ladle, which is a big, deep spoon on a long handle, useful for getting soups, stews, and porridge out of large, deep pots. By the looks of this, they were serving gruel, which is a cheap porridge that was often fed to the poor. One ladleful of gruel was most likely all that was given to them at mealtimes per diem, which is Latin for *per day.*

Copper

Observer: This is a copper. Very large copper pots were kept in a brick surround with a fire underneath. I think this must've been where they kept the food warm.

Aprons

Observer: Hmm...some aprons. Since they look a bit dirty, I'm guessing this is what the master of the workhouse put on to serve all the workers. Since there were so many people, he must've had assistance from some of the paupers, which is what the poor people in the workhouse were called.

High table

Observer: This looks like the table that the officials and administrators would have sat at. The bowls and cutlery are posher and are much bigger. I'm guessing they had plenty to eat and their stomachs were full, while the workers with their tiny bowls and one ladle of food, were left voraciously starving hungry!

Cross/crucifix

Observer: Religion played a big part here. There would be a church official called the *beadle* who would be responsible for the spiritual well-being and discipline of people in workhouses.

Rats

Observer: Oh! A rat! Such a common sight during this time. With all the overcrowding and unsanitary conditions, rats were everywhere, spreading diseases. They were such a problem that cities even had people who were professional rat catchers!

Puddle

Observer: Victorian England was not a nice place for the working class. There were very few laws governing the workplace. As a result, men, women, and even children worked long hours in dangerous and uncomfortable conditions.

Completion screen

You've given me lots of information to work with. I've put everything into my computer and checked my database. I think you're in the book *Oliver Twist* written by Charles Dickens! Well done on helping me piece it all together! You can go back through the streets and the workhouse if you'd like me to tell you about any of the objects again. Or if you've had enough, you can jump out of the book and come back to the real world. I've got some post-jump assessments for you to fill out so we can keep track of your book jumping progress!

Appendix B

Pre/Post Assessment

Part 1

Please read the following passage. You can have your carer read it out loud to you if that helps. When you are finished reading, please answer the questions that follow it. It's ok if you don't know all the answers – just give it your best guess!

The room in which the boys were fed, was a large stone hall, with a copper at one end: out of which the master, dressed in an apron for the purpose, and assisted by one or two women, ladled the gruel at mealtimes. Of this festive composition each boy had one porringer, and no more except on occasions of great public rejoicing, when he had two ounces and a quarter of bread besides.

The bowls never wanted washing. The boys polished them with their spoons till they shone again; and when they had performed this operation (which never took very long, the spoons being nearly as large as the bowls), they would sit staring at the copper, with such eager eyes, as if they could have devoured the very bricks of which it was composed; employing themselves, meanwhile, in sucking their fingers most assiduously, with the view of catching up any stray splashes of gruel that might have been cast thereon. Boys have generally excellent appetites. Oliver Twist and his companions suffered the tortures of slow starvation for three months: at last they got so voracious and wild with hunger, that one boy, who was tall for his age, and hadn't been used to that sort of thing (for his father had kept a small cook shop), hinted darkly to his companions, that unless he had another basin of gruel per diem, he was afraid he might some night happen to eat the boy who slept next him, who happened to be a weakly youth of tender age. He had a wild, hungry eye; and they implicitly believed him. A council was held; lots were cast who should walk up to the master after supper that evening, and ask for more; and it fell to Oliver Twist.

The evening arrived; the boys took their places. The master, in his cook's uniform, stationed himself at the copper; his pauper assistants ranged themselves behind him; the gruel was served out; and a long grace was said over the short commons. The gruel disappeared; the boys whispered each other, and winked at Oliver; while his next neighbors nudged him. Child as he was, he was desperate with hunger, and reckless with misery. He rose from the table; and advancing to the master, basin and spoon in hand, said: somewhat alarmed at his own temerity: 'Please, sir, I want some more.'

The master was a fat, healthy man; but he turned very pale. He gazed in stupefied astonishment on the small rebel for some seconds, and then clung for support to the copper. The assistants were paralysed with wonder; the boys with fear.

'What!' said the master at length, in a faint voice.

'Please, sir,' replied Oliver, 'I want some more.'

The master aimed a blow at Oliver's head with the ladle; pinioned him in his arm; and shrieked aloud for the beadle.

Question 1
What did the children eat?
a. Bread
b. Gruel
c. Bread & gruel
d. Nothing

Question 2
Who asked for more gruel?
a. The beadle
b. Jack
c. The master
d. Oliver

Question 3

When/in what year do you think this passage takes place?

Question 4

Why do you think that?

Question 5

Where do you think this passage takes place?

Question 6

Why do you think that?

Question 7

Please describe what is taking place in the passage.

Question 8

Why do you think that?

Question 9

Describe what you think life was like for a child in this setting. Please use at least 5 descriptive words, though you're welcome to use more!

Part 2

Please take a look at the following picture and answer the questions. Again, it's ok if you're not sure of the answers – just take your best guess!

Question 1

What is attached to the horses in the picture?

a. Trains
b. Bicycles
c. Carriages and carts
d. Cars

Question 2

When/in what year do you think this picture was taken?

Question 3

Why do you think that?

Question 4

Where do you think this picture was taken?

Question 5

Why do you think that?

Question 6

Describe what you think some of the problems would be for people living at that time.
Please use at least 5 descriptive words, though you're welcome to use more!