Digital Transformation from Traditional Education Towards VR Education : Case Study Plans

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***Abstract*—As Virtual Reality (VR) technologies have become popular and democratic in recent years, academic researchers have been exploring ways to employ advanced VR technologies in traditional education and edutainment. In this paper, we present comprehensive digital transformation case study plans about how to apply VR technologies to modern educations. In our proposal, the teacher standing in front of a blackboard is teaching in a classroom in a traditional way, while, after the digital transformation through our case study plan, the teacher will teach in virtual reality and students will present in a virtual classroom. In this paper, we will explore and prospect important considerations for achieving such a goal through our case study plans.**

***Keywords*—digital transformation; e-education; e-learning; edutainment; virtual reality.**

I. Introduction

With the rapid development of electronic multimedia technologies, education has become an interesting area for fast digital transformation. Such evolution in digital transformation from traditional education towards electronic education is inevitable due to the upgrade of modern computer technologies. In particular, Computer Graphics Animations (CGA) and Virtual Reality (VR) are two powerful areas that can affect the education industry in a tremendous way. With a realistic graphics rendering engine, various types of amazing effects can be visualized realistically on screens, or even on immersive devices such as virtual reality display headsets. This opens a novel vision of how education can affect students' lives.

Many recent research works have focused on VR education and VR training. Some examples include: children education proposed by Roussou et al. [1], immersive virtual reality museum educational tool proposed by Huang et al. [2], and virtual reality-based rehabilitation training applications for people with intellectual disabilities developed by Standen et al. [3]. In addition, Matsentidou et al. [4] developed a VR application for training and enhancing the social skills of children with autism through immersive visualizations in a VR cave environment, Webster et al. [5] proposed an immersive virtual learning environment for corrosion prevention and control training, Chang et al. [6] proposed an immersive virtual environment for foreign language teaching, Bastiaens et al. [7] studied the role of virtual world design for supply chain education, Rahimian et al. [8] developed an immersive game-like virtual reality interface for Architecture-Engineering-Construction (AEC) professionals education, Ali et al. [9] devised an interactive virtual chemistry laboratory for simulation of high school experiments, Griol et al. [10] proposed an approach to develop intelligent learning environments by means of immersive virtual worlds, Braun et al. [11] populated a virtual learning environment for interpreting students with bilingual dialogues to support situated learning in an institutional context, Kleven [12] proposed an approach for medical training and health education through a virtual university hospital, De Ribaupierre et al. [13] developed virtual reality serious games for healthcare training enhancement, Roussou [14] studied young learn-ers' activity within interactive virtual environments, Detlefsen [15] proposed a method to teach middle-school children astronomy using ego-centric virtual reality, and Izatt et al. [16] proposed an immersive visualization and fitting tool for neutrino physics education.

However, no research works have proposed a comprehensive case study plan on how to apply a thorough digital transformation from traditional education towards VR education. In this paper, we discuss the important facts about the teaching strategies in VR. Next, we propose three detailed case study plans for elementary school classes for teaching Chinese as a second language in virtual reality. These case study plans include (1) VR classroom activities, (2) a full VR lesson design, and (3) a multi-cultural project. In the end, we illustrate the diagnostic assessments for differentiation of students in a VR class.

II. Teaching Strategies in VR

An important question is: through VR technologies, what are the teaching strategies and activities that the teachers should plan to use to help students meet the lesson's objectives? In addition, what are the steps that the teacher will take to deliver this lesson (e.g., introduce the author, read the poem, etc.)? In this section, we list what we expect the teacher and students to do as part of this activity through VR teachings.

Critical Thinking. Critical thinking is very important for education. For example, in order to let the students think, students can be asked to write down the advantages and disadvantages of their choice of careers. Also, students can be asked to evaluate themselves and their peers, come up with a self-reflection, and revise the project at the end. In the end, such activity can be simulated in a virtual classroom that gives students rewards through virtual things such as VR flowers and

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VR toys, etc. to increase the students' interest in answering questions.

Group Work. In a VR classroom, students can be asked to evaluate their classmates and peers. Also, students can be asked to finish a task in their group by collaborating in VR.

Literacy skills. Finally, students can present their final work in writing and deliver it through electronic documents. This part can be done in VR living writing boards.

III. Case Study Plan I: VR Classroom Activities

In this section, we give some example of classroom activities planned for VR.

A. Activity1: Present Topic "Me and My Family" in VR.

We design a class activity in VR that allows students to present the topic "Me and My Family" in the a virtual classroom. In this class, the teacher will send the learning material to the students in advance, and they will present what they learn in the virtual class. The purpose of this activity is to stimulate the students' learning motivation, make connections with the language skills and real-world, as well as prompt the students' critical thinking and group work skills.

Before the VR Class. The teacher will send the instructions' video and the Quizlet link to the teams 3 days in advance. The students will learn the new words by themselves using Quizlet. The students will make a presentation about the topic before the lesson and present it in the virtual class. After the students finish their presentation, they will hand it in, and the teacher will let them know if they need to add something to reach the presentation standards.

During the VR Class. The students will present the topic in the VR classroom, including basic information about family members, their jobs and their own dream school, dream job, what are the advantages and disadvantages of choosing their dream school, why they choose a particular career, and so on. The students can choose VR video or VR slides, or VR 3D animation for this presentation. After that, the students will be asked to review their own presentation and their peers' presentation, writing feedback on the presentation through VR interactions.

After the VR Class. The students will be asked to revise their presentation and write down their self-reflection on what they learned from the presentation and how they can make it better next time. After that, they will hand in the final work for evaluation by the teacher. Also, the students will be asked to evaluate their experience in the VR classroom. This is important for improving the VR classroom application.

B. Activity2: Learning new Vocabulary and Sentences in VR.

Through help with VR applications, teachers may give the students more supportive and specific comments on their work through VR interactions. Teachers can comment on the students work and give them positive feedback, but that may not be specific enough in traditional classroom. Rather, in a VR classroom, teachers can give more specific feedback to the students and make the students feel they really did a great job on the presentation through VR gifts. Secondly, VR apps can remind teachers to ask students' opinions regarding previous presenters. In addition, VR apps can make the students interact more with each other, not only present by themselves. They can also discuss some points with their classmates through VR chat boards. Below is the detailed plan.

Before the VR Class. The students will be given the vocabulary Quizlet link in advance. They will study by themselves at home through the VR headset and will have a competition that will include the entire VR class.

During the VR Class. The students will be evaluated by the teacher if they already understand the pronunciation of the new vocabulary during the VR class. Besides, there will be a quiz competition to see if the students understand the meaning of the new vocabulary. The teacher will observe and take notes in the process of evaluating and make reteach plans as necessary through VR animations.

After the VR Class. The students will be asked to draw a picture or write a sentence using VR controllers, or explain in a different language the words they found hard to understand in VR.

IV. Case Study Plan II: A Full VR Lesson Design

Here, an example of a full VR lesson design is presented. The target amount of time for the full lesson is 40 minutes. During the VR class, first, let the students use Pin Yin to read simple texts independently. Then, let the students write in VR by dictating the Chinese characters to be learned under the Four Skills Requirement (listening, speaking, reading, and writing). After that, let the students understand basic, simple language materials closely related to their personal lives and everyday situations. In the end, let students continue to develop good habits in listening and speaking. Students will be able to present the topic "Me and My family" in Chinese. Students will be able to connect the prior knowledge (such as my family, hobbies, etc.) to the new knowledge (such as career, occupations, etc.). Students will be able to talk about their dream school and dream job in a critical way.

Evaluations of VR Class. The evaluation of the VR class can be done through three criteria: (1) Whether the students can use Chinese to do presentations; (2) Whether the students can pronounce different job names in Chinese correctly; (3) Whether the students can work in a team or individually to finish the Quizlet task on understanding the meaning of new words.

Student Diversity and Differentiation. Different students develop different skills according to their own personal weak points. For listening, teachers can give the same instructions to the whole class, but check with everyone if they understand the instructions or if they need extra support. For example, teachers can use some English to explain complicated instructions. Teachers can use Chinese to talk to advanced students to meet their needs. For reading comprehension, students can be

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asked to read most of the content. Teachers can ask students' opinions to see if they need help through VR hints. Students can use simple words and sentences in their presentation, but VR gizmos can help students improve the vocabulary when they need it. For speaking, when students are doing presentations, since they prepare in advance, there might not a big problem with it. However, when it comes to answering questions, teachers can give them a chance to choose the question they feel comfortable answering by doing VR quests. This way, the students with lower speaking ability will not feel nervous in the class. For writing, there can be writing homework after the VR class.

Formative and Summative Assessments. As shown in the described in-class activity of the presentation on the topic "Me and My Family", students will present the topic in the VR classroom, including basic information about family members, their jobs and their own dream school, their dream job, what are the advantages and disadvantages to choosing their dream school, why they choose their career, and so on. They can choose VR video or VR PPT for this presentation. As for dictation, there can be a dictation in VR or by VR robot for this unit about the words learned that day. There can also be a Quizlet competition on vocabulary-related jobs. After the unit, at the end of the week, there will be a summative assessment on the topic of career, including speaking, reading comprehension, writing, listening, and other VR class activities.

V. Case Study Plan III: A Multi-Cultural Project

Project Overview. Here, we give an example of a VR class project proposal called Minorities in China. The China Studies program includes multi-cultural projects about the ancient town of Lijiang and Naxi culture in China, in which students will learn about China's ethnic cultures and special cultural practices. The Social Studies course includes "Passport to the World", which will lead students to understand the cultures and cultural differences around the world. Therefore, the idea of this project was born with the idea of leading students to understand the culture and cultural differences of China and other parts of the world through the Google Earth VR app, and by consulting materials and personal experience and making a culture introduction VR PPT about a certain place on Google Earth through virtual tours.

Project Objective. Students can learn to use VR technology tools (such as Google Earth App) to search information and sort out the information in a logical sequence. The community can understand more about the minorities in China after listening to the students' presentations. The whole school community would be more respectful of different cultures and have a better understanding of the school mission.

Project Description. All the students are divided into four groups. In the VR class of Chinese studies, they will learn about the minority cultures of Naxi and the ancient town of Lijiang under the guidance of the teacher and they will experience the secrets of minority cultures in the process of learning Dongba pictographs through VR applications. Then, the teacher will introduce the cultural characteristics of different countries in theme classes. Later, the teacher will introduce several minority cultures other than Dongba culture, such as African minority culture, American Indian culture, etc. on VR Google Earth. The students will be allowed to choose or search the minority culture they are interested in. Later, the information will be collected in groups in order for the students to learn about the cultural characteristics of ethnic minorities they are interested in, to introduce them to their parents at home, and make a VR PPT. In the end, the students will collect information and write interview questions. They will interview teachers or adults at school about their understanding of the minority culture and their first impression of it. The students will make VR posters to briefly introduce this special culture and put them on the doors and windows in the virtual classroom. These proposed VR class projects align with the missions in art, technology, and culture. This project aligns with culture. In the implementation of this VR project, teachers will link it to the art class and students will create VR posters to demonstrate different minorities. All students will use VR technology tools to search for information and show the presentation, so this project aligns with technology and art as well.

Project Syllabus. In weeks 1-2, the teachers will introduce the minority groups to the whole class through the VR classroom. Then, the students will discuss what impressed them and what are the minority groups they are interested in. Then, the students will choose a minority group in China to explore in the Google Earth VR app. Between weeks 3-6, the students will work in a group to search information such as facts, traditions, taboos, dress, etc. In week 7, the students will present and make the survey in the VR classroom. They will also be giving presentations to the community members in the school to introduce different minorities and interview the community's opinions regarding different minorities. In week 8, the students will have an evaluation. They will make posters and post them in different places in the VR classrooms. Teachers will use this rubric to evaluate the students work and their projects.

VI. Diagnostic Assessments for Differentiation

Importance. The data collected from the pre-assessments in VR education can help the teacher easily have a general idea about the students' learning stages. It is important to know the students in-depth as well. It can also guide the formative assessment or the summative assessment later in the learning process. Teachers can target the students' weaknesses to give instructions and assessments for the students through personalized VR classes. It is important for grouping as well. Either for homogeneous or heterogeneous grouping methods, the teachers need to know the differences between the students in advance. Teachers can give specific support with the data collected from the students. This is similar to a doctor helping the patient according to the diagnostic results. For teachers themselves, it can also be helpful. Teachers can use the data to

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make teaching plans and learning objectives instead of wasting time teaching subjects all the students already learned or understand. For example, when the teachers get the data from the pre-assessment, they can delete the object that may appear on the standard guidelines, but actually, for these students, they all get a good understanding of it. In this way, time can be saved for both teachers and students. Meanwhile, the learning proficiency and effectiveness are improved. This practice can also help with school-wide learning. By getting the data on the students, teachers from the whole school can find out the weaknesses of the students and can also cooperate with each other to help the students according to the pre-assessment data. This is also useful for parents' communication. With the data of the pre-assessment, teachers can easily have the evidence to show the parents how much their kids improved and in what areas the progress was made.

Impact on Students. In a VR classroom, the students can be both interested and challenged. They will listen more carefully and pay more attention to what they are doing because the teaching content can be both interesting and challenging for most of the students due to the powerful algorithms employed in VR applications. They will get a chance to improve themselves by focusing on whatever they need according to the pre-assessment. The students will enjoy group work more because teachers can form the groups according to the pre-assessment results and the VR is user-friendly for easy interactions. The grouping method will make all of the students feel comfortable and safe, which can improve the working efficiency at the same time. The students will get an idea on what the teachers' expectation is and will have a clear aim about what they need to do at the next stage. Students will be less stressed when they face summative assessments at the middle or the end of the semester because they know that, although there will not be the exact same questions, the learning objective will be the same, and if they work hard during the learning process, they will make progress for sure. Students will be more motivated in the VR classroom. Students will participate more in the different VR activities because they know that all of the assessments are related to each other; if they work hard, they can get a good result at the summative assessment. Meanwhile, they will enjoy the VR interface of the virtual school.

Pre-Assessment vs. Summative Assessment. How can teachers align the pre-assessment and the summative assessment for Chinese education in VR? After having the pre-assessment (dictation for each unit) in VR, teachers will understand what they should focus on at the next teaching stage. Then, teachers will finalize the learning goal for the whole semester and arrange different goals into different learning periods, such as monthly goals, weekly goals, even daily goals. Then, when teachers prepare the summative assessment, they can make sure all the content that appears in the assessment had been taught already. Teachers can separate the small goals into different learning units. They can give students pre-assessment in VR (Quizlet and Kahoot, because for the CAL students, most of the content are words and sentences.) on every unit to find out the difficulties. After the pre-assessment, the teachers can use the RTI method to separate students into different groups. The teachers can give differentiated instructions according to the pre-assessment results. They can set up different goals for students in different tiers, give different instructions, and design appropriate VR activities for different students. They can summarize and review the semester goal at the end of the semester. They can finalize the summative assessment according to the students' academic performance in different tires and the pre-assessment results. In addition, they can give students the summative assessment containing the whole semester goal which aligns with the pre-assessment as well.

Information from the Pre-assessment Data. Here, we address the question on how can the data that teachers gather from pre-assessment inform instruction and grouping practices in the VR classroom as well as how to use this data to make the teaching plan. Teachers will delete the objectives students already learned based on the pre-assessment data. Teachers will focus more on the objectives students have common difficulties with during the VR class activities. For the students who have their own strengths, but show some difficulties, teachers will differentiate when implementing activities. Teachers will use the pre-assessment data to group the students according to the different learning activities through the VR technologies. Teachers will mix students with different levels when teachers want them to help each other through VR communications. Besides, when the teachers want to make the activity meet each level of students' needs, they will use a homogeneous group of students. Collecting the pre-assessment data lets teachers know exactly where each student stands compared to their classmates and peers nationwide. So, teachers can make different groups of students and give them differentiated instructions. For example, if they have similar interests, they will be grouped into one group when teachers have different topics in the class, but towards the same teaching objectives. When teachers want the students from different groups to help each other, they will group students in a heterogeneous way to mix students belonging to different levels into one group. With the data of the pre-assessments, teachers can use the it to develop individual academic learning goals with students. Going beyond the individual student level, teachers will collaborate with other teachers in the school and adjust the school-wide goal. For example, the pre-assessment data can be used when developing Chinese teaching VR apps. Teachers will delete the learning objectives of the words and skills all students already have based on the pre-assessment. The teachers will make a record about the pre-assessment for other teachers' reference. If teachers feel a learning goal should be moved from the VR classes, they will suggest making some changes to the VR teaching package.

VII. Conclusion

In this paper, we present several thorough case study plans for welcoming the digital transformation from traditional education towards VR education. We first discuss the important

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facts about the teaching strategies in VR by addressing four factors in VR language education: (1) Critical Thinking, (2) Group Work, and (3) Literacy skills. Then, we propose three detailed case study plans for elementary school classes teaching Chinese as a second language in virtual reality. These case study plans include (1) VR Classroom Activities, (2) A Full VR Lesson Design, and (3) A Multi-Cultural Project. In the end, we illustrate the diagnostic assessments for differentiation of students in VR class. As for the VR classroom activities plans, we propose two different in-class activities: (1) student presentations in VR and (2) learning new vocabulary and sentences in VR. In the full VR lesson design, teachers will emphasize students' skills in reading using Pin Yin, students' skills in writing with VR by dictating the Chinese characters and students' understanding of basic, simple language materials closely related to their personal lives and everyday situations. In the multicultural project, students will learn about China's ethnic cultures and special cultural practices through VR Google Earth App and learn to speak Chinese as a second language at the same time. In future work, we will extend our proposal into a real VR teaching application package and conduct a large-scale user study to apply such teaching plans to elementary schools' digital education. We believe our proposal and follow-up works will become stepping stones to open a new age of digital education through virtual reality.

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