Computational Thinking and Language Immersion with Umwelt

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Abstract. To improve computational thinking skills and second language acquisition in primary schoolers whose learning has been impacted by COVID-19, Umwelt presents a game that simulates real-life interactions and simple tasks (e.g., collecting several items given in the form of a computation problem, selecting an object with an identified color) to demonstrate the place of computation and language in everyday life through an XR system. The game consists of challenges that test the abilities of kids to break problems down into smaller parts, recognize patterns and important details amongst them, and develop step-by-step strategies to solve these challenges. These problems will require sizable amounts of interaction where kids will gain language learning skills in addition to computational thinking skills. Umwelt is built on the fundamentals of Krashen's Theory of Second Language Acquisition (SLA) and Natural Language Processing (NLP) systems. Noting the portability of Umwelt, children will have the opportunity to tackle problem sets and immerse themselves in new languages wherever they feel most comfortable and confident. The implemented Interactive Voice Response (IVR) system will guide users as they continue to understand the given questions, solve the tasks and familiarize themselves with these applications. Children will be able to enhance their computational abilities through these interactive activities. This method of gamification takes advantage of XR technology to provide all the necessary grounds for learning through games, a channel common amongst children. These principles, coupled with creative problem sets, prepare students for the immediate future based on Computer-Human Interaction while simultaneously raising them as world citizens. Considering the impact of COVID-19, houses have become the new learning environments of primary schoolers, and Umwelt's XR based structure builds on this by bringing the world to these children.

Keywords: Computational thinking · Computation · XR system · Natural Language Processing (NLP) · Interactive Voice Response (IVR) · Krashen's Theory of Second Language Acquisition (SLA)

1 Introduction

Only in the United States, the COVID-19 pandemic forced schools to close in spring 2020 and over 50 million students were asked to continue their education remotely [8].

C. Stephanidis et al. (Eds.): HCII 2021, CCIS 1499, pp. 249–257, 2021.
https://doi.org/10.1007/978-3-030-90179-0_32

According to a survey conducted by Youth Truth Student Survey, an American nonprofit occupied within "The Center for Effective Philanthropy" (CEP), although students state that they understand the benefits of online learning (flexibility, closure to family members), however, distractions at home, stress, and anxiety [3], and lack of social connections underscores the importance of modifications in online learning curriculums [8]. According to UNESCO's data, the extent of COVID's impact on learning has significantly increased during the April-May period due to localized and national lockdowns in low-income and high-income countries, resulting in a consequential decrease in the accessibility of face-to-face education. Combining the aforementioned consequences of school curriculums being taught and learned remotely, the weighted impact of COVID in learning and education arises as a major issue [5].

1.1 Learning During Covid

The negative effects of the pandemic particularly in language learning and the development of math and problem-solving skills of children is a great issue. Second language learning and teaching, alongside many other fields, were significantly influenced during the pandemic era. B.W. Sarnecka's studies show that social interaction is a key component to accelerating proficiency, fluency, and speaking skills in a second language, especially for children [7]. Temporary school closures and mitigation policies due to COVID resulted in the restriction of such interactions among children and teachers, directly affecting the learning efficiency of second languages. Supporting this fact, research conducted for English learning speakers shows that learners of the second language showed less development in speaking skills [14], which used to include social interactions, than in other areas.

2 2D and 3D Learning Environments

A study on "Student performance and appreciation using 3D vs. 2D vision in a virtual learning environment," aimed to investigate the differences in the performance and appreciation of students that worked in 2D and 3D virtual learning environments. It was seen that students were more appreciative of and better at performing tasks in 3D learning environments [13], which validates Umwelt's use of 3D visuals to engage with the learners.

2.1 XR Systems in Learning

Extended reality (XR) is a term that refers to all the combined real and virtual environments and human-machine interactions. The most common XR technologies are Virtual Reality (VR), Mixed Reality (MR), and Augmented Reality (AR). Virtual Technologies are found to be capable of improving students' academic performance and motivation by taking advantage of the students' free and secure environment and intriguing designs [9]. These immersive and interactive tools have the potential to increase learner motivation through gamification and engagement through their 3D field while promoting a student-centered learning experience [4], supporting collaborative learning, and enabling

learners to concretely and tangibly access previously physically inaccessible/invisible or abstract content [9].

During times of isolation, XR systems provide an interactive environment with the virtual outer world. Umwelt's proposed VR system's aim is to create the interactive world middle schoolers are lacking during online learning.

In addition to providing immersive and interactive learning experiences, VR, and XR systems in general, motivate students to explore new academic or nonacademic fields [2]. For instance, to help people grasp 3D concepts (e.g. geometry), studies have shown that through AR and VR, people can check out 3D geometric forms from multiple perspectives; they can rotate a shape to see it from different angles including looking from an internal point of view and external point of view [15] (Kaufmann). Umwelt aims to take advantage of this free space. Umwelt's 3D world creates an environment specific to the selected culture of the language the player wishes to immerse themselves in. The images of the game are from a Spanish perspective, the market contains objects indigenous to Spain and the actions of the characters represent the widely accepted courtesy displays. Taking advantage of the freedom provided by VR, Umwelt also aims to set different goals at different levels- or even different steps in a given level. The supermarket level aims to familiarize the player with cultural elements and their names. The player is then expected to break down the task (explained in detail at 3.1) and perform simple computation while also developing simple financial literacy through calculating for change.

2.2 Related Works

XR has only recently started being utilized in SLA. However, attributes of VR systems strongly complement that of SLA [10] As a result XR technology has been utilized by various applications designed to teach language. An example of this is Mondly. Mondly is an XR-based SLA application. Mondly also utilizes speech recognition systems to test pronunciation [11]. Speech recognition allows Mondly to also increase the amount of interaction, much like our goal with Umwelt. However, Umwelt follows a more rewarding and game-based approach to this concept, effectively combining it with computational skills, to allow higher acquisition rates.

Moreover, a system designed for SLA called Ogma also utilizes VR technology [12]. Ogma uses virtual reality to create an immersive experience in an environment representing a place related to the desired language. The system functions similarly to Umwelt, with a focal point on cultural immersion. On the other hand, Umwelt utilizes both cultural immersion and social interaction. In Ogma's pilot study "the effectiveness and enjoyability ratings given by users were significantly higher for the VR method." [12] This positive result provides insight into the expected research results from Umwelt's pilot test.

3 Game Design

3.1 Gameplay

The VR environment is assembled in Unity. The prototype consists of two main scenes: the start scene and the supermarket scene, labeled as Figs. 1 and 2. The start screen only

serves the purpose of an introduction to the supermarket scene. The demo only consists of one scene which is the supermarket. Once the character enters the supermarket, a notebook is displayed to greet the player and explain the task as seen in Fig. 3. The greeting is given in both English and Spanish but the rest is only in Spanish.

Fig. 1. Start scene

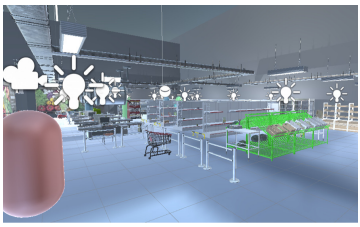

Fig. 2. Supermarket scene

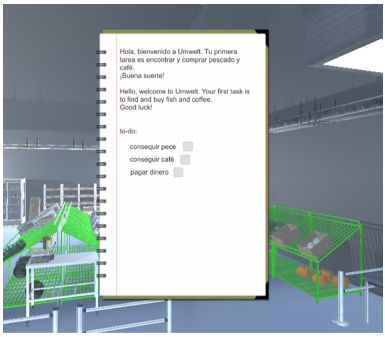

Fig. 3. Notebook with greeting and to-do list

The player is told to find certain items that are shown after the instructions: The desired objects are allocated through the aisles in the supermarket in a pre-arranged order. The player will have to rely on their common sense to locate the necessary aisles and examine the products on shelves to find required objects. To eliminate the chance of players finding the objects by chance, it is required that they are next to the object to pick it up. The game instructs the player to select a fish and a bag of coffee. The coffee aisle is the second aisle from the entrance and the fish aisle is located at the very end of the supermarket. When the player reaches the necessary sections and interacts with the containers, the required item is handed over to the player. Around the fish section, three NPCs can be found; a fish seller, a lady buying fish, and a coffee enthusiast. When the player approaches the NPCs, a dialogue is played. The coffee enthusiast expresses his love for coffee and the lady is buying fish in a conversation with the seller, as seen in Fig. 4. All of the dialogues are in simple grammar so as not to overwhelm the player. After acquiring the items, the player then has to go to the cashier to pay for the fish. When the player faces the cashier that says: “A fish and some coffee. Is there anything else?” in Spanish. The player thereafter has to give an appropriate response to advance the conversation. The same dialogue is repeated until the player informs the

cashier that's all. Through IBM Watson's voice recognition system the communication between the player and non-player characters (NPCs) is established. IBM Watson's Castilian Spanish model ("es-ES_BroadbandModel") is implemented. After informing the cashier, the cashier says "That will be 7 (monetary units) for a fish and some coffee". Then, the player has to utter a payment in the form of a sentence. To do this, the player must listen to other NPCs (non-player characters) to figure out the words they need, to form sentences. The conversation between the lady and the fish seller is especially informative in this regard. This develops the player's computational skills and improves their second language acquisition as the player needs to compartmentalize speech given by NPCs and recognize patterns to learn the language. Subtitles are provided to more easily understand the contents and the meaning of the spoken dialogue. After the player forms a sentence that indicates that they are paying the required amount of money for a fish and some coffee through speech, the cashier thanks the player. This is where the demo concludes.

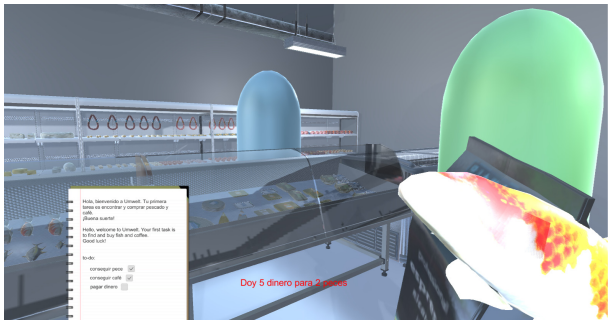

Fig. 4. The lady and fishmonger's conversation

3.2 Krashen's Theory of Second Language Acquisition (SLA)

One of Umwelt's aims is to provide a means of Second Language Acquisition. The foundations of Umwelt were built on Krashen's Theory of Second Language Acquisition (SLA), which consists of 5 fundamental parts. The Acquisition-Learning hypothesis, the Monitor hypothesis, the Input hypothesis, the Affective Filter hypothesis, and the Natural Order hypothesis [6] The initial step states that acquisition, the process children go through when learning their first language, should be prioritized in SLA as it differs from "formal" learning [17], which is based on conscious "knowledge" typically seen in student-teacher interactions. Concordantly, Umwelt focuses on highlighting acquisition instead of being taught an additional language. The player acquires language through interacting with NPCs, listening to them, and repeating the words and word order they use under similar circumstances. The game's levels replicate a student-centered environment utilizing acquisition to enable players to fully benefit from the available input. Even though traditional learning methods play a minuscule role in SLA, it still functions as a monitor to police the utterances of a language learner as given in the Monitor Hypothesis

[]. Umwelt accomplishes this through "monitoring" reactions of NPCs to the player's speeches. These can be in the form of facial expressions, gestures, or questions such as "Did you mean …?" Moreover, Umwelt's game design aids players in acquisition per the Input Hypothesis. The NLP system in Umwelt recognizes the level of the player in terms of language, and then provides input of a reasonably higher level. As a result, the acquisition process of players is guided according to their current level, allowing learners to go at their own pace. Throughout this entire process, the game allows the user to stay motivated by adjusting the level of difficulty and not discouraging the player, as well as establishing a simple reward system. When the player performs exceptionally well on a level, they receive a gift from the level's NPCs that allow them to unlock additional levels and locations throughout the game. This is in line with the Affective Filter hypothesis.

3.3 Simple Computation and Computational Thinking

Computational thinking (CT) entails four main processes. Decomposition, abstraction, pattern recognition, and algorithms. Decomposition is the breaking down of a problem into smaller parts, while abstraction is removing unnecessary details [16]. Pattern recognition is realizing a pattern between those parts, and algorithmic thinking is when we use those patterns to form a comprehensive step by step, set of rules [16]. All of which are expressed thoroughly in Umwelt's design, as will be mentioned later on. Umwelt transfers this type of thinking through two main methods, both of which are ingrained into the very function of the game. First is our method of language education provides a great means of CT education as well. A player has to break spoken language down in parts, recognize patterns of words and gestures or objects and then connect these to form their own sentences, essentially making an algorithm of their own. This method of SLA strongly integrates CT into acquisition. Additionally, Umwelt's gameplay involves a sizable amount of puzzles where players will need to follow the methods of CT in order to progress in the game (See Sect. 2.1 aisles for an example). As a result, players' CT skills are highly stimulated through every aspect of the gameplay. Simple computation, however, is a process of performing basic numeric and algebraic operations differing from the CT process. Umwelt also works to improve the computational skills of player's since, as seen in Dr. Rahmah Apen's study [1], while developing computational skills, retention of aspects of grammar increased drastically. Since Umwelt does not directly focus on grammar teaching, computation was integrated into its gameplay to increase retention from monitoring systems detailed in Sect. 2.2. Umwelt -in its demo- achieves computation based task implementation by the means of financial literacy. An example of this can be seen in the scenario given in Sect. 2.1. In this scenario, players are tasked with making the optimal choice, as a result the player uses computation to determine how much money to give the cashier, and how much change to ask for. This method was used for Umwelt's demo as financial literacy provides a tangible and objective method of measurement to look for any correlations between computational improvements and language acquisition.

4 Expected Research Plan

Through research, Umwelt aims to develop its content and format as well as enlightening theoretical information with empirical data. At Umwelt's development stage, the main research concept is testing the effects of implementing a language teaching approach via XR systems, 3D visualization, in an environment of cultural elements, supported by Krahsen's SLA, and the features of Umwelt as presented above rather than standardized digital language learning methods and products on learners' efficiency in learning and proficiency in the language. An additional aim is testing the effects of personalized learning approaches in language learning and teaching for Umwelt and different frequencies of exposure to the language via Umwelt on the proficiency of the learner for future improvements. It is expected that Umwelt, with its engaging features, helps learners of its target audience gain practice with Spanish grammar, speaking, and listening with comparably higher efficiency and productivity and resulting in a learner more proficient in the language than a learner trained with standardized methods, where "standardized methods" refers to popularized language teaching methodologies in digital apps.

Through this research, Umwelt can be proven or disproven of its effectiveness and be improved in various places, particularly on personalized learning, the optimal frequency of use, reconsideration of the implementation of SLA, and engagingness from students' test scores and feedback.

As Umwelt's target audience, 5th-grade students, with Turkish as their mother language, that voluntarily participates will be a part of the research. The following steps show the research process:

Students will be separated into two groups: Group A, which includes those who have had no formal education in Spanish, and Group B, which includes those who have. Students involved from each group will be sent a survey highlighting their interest in learning a new language, their interest in learning Spanish, their previous knowledge of any language, languages spoken and native speakers in their households, their familiarity with languages, and their specific familiarity with Spanish. After the survey, students will be grouped once again according to their involvement and previously shown interest in Spanish and other languages. This is required since familiarity with the language and exposure has a direct and significant impact on proficiency as concluded from Brière's studies. Then, students will be introduced to their working schedule and product. A group of students from Group A and Group B that contain students from all different subgroups will use standard digital language teaching apps, as the rest use Umwelt, whilst exposure to Spanish being kept the same for each student. The research will go on for one month. Students will follow this program with proper controlling periods to track their exposure time and progress. This part of the research will require the researchers to be highly engaged with the students to check their progress. After one month, students will take a test that tests only the topics covered on both of the platforms. The date of this test will not be announced to the students to make sure no intentional studying was present and to extract data with higher accuracy. This test will be based on speaking skills and pronunciation. Speaking skills will be valued particularly due to COVID-19's effects on children's proficiency in speaking and to test how our product can cope with this way of teaching. Afterward, points gained from the test will be analyzed to determine the effectiveness of our product and to improve its features based on that.

5 Conclusion and Future Works

Umwelt, though in its prototype stage, aims to provide a gamified environment to enhance learning. Currently, Umwelt only focuses on second language acquisition and includes some computational thinking elements but hopes to expand and cover a wide range of other supplementary options to aid other course contents and include more computational thinking in the process. The game warrants computational thinking-based approaches to SLA in a manner tailored to kids. Thus strengthening both simultaneously. Umwelt does not follow a certain curriculum; therefore, anyone can access the game without feeling alienated. Additionally, more complex sentence structures and an expanded set of vocabulary are soon to be introduced. The current gameplay of Umwelt is simple and easy to understand. Once the game is tested, Umwelt hopes to introduce a more personalized experience for students and implement visual feedback loops within its gameplay. It is true that the characters in the gameplay only accept certain phrases even though students may come up with sentences with different words that mean the same thing. This is why Umwelt hopes to enlarge its library and randomize the plot for future players. Umwelt also aims to implement Machine Learning systems to customize the game according to the player's level, increasing the efficiency of learning of individuals by letting them go at their own pace.

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