

3D Multi-User Virtual Environment in Language Teaching

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Abstract—This article focuses on the use of 3D multi-user virtual environment in language teaching and presents the results of a four-year research at the Palacky University Olomouc Faculty of Education (Czech Republic). Language teaching was conducted in an experimental form in the 3D virtual worlds of Second Life and Kately (experimental group) and, in parallel to this, there was also traditional teaching conducted on identical topics in the form of lectures using a textbook (control group). The didactic test, which was presented to both of the groups in an identical form before the start of teaching and after its implementation, verified the effect of teaching in the experimental group by comparing the achieved results of both groups. Out of the three components of mother tongue teaching (grammar, literature, composition and communication education) students achieved partial better results (in the case of points focused on the visualization of the subject matter, these were statistically significant) in literature. Students from the control group performed better in grammar and composition. Based on the achieved results, we can state that the most appropriate use of multi-user virtual environment (MUVE) can be seen in teaching those topics that have the possibility of dramatization, experiential learning and group cooperation.

Keywords—3D virtual reality, multiuser environments, online education, language education.

I. INTRODUCTION

AS a result of the global COVID-19 pandemic, the education sector is currently facing the challenge of rapidly implementing online educational tools into teaching, often in the form of a complete transition to purely online teaching due to imposed hygiene restrictions. Educational institutions at all levels of schooling as well as lifelong learning institutions were not sufficiently prepared for such a quick organisational shift – some of them face problems of insufficient digital competences of teachers or the lack of knowledge of specific online educational tools that could benefit their pupils and students. In addition to a number of online communication tools (such as ZOOM, MS Teams, Skype, etc.), there are also various Learning Management Systems and 3D virtual reality environments.

Even before the pandemic, there were a number of schools, especially in the USA, that taught their students in a 3D MUVE. For example, the large-scale project *Quest Atlantis* focused on children aged 9 to 15 had over 50,000 participants and more than 22 different countries participated in the projects run as part of *Quest Atlantis* [1]. In Atlanta, more than 38,000 students from 35 schools participate in a MUVE built using *OpenSimulator* [2]. We may also mention other projects, such

as Harvard University's *The River City Project* aimed at students from grades 6 to 9 [3]. The largest 3D virtual worlds, with millions of users from across the world, are *Second Life*, *Sansar* and worlds built using the aforementioned technology OpenSim, such as *Kately* [4]. The most common type of education in these virtual worlds is language teaching in particular, and many universities and other educational institutions use these 3D virtual environments to aid specifically with language teaching.

II. RELATED WORK

Despite the fact that much has been written about 3D virtual reality, there have been significantly fewer research studies mapping the effect of education through MUVES – which in addition to three-dimensional simulation of reality also allow for direct social contact with teachers and classmates – from among these studies, we may mention at least [5] or [6]. Nevertheless, such research is necessary to ensure that these environments are not included in the learning process without knowing what effects (whether positive or negative) teaching in this environment can have on the learning outcomes of students.

In our research, we focused on the use of MUVES in language teaching. At the Palacky University Olomouc Faculty of Education, we have been teaching through MUVES for over 10 years and have gradually moved from using the Second Life environment to building our own virtual faculty building in the OpenSim environment Kately, in which we gradually create our own 3D objects for language teaching [7]. We use this environment both for teaching the mother tongue and its individual components (grammar, literature, composition and communication education) and for teaching Czech as a foreign language (environments simulating various conversational environments).

Our research focuses on examining the impact of teaching in MUVES on learning outcomes in language teaching. As part of our inquiry, we posed the following research questions:

- 1) Does teaching in MUVES lead to better results in memorising concepts when compared to traditional teaching?
- 2) Is there a significant difference in learning outcomes when comparing MUVE teaching with traditional teaching?
- 3) Is there a difference between the results of men and women when comparing teaching through MUVES and traditional teaching?

To answer these questions, we have produced several

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environments in MUVE that can be used for teaching individual components of the mother tongue (grammar, literature, composition and communication education) and for teaching Czech as a foreign language.



Fig. 1 Virtual building of the Palacký University Faculty of Education in Kitley



Fig. 2 Example of an environment for teaching the mother tongue (teaching on the topic of reporting)

III. MATERIALS AND METHODS

The research survey was carried out over a period of 4 years using the method of mixed research design based on a combination of quantitative and qualitative approaches. From the point of view of quantitative research, there was the comparative analysis of the input and output didactic test in the experimental group taught through MUVE and the control group taught in the traditional way (teacher's lecture supplemented by a textbook). In terms the qualitative approach, there was a semi-structured written survey to determine the views of students of the experimental group on teaching through MUVE, processed via the method of grounded theory [8]. By dividing the answers according to certain criteria, the views of students were easier to sort through and determine where were the strengths and weaknesses of teaching in a virtual environment and identify what could be the biggest issues with its use in practice. Semi-structured questioning was always carried following the completion all the teaching units (i.e., after teaching all components of the mother tongue).

Teaching through MUVE was implemented for 3 basic

components of mother tongue teaching – grammar, literature and composition and communication education. For each of these components, 3D virtual objects for the various taught topics were created and as well as an input and output didactic test, which was identical for the experimental and control groups. The didactic test was evaluated statistically according to predetermined criteria, the validity and reliability of individual tests were verified. Validity was determined by the assessment of a relevant expert; reliability was verified via the Kuder-Richardson reliability coefficient and the halving method using the Spearman-Brown formula [9]. The reliability of the didactic test was calculated using the Kuder-Richardson reliability coefficient after the first grammar test. The reliability coefficient can take values from 0 (= complete inaccuracy and unreliability of the test) to 1 (= maximum accuracy and reliability of the test). For the purposes of pedagogical research, it is necessary to reach a value of at least 0.8 [9]. After substituting the values, we obtained a reliability coefficient of 0.803, so the test could be considered sufficiently reliable for testing students. To compare the effectiveness of both teaching approaches, we also used Student's t-test, which verified whether the differences in the results are statistically significant [9]. Sensitivity was assessed based on the results of calculating the upper-lower index (ULI) coefficient.

A. Statistical Evaluation of Data

The test results for each area were described using mean, standard deviation (SD), and median values. In addition to the point score, we also calculated the percentage of success in the test, where the total gross score was compared to the maximum achievable gross score for the given area of testing. The overall success in the test was calculated as the sum of the results in the test before and after the course. IBM SPSS Statistics version 22 was used to validate the hypotheses. Test results achieved in the control and experimental group as well as the results obtained in the group of men and women were compared using the Mann-Whitney U test. A non-parametric test was chosen due to the non-normal distribution of score values. Normal distribution was verified using the Shapir-Wilk test. All tests were conducted at a significance level of 0.05.

B. Respondent Set

The research group consisted of a total of 303 respondents – 160 of them participated in virtual teaching, 143 in theoretical teaching. The group of respondents consisted of students of Czech language and literature at the Department of Czech Language and Literature of Palacký University Olomouc. The average age of the survey respondents was 21.6 (\pm 0.3) years. All respondents participated in a quantitative survey through didactic tests before and after teaching. Students included in the experimental group – who were taught through MUVE – were also included in the qualitative research through semi-structured questioning.

In all teaching units, respondents received the same information, all participated in teaching in all three components of their mother tongue, all were assigned on the basis of predefined and described categories to a specific user level for

working with information technologies – the criteria for this were determined through the international concept of standardised computer skills, the European Certification of Digital Literacy and Digital Skills (ECDL) [6]. A total of 48.1% of students reached the basic level according to ECDL and 51.9% were intermediate according to the ECDL. The advanced user category was not represented in the research, as it could represent a contamination of better results due to the greater ability of these respondents to manage the virtual reality environment. As a result, one respondent who was determined as an advanced user was excluded from the group. At the same time, we maintained the homogeneity of the experimental and control groups.

IV. RESULTS

In the overall performance in the implementation of teaching units in the experiment, the overall average performance was better in the control group, which achieved an 8.3% better result (the total average performance of the experimental group was 43.8%, for the control group it was 48.1%, $p = 0.006$), Table I summarises the details.

TABLE I
OVERALL PERFORMANCE IN THE TEST

Components of the mother tongue teaching	Experimental group	Control group	Statistically significant difference
Grammar	27.8%	33.9%	+
Literature	60%	54.5%	YES
Composition and communication education	42.6%	51.5%	YES

The differences in the results between the experimental and control groups in the individual components of the mother tongue teaching were statistically significant, an overview is provided in Table II.

TABLE II
PERFORMANCE IN INDIVIDUAL COMPONENTS OF MOTHER TONGUE TEACHING

	Experimental group		Control group		P
	Average \pm SD	median	Average \pm SD	median	
Grammar (before course + after course) points	24.5 \pm 8.2	24.0	29.7 \pm 10.1	28.0	0.0001
Grammar (before course + after course) % of success	27.8 \pm 9.3	27.3	33.9 \pm 11.3	31.8	
Literature (before course + after course) points	26.1 \pm 6.0	21.0	19.6 \pm 4.8	20.0	0.01
Literature (before course + after course) % of success	60.0 \pm 16.7	58.3	54.5 \pm 13.4	55.6	
Composition (before course + after course) points	13.6 \pm 4.7	11.5	16.5 \pm 3.9	16.0	0.002
Composition (before course + after course) % of success	42.6 \pm 14.6	40.6	51.5 \pm 12.3	53.1	

Prior to teaching, the results in the area of grammar of the experimental and control groups were comparable. After teaching, there was a more significant improvement compared to the results before teaching in the control group –

improvement by 18.7%. For the experimental group, there was an improvement compared to the results before teaching by 7.8%. This difference was statistically significant ($p < 0.0001$). In the field of literature, there was the same average improvement after teaching in both groups – in the experimental group it was an improvement of 28.5%, in the control group there was an improvement of 29.5%. The difference in improvement results after teaching between the two groups was not significant ($p = 0.551$). In the area of composition, the results of both groups prior teaching were comparable, after teaching there was a greater improvement in the control group. The improvement in the control group was 39.5%, in the experimental group there was an improvement of 16.4% after teaching. This difference was statistically significant ($p < 0.0001$).

In the overall evaluation of all components of the mother tongue teaching, the control group achieved better average results, both among men and women. For men, the overall average performance was 4.5% better, for women it was 9%. In the experimental group, men and women did not differ in overall mean performance in the grammar test ($p = 0.228$), literature ($p = 0.830$), and composition test ($p = 0.598$). In the control group, when comparing men and women to the overall average performance in individual tests, it was found that men and women in overall performance did not differ in the grammar ($p = 0.189$), literature ($p = 0.805$) and composition ($p = 0.811$) tests. Thus, there is no connection between the average performance in each of the tests conducted on the experimental and control groups and gender.

As part of the experiment, we also looked for the influence of 3D visualisation of the subject matter for better memorisation of concepts and aspects. Within the didactic tests, 3 questions were selected for each component of mother tongue teaching, which could be easier to answer through 3D visualisation and working with the given objects in a MUVE. For 2 questions from the grammar test, a statistically significant difference ($p = 0.022$ and $p = 0.010$) was demonstrated in the sense that the average result was, contrary to our assumptions, better among members of the control group than the experimental group. For literature questions, a significantly better result (i.e., higher average value of the point score) was found among the experimental group ($p = 0.039$). Furthermore, there was a significant difference between the experimental and control groups in the results after teaching for question 3a ($p = 0.003$) and question 3b ($p < 0.0001$). The experimental group showed a higher average point score value – that is, a better result than the control group. For questions from composition and communication education, the control group had a significantly better results for question 3 ($p = 0.004$).

V. DISCUSSION

The results of our research did not show a significantly higher success rate of students in the experimental group. However, one reason for this could be the novelty of the MUVE environment in which they moved, so part of their attention was focused mainly on the ability to control their avatar, move in the environment and also explore individual details of the

environment. For the control group, which was taught through a traditional method to which they have been accustomed to for years, there was no such mental distraction. Therefore, future research is needed that would be focused on longer-term (e.g., one-year) teaching through MUVE, during which students would already be able to move in the environment with confidence. Such research could rule out with certainty that it is not the environment that causes worse results, but rather the novelty of bring present within it paired with having to divide one's attention on moving within the environment.

In the case of the literary component of mother tongue teaching, one of our hypotheses was clearly confirmed (with statistical significance $p < 0.0001$): that visualisation of the subject matter enhanced by manipulation of objects in MUVE (experimental group) will lead to better memorisation of elements and concepts than if the student only passively sits and listens to the teacher's lecture (control group). We believe that the main reason for this is that all students could be present in MUVE at the same time and that, in manipulating the objects (characters from Shakespeare's plays), they had to cooperate with each other to decide who will place what 3D object and where. Others observed their work. In the case of traditional teaching, students were merely introduced to the characters of Shakespeare's plays meaning that only their aural and visual sensory perceptions were involved in the learning, rather than also including kinaesthetic perception or even an emotional element (the visual experience of moving the characters, the need to negotiate with others, etc.). However, the effect of moving 3D objects was less significant in the case of grammar teaching (teaching the topic of archaisms and historicism, in which students had to assign concepts to individual 3D objects and move them to the same categorisation groups), in which control group students achieved better results. One reason for this could be the fact that, in this case, the approach was one of the individual works in the environment – students did not have to negotiate with others on how to manipulate 3D objects, they could move freely around and did not have a clear definition of who and when will manipulate the objects. In this case, it can be concluded that if teaching takes place in this environment, it is more appropriate to employ the method of mutual cooperation – in the case where the manipulation of 3D objects was controlled by the teacher and students had to agree on where the objects will go and how, they subsequently achieved better results than if they were left to their own devices and their work could lead to partial problems that teachers or other students were not even aware of. We therefore recommend that teaching through MUVE should be based primarily on guided learning and a cooperative approach; leaving the student alone to solve problems does not seem to be very effective.

However, there may have been other variables that affected the end results. The respondent pool itself represents a certain limitation, as it was composed only of students of humanities – it is likely that students from technical fields (or IT fields specifically) would have achieved different results. The level of the students' computer skills therefore played a role here, which is why we recommend that sufficient training time be devoted to learning how to work in a MUVE – potentially even

performing simple tasks – and only start the course once student is sufficiently confident in navigating the environment. Aside from this, it is important for students to master new types of communication (in the MUVE environment, this means mainly proximity chat, private chat and voice chat) as well as understand the differences in how sound communication works in MUVE in comparison with ZOOM, Skype, etc. (In MUVE, communication is simulated based on certain aspects of non-verbal communication such as proximity – characters speak louder if they are nearby and the volume of their voice decreases as they move away from each until it completely fades away).

In interpreting the above results, we are working from the assumption that the involvement of multiple sensory perceptions and the emotional component leads to a better memorisation of knowledge. According to Dale's [11] cone of experience, individuals should remember up to 90% of what they do (that is, they learn from experience). This section of the experience cone also includes participation in virtual teaching in the form of a virtual reality simulation. Similarly, Kalhous et al. [12] state that the more senses are involved in cognition, the more knowledge the learner should remember. We saw this reflected in the teaching of literature, but not in the teaching of grammar and composition. One of the factors that may be at work here is the aforementioned novelty of the virtual space and the difficulties that students with basic computer skills may have had with navigating the environment.

In terms of language teaching, based on our research results, we can recommend the use of MUVES especially for the field of literature, where the MUVE can be useful for topics that allow for dramatization, experiential learning, involvement and group cooperation. In fact, experiential pedagogy seeks to acquire new knowledge through the processing of ongoing experiences at various stages of their awareness by the one who is experiencing them [13]. A similar opinion can be found in [14], which recommends computer-supported collaborative education as a suitable educational tool for knowledge acquisition, emphasising (among other things) its use in educating participants who are physically distant from each other.

The results of our research are in line with the concept of active learning and cyber pedagogy introduced by Wang et al. [15], according to whom active learning is conditioned not only by cognitive factors, but also by other components of human cognition, such as emotional and social factors. Among the emotional factor, we also list the feeling of being oneself, which in MUVES is represented by an avatar that can be visually customised to suit the student's individual preferences.

According to Lukášová and Raise, satisfying social needs and cooperating with others in the work process significantly contributes to increasing motivation [16]. In order for teaching in a virtual environment to be successful, cognitive, social and emotional factors should be balanced and, at certain times, intersect.

VI. CONCLUSION

MUVE is currently one of the most important online tools

used worldwide, especially for language teaching, as it enables synchronous online communication in real time independent of physical space and, unlike other online tools (ZOOM, Skype, etc.), it virtually simulates the non-verbal components of communication (e.g., proximity, facial expressions, gestures, etc.), which are as essential to language communication as verbal communication. However, it is not always entirely suitable for language teaching.

Based on our results, we can say that the most appropriate use of MUVE can be seen in teaching topics that have the potential for dramatization, experiential learning, involvement and mutual cooperation of the group. In contrast, due to the need to divide one's attention between the subject matter and controlling one's virtual reality avatar, it is less suitable for teaching topics that lean more heavily on learning through memorisation or terminology (e.g., vocabulary, categorisation of grammatical phenomena, etc.). MUVE therefore seems to be the most suitable for the use of simulation of conversational situations (foreign language teaching through role-playing), literary topics (role-playing, dramatization) and for group teaching that requires participants to work together.

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