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Virtual Reality Retooling Humanities Courses: Finance and Marketing Experience at a Czech University

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Abstract: Virtual reality environments (VRE) allow users to visualize both real-life and imaginary activities. For this reason, they make appropriate training fields at universities, too. However, the positive or negative effects of VRE are still a subject of research. There is a need to verify methods of their deployment, student responses and the impact of VRE implementation. Science and medicine courses are frequently exploiting VRE, while their exploitation in humanities is much less frequent. In our paper, we describe and evaluate their application in finance and marketing courses. Both courses were designed and developed as part of a larger, potentially university-wide project. The courses were enriched by mazes including 3-D rooms with course content elements. Students could explore them and communicate with their lecturers and classmates. To allow anytime/anywhere access, the VRE does not require using any special interface. The finance course was organized as a pedagogical experiment with test and control groups. Due to organizational and scheduling reasons, the VRE in marketing served just as enrichment. At the end of the term, all students using VRE were given a questionnaire assessing their satisfaction. The majority expressed satisfaction. In the finance course, positive opinion was also supported by students' improved grades. In total, 87.5% of students agreed that the application of VRE contributed to gaining knowledge. Based on the positive experience and outcomes, the university plans to expand and to intensify its VRE-supported education.

Keywords: virtual reality; online education; VRE-supported education; VRE-supported finance course; VRE-supported marketing course

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1. Introduction

The COVID-19 pandemic underscored the importance of e-learning. It not only provided a way to guarantee uninterrupted educational access, but also demonstrated the importance of preparing high-quality online educational materials to prevent last minute improvisations. As shown in [1], similar improvisations have mostly led to the adaption of traditional classroom approaches rather than to the implementation of a new educational paradigm such as virtual classrooms [2,3] or MOOC's [4]—the ones which can be characterized as "pedagogical retooling" [5]. One new paradigm is the Virtual Reality Environment (VRE), broadly specified as "a digital representation of a three dimensional object and/or environment" for educational purposes [6]. Its applications are versatile: to facilitate experiential learning, increase the level of engagement and motivation and promote collaborative learning. All these features are critical for future managers and leaders. Below we demonstrate the VRE applications serving these purposes.

Having powerful information and communication technology (ICT) allows us to consider VRE as a retooling instrument for knowledge and skills delivery—in our case to transform university humanities courses and make them more interactive, offering "hands-on" elements. As [7] stresses, the leading idea of retooling should be based on a proper communication of teachers with their learners exploiting contemporary ICT. The VRE, which allows students to act and to conduct experiments, offers such an option. First, it entails the learners' immersion into a specific, realistic environment. Then, their individual experiences become a basis for wider discussions and confrontations, exploiting their real-life involvement, observations and challenges, together with textbook and study material content, course goals, etc. The visitors' telexistence is determined by their real-time interaction within the given environment in a 3D space plus their self-projection into it in the form of avatars [8,9]. In the examples below, students' avatars act on their behalf: as a company owner in the finance course or a new employee in marketing. The student–teacher communication is rearranged in innovative ways, e.g., by presenting educators as the avatars, too.

It all implies a high potential of VRE-tailored environments for education. It creates solid presumptions for the students' strong involvement into the subject matter as well as for their deeper and personalized comprehension of course aims and challenges. In this paper, we describe a pilot project using a VRE, developed for this project in our university—business partnership project with Presentigo, s. r. o. (Inc., Incorporated Company) The VRE was exploited as a development tool for two courses: finance and marketing at the Faculty of Economics at VSB–Technical University of Ostrava. How VRE functions and ways of communication with students are explained.

Although the first plans and designs existed prior the pandemic, the VREs themselves were developed during the crisis. For this reason, their implementation into classrooms was accelerated to facilitate online education with effective teaching tools and to minimize the emergency-enforced format (face-to-display lectures and seminars).

The research was conducted in collaboration with the educators of the Faculty of Pedagogy at the University of Ostrava. In essence, it concentrated on two research questions: *Can VRE facilitate development of knowledge and skills in humanities? Does the VRE facilitate knowledge and skills in particular courses?* A detailed description of VRE is in Section 2.2.

The speed of implementation caused by the sudden move to online teaching partially affected testing and verification of VRE classrooms. Only one VRE could be properly tested using the proper pedagogical experiment consisting of a test and a control group. In the second classroom, the VRE was also utilized, but due to various scheduling reasons, this group could not be pre-tested. In order to obtain full feedback, the students using the second VRE were also questioned on their opinions about this form of education.

The research's final results show a positive influence of VRE. The results of test group students are evidently better. All students working with VRE (i.e., the finance test group and the marketing VRE students) completed a questionnaire on its content, quality and their overall impression. Their opinions strongly in favored the VRE applications.

Our long-term desire is to exploit VRE in all appropriate humanities courses. In the Discussion section, we examine the possibility of generalization of our findings.

In the Conclusions section, the lessons learned outline the future of the exploitation of VRE in other courses, its potential and ways of improvement and expansion to other disciplines.

2. Methodology

2.1. Learning and Development

Learning and Development (L&D) is a popular educational methodology [10]. At the university level, it mostly addresses changing the traditional lecture-based teaching strategy to the project-based learning strategy [11]. In our research, we generalize the L&D approach; we apply it not to a subject but to a group of subjects. Our decision was to design and develop a contemporary tool based on VRE that could function as a platform

for contemporary education for years to come. Czech managers often criticize the low level of graduates' soft skills and practical competencies. In their opinion, graduates' knowledge of theory is satisfactory, but they have problems to applying it in the workplace [12]. As a result, universities take measures to fill in this gap and improve their educational processes [13,14]. Notice that such transformation should cover almost all courses. Moreover, its outcomes must be measurable. To guarantee this outcome, a combined team from VSB—Technical University of Ostrava and the University of Ostrava joined forces in a project to enrich the Faculty of Economics courses. VSB lecturers are responsible for their content and learning outcomes. The lecturers of the University of Ostrava manage and evaluate pedagogical experiments.

Within the project, L&D is interpreted as an educational research strategy. The "traditional" L&D applies to one subject; here it is understand as a tool for modifying a spectrum of courses. Its five steps applied to VRE are as follows:

- *Analyze training needs*: It is necessary to develop students' soft skills and relationships between theory and practice.
- *Determine the learning objectives*: In addition to their "traditional" knowledge, the students should become capable of understanding their roles in subject-oriented processes, communicate about them and apply them in a wider social context at (simulated) workplaces.
- *Choose learning methods and create teaching materials*: For each selected course, build a problem-oriented VRE that utilizes exploratory learning.
- *Accomplishment of qualification/training*: Ask students to enter VRE and solve the tasks. Allow them to communicate using individual and group conversation and/or to consult their educator, librarian, Internet sources, etc.
- *Evaluation of the capacity building/training process/project/program*: Use metrics to test the effectiveness of education.

Our long-term research consists of a series of activities presented in iterated rounds. Here, it entails programming an innovative VRE, its testing exploitation in education and its pedagogical evaluation. The first round starts with the design of a learning environment, followed by the implementation of its initial version, its pilot runs and pedagogical experiments. As most VRE applications contain 3D objects and defined operations, they fit well for science and medicine courses. Thus, our central research question was: *Can VRE facilitate development of knowledge and skills in humanities?* As no one is capable of retooling and testing all humanities subjects, we made it feasible by reducing the number to two typical samples: finance and marketing.

Below, the first round of our long-term research is described. The next section specifies our teaching and learning philosophy in detail: the design, development and implementation of courses, their application in online education, evaluation and proposals of modifications based on the experiment's results. In the future, the next round will begin. For this "narrower" goal, we posed an additional research question: *Does the VRE facilitate knowledge and skills in the particular courses?* Its aim was to learn more about educational practices which could be exploited in the systemic improvements of VRE. The experience gained can be used for inviting and training additional educators in the next project stages.

The typical features of our implemented environment are described in Section 2.2. During the pilot stage, only two courses were converted—one more STEM-like, one in "pure" humanities. In order to analyze the effectiveness and students' opinions of VREs, a pedagogical experiment was executed and evaluated—see Section 3.

2.2. Education Using VRE

Compared to the traditional university education based on face-to-face lectures, in campus labs and seminars, VRE-assisted education represents a new paradigm [15]. In our case, it allows excursions to out-of-campus virtual environments—into simulated companies. The reason for our choice was to bridge a gap between students' theoretical and practical knowledge.

Jansen expressed it as follows [16]: "*In management accounting, it is uncommon to review the literature with the aim of shaping a solution for a practical problem*". To simulate the situation better, the finance course's VRE was intentionally formed to evoke real-life problems and guide our students to their solutions. Similarly, the VRE in the marketing course introduced students into a virtual company with its typical problems. Again, it is a sort of student incubation and intertwining of the course theory and its practical applications [17]. We believe that such incubation can be conducted in both real and virtual environments, yet virtual environments are more easily accessible.

VRE's are complex environments requiring extensive technology infrastructure and support. To develop and maintain their quality requires sufficient resources. Therefore, it is necessary to build a university-wide strategy of their usage. It should comprise [18]:

- Acceptance of the strategic importance of massive technology-supported education;
- Transformation of learning objectives and creation of supportive digital content;
- Staff development and in-service teacher training;
- Development of virtual classrooms, laboratories and courses;
- Execution of courses and quality control;
- Sustainable development of methodology and its practices.

The above principles guarantee uniform organizational standards at the whole university in order to unite approaches to course design, development and execution. The aim of these standards is to simplify the students' and educators' orientation and movement in the university cyberspace. Deviations from these standards could be allowed, but reasons behind such decisions should be properly explained. In the case of virtual reality, a multimedia-based semiotic system proposes a meta-story (the course content) composed of a set of short stories and a set of available moves among them, in accordance with prescribed rules. As a whole, they form a "playground" delivering knowledge and expanding skills of learners [19].

For similar reasons, institutional educational philosophy should also be amalgamated to fit a contemporary paradigm. Stracke's principles of open education offer such a unification base which does not prioritize any particular field of study because it addresses the students and their needs [20]:

1. Learners cannot be forced to learn but can only learn by themselves.
2. Learners have to explore and create their own knowledge, skills and competencies.
3. Educators should not be teachers but facilitators of these self-directed learning processes.

Virtual reality environments correspond to all the above requirements. On one side, they allow forming a unified platform for any variety of courses. On the other side, free moves of avatars open a large space for self-learning in the context of constructivism. Several retooling approaches to a variety of university subjects are described in [21]. The main aims of retooling approaches are to enhance learner's imagination, to facilitate interactions among students, teachers and the learning environment, to increase their motivation, to offer them a different experience, etc. Babich identifies several ways VRE can change education [22]:

- *Visual learning*—VR is helpful for a group of visual learners. For example, presenting technology in 3D environments is enormously useful in understanding how such a technology works.
- *Feeling of presence*—Rather than reading about the topic in textbooks, students can wear a virtual reality headset and be virtually transferred to the location.
- *A virtual laboratory*—Science labs allow students to investigate scientific phenomenon and see inside how the world around them works, based on practical know-how. However, such environments are high-priced and almost impossible to scale. Instead of visiting a physical one, a virtual laboratory can be simulated. Students obtain proactive experience and engage in exciting exercises relevant to real-world practices. Virtual reality provides good learning opportunities and the ability to scale.

- *Learning by doing*—Learning outside the classroom helps students to acquire practical skills rather than simply reading instructions. Students are stimulated in the virtual reality environment to find out things for themselves and have a chance to learn by doing things.
- *Emotional reaction*—Students can recollect various details through the emotional reactions and increase their interest in the virtual reality environment.

The variety of potential approaches is very wide, in particular in STEAM courses [23–28]. Often, they require specific devices (glasses, gloves, tools…) to make the virtual reality ever more truthful [29]. A tested VRE environment is accessible via web browsers. It does not require more than traditional equipment—a computer connected to the Internet, keyboard and mouse. Thus, one of goals of our research was to learn to what degree such "VRE without VRE-equipment" can evoke similar immersion of agents as the ones with VRE-equipment do.

The university-wide strategy [18] recommends building a platform which could be used in a variety of courses, possibly in all. Our VRE campus is built as a structure with a number of mazes–microworlds. As every maze is an isolated omnipotent microworld, it can be extended to a course. In the future, all courses could be located on this platform. The students would visit them via their avatars and communicate with each other. They can share the materials which they consider to be of mutual interest. The movement between maze rooms is unrestrained but can be blocked by conditions (for example by access privileges or fulfilling a task). The entire VRE space is accessible 24/7 in both synchronous and asynchronous modes. It means that the students can work there at any time, not only individually, but also in teams, upon their mutual agreement.

Every room in the learning space contains a piece of information related to the course content. Basically, the VRE allows for the traditional content to be directly transformed to a series of activities. Such a transformation should bring significant added value and not become a transcript of a plain textbook onto the web resource. Authors are emphatically discouraged from such practice. The revolutionary significance of VRE consists in its capability to move around course material much more freely, to exploit 3D content, to communicate among learners, to interact with the objects, etc.—see Figure 1. The experts from our business partner assisted in course design and development in order to maximize the power of VRE tools for knowledge delivery.

Figure 1. Avatar giving a suggestion to the learner.

Another aim of this pilot project was to test the appropriateness of the platform. Courses at the Faculty of Economics are a mixture of STEM and humanities. To learn the platform sustainability, a typical STEM course (finance) and a typical humanities one (marketing) were selected as appropriate candidates.

To become a foundation for a mass exploitation by our university, VRE only requires commonly accessed technology: a computer with a keyboard, mouse, speakers, microphone and browser. No special devices (e.g., VR headsets or gloves) are presumed as parts of the solution because they would limit our presumed anywhere–anytime VRE usage and/or discriminate against some students.

From the software point of view, VRE is a standard client–server solution processed over the web using the Software as a Service (SaaS) format. In this sense, the university is one of the clients. Other important features of VRE are:

- Each course represents a maze structure with rooms specified by its "course owner"—usually its teacher;
- The move between the rooms (including a teleporting) is accomplished by the manipulation of the avatar;
- Every avatar represents a user—a student or a teacher;
- The avatars inside the structure can communicate with each other (talk and chat);
- The room addition and removal are performed by using predefined tools;
- The rooms can be "furnished" by adding and editing templates and links to applications.

The last two features are usually secured in advance by the course designer/owner. The course activities can be very complex. That is why the preparation of any course should precede its implementation and be designed using a scenario. Below we outline two scripts used in our pilot study.

The main aim of the finance course is the introduction to accounting. Lecturers' experience showed that many students find it quite difficult to understand the relationships between the company's activities and their reflection in accounting records. The scenario therefore tries to simulate links between them. After entering VRE, the student's avatar is an entrepreneur just starting a new company. He/she has to buy/rent an office or workshop space, hire employees and buy technology, tools and raw material. Every decisions is recorded in a spreadsheet formatted as an accounting sheet. After approving the transaction, the balance is automatically recalculated, and the students can make their next decision. Such a sequence can lead to either a sustainable development or a bankruptcy. In order to manage the process, the student should regularly evaluate the state of his/her budget, its revenue and its expenditures. Thanks to the VRE, the student can more easily comprehend the meaning of figures in the book and their connection to the company's financial health.

The marketing course gives a systematic, complex and contemporary overview of marketing theory and practices. Its aim is to guide the students through the field and provide them with the knowledge and skills necessary for their application in day-to-day business. The VRE rooms illustrate concepts such as motivation, negotiation, product marketing, an optimal selection of a product, a correspondence between a product and its marketing strategy, etc. The rooms allow various student activities except for content rearrangements because the capacity of the VRE system does not allow keeping a separate copy for every user. Without such copies, someone's unexpected modifications (not initiated by the teacher or a vicarious individual) could mislead his/her partners. In their reflections, students call for this sort of freedom, and the university plans to permit it in the future, if its ICT infrastructure allows it.

2.3. Measuring Course Effectiveness

Our primary research question was: *Can VRE effectively support courses in humanities?* For that reason, the leading methodology of our project is L&D. Its key ideas are based on creating an innovative approach which speeds up and facilitates comprehension (abbreviated from [27]):

1. Supportive environmental conditions that foster strong relationships and community.
2. Productive instructional strategies that sustain motivation, competence and self-directed learning.

3. Social and emotional learning that fosters skills, habits and mindsets that enable academic progress, efficacy and productive behavior.
4. System of supports that enables healthy development, responds to student needs and addresses learning barriers.

These goals are global and long-term and can only be achieved in a gradual manner. Our project has achieved the first step. As mentioned above, our systematic development of two described VRE's was affected by the COVID-19 pandemic. The lockdown arrived during their final completion and partially affected the end of the pilot stage. Both virtual-reality-supported courses (marketing and finance) were almost complete prior to the pandemic and ready to be tested. Due to the circumstances (namely the shortage of staff), the organization of the test phase required some improvisation. Only the finance course was run using a standard pedagogical experiment. The marketing course was simply introduced to a group of volunteers. During the spring of 2022, both courses were taught at the VSB—Technical University of Ostrava. To minimize external undesired effects (e.g., different approach to teaching or different course requirements), the learning objectives and teaching style of educators were synchronized to match the online format.

Upon mutual agreement, the course format adopted two approaches:

(a) The finance course with the test and control groups allowed comparing the outcomes and verifying whether the newly developed tool influences students positively.
(b) The marketing course used its VRE version in volunteer student groups.

The attitudes of the students to both VRE courses were investigated at the end of the term. Our aim was to learn whether the developers' efforts targeted the critical issues of the courses, in particular the relationship between theory and its practical application. Specifically, due to the distance education, the students could be confused about the innovative approach, and also the errors in the VRE design could mislead them. This resulted into another research question: *Does the VRE facilitate knowledge and skills in the particular courses?*

In accordance with the above research aims, two research methods were used to analyze the courses' outcomes. First, the marketing final results of tested and control groups were compared using descriptive statistics. Secondly, in order to investigate the students' attitude on the virtual reality support, a survey among all those who participated in VRE-supported courses was conducted and evaluated.

3. Results

3.1. Sample

Both courses (marketing and finance) are parts of the bachelor study program at the Faculty of Economics of the VSB—Technical University of Ostrava.

A total of 74 students took the finance course (27 females, 47 males), 28 of them with the VRE support (14 females and 14 males), 46 without it (13 females, 33 males).

The marketing course was taken by 164 students. Out of them, 44 students studied with VRE support (25 females, 19 males), 120 without it (89 females, 31 males).

In the beginning of the course, all students were informed about their inclusion in the pedagogical experiment and the potential risks which the VRE-support classes face due to the pilot character of their course. The informed consent of students with their inclusion was obtained.

3.2. Quantitative Research

The finance course was organized as a pedagogical experiment. The tested group of 14 male and 14 female students was using the VRE. The control group (13 females, 33 males) was working without it. To avoid unwanted influences of the teaching style on the experiment results, both groups were instructed by the same educator. In accordance with suggestions in [30,31], the teacher was coached to keep the same speed of progress during the term and to be equally supportive of the students in both groups.

The final grade of the course was based on the results of four tests. The average numbers of points achieved by each group in the tests (plus their final grade) is in Table 1.

Table 1. Average achievements by the groups.

	Test Points				Total
	Profit and Loss Statement	**Cash Flow (Direct Method)**	**Balance Sheet**	**Cash Flow (Indirect Method)**	
Tested group	4.07	3.75	6.54	1.93	16.29
Control group	3.75	3.39	4.66	1.09	12.89
Difference	0.32	0.36	1.88	0.84	3.40

The results of the group utilizing the VRE support are all higher. The difference is more visible in the tests addressing two more advanced methods. The progress of VRE-supported students is even more visible in Table 2. In this table, their grades are considered 100% and compared with the other group.

Table 2. Relative comparison of the achievements.

	Test Points				Total
	Profit and Loss Statement	**Cash Flow (Direct Method)**	**Balance Sheet**	**Cash Flow (Indirect Method)**	
Tested group	4.07 = 100%	3.75 = 100%	6.54 = 100%	1.93 = 100%	16.29 = 100%
Control group	92.1%	90.4%	71.2%	56.5%	77.9%

The proportional difference shows a growing gap. The results of students not working with VRE are falling lower and lower during the term. In the course's final results, the difference represents more than 22%. Naturally, this is an isolated experiment. Despite its rather convincing evidence, the real influence of VRE deserves further investigation.

There are no corresponding results for the marketing course. It was taken by a much larger number of students at a much greater number of study branches. To prevent complications within the university schedule, it was impossible to distribute these students into two groups with a comparable structure of demographic characteristics. As a result, no statistical evaluation could be calculated. As the VRE for the course had been built, we decided to run its trial version in order to test its functionality and learn about the students' reactions to the new way of education. The opinions of the students were collected and are included in the below survey results.

3.3. Students' Opinion Overview

At the end of term, a questionnaire was distributed among all students who participated in the classes with VRE. Out of 72 such students, 56 responded—31 females and 25 males. The first question was: *Based on experience from this school year, what is your overall opinion on virtual-reality-supported education?* The results are in Table 3.

Table 3. Overall opinion of students.

	Positive	**Neutral**	**Negative**	**No Opinion**
Respondents	39	12	4	1
Ratio	70%	21%	7%	2%

The positive attitude strongly prevails.

In the second question, the students expressed their evaluation of the virtual reality tools: *What is the influence of the virtual reality on education processes?* Table 4 shows the results.

Table 4. Influence of virtual reality on student results.

	Substantial Improvement	Certain Improvement	No Improvement, No Detriment	Detriment	Substantial Detriment
Respondents	13	29	7	6	1
Ratio	23%	52%	13%	11%	2%

Similarly to the previous answers, more than 70% of respondents see the application of VRE as an improvement. Only 13% take it as a detriment; the same percentage do not see it either as an improvement or a detriment.

In order to point to their preferred features, the students could select up to three properties of VRE they value as particularly advantageous. In Table 5, features are ranked by their popularity.

Table 5. Preferred VRE features.

Feature	Preferred By
Visualization of learning material	32
Interactivity	31
Access anywhere	26
Access anytime	26
Simpler orientation in learning material	12
Better concentration on the topic	11
Faster access to literature	10
Other	2
No advantages	2

The students could also point to negatives connected to their use of VRE (using multiple selections from a list). The outcomes are presented in Table 6.

Table 6. Drawbacks of VRE.

Drawbacks	Experienced By
Learning new IT skills	23
Growing demands on the Internet connection	19
I experienced no troubles	15
Growing hardware demands	13
Software non-compatibility	10
Other	10

Negative factors have to be taken into account when the pilot stage will proceed to massive implementation. For example, some manipulation standards should be generally accepted in order to reduce the necessity to learn new skills with the next VRE application. Otherwise, the number of student problems might grow exponentially.

Design, development and implementation of VRE-supported courses are difficult tasks. These processes are long-lasting and rather expensive. Undergoing this process can be effective only when eventual implementation becomes efficient. That is why we posed the following question: *To what degree did the application of VRE contribute to your gained knowledge?* Table 7 shows the student answers.

Table 7. Contribution of VRE to student knowledge.

Contribution to Knowledge	Students	Proportion
No contribution	7	12.5%
Up to 25%	22	39.3%
Between 25% and 50%	14	25.0%
Between 50% and 75%	10	17.9%
More than 75%	3	5.4%

If other courses could achieve a similar success rate, then the creation and exploitation of VRE would certainly be worthy of efforts and investment. For this reason, it has been important to ask the students about their ideas concerning the communication within VRE and the organization of work. Therefore, the next two questions were optional and open-ended. They sounded similar. The first one was: *Presuming that you could contribute to the improvement of the pedagogical side of VRE, what problem would you solve first (by adding/reduction/modification)?* The second one asked for potential software improvements. There were 31 answers, most of them expressing the student's satisfaction. They mostly suggested to continue this method of teaching. For example:

- To increase the number of problems implemented in VRE and their proportion;
- To introduce the problem directly in VRE in its full complexity (the introduction is primarily conducted briefly using oral or written notes by the lecturer);
- To support the operability of VRE on other platforms;
- To add tools for making student notes or comments;

The most frequent issue addressed the ratio of VRE-supported course topics to those taught by traditional methods.

We also included the following question: *If a course would be offered in two versions—with and without VRE—which version would you prefer?* A total of 32 students would prefer the one with VRE, 8 without it, 16 have no preference.

The final open-choice question asked: *If you could suggest a next course for getting the VRE support, which one would it be?* A total of 33 students gave their suggestions. The management course was the most frequent candidate but also more formal courses, such as mathematics, microeconomics and macroeconomics, appeared on the list. It implies that students are aware of the VRE capability to visualize the issues they perceive as difficult.

Students' free comments contained additional compliments which reflect the preferences of students with different cognitive skills: *The course kept my attention during the entire session. No other course was capable of this.* Or: *In was not bad. In the beginning, I was a bit confused but in a stepwise manner it became fun. Chat is a perfect option.* Or: *The method is perfect for evening tasks which are not time limited. One can play and run VRE, complete his/her duties, replicate the tasks and create new ones.*

The fact that the respondents are ready to utilize VRE courses more frequently, with a greater number of problems of higher complexity, is another indicator of their overall satisfaction.

4. Discussion

The current employment of VRE does not cover any course subject in its entirety. In the pilot stage of the project, our aim was to test its potential as an educational tool in a humanities study program. The current literature review indicates that the VRE environments primarily address science and medicine courses in order to offer their students experiences unavailable otherwise—see for example [32–34].

As our survey indicates, students in humanities are happy with its usage. They are certain that it helps to expand their knowledge and would welcome its application in other courses as well. Their subjective opinion has been supported by the finance course

quantitative results. The VRE seems to positively influence their knowledge and skills. This conclusion coincides with similar findings, e.g., [35,36].

Our experience shows that design and development of such courses tends to be a difficult task, requiring collaboration with VRE experts. In our case, the cooperation with developers of the particular software was vital. Similar difficulties might be the reason why we could not find more VRE-based courses. There are a few similar business applications based on gamification in marketing [37], but they are oriented to business partners, not students. Role-playing approaches to education [38,39] are more common. Unfortunately, in role-playing scenarios, only a few students are directly involved in these "dramas"; most of them are just the audience. This method is therefore appropriate for small classes only.

Thorsteinsson [40] identified pedagogical issues with using the VRE to support ideation, and the author points out the fact that the teachers must familiarize themselves with virtual reality functions and appropriate them to their learning objectives. This becomes a hurdle to many. Even a student pointed it out in his comment: *Our teacher was superb, but I do not believe that all educators can manage it*. Overcoming this hurdle requires collecting the best VRE authors' and users' experiences and disseminating them among all parties. Otherwise, the outcome will be equal to a traditional e-learning management system with advanced graphics.

There are several other issues deserving one's attention. As the quotations at the end of Section 3 indicate, the variety of individual approaches to each piece of knowledge requires different degrees of attention from particular students with their distinct learning strategies. For this reason, both educators and designers must be simultaneously trained, not only in the exploitation of VRE tools, but also in interrelationships between the VRE mazes and targeted educational aims. In this way, the collaboration with Presentigo, s. r. o. (Inc., Incorporated Company), the VRE developer, demonstrated its value. Educators' requirements and remarks were quickly implemented in VREs. It opens a space for building a new methodology. Every VRE application must be subject-specific because the concept "one model fits all" is far from the truth. The concept of L&D—Learning and Development—takes on a deeper meaning. Consequences of a wrongly comprehended unity can be found in [41,42].

On the student side, the combination of self-initiated activity, problem solving and collaboration with classmates enhances tacit knowledge—the one which is informal and present in human brains only. According to [43], the development of tacit knowledge is a central issue in education. Due to its reliance on a person's own problem solving, skills and competencies, VRE is suitable for the task. Learning from isolated cases requires a certain capability of abstraction that otherwise comes only with age and practice. In [44], one finds a special model of teaching applicable for younger learners. The VRE can accelerate these long-lasting processes as well.

Under the described conditions, the VRE is capable of creating environments for open learning [20]. In the VRE, students are not forced to learn. Instead, they explore and create their own knowledge structures, skills and competencies. As one quoted student noticed, the process calls for a modification of teacher behavior. Educators are no longer "exclusive sources of knowledge" but facilitators of students' self-directed learning processes.

Moore [45] underscores the fact that the computer is being redefined as an interface within a more and more human environment rather than simply an advanced storage and retrieval mechanism. As such, it lies at the foundation for a new educational paradigm which facilitates reaching several outcomes that were only weakly supported in traditional education: simulation, training, access to limited resources, distance learning, constructivism, collaboration, gamification and so on [21]. These authors also stress the ability of this approach to support intrinsic factors such as increased motivation and joy, personalized learning, deeper learning, etc. At the same time, they point to drawbacks, such as costs, additional training, problems with input and output technology, software usability and so on. All of these problems fairly coincide with our experience, gained during the design and development process, as well as with the students' survey results.

Educators and developers have to learn, too. That is why VREs should include tools for tracking an individual student's activity: time spent on a certain activity, movement between the rooms, frequency of communication, level of collaboration, etc. Their aim would be: (a) the identification of "interesting" activities, i.e., those the students visit more frequently, and (b) learning from them in order to increase the number of visits of rooms with key pieces of knowledge.

5. Conclusions

The pedagogical experiment and the survey of student opinions demonstrated the high potential of VREs. As shown above, the VREs proved their quality in science, technology, medicine and other fields oriented primarily on familiarization with three-dimensional objects. Humanities and social sciences work mostly with abstract objects, concepts and ideas. Thus, our key research question was: *Can VRE effectively support humanities courses?*

In order to find a response, our pilot project addressed one STEM-oriented course and one in "pure" humanities. In the first one (finance), we could support our positive conclusion by quantitative results, in the second (marketing) by positive reactions of students. The results suggest that there are good reasons for building similar courses. Soon, we invite another group of participants, working on their design, development and application. Based on our experience, we can offer the following suggestions to future developers:

- *Analyze training needs*: Learn from practitioners which skills and competencies the graduates of your course lack.
- *Determine the learning objectives*: Select those which can be supported by VRE. Do not hesitate to consult designers of already functioning VRE-supported courses about their best practices.
- *Choose learning methods and create teaching materials*: Prefer exploratory learning. Design 3D-based open-ended tasks. Open room for communication of avatars (teachers and students, possibly visitors) and presentation of their work (documents, drawings, etc.)
- *Accomplishment of qualification/training*: Explain to your students how to consult their educator, librarian, Internet sources, etc. Ask them to be active self-learners. Control their operations within the VRE, yet minimize your interference. Award those who facilitate their classmates' work and participate in advising.
- *Evaluation of the capacity building/training process/project/program*: Use metrics to test the effectiveness of the education and gained knowledge, skills and competencies.

The second research question was: *Does the VRE facilitate knowledge and skills in the particular courses?* Again, both data and opinions indicate clear benefits for graduates. For example, only 12.5% of students attending VRE versions indicated no contribution of the VRE to their knowledge. The rest (87.5%) perceived it as a positive factor. Other results also demonstrate the positive influence of the VRE on students' learning experience. The previous set of suggestions can motivate other course developers to achieve similar teaching outcomes.

Despite the limited size of our project, we can conclude:

- The VRE mazes were developed for two pilot courses at one faculty. They were created thanks to a close and efficient collaboration between the programmers and educators. This small team could complete and test the VRE mazes during the lockdown. The team has obtained enough experience to serve as advisors in future similar developments. The team's composition allows for providing consultancy in both education- and technology-related elements.
- Our VREs do not require any specialized devices such as VR glasses or gloves. The lockdown-enforced online education changed this essential drawback into a benefit. The absence of sophisticated hi-tech devices formed conditions for wider and faster spread of VRE-supported courses. Every students could participle in his/her courses using just standard computer equipment. In the future, it might be beneficial to proceed in the same direction.

Based on our results, we can also recommend that universities consider using VREs in other courses. Naturally, the process will not be easy and may be long-lasting. The lessons learned by the participating educators from the course design, development and testing runs show that, regardless of the subject, courses have to follow principles of constructivism [46]. Moreover, a unified structure and manipulation procedures of different VREs is a must. Developers have to agree on a unified layout and communication standards in order to minimize confusion and the necessity of re-learning [47,48]. Such an approach creates a friendly environment with minimum barriers for learning and optimal space for creativity, reception of new knowledge and adoption of practical and long-lasting skills. Last but not least, the educators must be trained in using the VRE features in order to facilitate student progress.

Our results serve as encouragement for the design of additional courses. Nevertheless, to make courses fully supportive and trustworthy, further investigation is necessary. Here are potential research directions:

- The number of courses and students has been small. To obtain more reliable evidence, their number and the number of participating students must be increased.
- The positive opinion on courses might be influenced by the novelty of the teaching method. Now, it is important to study whether the positive assessment stays unchanged with the repetitive implementation of VREs in the same (and later in other) courses.
- To add new research questions: Will the design and development of new courses and/or the incorporation of specific VRE interfaces bring overall educational benefits that go beyond these courses? If so, will the growth outweigh the invested costs?

Education with the VRE changes one of the traditional principles of teaching humanities. It allows for a move from reading and lecturing about facts and rules to actual problem solving. In our particular case, the problems could lead to setting relevant values, communication skills and critical thinking. The VRE mazes may contain (intentionally) misleading and false information and, in this way, teach students to identify and disclose them [48]. Such an approach belongs among the most critical ones in talent discovery [49]. The VRE can in this way help educators in distinguishing among those who are just memorizing and repeating "eternal truths" and those using their own mind.

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