Discover Education

Case Study

A case study of an immersive learning unit for German as a second language

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Abstract
More and more children and adolescents in Switzerland show serious deficits in their German language skills. In order to specifically promote the language skills of students with a non-German first language, special lessons in German as a second language (GasL) are therefore offered in addition to the regular lessons. The aim of this case study is to evaluate the impact of a pedagogically sound immersive virtual reality learning unit for GasL lessons, which offers students the opportunity to actively speak German and to demonstrate this in the context of two GasL lessons. The research design is based on the "Design Science Research Framework". In this context, the virtual reality learning unit was designed as an innovative prototype (artifact) and iteratively improved. The design considered the didactic framework of the official curriculum as well as the eleven general design guidelines for virtual reality learning units in an educational context. The virtual reality learning unit was tested in a field experiment with five students each at an elementary school and at a secondary school. The students found the virtual reality learning unit as a whole attractive and motivating. But there are operational challenges and necessary prerequisites that have to be considered and created in order to pragmatically and sustainably integrate immersive virtual reality learning units into the existing GasL lessons.

1 Introduction

The lack of German language skills among children and adolescents is a central issue in current Swiss education policy [1]. In the canton of Zurich, more than one in three elementary school children now comes from a home where German is not spoken as a first language. However, more and more elementary school children in whose home German is spoken as a first language show serious deficits in their German language skills. For the students, however, a comprehensive knowledge of German is of particular importance, as it is a fundamental tool for acquiring knowledge, understanding culture and interacting with fellow students and teachers in their everyday school life [2]. The German language skills acquired at school have a significant influence on their graduation, their chances of an academic career as well as on their later job prospects and thus on a large part of their further life [3].

While language skills exist intuitively in the first language, they must be consciously built up for German as a second language [4]. In order to specifically promote the development of language skills in students with a non-German first language, special GasL lessons in elementary school in addition to the regular lessons [5] are offered. Nowadays, this is indispensable so that the students can improve their lack of German skills as quickly as possible and thus successfully participate in regular classes.

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However, traditional language instruction comes with a number of challenges that make second language learning a challenging and time-consuming process for many students [6]:

- The average speaking time of teachers often exceeds that of students in language classes by far [7]. This leaves little time for students to actively use the new language in authentic language situations and thus improve their communicative skills.
- Furthermore, many students have inhibitions about making mistakes because they are afraid of embarrassing themselves in front of their classmates [8]. This makes it particularly difficult for them to realize their full potential in a classroom.
- Another challenge is the promotion of individual strengths and weaknesses [9]. Depending on their background, students usually have different prior knowledge and language levels. In language classes, however, there is often only limited time available to support the students with individual learning content.

In recent years, the use of digital technologies in language acquisition has become increasingly important [10]. They serve not only as a tool but also as a driver to create new digital learning environments for language acquisition. In particular, immersive virtual reality systems are increasingly used in technology-enhanced language acquisition due to significant technical advances and decreasing hardware costs [11]. Some of the ways in which immersive VR can have a positive impact on language learning are:

- learners not only learn the subject matter through VR, but can also experience it and actively engage with it [12].
- the immersive character of VR makes it possible to involve learners more intensively in the language culture and create realistic simulations [10, 13], which supports the deepening of the learning process, the promotion of long-term memory [14] and learning fun [15].
- no inhibitions or fear of making mistakes [16, 17].
- Increased motivation and engagement [12, 18].

This opens up new possibilities for integrating this technology into traditional school-based language teaching. In doing so, its use seems to be associated with a variety of opportunities to address the existing challenges of traditional school-based language instruction. Some of these challenges are discussed in more detail below:

- The availability of suitable content is essential for the effective use of VR in language learning. Currently, however, there is only a limited selection of commercial content for language learning [18, 19]. The increased use of customized in-house developments indicates that the existing content does not fully meet the needs of users [18, 19]. The preference for customized VR content suggests that teachers want greater control over VR content and need user-friendly applications to create VR content [18].
- Immersive VR offers realistic simulations that enable learners to actively engage with the content. However, there is a risk that such virtual 3D environments cause a high cognitive load, which can lead to cognitive overload for users [20–22]. In addition, there is a risk that learners will be distracted from their task by the VR content [6, 21].
- Another challenge when using VR is the undesirable side effects summarized under the term "cybersickness", which can lead to physical symptoms and discomfort for users ([23], pp. 60–62, [11], pp. 163–174, [24], pp. 31–32). Symptoms of cybersickness include headaches, pallor, nausea, vomiting, ataxia (impaired coordination of movement), drowsiness, dizziness, fatigue, apathy (listlessness) or disorientation ([23], p. 60). It should be noted that users do not have to move while using VR to be affected by cybersickness. For example, cybersickness can also occur in people who are sitting still ([19], p. 60).

2 The study

Following subsections cover the organization and execution of the study presented in this article.

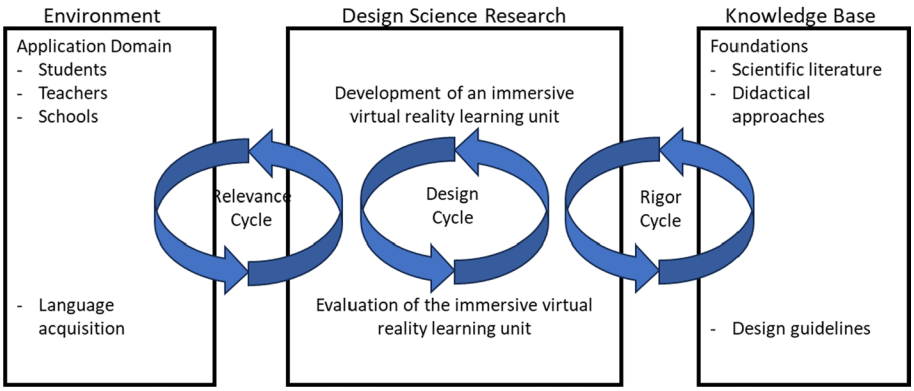

Fig. 1 Adapted procedure based on Hevner [25]

2.1 Research design and applied methodology

In order to achieve the goal of designing a pedagogically sound immersive virtual reality learning unit for teaching German as a foreign language in a comprehensible way, the Design Science Research Framework (DSR) by Hevner [25, 26] was applied for this case study as depicted in Fig. 1.

According to DSR, the virtual reality learning unit represents the innovative prototype (artifact). The development of the prototype was iterative (design cycle) and followed an evolutionary prototype approach [27]. The verification of each iteration is based on feedback from the students, who tested the virtual reality learning unit in a pilot study. The feedback was provided by means of a quantitative survey.

The evaluation of the virtual reality learning unit is performed by a questionnaire. The main part of the questionnaire is based on the "Core Module" of the "Game Experience Questionnaire" (GEQ) developed by Ijsselsteijn et al. [28] and is extended by three questions about demographics and six questions regarding the overall evaluation and specifics about the content of the learning units.

Methodologically, we followed the phases of a field study [29]. After validating the learning unit in iterations with separate subjects we tested the questionnaire with a test subject whether it is comprehensible for the specific age group in this study. The learning unit underwent examination on 2 distinct days with participants from an elementary school and a secondary school. Two dedicated rooms were allocated for the assessment of the learning unit and the subsequent completion of the questionnaire. A designated facilitator was present in both rooms. Subjects were individually retrieved from their regular classes and afforded the opportunity to assess the learning unit in a reserved room. Commencing the session, a brief orientation was conducted, elucidating the procedural aspects of the implementation. Subsequently, subjects were instructed on the operation of the virtual reality goggles, along with guidance on selecting their preferred native language.

Following the evaluation of the learning unit, subjects were individually escorted to the second room to finalize the questionnaire. An introductory briefing on the questionnaire's structural framework was provided. Emphasis was placed on the availability of the contact person for addressing queries or uncertainties during the questionnaire completion process. The questionnaire results were evaluated by simple descriptive means [30], e.g., average, mean.

The relevance of the research is composed of the problems in the application environment mentioned in the introduction from the fields of education and technology. The existing knowledge and thus rigor has been considered through a literature review. The knowledge gained from the Case Study contributes to the practice and knowledge base.

2.2 Conception of the virtual reality learning unit

The goal of the virtual reality learning unit is to support the students in building up the basic skills in the competence area "speaking" for German as a second language. The students are therefore given the opportunity to actively speak German in various sections. The content of the virtual reality learning unit is based on the topics defined for German as a second language lessons and the teaching material used. It is divided into four different sections: the intro, the first unit, the second unit and the outro. The first and second units are each divided into two paths, which in turn consist of a section for improving pronunciation and a section for training dialogs as depicted in Fig. 2.

The learning unit for the longitudinal is conceptually the same but with seven units. Due to time restrictions each unit does only consist of one pronunciation and dialogue section instead of the two as depicted in Fig. 2.

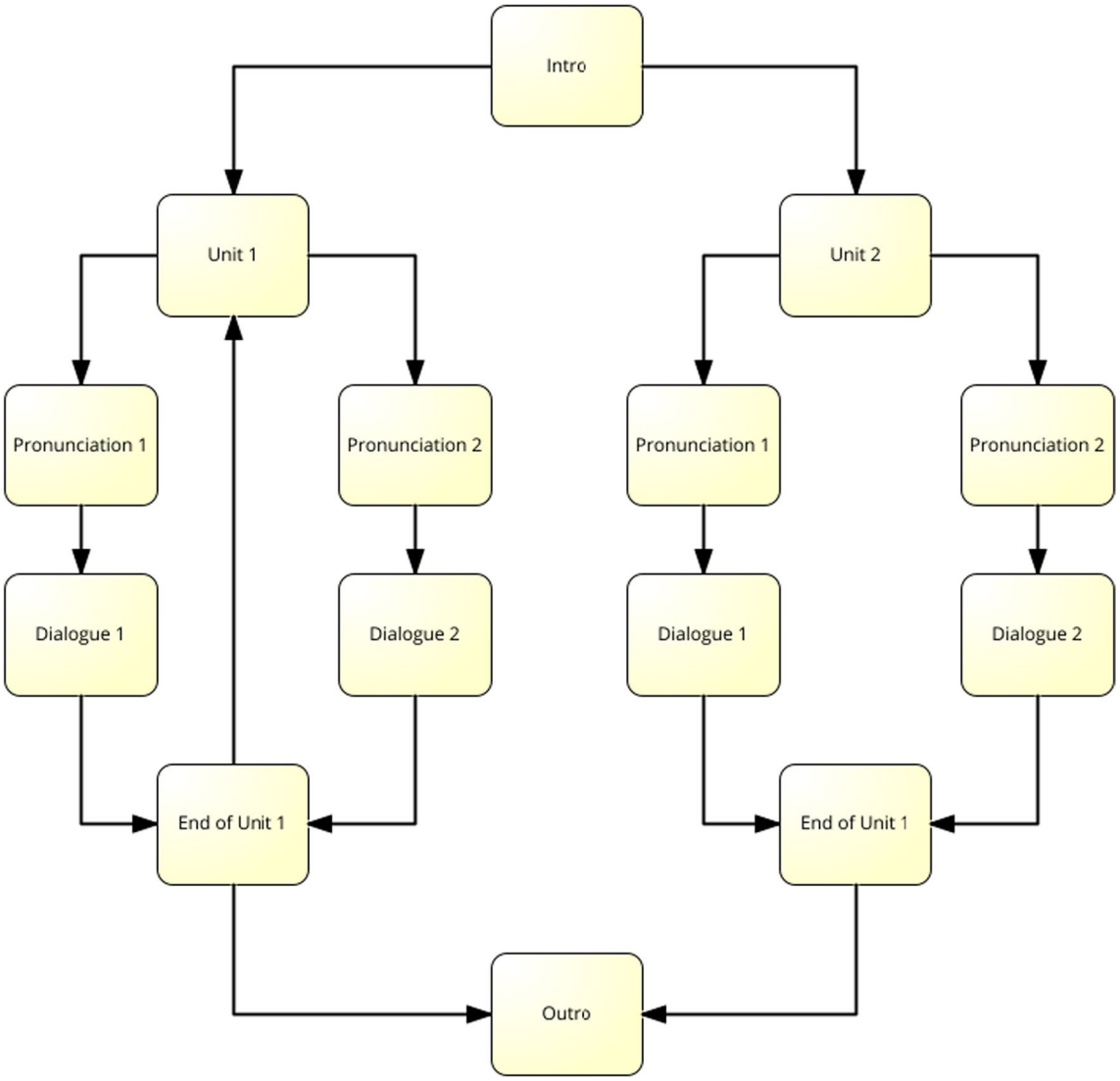

Fig. 2 Structure of the virtual reality learning unit

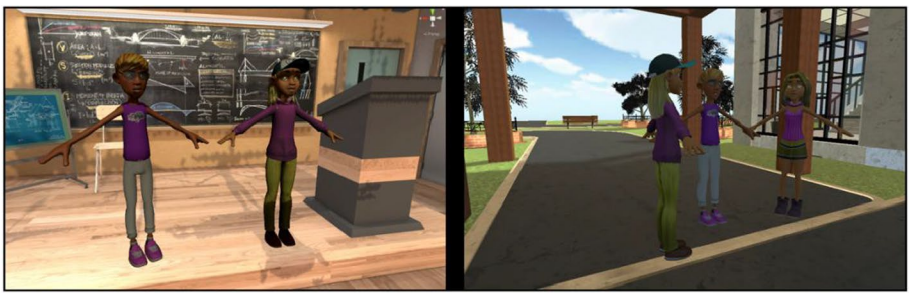

Fig. 3 Scenes of the virtual reality learning unit (own representation)

The students are accompanied throughout the virtual reality learning unit by the virtual character "Daniel". Daniel translates the German content into the students' native language to ensure that the content is understood. In addition to Daniel, there are three other virtual characters: "Julia", "Helena" and "Peter". They are introduced during the virtual reality learning unit and speak to the students in German. The individual sections of the virtual reality learning unit take place either in the "Classroom" scene or in the "Schoolyard" scene. The Classroom scene is based on a classroom and the Schoolyard scene on a playground as depicted in Fig. 3. The three virtual characters are deliberately visualized by toon avatars to avoid the danger of the "uncanny valley" effect [31].

In the following, the content of unit 1 will be discussed in more detail. Conceptually, the content of unit 2 is structured analogously but with a different topic.

2.2.1 Start intro

The first section serves as an introduction to the virtual reality learning unit. The students are in the Classroom scene. First, the characters Daniel and Julia introduce themselves as their new Swiss classmates. Then the students have the opportunity to look around the virtual environment. Daniel then asks them for their first name and asks them to say it out loud. The students now can actively speak for the first time in the virtual reality learning unit. The name will be used during the virtual reality learning unit to address the students personally. To navigate between the different sections of the Virtual Reality Learning Unit, the three terms "Next Unit", "Repeat" and "Finish" are often needed. First, Daniel explains the terms in his native language before Julia translates and pronounces them in German. Daniel then asks the students to repeat the three terms in German—the terms are displayed as text windows in the virtual environment. The accuracy of the pronunciation does not play a role at this stage of the virtual reality learning unit. Any input, regardless of whether it is correct or incorrect, is accepted so as not to frustrate the students.

2.2.2 Start unit 1

The first unit begins with an introductory section. The students are in the Classroom scene with the characters Julia and Daniel. The students can choose between two different paths, each consisting of a section for improving pronunciation and a section for practicing dialogues. Julia and Daniel recommend that students start with the first path.

2.2.2.1 Unit 1: pronunciation 1 The learning content of the section is based on the second GasL topic "Introducing oneself" and was therefore developed on the basis of the teaching materials "Pipapo 1, Lerneinheit 1" [32] and "Startklar A1, Lerneinheit 1" [33]. The section focuses on five German questions that are needed to get to know the classmates better. Daniel explains the meaning of each of the five questions in the students' native language. After that, Julia first pronounces a part of the question in German. The students are now asked to repeat the part in German. Julia then pronounces the entire question in German. The students are now asked to repeat the entire question in German.

After going through the process for all five questions, the second round starts: Julia speaks out the parts as well as the whole questions in German one more time. The students are again asked to repeat them in German, but this time the text windows are no longer displayed. In addition, the accuracy of the pronunciation is checked by the integrated speech recognition. The students have two attempts per input to achieve a correct pronunciation. If the first attempt fails, the text window is displayed as a help for the second attempt. If the second attempt also fails, Julia switches to the next section or the next entire question.

2.2.2.2 Unit 1: dialogue 1 The students are now in the Schoolyard scene with the characters Peter and Daniel. First, the character Peter is introduced as another Swiss class member. Then, the students can get to know Peter better by asking him the five German questions from the previous section in a dialogue. Daniel explains to the students in their native language which question they should ask Peter next. The question is then displayed to the students as a text window in the virtual environment. Peter gives a scripted answer for each question. In an advanced version the scripted version is replaced by the response based on a large language model (LLM) [34].

2.2.2.3 Unit 1: pronunciation 2 The content of the section is based on the second GasL topic "Introducing oneself" based on the same text books. The section focuses on five German statements that are needed to introduce oneself to classmates. The students take the role of the fictional character "Alex" in this section. Daniel explains the meaning of each of the five statements in the students' native language. Afterwards, Julia first pronounces a part of the statement in German. The rest of the pronunciation section is designed analogously as Pronunciation 1.

2.2.2.4 Unit 1: dialogue 2 The students are now in the Schoolyard scene with the characters Helena and Daniel. First, the character Helena is introduced as another Swiss class member. Next, the students can introduce themselves to Helena by using the five German statements from the previous section to answer her questions in a dialogue. Daniel explains to the students in their native language what question Helena asked them. The appropriate answer is then displayed to the students as a text window in the virtual environment. Accuracy of pronunciation

does not matter in this section. Any input, whether correct or incorrect, is accepted to ensure a fluent dialogue. The design is analogously as for the section Dialogue 1.

2.2.3 Implementation of the design guidelines

As part of the design process, the general design guidelines for virtual reality learning units in an educational context according to Johnson-Glenberg [35] were considered. In the following, we will discuss how the design guidelines were implemented in each case:

2.2.3.1 Assume every learner is a VR newbie—start slow In the first section ("Start Intro"), the students are first introduced to the virtual environment and the overall situation step by step. They can then decide whether they want to continue with the first, easier unit or with the second, more challenging unit. The two levels of difficulty cover different performance levels and give the students a feeling of freedom of choice.

2.2.3.2 Scaffold—introduce cognitive steps one at a time In the sections on improving pronunciation, students first learn the meaning of the questions and statements in their native language. Then, depending on the unit, they practice a section before repeating the entire question or statement. In the sections for training dialogues, the students then have the opportunity to combine the previously learned content and apply it in authentic language scenarios.

2.2.3.3 Co-design with teachers During the conception of the virtual reality learning unit, contact was made with two GasL teachers at an early stage. The learning content was selected in consultation with them. This ensured that the learning content was correctly contextualized and relevant for the implementation with the GasL students.

2.2.3.4 Use guided exploration Throughout the virtual reality learning unit, the students are accompanied by the virtual character Daniel, who guides them in exploring the virtual environment. Various introductory sections ("Start-Intro", "Start-Unit1", "Start-Unit2") are designed to ensure that the students can easily find their way around.

2.2.3.5 Minimize text reading The virtual reality learning unit is based on verbal interaction between the virtual characters and the students. Instructions are given in verbal form. The use of text is minimized and limited to the text fields that are displayed to the students in context.

2.2.3.6 Build for low stakes errors early on In the virtual reality learning unit, various opportunities have been integrated in which the students can make mistakes early on. At the beginning of the pronunciation improvement sections, any input is accepted, regardless of whether it is correct or incorrect. After that, students have two attempts to pronounce the sections or the entire questions and statements correctly, depending on the unit. This allows students to continuously improve and learn from their mistakes.

2.2.3.7 Feedback—unobtrusive, actionable and well-timed In the second part of the pronunciation improvement sections, the accuracy of the pronunciation is checked by the integrated speech recognition. If the first attempt fails, the text window is displayed again for the second attempt. This provides students with unobtrusive and immediate feedback.

2.2.3.8 Design in opportunities for reflection The virtual reality learning unit is divided into phases in which the students are actively involved in verbal interactions with the virtual characters and phases in which the virtual characters only talk to each other. The varied structure enables the students to reflect on and process the content they have learned.

2.2.3.9 Encourage collaborative interactions The students are accompanied by the virtual character Daniel throughout the entire virtual reality learning unit. In addition, three other virtual characters are introduced in the course of the virtual reality learning unit. By interacting with the different characters in the respective sections, a social and collaborative multiplayer experience is created.

Table 1 Demographic questions

Question	Id
How old are you?	DI1
What gender do you identify yourself as?	DI2
Do you have any previous experience with virtual reality?	DI3

2.2.4 Technical realization

The learning unit was realized with the integrated development environment Unity,[1] assets from the unity assetstore,[2] e.g., classroom, schoolyard, and a self-developed code generator [36, 37] that allows code free realizations of learning units with verbal interactions. As a reference for the development the guidelines for developing VR and AR based education and training systems of the respective whitepaper[3] by ISO/IEC 2019 were considered and where appropriate followed.

The first step in the development process consists of the design of the multilinear narrative with twinery.[4] Twinery is an open-source tool for telling interactive, nonlinear stories. Twinery offers a text-based user interface. For our purposes the textual information is enriched with a set of special literals that are used to trigger runtime macros. These runtime macros are needed in a subsequent step to initiate the interactions in the virtual environment.

The second step in the development process features the design of the scenes where the multilinear story will play. For this use case two scenes were designed:

- A classroom scene where the user gets acquainted with the two main computer animated characters Daniel and Julia and where pronunciation is practised.
- A schoolyard scene where the user gets into contact with the additional computer animated character Peter. In this scene dialogues are practised.

For both scenes existing 3D models from the assetstore are used and combined. The cartoon like humans are taken from an asset as well and are configured with gestures, mimics and lip sync.

The last step of the development process is characterized by the generation of code from the multilinear story made in Twinery. This process is automated and only some final configuration is needed at the end of the generation process.

2.3 Data collection (questionnaire)

The virtual reality learning unit for German as a second language was tested in two different courses. A questionnaire was given to all students immediately after the implementation of the virtual reality learning unit in order to document their feelings and thoughts. In the following, the three different components of the designed questionnaire are discussed in more detail.

At the beginning of the questionnaire, demographic information about the students' background is obtained through three different questions (Table 1).

The main part of the questionnaire is based on the "Core Module" of the "Game Experience Questionnaire" (GEQ) developed by IJsselsteijn et al. [28]. The GEQ is a self-report instrument to characterize the diverse experiences and impressions of playing digital content [38]. The Core Module is a central component of the GEQ and focuses particularly on the feelings and thoughts of the users during gameplay. The questionnaire of the Core Module contains 33 standardized questions, which are divided into seven different dimensions.

Competence describes the motivation to master a game or to make progress in it [39]. Users experience a sense of accomplishment when they continuously work towards meaningful goals that are difficult but achievable. Fulfillment of the dimension is assessed by the five questions shown in Table 2.

[1] https://unity.com/.
[2] https://assetstore.unity.com/.
[3] https://www.iso.org/files/live/sites/isoorg/files/developing_standards/who_develops_standards/docs/White_Paper_VRAR.pdf.
[4] https://twinery.org/.

Table 2 Questions concerning competence

Dimension	Question	Id
Competence	I felt skillful	CO1
	I felt competent	CO2
	I was good at it	CO3
	I felt successful	CO4
	I was fast at reaching the game's targets	CO5

Table 3 Questions concerning sensory and imaginative immersion

Dimension	Question	Id
Sensory and Imaginative Immersion	I was interested in the game's story	I1
	It was aesthetically pleasing	I2
	I felt imaginative	I3
	I felt that I could explore things	I4
	I found it impressive	I5
	It felt like a rich experience	I6

Table 4 Questions concerning flow

Dimension	Question	Id
Flow	I was fully occupied with the game	F1
	I forgot everything around me	F2
	I lost track of time	F3
	I was deeply concentrated in the game	F4
	I lost connection with the outside world	F5

Table 5 Questions concerning tension and annoyance

Dimension	Question	Id
Tension/annoyance	I felt annoyed	TA1
	I felt irritable	TA2
	I felt frustrated	TA3

Sensory and imaginative immersion describes an intense gaming experience in which users feel "immersed" in a virtual world and are "immersed" in this artificial virtual world [40]. The fulfillment of the dimension is checked by the six questions shown in Table 3. Half of the questions refer to sensory immersion, the other half to immersion generated by imagination [38].

Flow describes a feeling of pleasure that occurs when a balance between skill and challenge occurs during an intrinsically rewarding activity [41]. Flow states include feeling in control and "merging" with the activity as well as experiencing "temporal distortions" [42]. Fulfillment of the dimension is assessed by the five questions depicted in Table 4.

Tension/annoyance describes a feeling of frustration and anger that often occurs during competitive or otherwise unsatisfying gaming experiences [43]. In particularly extreme cases, the gaming experience ends in a high-intensity, negative emotional experience that can lead to loss of mastery ("gaming rage") [44]. The fulfillment of the dimension is tested by the three questions shown in Table 5.

Challenge describes a challenging game experience in which users can make progress in a game despite ongoing confrontation with the threat of failure [45]. In this regard, a balanced game experience offers challenges that are demanding but also not too difficult. The fulfillment of the dimension is checked by the five questions shown in Table 6.

Negative affect describes an unsatisfactory gaming experience that evokes negative emotions in users [43]. Content that users find frustrating, monotonous, unpleasant, or even depressing is often the decisive factor for an unsatisfactory gaming experience. The fulfillment of the dimension is checked by the four questions shown in Table 7.

Table 6 Questions concerning challenge

Dimension	Question	Id
Challenge	I thought it was hard	CH1
	I felt pressured	CH2
	I felt challenged	CH3
	I felt time pressure	CH4
	I had to put a lot of effort into it	CH5

Table 7 Questions concerning negative affect

Dimension	Question	Id
Negative affect	It gave me a bad mood	NA1
	I thought about other things	NA2
	I found it tiresome	NA3
	I felt bored	NA4

Table 8 Questions concerning positive affect

Dimension	Question	Id
Positive affect	I felt content	PA1
	I thought it was fun	PA2
	I felt happy	PA3
	I felt good	PA4
	I enjoyed it	PA5

Table 9 Questions concerning the overall evaluation

Question	Id
How long was my playing time	R1
I was satisfied with this virtual reality learning unit as a whole	R2
I would like to participate in another virtual reality learning session	R3

Table 10 Questions concerning improvements

Question	Id
What would you add to this virtual reality learning session?	CHG1
What would you remove from this virtual reality learning session?	CHG2
Do you have any additional feedback?	CHG3

Positive affect describes a satisfying gaming experience that evokes positive emotions in users [43]. The ability of games to be "fun" and to offer users a "good time" is often decisive for a satisfying gaming experience. The fulfillment of the dimension is tested by the five questions shown in Table 8.

As the third and last part of the questionnaire, six questions are asked that are intended to investigate additional aspects that were not covered by the previous questions. First, the students are asked in an open question to give an assessment of the duration of their respective playing time in minutes. Two further questions concern the overall evaluation of the virtual reality learning unit (Table 9).

Finally, three open-ended questions are used to collect suggestions for improvement from the students (Table 10).

The finalized versions of the designed questionnaire are available in the five native languages of the participants: English, German, Albanian, Russian, and Greek.

This case study was accompanied by a longitudinal study comprising two male participants both of age 10. This study consisted of 7 interventions over a time horizon of 7 weeks. For this purpose, a very simplified questionnaire

Table 11 Participants of the field study

School	Subject	Mother language	Used language	Age	Gender	VR experience
Primary	1	Albanian	Albanian	11	Female	No
Primary	2	Albanian	Albanian	11	Female	No
Primary	3	Albanian	Albanian	12	Male	Yes
Primary	4	Greek	Greek	11	Female	No
Primary	5	Azerbaijani	English	11	Female	No
Secondary	1	Russian	English	13	Male	Yes
Secondary	2	Bulgarian	English	14	Female	No
Secondary	3	Russian	Russian	15	Female	No
Secondary	4	Russian	Russian	12	Male	No
Secondary	5	Russian	Russian	14	Male	No

with the questions CO3, CO4, PA1, CH5, CHG1, and R3 was used. The main reason for using a reduced set of questions was the time required to complete the full set of questions. The concrete choice of the above six questions was focused of the primary goals of the longitudinal study, i.e., subjective perception of the subjects, attractiveness of the virtual learning venue.

2.4 Procedure (field study of the virtual reality learning unit)

The virtual reality learning unit was tested on 2 different days with students from an elementary school and a secondary school. Two separate rooms were available for testing the virtual reality learning unit and completing the questionnaire. A contact person was present in both rooms. The students were picked up individually from their regular classes and had the opportunity to test the virtual reality learning unit in the first room. At the beginning there was always a short introduction: the students were first informed about the procedure of the implementation. Then they were instructed on how to control the virtual reality goggles. It was also explained to them how they can select the native language that suits them best.

After testing the virtual reality learning unit, the students were each accompanied to the second room to complete the questionnaire. They were first given an introduction to the structure of the questionnaire. It was explicitly pointed out that they always had the possibility to ask questions to the contact person in case of any ambiguities.

As mentioned above a longitudinal study was conducted concurrently. For this purpose, 7 consecutive multilinear stories based on the same VR-App were designed and provided. During this longitudinal study the boys filled out the simplified questionnaire for each intervention. Additionally, their parents were asked for each intervention to fill out a respective questionnaire as well. In the midst of the study and at the end the teachers of the boys were interviewed about their observations during the conventional classes. Findings from these interventions are not documented in detail but did not disclose any discrepancy with the findings from the main case study. Rather, they confirmed the observations.

2.5 Participants

Following Table 11 describes the subjects participating in the field study.

School indicates the type of the school, either primary or secondary school, where the subject attended at the time of the field study. The used language denominates the language used in the learning unit. For two participants it was different from the respective mother language.

3 Virtual reality in language education

Immersive virtual reality systems are becoming increasingly important in technology-enhanced language learning [10]. Their use in traditional school-based language instruction is associated with a number of different opportunities and challenges [13, 18, 20]. The following sections cover a not conclusive list of opportunities, challenges, existing applications, as well as design guidelines.

3.1 Opportunities

The use of immersive virtual reality in language acquisition offers several opportunities for the school context to support students' successful learning of a second language [18]. Some, for this case study relevant, opportunities are discussed in more detail below.

- One possible advantage of using immersive virtual reality in language acquisition is the possibility to train the new language directly in the application context [10, 46]. By "immersing" students in simulated environments of authentic language scenarios, such as a restaurant or a train station, they can actively speak the language in the context of use, rather than just passively learning it [47]. This helps students build contextual language skills early on, which will be needed later to master the transfer of practice from language teaching to real language scenarios. Compared to role-playing, which is a well-established approach in the classroom, virtual reality offers an individual, possibly personalized, learning venue with no human interference. Role-playing has the potential disadvantage that the social interactions between the players diverge [48].
- Another potential advantage of using immersive virtual reality in language acquisition is the opportunity to practice the new language in a virtual environment without inhibitions or fear of making mistakes [16, 17]. Acquiring a new language is often a nerve-wracking and uncomfortable experience [8]. Fear of making mistakes can affect self-confidence and reduce motivation. However, with the use of immersive virtual reality, students can be immersed in authentic and realistic virtual worlds where the fear of making mistakes is removed. This allows students to practice language without pressure and without the feeling of being watched.
- Another advantage is the ability to tailor the learning content and environment to students' individual prior knowledge and learning preferences [10, 49]. Language acquisition is a complex process that works differently from person to person [50]. Various factors such as personal aptitude, motivation, and prior knowledge affect the individual's pace of learning. The goal of language teaching is to include all students equally by not neglecting the lower achievers and encouraging the potential of the higher achievers.

3.2 Challenges

The above mentioned opportunities are countered by several challenges that must be overcome for successful use in a school context [13, 20]. Again, for this case study relevant challenges are discussed in more detail below.

- A first challenge is the high effort of a successful implementation [20]. This is influenced by a number of different aspects. The acquisition of current immersive virtual reality systems is associated with high costs for schools, as they require large numbers of units (class sets) [24, 51, 52]. In addition, there are the costs of purchasing suitable software for language acquisition as well as multi-device management. Furthermore, teachers need appropriate media didactic and technical training for handling the immersive virtual reality systems as well as the corresponding software to ensure that the use in language classes works smoothly. Last, there is a need to develop pedagogically sound virtual reality learning units that are available to teachers for direct use or adaptation [10]. However, application and educational standards are first needed for development, but these do not yet exist.
- Another challenge are physical symptoms, which are summarized under the term "cybersickness" and can be roughly compared to classic seasickness on a strongly moving ship [24, 53]. Symptoms include headache, drowsiness, nausea up to and including vomiting, a disturbance in movement coordination, or even disorientation. The symptoms can occur both during and after the use of immersive virtual reality systems. Around 10% of users feel cybersickness after some time depending on the locomotion in VR and the movement of virtual objects.
- A third challenge is the insufficient representation of one's own body in the virtual environment [23]. In building new language skills, nonverbal communication plays an important role [54]. When using immersive virtual reality for language acquisition, students are therefore dependent on transferring their gestures, facial expressions, and body posture from the real world to the virtual environment as precisely as possible. However, current immersive virtual reality systems often only depict the movement of the hands, which means that a large part of the nonverbal communication is lost when interacting with other "real" players or with non-player characters (NPC) in the virtual environment. However, this drawback will gradually vanish with more powerful VR headsets.

3.3 Concrete offers

In the meantime, various offerings exist on the market that have been specifically designed for language acquisition with immersive virtual reality. The offerings range from face-to-face classes supported by virtual reality glasses to virtual platforms that can be used from home with their own virtual reality glasses [52, 53, 55–57]. The application of these platforms in public schools fails due to the given teaching materials and accompanying didactic frameworks of the curriculum. Therefore, these offerings are primarily made by private language schools that can build the didactics around the VR-apps.

3.4 Design guidelines for virtual reality learning units

The design of virtual reality learning units in an educational context is a complex undertaking, where the challenge is primarily to combine high-quality pedagogy with sustainable entertainment [35]. In this context, the objective of virtual reality learning units in an educational context differs significantly from the objective of virtual reality applications from the gaming industry [12]. For this reason, other design guidelines must be considered when developing virtual reality learning units in an educational context. Southgate [58] dives in chapter 3 of his book even more into this topic and points out various differences and affordances. But Johnson-Glenberg developed one of the first sets of design guidelines for virtual reality learning units in an educational context. The set includes eleven general design guidelines that were compiled with pedagogical requirements and the best possible learning progression in mind.

Another important aspect to be considered in the design of virtual reality learning units in the educational context is the respective didactic framework. These include all organizational and methodological specifications that are necessary for a successful educational process [59]. In concrete terms, this means that the didactics should be based on the prescribed teaching material and that the content taught must follow the structure of the teaching material. For this case study the text books "Pipapo" [32] and "Startklar A1" [33] were given by the curriculum.

3.5 Research objectives

With this study following research objectives were tackled:

1. How must an immersive virtual reality learning unit for GasL lessons be designed (see Sect. 2.2) so that it fulfills the design guidelines (see Sect. 2.2.3) for virtual reality in education?
2. How do the students rate such an implementation of an immersive virtual reality learning unit for GasL lessons (see Sect. 4)?
3. What prerequisites must be observed or, if necessary, created so that immersive virtual reality learning units can be pragmatically integrated into existing GasL lessons (see Sect. 4.9)?

4 Results

Six girls and four boys participated in the experiment. The average age of the participants was 12.4 years. Two of the participants had already had experience with a VR headset. The two boys who participated in the longitudinal study were both of age 10. Both had prior experience with gaming but not with VR.

4.1 Competence

Questions CO1-4 in Table 12 were predominantly rated cautiously by the students. Due to their limited previous experience, the students showed a certain degree of uncertainty and nervousness in dealing with the new digital medium. This could also have had a negative impact on their sense of success.

Table 12 Results regarding competence

Id	Competence	ø
CO1	I felt skillful	3.70
CO2	I felt competent	4.00
CO3	I was good at it	4.10
CO4	I felt successful	3.70
CO5	I was fast at reaching the game's targets	4.40
		ø 3.98

Table 13 Results regarding sensory and imaginative immersion

Id	Sensory and imaginative immersion	ø
I1	I was interested in the game's story	3.80
I2	It was aesthetically pleasing	3.60
I3	I felt imaginative	3.40
I4	I felt that I could explore things	3.70
I5	I found it impressive	4.56
I6	It felt like a rich experience	4.40
		ø 3.91

Table 14 Results regarding flow

Id	Flow	ø
F1	I was fully occupied with the game	4.30
F2	I forgot everything around me	3.90
F3	I lost track of time	3.50
F4	I was deeply concentrated in the game	4.20
F5	I lost connection with the outside world	3.10
		ø 3.80

Question CO5 on the other hand, was rated higher. The positive result indicates that the students were able to work towards meaningful goals that were difficult but still achievable.

4.2 Sensory and imaginative immersion

The results of questions I1–4 in Table 13 correspond to the answers depicted in Table 19 regarding the suggestions for improvement. The students stated that they would like to see a more modern design of the virtual environment and more opportunities for movement.

The positive results of the questions I5 and I6 indicate that the students were impressed by the test of the virtual reality learning unit and perceived it as an enriching experience. Overall, this dimension was positively evaluated with M = 3.91.

4.3 Flow

Basically, the results of questions F1–5 in Table 14 correspond to the observations during the tests of the virtual reality learning unit. Due to their limited previous experience, the students also needed a certain amount of support during the tests, which manifested itself in various queries and the help needed to correct the position of the virtual reality glasses, among other things. The repeated interruptions may have had a negative impact on the students' feeling of immersing with the activity and thus on their flow state.

The students were each given twelve minutes to test the virtual reality learning unit. However, the subjective assessment of the average VR time of 7.30 min was significantly shorter than the actual playing time. This deviation actually indicates a high degree of immersion and flow, since the students experienced a subjective distortion of their time perception. At the same time, however, the assessments specifically contradict the result of question F3. This indicates that

Table 15 Results regarding tension and annoyance

Id	Tension/annoyance	ø
TA1	I felt annoyed	1.30
TA2	I felt irritable	1.10
TA3	I felt frustrated	1.00
		ø 1.13

Table 16 Results regarding challenge

Id	Challenge	ø
CH1	I thought it was hard	1.90
CH2	I felt pressured	1.30
CH3	I felt challenged	2.30
CH4	I felt time pressure	1.60
CH5	I had to put a lot of effort into it	1.70
		ø 1.76

the students were not aware that their assessments were significantly shorter than the actual duration of their playing time.

4.4 Tension/annoyance

The results of questions TA1–3 in Table 15 indicate a satisfying game experience in which the students did not feel any frustration and/or anger. Overall, this dimension was rated extremely positively with M = 1.13 where positive has the meaning of now or few tension/annoyance.

4.5 Challenge

The results of questions CH1–5 in Table 16 indicate on the one hand that the students hardly experienced any negative stress. On the other hand, they also suggest that the virtual reality learning unit was not perceived as excessively challenging.

The students were possibly even underchallenged in certain tasks. This would also correspond to the feedback of the students, who stated in Table 19 that they would like to see an increase in the level of difficulty of the virtual reality learning unit.

4.6 Affect

The results of questions NA1–4 indicate a satisfactory playing experience, which the students perceived neither as frustrating nor as monotonous, unpleasant or depressing. Overall, the dimension "negative affect" was rated significantly positive with M = 1.62 as shown in Table 17.

The results of questions PA1–5 on positive affect coincide with the results on negative affect. They indicate a satisfying gaming experience that evoked positive emotions in the students and provided them with "fun" and a "good time".

4.7 Overall rating

The students were able to give an overall rating for the virtual reality learning unit by answering the three questions in Table 18. R1 was already mentioned in chapter 8.3. All test subjects estimated the playing time to be much shorter (ø 7.4 min) than the actual playing time of 12 min. The result of question R2 shows that the students were extremely satisfied with the virtual reality learning unit as a whole.

Table 17 Results regarding negative and positive affect

Id	Questions about negative affect	Mean value
NA1	It gave me a bad mood	1.20
NA2	I thought about other things	2.20
NA3	I found it tiresome	1.40
NA4	I felt bored	1.67
		ø 1.62
Id	Questions about positive affect	Mean value
PA1	I felt content	4.30
PA2	I thought it was fun	4.20
PA3	I felt happy	4.60
PA4	I felt good	4.60
PA5	I enjoyed it	4.70
		ø 4.48

Table 18 Results regarding the overall rating

Id	Question	ø
R1	How long was my playing time (the number indicates the minutes)	7.4
R2	I was satisfied with this virtual reality learning unit as a whole	4.40
R3	I would like to participate in another virtual reality learning session	4.30
		ø 4.35

Table 19 Answers regarding improvements

What would you add to this virtual reality learning session?	#
Integrate movement possibilities	3
Make voices more realistic (virtual characters)	3
Increase difficulty	3
More modern design of the virtual environment	3
Add more everyday situations (scenes)	2
Consider Albanian dialects for languages	2

The results of question R3 showed a difference based on age. The younger students (ø 4.8) seemed to be much more curious about the test of the virtual reality learning session, whereas the older students (ø 3.8) were less impressed due to their greater age-related experience with digital media. For this reason, they would possibly also be less interested in participating in further VR based learning. Overall, the virtual reality learning unit was rated very positively with a total score of M = 4.35 for both questions.

4.8 Suggestions for improvement

At the end of the questionnaire, two open questions were asked to collect suggestions for improvement from the students. For the first question, the students expressed six different aspects that should be added to the virtual reality learning unit as depicted in Table 19.

Table 20 General feedback

Do you have any additional feedback?	#
Virtual environment was authentic	2
Virtual reality goggles weight too high	2
Only as a supplement to traditional teaching	2
Explanations in native language were helpful	1
Quiet environment was useful	1
Strain for eyes was high	1

The first aspect relates to the integration of additional movement options in the virtual reality learning unit, as this was perceived as too "static". However, movement was only restricted based on the setup of the Quest2 and not due the VR-App. Furthermore, the students expressed the wish for a more realistic design of the voices of the virtual characters, as these were partly perceived as too "mechanical". The voices used were neural voices provided by the Microsoft Azure platform. Although many languages are supported the degree of realism is best for English. Since the native languages of the participants were other than English these voices suffered from less realism. The third aspect concerns an increase in the level of difficulty of the virtual reality learning unit. Again, this requirement can easily be fulfilled for extended field studies. The fourth and fifth aspects refer to the design of the virtual worlds. To keep the effort low for the prototype standard scenes with minimal changes were used. For a commercial product this approach would not be sufficient. A considerable effort would need to be invested in the design and usability of the scenes. Finally, the students also expressed the wish to take into account the different Albanian dialects in order to better understand the virtual characters. Since Albanian is not a well supported language by the Microsoft Azure platform other providers of voices may have to evaluated or own neural voices have to be developed. Again, this may be necessary for a commercial product but was outside the scope of this use case.

As general feedback the students expressed six topics (Table 20). The authenticity of the virtual environment, the explanations in the native language, and the quiet environment during the tests were highlighted as very helpful. On the other hand, the weight of the virtual reality goggles as well as the high strain on the eyes were highlighted negatively. There, the future development of the technology will have to be assessed. Furthermore, it was expressed that the virtual reality learning unit should only be used as a supplement to traditional teaching which is absolutely in line with the didactical concept.

4.9 Prerequistes for a pragmatic integration of VR learning units

Three weeks after the successful implementation of the virtual reality learning unit, the two GasL teachers were contacted again by e-mail as part of a "follow-up". The goal was to find out which prerequisites from their point of view would have to be considered or, if necessary, created so that immersive virtual reality learning units could be integrated pragmatically into the existing GasL lessons. The feedback partly overlapped with the identified challenges from the literature analysis. The feedback was divided into the categories didactical, organizational, and medical.

- With regard to the didactic requirements, it was first emphasized that it must be scientifically proven in which situations the use of virtual reality learning units has a beneficial effect on language acquisition. In addition, the availability of pedagogically sound and, above all, appropriate learning content that corresponds to the language level of the students would have to be guaranteed. The virtual reality learning units should only be used as an aid to supplement traditional language instruction. In addition, parents must be informed in advance about the use of virtual reality and be enthused about it. But also the teachers would have to be convinced of the use for a successful integration. Finally, it would have to be ensured that enough space is available for use—ideally, separate and quiet rooms should be available.
- With regard to the organizational requirements, it was first emphasized that sufficient financial resources would have to be created for the purchase of the virtual reality glasses, the establishment of the necessary infrastructure (WLAN, multi-device management software), and maintenance. In addition, the teachers would each need training to acquire the media didactic and technical skills required for use. Furthermore, the virtual reality learning units would have to be able to be used by the teachers without great effort (no programming, etc.). The use would

have to be intuitive and, above all, require little preparation time. Furthermore, it would be important that the virtual reality learning unit is technically designed in such a way that the design of the virtual environment and the appearance of the virtual characters appeal to the students and thus arouse their interest in using it. Finally, data protection would also have to be guaranteed.

- With regard to medical requirements, it was first emphasized that guidelines would have to be developed that specify with which pre-existing conditions the use of virtual reality learning units is not recommended. In addition, guidelines are needed on the maximum medically acceptable duration of use. Finally, the handling of side effects (cybersickness) during and after use would also have to be comprehensively clarified.

5 Conclusions and outlook

A critical aspect arises from the "novelty effect" that can occur when new digital media are used in a school context [60]. The effect is associated with increased motivation to learn and an intensification of learning activities brought about by interest in the new digital media [61]. However, there is a possibility that the effect will quickly wear off again if the new digital media are used over a longer period of time. For eight of the ten students, the test of the virtual reality learning unit was their first experience with virtual reality glasses. Part of the positive feedback could therefore also be due to the fact that the experience with this new digital medium was a welcome change from traditional teaching. Findings from the longitudinal study which lasted over a period of 7 weeks did not show the "wear off" effect. But anyways, to verify this, the use of virtual reality learning units should be tested over a longer time horizon.

Another critical aspect results from the limited amount of available learning content and difficulty levels within the virtual reality learning unit. Already at the beginning of the conception of the virtual reality learning unit, the different previous knowledge and language levels of the individual students were discussed with the GasL teachers. For this reason, the virtual reality learning unit also takes into account two different GasL topic areas ("Introducing oneself" and "Making contacts") as well as two different levels of difficulty. For more precise feedback, however, the virtual reality learning unit should be tested with a larger number of different learning contents and different levels of difficulty. In this way, more attention can be paid to the individual prior knowledge and language levels of the students and thus more well-founded feedback can be obtained. Again, findings from the longitudinal study support the observations from the main case study. Simultaneously, variations in the VR world are important for keeping a high attention level even over a rather short period of 7 weeks.

The design of the VR worlds was not in the focus of this study. However, taking the feedback in Table 19, e.g., more modern design of the virtual environment, add more everyday situations (scenes), it is obvious that the design of the virtual environment has an influence on the perception of the subjects. Vergara et al. [62] point out the relevance of the design and propose a general flowchart for the design. Although the design proposal was elaborated for engineering it is well adaptable to other fields. Hence, for further studies it may be beneficial to consider the visual design carefully in order to avoid any interfering factors.

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Declarations

Consent for publication Informed consents (consent to participate and consent to publish) were obtained from all participants.

Competing interests The authors declare no competing interests.

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