LEARNING AND TEACHING
IN VIRTUAL REALITY

POSSIBILITIES AND LIMITS OF
COLLABORATIVE IMMERSEIVE
VIRTUAL ENVIRONMENTS

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Summary 120
The use of immersive virtual reality (iVR) in various domains is an undeniable trend of the present. It is no longer a question of whether to use this medium but how to implement it as efficiently as possible. The aim of the applied research project “Education in Collaborative Immersive Virtual Reality” (EduINCIVE) was to develop our own open-source software platform, eDIVE, for online collaborative work in immersive virtual reality, design educational programs, including teaching scenarios for two areas – foreign language instruction and geography, empirically validate the entire system, and implement it in target institutions.

When creating teaching scenarios and content, we consistently focused on the needs of the target groups, including students, teachers, and librarians, for whom our solution was also aimed. In designing educational applications, we adhered to several fundamental principles:

1. Although immersive reality has great potential as a medium, it must reflect on its limitations, approach it critically, and not be carried away by “techno-optimism”. Some users may also be unable to use this relatively young medium or only to a minimal extent. Therefore, to ensure inclusivity, developing and maintaining conventional 2D interfaces for all created applications is necessary.

2. We also do not see the point in adapting all educational topics to immersive virtual environments, especially those that can be effectively taught through traditional methods. When selecting topics for implementation in the virtual environment, we primarily look for those with a significant leverage effect. Thus, we primarily view immersive virtual environments as a complementary medium that complements and enhances current teaching methods.

3. A different medium also demands different teaching approaches and the application of didactic procedures. It is not meaningful to use analogous approaches as in the real environment. It is necessary to identify the advantages of the new medium, leverage its potential, and tailor courses to users’ needs. Painting with oil or watercolours is different; different tech-
Techniques are required to maximise the potential of the given medium. The same applies to teaching in a real classroom or a virtual environment.

This book consists of five chapters. The first chapter “Immersive Virtual Reality as a Tool of Choice” introduces the reader to virtual reality technology, its advantages, and application areas. In the second chapter “Theoretical Background of Education and Research in Immersive Virtual Reality” the topic of immersive virtual reality is anchored in current theories. This is followed by two chapters presenting the outputs of qualitative empirical research. In the third chapter “From Classroom to Anywhere: Implementing Didactic Principles in Virtual Reality for Language Education” the experiences of university students in a semester-long course of English as a foreign language, conducted entirely in immersive virtual reality, are presented. The fourth chapter subsequently presents the results of a qualitative study of a selected scenario in the field of geography. The entire monograph is completed with the chapter “Implementing collaborative immersive virtual reality into libraries”, which introduces the reader to the results of the experimental deployment of immersive virtual reality and collaborative teaching in several libraries.

During the development of the eDIVE application and the creation of educational courses, during the experimental deployment of the entire solution, and its empirical validation using both quantitative and qualitative methodologies, many experiences and insights were gained. From the initial design of the teaching scenario to the final version, several iterations were carried out, incorporating feedback from instructors and students. Teaching scenarios and procedures did not originate from the desk but were based on the requirements and needs of users. The medium’s potential was maximised for the selected and implemented topics, while efforts were made to compensate for its limitations as much as possible. So, does immersive virtual reality offer a better alternative for education? Our recurring experiences show that immersive virtual reality, or the educational topics we chose and tested, are comparable to traditional education. In certain areas, immersive virtual reality can bring advantages. Although this technology has inherent limitations that disqualify it as a dominant form of educational media, it introduces an exciting quality to education. The experiences of teaching foreign languages in real classrooms or through online video chats are undoubtedly diverse. Nevertheless, how often do students spontaneously start dancing after completing a course? Immersive virtual reality provided us with this experience.

During the course of the “Education in Collaborative Immersive Virtual Reality” project, we gradually explored the possibilities and areas of further application of iVR media. Currently, based on the experience from the original research,
we are pursuing two additional lines. While teaching in iVR, students repeatedly provided feedback that they perceive iVR education as more like the real environment than online 2D-screen-based learning, especially regarding social aspects. Collaborative iVR is now being developed as a tool for enhancing social cohesion among full-distance education program students, for whom iVR could substitute for the missing direct interaction with their peers. Positive experiences with teaching English as a foreign language led us to expand our scope, and our new goal is to develop not only language skills but also help students explore different cultural areas. This is achieved through theatre plays in iVR, focusing on discovering Chinese culture.
Chapter 1

iVR as a Tool of Choice

Alžběta Šašinková

This chapter explores Immersive Virtual Reality (iVR) as a versatile tool for scientific research, particularly in education and psychology. It traces iVR’s evolution, emphasising the significance of head-mounted displays and the continuum of immersion levels. The chapter categorises iVR designs, focusing on individual and group engagement. Highlighting iVR’s role as a research tool and its use in simulation studies, the chapter also addresses its potential as a new medium for educational interventions. It concludes by acknowledging challenges and opportunities in studying iVR-specific phenomena and advocating for a nuanced approach to leveraging its potential for research and education.

In recent years, the question of what service immersive virtual reality (iVR) will do for humankind has been brought up many times. Sometimes, we were offered techno-optimistic, yet dystopian visions of virtual futures (e.g., Spielberg, 2018). From the 1960s, when the first head-mounted displays were developed, the topic has been spiralling into and out of public focus and to this day, a conclusion about the potential of iVR has not been reached, at least for the current state of affairs and the foreseeable future. Too many questions remain, and the answers are still rather scarce. Hereby lies the motivation to examine the possibilities of using iVR as a tool of scientific research. To offer an illustrative yet critical overview of what VR might bring to education and education research, this chapter was adopted from work, originally specifically focused on psychological research (Šašinková, 2023).

Virtual reality has been defined as a computer-generated environment either simulating an existing environment or creating fantasy-like worlds. Its immersive effect means that the user feels deeply engaged (“immersed”) in the virtual world both on the cognitive and affective level, and on the social level should the environment be collaborative. The immersion generally invokes disconnection from the perception of the outer physical world. The immersion is determined by several features of the environment and the first – and crucial – is the technology used to enter the iVR. The key to understanding the variability of iVR described in many articles is realising that immersion is not a binary variable (immersive vs. non-immersive), but rather a continuum starting from environments with a very
1. iVR as a Tool of Choice

mild immersive effect (e.g., desktop-based virtual worlds, similar to captivating movies), including environments with a higher level of immersion such as large screen presentations of virtual environments or in C.A.V.E.s (e.g., Freina & Ott, 2015; Radianti et al., 2020). The highest achieved level of immersion has been reported when virtual worlds are presented through head-mounted displays. These devices provide not only a stereoscopic display of the environments – inducing a 3D experience but also a combination of a spatial sound system and modes of interaction with the environment or potential collaborators that resemble the real world so strongly that we may call this experience fully immersive. Head-mounted displays (HMD) combined with default controllers are the technological setting that lies within the focus of this book.

Outside of the level of immersion as a key variable, there are various means of designing an iVR experience that form the way iVR works.

![Diagram of iVR experience categories](image)

Figure 1.1: The two axes provide a means of describing the categories, starting with the simplest, individual passive use of iVR (bottom left, iVR provides a passive experience to a single user at a time) and ending with the most complex designs that represent modes where the users are able to control/make changes to the environment which result in changes for other users (top right). Adopted from Šašinková (2023).

When we drop the graphical complexity of the virtual environments and focus merely on the means of work in iVR (which are the key interest and source of data
for educational research), the two axes on which each iVR design may be placed point from individual to collaborative use, and from passive to active to interactive (see Figure 1.1). It is, however, necessary to point out that unlike on the Y axis (representing individual vs. collaborative use of VR), the X axis visualises different levels of activity. And these cannot be understood as strictly separated categories – borderlines between them are often blurred and thus the axis should be considered as representing a near continuum with concrete examples picked and explained in more detail. To help structure and describe the broad possibilities of how iVR may be used, it is useful to list examples of articles that describe each particular setting included in the figure.

**Individual – passive: Observation**

Using iVR in an individual passive manner, means the user is exposed to the virtual environment, but is given no tools to move inside the environment and is limited to a mere observation. Typically, a 3D cinema could work as an example. In education, presenting stimuli in an immersive manner, yet without any active contribution by the learner may – from what data has shown us (Kramosilová, 2023) – have a potential to engage learners for a shorter period of time, although many have reported that in the very initial phase of learning, such illustrative content was captivating (Makransky & Petersen, 2021). Ecosphere (PHORIA, 2020) may serve as an example of VR applications that work on this principle.

**Individual – active: Exploration**

For the user to explore an environment actively, meaning to move their perspective and position (i.e., subjectively walk around inside the environment), the environment requires a different technological background. While for the passive observation, a mere 360° video is sufficient, a “plastic” environment to walk through demands being coded in a game engine with 3D objects inserted into it. The exploration here is defined by an absence of controllers and interactive objects that would react to the user’s bidding. An example of this setting would be a virtual tour through the demolished Assyrian palace of Nimrud designed at Yale university (Shedd, 2017).

**Individual – interactive: Control**

When an individual is exposed to a virtual environment, is allowed to explore it freely, and is equipped with tools to interact with and actively influence the environment, we may speak of a mode of control. This setting is suitable for simulation studies in which researchers wish to analyse behavioural patterns. A VR-based
flight simulator might serve as a typical example here (Guthridge & Clinton-Lisell, 2023). In our study comparing wayfinding strategies in a real building and its digital twin in iVR by Stachoň et al. (2022), learning about escape routes is an interesting learning objective. The interactivity between the participants and the environment lay mostly in opening doors and simple problem solving that were related to the topic of a simulated evacuation. These studies provide an image of usefulness utilising iVR in an individual interactive setting, yet both would benefit from a group administration as the presence of other people (or their virtual representation – avatars – in this case) could affect the reliability of the observation (e.g., consultation with a co-pilot).

**Group – passive: Joint observation**

Passive group presentation of iVR to participants is a topic that divided academia in previous years. As the technology entered the world of research, a novel approach needed to be developed towards experimental rigour. The passive collaborative administration of iVR was introduced, for instance, in studies from the field of educational psychology such as Parong & Mayer’s comparison of the instructional effectiveness of iVR (2018). In this study, a similar biology-related presentation was given to students in iVR and a regular classroom. The authors concluded that since students who viewed a regular slideshow outperformed the students who viewed the slideshow in iVR in a post-test, iVR was proved less effective. Other authors, however, believe that these results – closely linked with the collaborative passive setting – should be approached with care as the experimental design does not reflect on the specific features of iVR. The utilised setting (passive presentation of a regular slideshow in an immersive environment without including any interaction) may, in fact, cause artefacts or false correlation and the essentials of the research may get lost in the need for control. For more details on this methodological stance see Šašinka et al. (2019).

**Group – active: Joint exploration**

Similarly, to the individual active setting, the collaborative active setting would mean that a group of users or participants find themselves in the same virtual environment at the same time and they can communicate with each other. In this mode of collaboration, the group may take advantage to navigate each other through the environment or its parts and give each other advice or comments. In research, a typical iVR-based tool used in this mode was Google Expedition (now discontinued platform for field trips to interesting locations). One example for all can be found in Ebadi and Ebadijalal’s study of using Google Expedition to
raise willingness to speak in language education (2022). This iVR setting seems to be efficient under certain conditions and one of them – as discussed by Ebadi and Ebadijalal, too – is interrupting the work in iVR to revise, summarise, share experiences, or make notes, etc., with a frequency adequate to the type of tasks the group is solving. If we stick to the framework of Hesse et al. (2015), this setting could be explained as the element of communication, described by the “exchange of knowledge or opinions to optimise understanding by a recipient” (Hesse et al., 2015).

**Group – interactive: Collaboration**

The setting which could be described as collaborative active is the most complex and rich in potentially collected research data. Notwithstanding, that naturally goes hand in hand with many more intervening variables. This setting means active contributions from at least two participants attending the same virtual location at the same time while they have the tools and power to control and make changes to their environment, subsequently influencing their own experience as well as their partners’. This setting lies in the particular focus of interest of the authors of this monograph. It is this setting in which our studies focused on education in iVR are located and for which they are specifically designed. Collaboration here is defined as a joint activity of a group that works synchronously together to solve a problem in iVR. As this setting is crucial in our research, more examples from our research group’s published work are listed here: All these studies were aimed at designing, validating, and exploring iVR as a tool for collaborative experiential hands-on learning (Jochecová et al., 2022; Sedlák et al., 2022). In all these studies, participants were introduced to and trained at a fully interactive iVR platform (some developed by third parties, and some used the eDIVE platform developed within research projects at Masaryk University (Šašinka et al., 2021). The group of participants held meetings in environments specifically designed for a particular educational intervention, be it an English conversation lesson or a hypsography lesson. Importantly, the environments always offered a wide variety of tools and activities gradually utilised during a combination of teacher- and student-led activities.

It is essential, at this point, to establish the concepts of cooperation and collaboration for this work as some authors distinguish these terms. For example, Hesse et al. (2015) consider cooperation to be an element inherent to collaboration and meaning an agreed task division, while collaboration is understood as a more complex coordinated action including communication, cooperation, and responsiveness. We focus strongly on the collaborative aspects of utilising iVR in research. This orientation originated in the very nature of this technology that
promises to enhance collaboration significantly (Jochecová et al., 2022; Lin et al., 2013) and therefore where we refer to collaborative iVR (or collaborative immersive virtual environment, CIVE), generally multiplayer or group mode is meant.

In a world of perfect scientific rigour, the right path for researchers to follow would probably lead gradually from researching the simplest (observation) to researching the most complex settings in which users affect/control the environment, resulting in affecting other users’ experience (collaboration). In the real world, though, the shift is neither gradual nor follows the progress of state-of-the-art knowledge. In reality, the pace of development is so fast that it requires researchers to jump from simple to very complex settings, collecting findings as they go. This rapid progress provides space for much more basic research than has been done by now (e.g., the optimal cognitive load for various tasks, optimal visual complexity, amount of distractors for various tasks, optimal visualisations of users’ avatars, and many more).

1.1 **Researching VR**

Another perspective to take when considering iVR in the context of educational research is the variability of approaches toward the technology. It is a non-trivial task to identify the possibilities and opportunities that iVR can bring into a researcher’s or educator’s work. Ugwitz et al. (2021) describe a tool developed to design and evaluate experiments in iVR and during working with this tool, it became quite clear that one cannot define their research-related needs to be met by the newly designed tool without a profound understanding of and great experience with the technology in question. Simply put, a researcher needs to know their iVR before finding out what to do with it.

Based on the knowledge gained from the above-mentioned work, the following paragraphs structure and summarise the possibilities of utilisation of iVR in research, employing various approaches. It is not an ambition of this chapter to cover all the research conducted in and via iVR, which would be not only pointless, but even implausible since the research progresses at an extreme pace and the text would quickly become outdated. The objective is to offer an original conceptual framework for utilising iVR with illustrative examples.

1.1.1 **iVR as a research tool**

The first approach to implementing iVR is using it as a research tool. More precisely as a medium to examine a specific phenomenon such as perception or atten-
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We studied attention distribution during presentation of complex stimuli in iVR using eye-tracking (Šašinková et al., 2023). Similarly, attention throughout a lecture can be examined in a virtual classroom as originally designed by Rizzo et al. (2000).

**Ecological validity**

What is important for this approach is taking the advantage of the high level of experimental control while assuring reasonable ecological validity, which provides a chance for resolving one of the eternal trade-offs in psychological and educational research as suggested by Loomis and his colleagues already in 1999. In reaction to arguments such as those of Burgess et al. (2006) that many established psychometric methods were developed to assess constructs without concern with their potential to predict functional behaviour and that is where, for example, Parsons (2015) sees the potential of iVR. Kothgassner and Felnhofer (2020) agree, although they prudently raise a warning that social aspects of iVR remain most unexplored and in the field of social psychology, nearly all traditionally studied and accepted constructs will need to be revised and, perhaps, re-operationalized. In line with this conclusion, the LICS research group (Laboratory for Information and Cognitive Sciences) at Masaryk University has been lately focusing on social aspects of iVR, particularly in the context of collaborative education and in the studies that are either currently running or under review, social interaction is always included as one of the key topics both in qualitative and quantitative studies.

Compared to 1999 when Loomis, Blascovich, and Beall published their review, though, a lot has happened in the world of iVR and it is not unreasonable to say that the artefacts they worried would occur when using iVR as a research tool would be at least partially eliminated by now (as, e.g. the users’ physical comfort increases and the technological progress made the iVR experience more pleasant, or less unpleasant to those who do not take it well). It is essential to note that although iVR enables the creation of highly immersive, convincing, engaging, and complex environments (raising the ecological validity as mentioned above) in which to conduct research, the researchers’ autonomy during the design process is mostly diminished because designing an experiment then goes hand in hand with its coding. This condition was the major motive behind our work on Toggle Toolkit (Ugwitz et al., 2021) – to provide a tool for researchers who do not possess coding skills, although a certain level of technological literacy is always necessary.
Richness of data

The technology on which iVR is based offers immense possibilities in terms of richness of collected data. There are technological features inherent to head-mounted displays and to the designed environments that allow for seemingly nearly effortless logging of events and measures that would be barely available in real life or their logging would require complicated, prudent, and even disruptive experimental design.

We have previously briefly summarised the categories of data that may be collected and analysed due to the iVR technology (Šašinková et al., 2020), where we focused on the specific context of education in geography. The categories, however, remain the same if considered for the broader field of educational research:

1. Position and direction data
2. Gestures and postures data
3. Interaction data

When using iVR as a research tool, researchers may highly efficiently replace (or enrich) behavioural observation with “hard” data logged directly by iVR. This way, we get detailed information about gaze direction (in case of HMD without incorporated eye-trackers, head position can be often used for reference, albeit with lower accuracy (Niehorster et al., 2017), which allows for measuring synchrony which has long been considered a key variable of collaboration in iVR in Stanford’s Virtual Humans Interaction Lab’s research (Bailenson et al., 2008; Döveling & Konijn, 2021; Han et al., 2023). More and more available HMDs come with incorporated eye-trackers and although VR eye-tracking still faces certain challenges, the data collection is significantly easier than with regular mobile or stationary eye-trackers. Locomotion is a phenomenon that is typically rather difficult to log precisely in real life conditions, however, the information about the position of each avatar may be received 120 times per second, if desirable. Due to increasingly precise hands tracking in every new model of HMDs, gestures and postures are free to be explored, although with this type of data we enter the realm of social psychology and – as mentioned above already – caution is necessary when interpreting data on social interaction (both verbal and non-verbal) because we have so far reached an unsatisfying evidence about context in which the behaviour patterns are truly comparable with those in a real world. In a perfect world, every interpretation of behavioural patterns observed in iVR would be preceded by a comparability of iVR and real-life patterns.
Similarly, data on interaction both with other participants (or their avatars, respectively) and with components of the environment (that means manipulation with virtual objects, making changes to the environment), require exploratory analyses before we will be able to utilise and interpret them with a proper background.

To conclude this subchapter, it is important to note that logging this kind of information needs to be a part of a design of the iVR platform in use and this means of utilising iVR is attributed to platforms specifically developed for research (or education, for instance), because regular available platforms (e.g., Engage, Zoe, Arthur, Mozilla Hubs, etc.) do not provide the option of defining our research interest and data logging respectively.

1.1.2 iVR for simulation

Another case for using iVR in educational research would be simulations, which in this context means reaching the highest possible level of resemblance to an experience of a model environment, whether it is already in existence or currently designed. In other words, the “what-if” research. Class management simulators are a topic currently shaking the world of education: What if a student starts disrupting my class? What if I lose my temper? What if I focus on keeping eye-contact with all students in my class? What if I fail to keep the interaction level high enough? These are just examples of questions the educators (or teachers in training, typically) may examine and test in class-management simulators such as the one developed at University of Central Florida (“UCF Center for Research in Education Simulation Technology”, 2023).

Generally, iVR-based simulations have a great potential to test hypotheses in a safe environment (with no actual buildings being put on fire), with immensely lower costs, and with the chance to visualise physically unavailable sites or situations. Various training facilities may profit from this technology and design studies of efficiency, whether they choose to use flight simulators (Valentino et al., 2017), driving simulators (Cao et al., 2020), or dialysis employee training simulator (Lifeliqe, 2021). The core demand, crucial in this type of iVR utilisation, is fidelity and highly realistic graphic design (Basdogan et al., 2007; Ihemedu-Steinke et al., 2015; Lamata et al., 2006).

1.1.3 iVR as a new medium

The novel, perhaps the most creative approach to iVR in research, is searching for tools and methods of work adjusted to and inspired by the affordances of the
technology. In other words, using iVR as a new medium to employ in activities traditionally conducted in real environments. To explain the conception better, a paper describing a pilot study of iVR-based educational interventions can serve as a suitable example (Šašinková et al., 2023). In this qualitative study, we analysed the in-depth feedback on English-as-a-foreign-language (EFL) lessons of our original design, which we collected from experienced EFL teachers. To describe the stimuli, however, we needed to tackle the matter of how we developed the plans of these iVR-based lessons. The lesson plans were the result of fusion of knowledge of various experts: cognitive psychologists, educational scientists, EFL teachers, and UX experts. The design process consisted of several phases during which we identified topics and language teaching tools and methods that may be transferred into iVR, then we tested the teaching activities directly in iVR and searched for ways to use them for the best possible profit of the learners. This creative process of adaptation of existing methods to the novel medium (iVR) was immensely time consuming and demanding in terms of variability of necessary expertise, but ultimately fruitful as confirmed by the learners' feedback in various stages of the intervention's validation (Káčová, 2021; Pelčáková, 2022).

Sadly, not many studies on iVR education attach detailed lesson plans or description of the instructional design process. For an instance of precise and elaborated teaching materials, we suggest consulting Stanford’s Virtual Human Interaction Lab website where descriptions of VR activities as well as real-life follow-up activities are published (VHIL, 2021).

It is worth noting at this point that iVR is not a youngster-only tool and that with the rising level of user-friendliness of the hardware and the software, the barrier of digital illiteracy and technology-related anxiety reported by Bauer and Andriga (2020) will be overcome soon and iVR may serve all age groups fairly well in the future.

1.1.4 iVR as a Subject of Research

Finally, studying iVR itself comes to close the list. While many authors mentioned above have preferred stepping right into the world of applied or more complex basic research including iVR, there are psychological phenomena very specific for iVR or those that tend to work very differently in iVR compared to real life. Some of those iVR-specific constructs relevant to education and often subjected to research are immersion (Frost et al., 2022; Sedláček, 2016), sense of presence (Huang et al., 2020; Riches et al., 2019; Servotte et al., 2020; Uhm et al., 2020), cybersickness (Caserman et al., 2021; MacArthur et al., 2021; Servotte et al., 2020; Weech et al., 2019), iVR-induced depersonalization and derealization (Barreda-Ángeles &
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Hartmann, 2023; Peckmann et al., 2022), perspective taking (Herrera et al., 2018; Herrera & Bailenson, 2021; Mado et al., 2021; Parsons, 2015; Van Loon et al., 2018), and more. This list is neither exhausting, nor does it cover features of iVR studied primarily by other fields, such as computer science, human-computer interaction, or user experience.

1.2 Discussion

Immersive virtual reality is a medium that brings along a great prospect for studying processes and phenomena that used to be latent or very difficult to observe directly. This chapter attempts to provide a comprehensive overview of the topic of iVR in research together with practical examples of studies conducted directly in iVR. It is, however, necessary to keep track of the potential challenges and drawbacks of iVR-based research to avoid methodological failures.

First and perhaps the most important notion in place is that when conducting experimental research belonging to the above-mentioned categories (i.e., where iVR is not a subject of research itself), researchers should keep in mind that rigorously speaking no rules known and proven from the real world can be simply applied to the virtual worlds. And neither do well-tested ice-breaking activities or interaction increasing mechanisms in lessons work the same way. Which makes this kind of innovation time-consuming for the educators as all activities need to be tested directly in VR before bringing them to class.

As sceptical as it sounds, it does not necessarily mean that the validity of iVR-based research must generally be dubious. It merely directs researchers’ attention to the fact that despite its potential to raise the ecological validity, iVR may also work as an intervening variable, and that appropriate measures need to be taken especially during the research design process. The further paragraphs elaborate this for stated types of iVR.

In case of simulation research, which is especially beneficial where real conditions are unavailable or dangerous, special care needs to be put into empirical validation of the actual equivalence of the environment in the particular context. For example, in our study comparing evacuation behaviour in real buildings and their digital twins during a simulated fire evacuation, we received reasonably similar eye-tracking and locomotion patterns from iVR and a real building (Stachoň et al., 2022). We may conclude that escape behaviour can be satisfyingly simulated in a digital twin of a building in iVR. Whether such conditions can with clear conscience be used in fire safety training (although it is a fairly close topic), however, still remains questionable. To back up such procedure there is a need
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for research such as the one by Morélot and her colleagues (2021) who subjected iVR to an empirical validation in this specific field and found that iVR enhanced merely procedural learning but did not affect conceptual learning. Importantly, they confirmed previous results (Jung & Ahn, 2018) that it is specifically immersion that is linked with the improved performance (unlike sense of presence). One more of their conclusions states that gesture-based controlling of the iVR had a positive effect on procedural learning, too, which brings up the great question lingering upon the second type of use of iVR: iVR as a new medium.

IVR as a new medium has been in the centre of our research in recent years within the applied project called Education in Collaborative Immersive Virtual Reality. As the project has focused on two topical lines of geography education and English as a foreign language (EFL) education, we have had the opportunity to collaborate with information scientists, educational scientists, and EFL experts on developing a virtual curriculum and as we described in our papers, the design process was a field research per se. We had an entire team of researchers from various fields iteratively suggesting, testing, and validating hypotheses about what would and would not work in an iVR-based lessons, what topics and what kind of environments would be the most relevant and suitable to be presented in iVR, what types of activities (proven by years of regular teaching practice) would be functional in iVR and which ones would not flow well or would not benefit the learners. And perhaps most importantly – what features and affordances of iVR should be utilised and how? The process of designing and redesigning our five EFL lessons lasted several months. And that is where the important point lies about using iVR for fields that had been already explored thoroughly in the “real” world: The quality of iVR intervention – and thus its benefit and efficiency – depends heavily on the deliberation of its design. Analogically to the previous paragraphs – we cannot expect the learning mechanism to work the same way in iVR as in the real world. Hence, to take full advantage of the potential of the technology, the affordance and possibility of iVR must be reflected in the design. Returning to the field of research, the implications are these: When designing experiments comparing iVR and real environment (or designing educational interventions of any kind, for that matter), follow the media-enables-method hypothesis (Moreno & Mayer, 2002) suggesting that various media (e.g., iVR) may represent an adequate choice for specific methods (e.g., in the context of language learning, a role play). Simply put, to take the best possible advantage from the novel technology, both researchers and educators need to adjust their ways to its critical features.
1.3 References


1. iVR as a Tool of Choice


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Chapter 2
Theoretical Background of Education and Research in iVR

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Analysing pedagogical paradigms in iVR development unveils a dominance of constructivism and behaviourism. Constructivist approaches emphasise qualitative research, rooted in Vygotsky and Piaget’s theories. Behaviorism favours a quantitative approach, focusing on measurable outcomes and often neglecting long-term effects and social interactions. Pragmatism, inspired by Dewey, highlights the unity of thought and action, influencing the creation of environments connecting with real experiences. The combination of these paradigms shapes diverse perspectives on education in iVR.

Analysing fundamental pedagogical concepts and paradigms, coupled with a deliberate commitment to these principles, enhances our ability to grasp various aspects in designing educational tools, like iVR environments. This analysis is equally valuable in studying the limitations and applications of these tools. A review of the literature reveals that studies predominantly focus on experimental approaches in specific contexts or with specific objects. Embracing a sharing paradigm could help a broader critical analysis of the overarching phenomenon associated with collaborative iVR work.

The distinction between theoretical and paradigmatic concepts in research holds undeniable value and maintains a longstanding tradition. In the field of educational sciences, research often adheres to an explicit constructivist paradigm (Cobb & Steffe, 2011). This paradigm is characterised by its emphasis on students’ perspectives on an issue (Levin, 2000; Young, 2006). Additionally, it highlights their active participation in theory formation (Nicholls, 1992). Similarly, studies with this paradigm may explore teachers’ perceptions of specific phenomena (Davis, 1990; Prawat, 1990; Tattu, 1998). Other researchers investigate constructivism as a teaching approach which aligns with this paradigmatic framework (Naylor & Keogh, 1999; Tobin, 1993; Garrison, 1993).

The key to studies of this nature lies in their consistent ability to capture the relationship between the implementation of a specific pedagogical intervention and the methods used to measure and interpret its effects. This is because if we are addressing the “big questions” such as evaluating educational effectiveness, we in-
variably find ourselves simplifying the concept of an “effect”. This simplification may involve employing behaviourally oriented measurements for an educational intervention through methods like pretest-posttest analysis (Debeer et al., 2021), utilising science-based quantitative statistical processing methods. However, it is important to note that effectiveness, in this context, is quite different from, for example, the development of moral and spiritual values (Azimovna, 2020) or the measurement of attitude change within a constructivist framework (Ollis, 2017).

Additionally, a distinct scenario emerges when examining the transformation of metaphors that reflect certain situations’ internal structuring and experiential aspects, as explored through approaches associated with pragmatism (Cerny, 2020; Švec et al., 2016).

The assessment of the effectiveness, functionality, or quality of a particular educational tool or lesson hinges on the presence of a robust, pragmatic framework. This framework serves to define precisely the scope of the educational intervention, the nature of the learning process and how it occurs. Moreover, a good knowledge of the chosen paradigm is also essential for developing and designing specific lessons and educational tools, as differing paradigms give rise to distinct learning environments.

For instance, in constructivist approaches, collaborative teamwork often takes precedence (Moore, 2005). Connectivism, on the other hand, leans towards cultivating personal learning environments (Brandao & Algarvio, 2020). In contrast, behaviourist approaches commonly employ drill-based exercises (Delazer, 2005).

When analysing studies that deal with immersive virtual reality, their grounding in pedagogical or philosophical foundations is rather limited. For example, Marin-Morales et al. (2018) employ a rigorously structured research design, but fail to justify the design of the objects in which the experiments occur. Similarly, Johnson and Lester (2016) analyse virtual teaching assistants through the lens of pedagogical factors, emphasising the importance of application effectiveness. However, their study ultimately concludes by stating that these measurable factors, in terms of behavioural reduction, are only a fraction of the broader scope encompassing educational effectiveness and the overall educational environment.

Therefore, this chapter will analyse selected paradigmatic approaches concerning the utilisation, design and evaluation of immersive virtual reality. Drawing from a critical examination of existing research studies, our objective is to identify the prominent pedagogical approaches and constructs that have been applied in the field of iVR development, elucidate their intricacies, and establish connections to specific research investigations or projects.
We are aware of all this analysis’ limitations. There is the intricate blending of paradigms, a common feature in our postmodern society, and the potential existence of other paradigms or their broad interpretations. If we speak of constructivism, we mean the tradition from Piaget (1955) to Berger and Luckmann (1967). If we talk about design approaches, we may highlight fundamentally different concepts from speculative or critical design compared to classical service design or design thinking commonly used in education. Therefore, our analysis should be viewed more as a quest for ideal, pure Weberian types—specific ideal mental models that never appear in pure form in practice but allow us to think more systematically and deeply about how we research and develop immersive virtual reality in education. Despite these limitations, understanding the different starting points is essential for understanding the whole research approach, the differences in some approaches and the possibility of transferring the results of one experiment to another only when they are part of the same paradigm.

2.1 Pragmatism and embodied mind

One of the most influential theories that have influenced the development of various implementations of immersive virtual reality in education is pragmatism (Johnson-Glenberg et al., 2016; Lindgren et al., 2016). Central to pragmatism is the belief that there is no sharp line between thinking and acting. Thinking and acting form an interdependent whole, a critical educational premise. We learn through action, believe through movement, and act through thinking. To develop an interactive environment is to accept the assumptions of pragmatist thinking because we expect that interactivity should lead people to think in a certain way. Almost every setting relies (at least in certain parts of the experiments) on pragmatist beliefs about the unity of thought and action (Johnson-Glenberg et al., 2016; Lindgren et al., 2016). The study by Johnson-Glenberg et al. (2016) is an almost ideal illustration. It does not cite pragmatism as its starting point. Still, the whole idea of the experiment is based on the notion that if a student has a lived experience of a particular virtual environment, he or she will be better able to imagine what centripetal force means. In the theoretical framework, the authors aim to demonstrate that ordinary people’s ideas are linked to abstract concepts. These abstractions, when disconnected from real-world experiences and physical sensations, fail to provide a sufficient understanding of crucial physics concepts. Consequently, the authors argue that immersive virtual reality serves as a means to effectively connect these physics concepts back to experiences with nature, making them more accessible.
Like Johnson-Glenberg et al. (2016), Lindgren et al. (2016) also build their foundation on the embodied mind concept, which is tied to the learning process – they write about embodied learning or embodied interaction. They too, work with physics and the experience of simulating physical phenomena. Again, their starting points are more profound and anchored in pragmatism, because the learning process is linked precisely to the combination of thinking and acting while interacting with the virtual environment.

An example of an experiment designed in this way is the work of Lindgren et al. (2016). They compare how students’ embodied and purely rational experiences differ with respect to their ability to work through the laws of physics. They describe the project under study as follows:

\[
\text{The intent is to embed participants in the phenomenon they are trying to understand, in the spirit of what Colella (2000) calls “participatory simulations.”} \\
\text{The primary objective of MEteor users is to utilize their bodies to make accurate predictions of how the asteroid will move when it encounters forces such as the gravitational fields of nearby planets (...)}. \\
\text{Users enact their predictions in two phases. First, they move their bodies to place an asteroid into a “virtual spring launcher” (...) and set the initial launch parameters (position, speed, and angle) that they believe will accomplish the goal of each level (e.g., hitting a target located at the end of the simulation platform). Second, they initiate their launch by stepping forward in the spring launcher and moving through the simulation in the path they expect the asteroid will travel. The learner is given feedback on their performance in real time by showing the actual path the asteroid would take if governed by the laws of physics (Lindgren et al., 2016, p. 177).}
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Dewey’s version of pragmatism (1923) has undergone a complex historical evolution in the American context (Hroch et al., 2010). On the one hand it has shifted from philosophy departments to language departments, but on the other hand, it has had lasting implications for educational foundations. Due to political influences in American universities, pragmatism subtly underlies many academic studies. At the same time, it must be emphasised that the concept of the embodied mind is directly rooted in Dewey’s philosophy. This concept is developed in philosophy mainly in the pragmatist tradition represented by figures such as Lakoff, Johnson, and Rockwell (Johnson, 2017; Lakoff & Johnson, 1999; Rockwell, 2005).

However, studies on immersive virtual reality tend to cite Lakoff’s approach sparingly. When Lakoff is referenced, it is mostly about cognitively oriented concepts (Sanchez et al., 2000; McMahan & Buckland, 2005), which oversimplifies the utilisation of his ideas. Ladendorf et al. (2019) Ladendorf et al. (2019) incorporate
Lakoff and Johnson into their theoretical background for developing the “A Hypothetical Model of Immersive Cognition” but do not explicitly engage with pragmatism. Additionally, Morie (2007) adopts a partial pragmatist approach with reference to Lakoff and Johnson but does not explicitly endorse pragmatism in their work.

In reflecting on working with immersive virtual reality, two additional concepts from pragmatism play a crucial role beyond the link between thinking and acting. Firstly, the impact of the environment on the structuring of thought and action influences the formation of mental models. Secondly, the concept of the embodied mind, previously mentioned, requires a deeper understanding beyond what may be apparent when examining individual empirical studies that make reference to it (Lakoff, 1990).

Pragmatist-oriented authors have long discussed how the environment influences the development of fundamental mental tools, such as base categories, prototypes, and metaphors. Lakoff (2008) talks about how different environments lead to the formation of different base categories, which are the basic mental instruments in which thinking occurs. This means that a change in environment may not only mean more extraordinary vividness, fun, or motivation but also leads to a different structuring of cognition. The learning process relies heavily on selecting appropriate environments.

According to Johnson (2007; 2017), understanding the world within a specific domain is a complex process wherein the physical aspect plays a significant role. Importantly, cognition arises from the interaction between the learner and the environment they are in, primarily because cognition is holistic rather than atomic in nature. An example of a study that implicitly moves in this field is Marín-Morales et al. (2018), who traces the relationship between the environment and emotion in a changing climate. These changes can then have implications for motivation and the rational aspects of the learning and perception processes.

According to Dewey (1923; 2001), cognition and learning are a matter of interacting with a situation. The teacher’s role is to exemplify suitable situations within which the learning process unfolds. Each situation is inherently intricate, with our responses encompassing emotions, rationality, and past experiences.

For example, if Merchant et al.’s study (2014) involves instructional preparation before engaging with virtual reality, it aligns with Dewey’s notion of education. According to Dewey (1934, 2009), education involves intentionally crafting an environment that the teacher astutely observes in specific aspects. Characteristic of
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this educational concept is the creation of learning environments, interactions, and tasks that connect the learning process with physical experiences.

Pragmatism emphasises the fundamental role of physical engagement, whether it involves movement (such as travel, manipulation of objects, riding a carousel, etc.) or experiences related to a particular scale (like walking on a map, comparing buildings based on the experience of size, etc.). In pragmatism, learning goes beyond mere imagination confined to the brain; it encompasses a holistic, whole-body experience. The whole history of pragmatism is characterised by a distinctive starting point centred around the embodied mind.

Metaphors’ findings (Lakoff & Johnson, 2008), representing the basic structure of the human worldview rooted in bodily experience according to pragmatism, are crucial to research practices. Johnson (2007) provocatively notes that angels cannot think, speak, or cognise like the humans do because they do not have a body. The embodiment fundamentally influences language structures (e.g., the association of good things with up and bad things with down), our problem-solving reflections (“time is money”), and the formulation of disciplines like mathematics (Lakoff & Núñez, 2000) or social systems (Lakoff & Johnson, 1999).

Considering the embodied mind approach as a learning starting point goes beyond techniques and environment design (Lindgren et al., 2016). It becomes a fundamental assumption about knowledge, thinking, and their organisation.

2.2 Constructivism

Constructivism, in contrast to the relatively cohesive nature of pragmatism, is not a singular, unified school of thought. The differences between social constructivism as formulated by Berger and Luckmann (1967) and constructivism rooted in Piaget’s (1955) developmental-psychological conception or Vygotsky’s pedagogical-educational outlook are considerable. Rather than framing it as a singular constructivism, it would be more accurate to describe it as a collection of constructivisms. However, our focus is on identifying specific clues or structures relevant to the realms of education and immersive virtual reality that are critical and effectively utilised.

Historically, constructivism emerged as a continental response to behaviourist theories and empiricism, which embraced an objectivist and evidentialist approach to reality. The essential premise is that reality is not predetermined but is instead formed within the mind of the individual (according to Vygotsky 1980) or within society (as proposed by Berger and Luckmann, 1967). It is shaped by a
broad cultural and social experience, influenced by prior perceptions. Representatives of different cultures, communities, or historical periods may view a particular environment, phenomenon, or problem through different perspectives and draw different conclusions.

This belief leads constructivists to prioritise qualitative research methods, particularly in education. The goal is to comprehend the learner’s pre-understanding and systematically engage with it. To illustrate this approach practically with didactic methods, we could offer the following examples: Double-loop learning – is a dynamic approach to learning that argues that the learning process is based on interaction with the world. It involves repeatedly examining and challenging mental models to determine if they offer a more effective or successful solution to a specific problem. This concept underlies heuristic learning and problem-solving. E-U-R – is a model of constructivist learning based on three interdependent phases in the learning process. The student must first become aware of their existing knowledge about a particular issue. Subsequently, the learning process occurs utilising various styles and methods. Finally, in the third step, reflection on the learning experience and the transformation of knowledge occurs (Glassman, 2001).

Learning to correct misconceptions is a model of learning that aims to identify a learner’s misunderstandings about a problem and then employ tools to rectify those misconceptions. It’s crucial to note that these misconceptions are not isolated errors; fixing one often leads to changes in broader mental models. Contrasting with pragmatism, constructivism serves as the clear starting point to which many studies explicitly refer. Review studies, such as those by Pellas et al. (2020) and Di Natale et al. (2020), consider constructivism—particularly in relation to Piaget (1955)—as a foundational element for designing learning environments in virtual reality. Passing et al. (2016) connect their experiments in developmental psychology to Piagetian constructivism, explicitly linking their research methods to theoretical foundations. Similarly, Wong et al. (2019) demonstrate a connection to developmental psychology through Piaget in a medical study, even without an explicit educational context.

Jackson and Fagan (2000) draw from Piaget’s emphasis on learning through action and experience, concepts that are equally fundamental in pragmatism. In a similar vein, Šašinka et al. (2018) integrate the assumptions of both Dewey and Piaget in discussing the results of their experiment, revealing a constructivist-pragmatist blend. For example, a relatively common approach is taken by Yang et al. (2020), highlighting that constructivism is more learner-centred than learning-centred, an essential pedagogical principle. Nevertheless, it is acknowledged as a weak-
ness, considering that all education is fundamentally centred around the learner, as analysed by Šip (2016).

In several studies, Vygotskian-inspired approaches are prevalent in the context of immersive virtual reality, often serving as an explicit framework for their development. Cowling and Vanderburg (2020) use zones of proximal development and aspects of social constructivism to make the teaching of physics in virtual environments more comprehensible. This theme is further explored by the extended team of Vanderburg et al. (2021), employing a double-loop for the learning process. Lau and Lee (2021) use Vygotsky’s emphasis on gradually building experience in their research on adult education. Here, novice entrepreneurs develop their businesses in a virtual environment, reflecting on their experiences and entering practice with a revised mental model through a double-loop model.

George et al. (2020) working with feedback learning within a constructivist paradigm, align with these studies. They propose that every object and interaction opportunity should incorporate feedback that contributes to the learning process.

In general, constructivist-oriented studies explicitly outline their theoretical foundations, frequently referencing figures like Piaget and Vygotsky in virtual reality research. Virtually all these studies incorporate some aspects of constructivist pedagogy, whether it is related to age cohort, active learning, altering mental models, double looping, or placing emphasis on exploration and feedback.

These elements collectively form the standard Occadian notion of the educational process itself. It is important to note that while studies within the constructivist framework share common elements, they do not form an ideologically coherent group (Adom et al., 2016; Steffe, L. P., & Gale, 1995)). Research often refers to constructivism broadly or selectively. In this context, the dedicated studies by Cowling and Vanderburg (2020) and Vanderburg et al. (2021) stand out as they make a concerted effort to systematically consider the theoretical assumptions implicit in developing virtual environments for teaching specific topics in physics. This approach deserves recognition.

Vanderburg et al. (2021) aim to create environments in which the visualisation of physical phenomena and interaction with the educator is so engaging for students that they can reflect on and use the topic of electromagnetism on their own based on their experiences and discussions:

*The intervention will present a virtual classroom environment where the teacher will be able to model the three different electromagnetic principles in three different scenarios. The first scenario will visualise charged particles as*
balls of assorted colors and sizes to represent charges and masses with radiating lines of electric field around them. These fields will interact with each other, demonstrating electrostatic forces. These particles can also be moved through magnetic fields to demonstrate the electromagnetic force on these particles. In the second scenario, the teacher will be able to model an electrical wire shown as a cylinder containing charged particles. The teacher can then move the wire inside a magnetic field, and this will cause the movement of the particles along the cylinder as a depiction of the generated electric current. The third scenario will again have these cylinders of charged particles; however, the teacher will now create a current that generates concentric circles around the wire, depicting the generated magnetic field. Importantly for the implementation of the Vygotskian framework, students will be able to interact with other students and the instructor in the virtual environment (via each participant wearing their own headset), allowing for instruction to occur within the environment. The instructor will guide this interaction by taking control of the room and objects within it, whilst students can ask questions and see interactions through their headset. (Vanderburg et al., 2021, p. 96)

Typical activities associated with the constructivist approach include problem-based learning, solving ambiguous tasks, and engaging with personal beliefs and preferences. In constructivism it is characteristic that beliefs and learning are not primarily individual but social constructs. Therefore, a constructivist approach often involves tasks that encourage discussion, collaboration, and other social interactions (Steffe & Gale, 1995).

As such, constructivism is a response to what we will collectively refer to as behaviourist approaches, with cognitive approaches also falling under this umbrella (Fletcher-Wood, 2018). The shared perspective among them regarding virtual environments is the belief that the ultimate aim of education is the effectiveness of learning. Learning is understood as the acquisition of specific skills, knowledge or beliefs, measurable through appropriate psychometric or pedagogical tools. Characteristic of these studies is the monitoring of pre-tests and post-tests focused on learning outcomes.

Traditionally, behaviourism draws from two main sources that have shaped its understanding of human thinking and associated learning. The first source rooted in the empirical approach, which gained significant popularity at the turn of the 19th and 20th centuries. Much like Husserl (1970) sought to make philosophy a rigorous science, behaviourism strives to make psychology an empirical, measurable, and statistically editable science. The emphasis on empirical evidence is simultaneously coupled with the belief that the primary goal of psychology is not
introspection (subjective looking) but objective measurement. This emphasis on empirically oriented objectification can be regarded as the first foundation of the behaviourist approach (Hatfield, 2002).

The second source is the mechanistic approach, which was pivotal in the early days of behaviourism (Schneider & Morris, 1987). While its simplistic form is gradually diminishing in terms of differentiated outcome measurement, it remains unchanged in the concept of lesson design and learning environments. The mechanistic approach is often associated with Pavlov and his research on reflexes (where stimulus implies response) or Watson. According to Watson (Schneider & Morris, 1987), consciousness does not exist; rather there is a sophisticated response to stimuli and gradually acquired experience. Genetics or personal predisposition are deemed to play no role in the learning process. The internal processes within an individual are considered a “black box” that does not warrant much attention (Logue, 2023; Ziafar & Namaziandost, 2019; Burnham, 1968).

Thus, the classical behaviourist scheme of educational interaction takes the form shown in Figure 2.1 (source: own).

![Diagram of a behavioral experiment](source: own)

Figure 2.1: Diagram of a behavioral experiment

The initial state refers to the knowledge, skills and attitudes possessed by the population under study before the start of the experiment. It is usually described in methodological studies as a description of the sample. The goal of the intervention is to change the outcome state to the goal state by a precisely predefined procedure (algorithm). Pretest and posttest indicate changes due to the intervention between the initial and final states. Pretest and posttest (Shi et al., 2022; Choi et al., 2022) are designed as identical tests or to assess the same learning outcomes. In constructing these tests, different frameworks or standards may be utilised to ensure high validity and reliability.

In experiments of this nature, intervention often involves establishing a control group that either undergoes no intervention or receives a specific form of intervention. In our context, we are working with an immersive virtual reality environment designed to achieve a particular educational goal. The design (Figure 2.2) of such an environment typically follows a linear structure at this stage (source: own):
What is significant about this schema are several elements that make the behaviourist-oriented paradigm a relatively robust and efficient tool for designing educational activities (Halabi, 2020). The first aspect is the belief that the educator can and should set educational objectives either creating them or adopting them from a specific frame of reference or curriculum. From there, they identify learning outcomes and seek the most effective ways to achieve them. The development of the virtual reality environment and the task for the students to learn something are tied to a specific assignment, such as “identifying the tops of mountains and valleys on a map by working with contours.” In this approach, the environment and the task are closely linked, forming a primarily coherent whole with clear optimization opportunities based on measuring the achievement of learning outcomes (Hamilton et al., 2021). The scheme then implements this evaluation process discussed in the previous paragraphs.

Behaviourist methods typically ignore an individual’s qualitative perception of a specific environment, placing a strong emphasis on quantitative research conceptualization. This approach often involves robust statistical treatment (Taçgin, 2020; Villena et al., 2022). With a primary focus on measuring learning outcomes and minimising external distractions (like learning outside the intervening educational unit), this conceptualization often leads to research that concentrates on one or a few individual interventions that the researcher can completely control. Focusing solely on educational outcomes, while beneficial for aligning with the neoliberal view of education as an investment to be optimised, comes with limitations. This approach often overlooks long-term effects, the connection between lessons learned and real-world application, as well as the social interactions and feelings of students. While it results in neat and consistent research data, there is a need for more to fully capture the richness of the actual educational experience. An example of research using explicit tasks tied to research instruments is found in the study by Zając-Lamparska et al. (2019). They mention in the discussion of the results:

*As expected, before training, participants with mild dementia demonstrated lower cognitive performance than healthy older adults. In a few relatively easy cognitive measures no significant group differences were observed. (...) Both groups showed progress in the course of training. Nevertheless, among older*
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Adults with mild dementia not only less progress, but also there was a large withdrawal of participants from the sample. Therefore, the results obtained in the group of persons with mild dementia are less reliable and should be interpreted with caution (Zając- Lamparska et al., 2019, p. 4.).

Hamilton et al. (2021) examine individual iVR studies through this lens, aiming to provide a quantified understanding of the specific learning outcomes it supports. A similar approach is taken by Merchant et al. (2014). Selzer et al. (2019) then show how the behavioural approach translates into the development of specific environments. They explore various immersive environments and measure the educational effects achieved in each. Based on their findings, they conclude that less expensive solutions can yield similar outcomes to more costly ones.

Similarly, Albus et al. (2021) compare learning in a traditional classroom with that in an iVR, focusing on measures of cognitive load and other parameters. This study exemplifies why we chose to link cognitivist and behaviourist approaches. This combination reflects a significant trend in iVR research, where learning outcomes are centred around measures of motivation (Makransky et al., 2019), cognitive load (Liu et al., 2022), or other psychometric parameters.

2.3 Design-oriented approaches

Design thinking, or design-based approaches in general, represent a diverse group of practices or thought anchors in orienting both efforts in developing individual educational objects and their research. The notion of design thinking emerged in the middle of the last century and has come into more comprehensive discussion, as has its application to education, since the late 1990s (Koh et al., 2015; Kimbell, 2011; Plattner et al., 2009).

If we were to trace its origins, we find them in a version of philosophical positivism, which later evolved into paradigms like action research. This approach is grounded in the belief that we can only approximate knowledge of reality. We can progressively (through iterations) get closer to understanding reality, but achieving complete knowledge is impossible. In contrast to the behaviourist approach that relies on standardised tests and norms for user interaction, design methods centre around working with a prototype that the user engages with (Andriessen, 2008; Branch, 2009).

The description of the design is associated with many methodologies. In educational environments, the most frequently talked about is instructional design, connected to the ADDIE model (Allen, 2006; Branch, 2009). For service design,
the double diamond model is commonly discussed (Kochanowska & Gagliardi, 2022; Gustafsson, 2019), though it’s not without criticism (D’Agostino & Santangelo, 2012; Nessler, 2016). We will illustrate the conceptualisation of work or approach in design thinking with the ADDIE model (Figure 2.3).

The process begins with an analysis of the situation or problem, a key feature of design thinking. This approach involves gathering a wealth of information before diving into the actual design. Various specific methods and practices have been developed to collect this information (Chou, 2018; Panke, 2019; Chasanidou et al., 2015), such as personal work, word Caffe, scenario work, various user testing methods, heat maps, etc. (many of these methods originated in other approaches, but the design approach has adopted and adapted them to its needs).

The analysis leads to a specific design assignment, often prototyped in the form of diagrams or pictures, which is then shared with the community. The community interacts with it providing data for further analysis and direction in development. Ideally, there are several such design cycles. The more authors rely on design approaches, the shorter and more frequent the interaction cycles become. However, it’s essential to consider the capabilities of the community and the economic aspects of this approach (Stickdorn et al., 2018; Leifer & Steinert, 2011). The different phases serve to approach the truth gradually. Each iteration cycle changes the phenomenon under study and allows it to be optimized step by step. The key is that all changes are evaluated and that the user’s interaction with the prototype is always the deciding judge of how the final solution looks and performs.
The basic reasoning behind (part of) the design approaches emphasising the development of iVR environments is as follows. The decisive factor for the final form of the product is the user, whether it is the student or teacher interacting with the environment. Predetermined learning outcomes or curriculum documents play a lesser role, serving more for the first analysis than actual development. Moreover, users often cannot articulate their expectations and needs until they’ve experienced a specific product. Therefore, working with a prototype that guides and structures feedback for further incorporation by developers becomes essential.

Such an approach is associated with many limitations and criticisms, including high development costs, the absence of a perfect solution (only an approximately right one), challenges in the target group articulating their needs, and solutions being less transferable. This means that development often has to start anew, and the simple adaptation process seen in approaches like behaviourism or partly in constructivism may not apply. Simultaneously, this approach significantly diminishes the authority or power’s role as a critical actor in the educational process (Basse & Airoldi, 2018).

There are two main objections to this criticism. Firstly, the design approach, including its application to educational objects, is gaining increasing popularity. This means that practice and based on empirical evidence, this approach is considered functional. The second argument is that the emphasising the user when we want the user to be able to actively engage with the prototype. The knowledge, cultural background, and social perspectives of the developer and the user may be very different, requiring an approach that focuses on educating the learner rather than merely presenting a topic from the developer’s viewpoint. In this respect, design approaches can be said to be pedocentric.

In terms of methodological approaches, we distinguish between two closely related concepts that strongly interact with each other:

- **Design through research** (Schoonderbeek, 2017; Fekete, 2019). His approach emphasises that any design or process must be underpinned by research. Design is transitioned from an initially art-oriented environment to a scientific or scientific-technical field.

- **Research through design** (Roggema, 2016; Verbeke, 2021). Research is carried out based on user interaction with the prototype or the final product. The research aim is not a general declaration of knowledge about what users think or do but a specific description of their behaviour and actions when interacting with a given object or service.
In light of the above, it is clear that the two approaches are complementary, as design thinking is interactive and cyclical (Figure 2.4).

These research and development paradigms are also applied in the field of iVR. The combination of environment development and research is essential to the design process. As it is an iterative process, implemented iteratively and focusing on different aspects of the prototype at different stages of testing, lacking knowledge of this paradigm may make the research appear less rigorous. Typically, it also involves working with a smaller sample of data at each step of the research. Additionally, research methods often feel less replicable because their goals are subjective. The researcher’s goal may be to test the prototype and gain empathy and experience with the target group, which design methods also serve to accomplish (Jiancaro, 2018).

An example of this approach can be seen in the work of Fross and Bielak-Zasadzka (2019), who focused on how to help architects think outside the box about space and spatial solutions for different buildings through iVR. They proposed modifications and recommendations for further development based on the information gathered on the different test variants. In their study, Giorgi et al. (2022) explore how vulnerable groups perceive their environment and propose enhancing their existing visualisation methods with virtual imaging techniques. Lupo and Vitale (2018) also talk about the importance of this method regarding the social and value aspects of education when designing activities in a museum. Jochecova et al. (2022) focus on how geography teachers work with a peer learning application and reflect on their recommendations for further development.

In their study, Wang et al. (2022) carefully describe the entire design process, emphasising an iterative cycle that allowed them to test their educational game three times with students. The study comprehensively covers the working process from design to the final product.

In outlining their research methods, Yu et al. (2021) explicitly reference a design approach and an iterative mode of development involving users:
The intelligent VR interactive system was developed by the research team for learners to learn pour-over coffee brewing. This study follows the phases of the ADDIE model to create and evaluate the system. (...) The research team executed the design of an intelligent VR interactive system from the analysis phase to the evaluation phase in order. The suggestions provided during the evaluation phase can inform future revisions of other phases. The following is a detailed description of each phase of the process of developing the intelligent VR interactive system (Yu et al., 2021, p. 3).

Yu et al. (2021) apply the ADDIE model to develop a virtual reality system to teach coffee brewing. The study carefully describes the steps in a single interaction cycle. They evaluate a sample of 103 participants measuring the effectiveness of the learning process related to the practical skill of coffee preparation. Fudholi et al. (2020) use 16 potential future teachers to use the ADDIE model to create a safe learning environment that helps teachers understand these children. The application of the model is interesting because evaluation is seen as an integral part of all the steps in the ADDIE model.

### 2.4 Logocentric Approach

While all previous paradigmatic approaches have been pedocentric or user-centred, our latest approach breaks out of this pattern. Named logocentric, based on the distinction between pedocentric and logocentric teachers, it is not primarily concerned with reflecting on educational interaction but with the development of the virtual reality environment itself. In this respect, it is not constituted by subscribing to a particular school of thought or tradition, but focuses on making the best possible virtual environment. Thus, we abandon the user perspective and emphasize a normative approach (features, quality, appearance, performance, capabilities – of the virtual environment). The metrics emphasised by authors researching in these environments often have no direct relationship to user behaviour or may not investigate it. The primary goal is the virtual environment itself (Maletic et al., 2001; Garver, 1977).

Motivations for this approach can vary. For example, in cultural heritage protection or the creation of virtual models of buildings, the critical parameter is the fidelity of the display or other attached information, rather than a specific educational experience. Similarly, in applications related to art, the virtual artefact can be an end in itself, showcased in virtual galleries and museums highlighting the size and complexity of collections. This approach is also common in developing
and testing specific technological innovations, processes, or tools, such as in software development.

Typical of this approach is working with a case study that represents a specific product or process. Educational use in this case is a secondary consideration, resulting in specific objects and environments where educators can contemplate how to work with them and what to teach a particular student. This approach is generally valuable because of its technological or design innovation. However, it occasionally results in the creation of impractical or inadequate environments. Importantly, it does not guarantee or describe educational aspects beyond general propositions.

An example is the study by Maletic et al. (2001), which focuses on the issue of VR development for visualising software development at the conceptual schema level. This study exemplifies a logocentric approach, clearly identifying a known problem or task in advance and expertly solving it through implementation. Thus, it is the software developers who know what the users’ requirements are and how they will work with the tool:

*We envision a powerful application of MCRs (Multiple Collaborative Representations) in the visualization of software. Here the large number of dimensions of a software system may be partitioned across multiple users to assist in reducing the overall complexity of the content being visualized. The goal of research in MCR is to develop techniques to allow participants to coordinate their interpretations of each representation to enable a more efficient collective understanding of the data being explored* (Maletic et al., 2001, p. 5).

Kourtesis et al. (2020) describe the creation of a specific research tool, tested by 25 users, with a main focus on system development. In their next study, Kourtesis and MacPherson (2021) describe how iVR can be used for specific psychological testing. De Paolis et al. (2022) describe a virtual park environment evaluated by users after creation, emphasising the methodological sequence of first building the environment, with evaluation enhancing control or user experience. Similarly, Lotfi et al. (2023) describe creating a virtual model of the Church of Gesù Nuovo in Naples, used by students compared to traditional visual materials, emphasising the digital environment’s existence rather than the learning environment and tasks within it.

It is difficult to systematically analyse philosophical and pedagogical-philosophical approaches in studies focusing on virtual reality and its educational use, as most studies do not explicitly work with these assumptions. In this respect, our analysis is more eclectic, not capturing all possible approaches.
2. Theoretical Background of Education and Research in iVR

After all, the term “paradigm” itself could be a separate topic for critical discussion. Our research aimed to show the ideas and concepts found in the field of iVR, particularly regarding specific study and research methods. We aimed to show how the paradigm in this specific field influences the investigation and development of environments and tasks, the measured characteristics, and the overall thinking about what such development should involve. We summarise some of our findings in a simplified Table 2.1 (source: own).

<table>
<thead>
<tr>
<th>Paradigm</th>
<th>Key starting points</th>
<th>Measuring instruments</th>
<th>Limits</th>
<th>Emphasis on</th>
<th>Key concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pragmatism</td>
<td>the connection of body and mind, experience as a formative concept</td>
<td>research on metaphors, creativity</td>
<td>poorly measurable outputs</td>
<td>experience</td>
<td>environment and body</td>
</tr>
<tr>
<td>Constructivism</td>
<td>social and cultural influences on belief formation, individually and socially interacting experience</td>
<td>qualitative methods</td>
<td>poorly measurable outputs</td>
<td>construction of a new mental model</td>
<td>culture as a dynamic structure</td>
</tr>
<tr>
<td>Behaviourism</td>
<td>learning is the result of stimulation</td>
<td>pre-test, post-test</td>
<td>reducing education to a short-term intervention</td>
<td>learning outcomes</td>
<td>interventions</td>
</tr>
<tr>
<td>Design thinking</td>
<td>iterative development</td>
<td>design thinking tools</td>
<td>difficult product portability</td>
<td>design process</td>
<td>user</td>
</tr>
<tr>
<td>Logocentrism</td>
<td>quality of the object</td>
<td>diverse, industry-sensitive</td>
<td>lack of emphasis on the student</td>
<td>quality of the object</td>
<td>object</td>
</tr>
</tbody>
</table>

Table 2.1: Comparison of paradigms

We want to highlight that each approach may be relevant to the development of learning objects and each brings its own perspective. Different paradigms imply fundamentally different object development strategies. For example, in logocentrism, the created object is first carefully constructed and only tested when it is complete, with testing more focused on controlling technical aspects. In contrast, in the design approach, we see iterative work with prototypes where the target group gives continuous feedback.

Marougkas et al. (2023) conducted research similar to ours, retrieved 17 studies from the Scopus article database, and analysed them. Their results identified theories or approaches of iVR research. In our study, we blend behaviourist and cognitivist approaches (because they share critical design aspects), whereas Marougkas et al. (2023) would assign them to distinct categories. This analysis
offers a deeper framing of the topic in the setting of the philosophy of education to an extent that has yet to be published. In contrast to the Marougkas et al. (2023), we did not start deductively from pre-selected studies, but proceeded abductively, with retrieved studies being added to paradigms and paradigms shaped by emerging studies. Thus, on the one hand, we respect the postmodern approach (practice determines theory); on the other hand, we were able – thanks to the philosophical approach – to analyse the studies in sufficient depth specifically with respect to the research approaches and the studies’ own thought construction.

We believe that this fundamental paradigm analysis can bring two essential elements to the design of environments and tasks in iVR:

1. A more explicit link between the design and research questions and the related methods can positively impact the quality of individual outputs.

2. A deeper understanding of others’ approaches where we would have taken a fundamentally different approach, pursued different variables or emphasised different validity and reliability of research methods.
2. Theoretical Background of Education and Research in iVR

2.5 References


2. Theoretical Background of Education and Research in iVR


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Chapter 3
Implementing Didactic Principles in VR for Language Education

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This chapter explores virtual reality (VR) in language education, emphasising VR’s role as an augmentative tool rather than a complete replacement for traditional methods. It discusses how VR creates immersive, contextually rich environments for language learning, enhancing students’ engagement and understanding. The effectiveness of VR in education depends on educators adeptly integrating their teaching skills with VR technology. Key themes include the significance of immersive experiences, the role of avatars in fostering confidence and reducing judgement fears, and the importance of context in language learning. The chapter includes student insights from VR-enhanced English classes, analysed through pedagogical theories. Findings highlight VR’s potential in education, provided it is integrated thoughtfully to maximise learning opportunities and overcome limitations. The study concludes that a practical VR learning experience relies on a well-designed environment, relevant context, and appropriate avatar use.

This chapter provides both a theoretical and empirical exploration of didactic principles pertinent to virtual reality (VR) education, particularly within language education. It highlights not just the potential of VR but also its inherent constraints. Positioned at the nexus of change, teachers are not merely implementers but vital partners, facilitators, and architects in curating educational experiences that resonate with the shifting contours of the modern world (Rosa, 2015). This discourse further delves into the role of VR technology in pedagogical contexts. VR is viewed not as a replacement for real-world experiences but as an augmentative tool, enriching conventional teaching approaches by generating unique environments challenging to replicate in conventional classrooms. However, the effectiveness of VR is not solely contingent on the technology but also on educators, who are tasked with adapting their traditional pedagogical techniques to leverage the opportunities of the virtual reality (cf. Cheng & Tsai, 2019; Di Natale et al., 2020; Vogt et al., 2021; Marougkas et al., 2023). This chapter encapsulates reflections from students enrolled in VR-enhanced English language classes. Insights were dissected and viewed through the prism of pedagogical theories using the thematic analysis method. Research has shown that to fully exploit the potential
of VR in education, a relevant context is needed, complemented by spatial cognition, somatic experience and immersion in the form of an avatar.

**BEYOND TEXTBOOK BOUNDARIES: THE DYNAMIC CONVERGENCE OF LANGUAGE LEARNING AND VR IN EXPERIENTIAL EDUCATION**

Traditional educational approaches can lead to a disparity between theoretical knowledge and practical application. It is simply because the moment we learn a theory, there is no way to test it in practice (McGarr et al., 2017). VR technology emerges as a potential bridge connecting abstract theoretical knowledge with experiential practice, primarily by immersing learners in contextually rich environments and situations.

Initially, it is essential to define what we mean by “situation.” From a pragmatic perspective, a situation is an environment characterised by experience and interaction. In pedagogical terms, learning is most potent when anchored in genuine, real-world situations, facilitating a deeper understanding of theoretical concepts (Dewey, 2007). Therefore, learning should not be a passive absorption of information but an active engagement in dynamic environments that encourages students to interact and explore.

Moreover, language plays a pivotal role in shaping our perceptions. Lakoff and Johnson (2003) posited that our interpretation of the world is not just factual. It is influenced by our language, with metaphors playing a crucial role in moulding our understanding. Thus, in educational settings, language conveys information and frames our comprehension and interaction in various situations.

In VR-based education, “situation” transcends physical settings, replicating real-world challenges. It also encompasses a metaphorical structure that aids students’ thinking and understanding. Thus, the situation is perceived within VR as a multifaceted, evolving environment, drawing from tangible experiences and metaphorical interpretations.

Within VR-based education, specific teaching situations are vividly replicated and enriched by visual and thematic contexts. Drawing from Lave and Wenger’s (1991) concept of situated and spatial cognition, knowledge is deeply rooted in its cultural, physical, historical, and social surroundings. Hence, learning becomes more impactful when tightly woven with its context. It underscores the potential of VR in forging interactive, topic-specific environments (Parong & Mayer, 2018). These digital environments and situations can reflect the tangible world or communicate through metaphorical narratives, recreating historical contexts with a sense of presence and authenticity. Combining visual and auditory stimuli
3. Implementing Didactic Principles in VR for Language Education

in a specific VR location can help students create a robust multi-layered learning experience (Krokos et al., 2019).

Language learning requires students to develop the ability to use language effectively and aptly in real communication situations (Huang et al., 2021). Traditional textbooks can only provide a limited context for such situations. The implementation of VR expands the possibilities of educational processes in language teaching – especially its pragmatic component (Chen et al., 2022). VR’s context-rich setting allows learners to engage with language in scenarios beyond theoretical constructs. Another vital element is the interactivity and dynamism of the VR environment, where students can interact not only with other characters but also with objects and navigate diverse situations.

In fact, in a well-chosen context, the pragmatic side of language becomes much more alive and accessible because learners are not just passive recipients of information but active participants in the language process. While it is theoretically possible to create real-world contexts in traditional teaching, the practical implementation of such situations can be complicated and time-consuming. VR offers an elegant solution by providing rapid access to rich, diversified, and deeply contextualised experiences. Education is all the more anchored if experienced at the somatic-cognitive level.

FROM SURFACE TO SOUL: THE POWER OF DEEP IMMERSION AND BODY-MIND SYNERGY IN VR TEACHING

One of the defining features of VR technology is its capability for multisensory engagement. Edgar Dale’s Cone of Experience model (Dale, 1969) suggests that individuals retain information more effectively when they actively experience and engage with it, compared to passively receiving data, such as through reading (Lee et al., 2023). This multisensory approach encompasses experiences deeply connected with one’s body. From an epistemological perspective, our somatic experiences are foundational touchpoints in shaping our understanding of the world. VR technology emerges as a potent conduit bridging physical sensations with cognitive processes. However, achieving this profound connection demands a deep immersion, influenced not just by the visual elements of the VR environment but also by the situational contexts and interactions.

Immersion is pivotal for the efficacy of VR in educational contexts. Immersion encapsulates the sensation of genuine presence within a digitally-constructed environment (Guerra-Tamez, 2023). This sensation fosters deeper engagement and enhances learning outcomes. To realise optimal immersion, ensuring high-
quality visual and auditory elements is imperative. These elements should not only be authentic but also be structured with user experience in mind. Such meticulous crafting amplifies the immersion experience and mitigates issues like motion sickness. However, without adequate immersion, students may not feel connected to the content, potentially diminishing their motivation and undermining the overall effectiveness of VR in education.

In teaching, the synergy of the proper context with profound immersion can amplify the somatic-cognitive experience. In such a setting, learning transcends mere cognition, resonating with bodily and emotional dimensions. In a VR-driven lesson, the entirety of a student's being participates, enriching their engagement and comprehension. Viewing VR's potential in education through the lens of experiential realism allows us to cultivate learning experiences that traditional classrooms might find challenging to replicate (Lakoff & Johnson, 1999). Interactions within VR offer sensory and physical experiences and promise to enhance comprehension and mastery of subjects, such as languages.

For pedagogical success in VR lessons, it is essential that situations are crafted to ensure students strike an optimal balance between the challenges presented and their own skill sets. Csikszentmihalyi (2008) termed this balance, where deep focus and engagement in learning converge, as the “flow state.” Students are fully immersed, their bodies and minds aligned in concentration and motivation. The immersive capabilities of VR can effectively mitigate the external distractions commonplace in conventional learning settings. Furthermore, the dynamic nature of VR facilitates the tailoring and adaptation of learning content and challenges, such as vocabulary, to suit individual student proficiencies. This meticulous calibration aids in preserving the vital equilibrium between challenge and skill, underpinning the essence of flow.

With its interactive and dynamic characteristics, the virtual environment enables individuals to actively forge their comprehension of the pedagogical context instead of merely being passive recipients of information. As previously discussed, a contextualised setting amplifies the learning impact by harnessing spatial cognition. When combined with the diverse learning scenarios available within VR lessons, students transition from passive observers to active participants, learning not just about a subject but directly within and through it. Analogous to how we understand the tangible world via our bodily experiences, our grasp of the virtual world is mediated through an avatar, our digital self-representation.
Mirroring ourselves: The avatar experience and the importance of facial expressions

Traditionally, identity has been perceived as an individual’s core essence. However, our understanding of identity is shifting to something more fluid. Rather than being fixed, identity constantly evolves, influenced by experiences, interactions, contexts and situations we encounter.

With the emergence of digital technologies, online personas, and virtual realities, the exploration and redefinition of one’s identity have become more accessible than the physical one. Users now have the flexibility to craft new identities, delve into various facets of their persona, customise their engagements, and gauge their comfort within these newly formed identities (Davis & Chansiri, 2019). The avatar is central to this digital realm, a virtual representation of oneself. We navigate, engage, and learn through this digital embodiment in VR.

Much like the principles of constructivist learning emphasise the acquisition of knowledge through experience, in VR, these experiences are mediated via our avatar. Here, the demarcation between reality and the virtual becomes indistinct, presenting intriguing ramifications for pedagogical methodologies. As highlighted by Damasio (2018), the visceral and emotional encounters within VR can influence our actions and viewpoints in the real world. It suggests that the mind and body are not isolated entities but interlinked, jointly shaping our subjective experiences.

Research within the realm of VR indicates that embodiment is a pivotal element in facilitating the transfer of experiences from virtual reality to the real world (cf. Yee & Bailenson, 2006; Cogburn et al., 2018; Gall et al., 2021). The pedagogical implications rooted in this concept of embodiment are profound. However, realising this potential demands a concerted effort. Developers shoulder a significant responsibility to craft enriching learning environments. Equally vital is the role of educators, who should harness the environment’s potential and curate educational narratives that boost student motivation and create optimal learning conditions. Particularly in language-oriented lessons, the context of a location and its inherent situations can be further enhanced by integrating contextually relevant characters, or avatars, into the instructional landscape.

Promoting the pragmatic facet of language through VR could lead to a more profound and enduring mastery of linguistic skills. Additionally, it is crucial to foster interactions that resonate emotionally with the student. Absent such engagement, VR settings risk becoming mere static scenes. Concurrently, a weak embodiment can diminish a student’s immersion in VR. A disparity between the represented
identity and a context that feels inauthentic or underwhelming can undermine the overall educational efficacy of VR.

Just as real-life interactions hinge heavily on non-verbal cues, it is essential to consider how such nuances can be integrated into virtual avatars in VR. Observing learning from the perspective of Albert Bandura’s (1977) social learning theory, or the mirror neuron theory (Fan & Luo, 2022), it becomes evident that visual observation plays a pivotal role in our learning process. Within VR, we can craft either lifelike or wholly abstract scenarios, offering experiences that would be challenging to realise in a conventional classroom setting (Hamilton et al., 2021).

Moreover, Stephen Krashen’s Affective Filter hypothesis emerges as highly relevant (Chen, 2022). This hypothesis underlines the critical role of emotional factors like motivation, self-confidence, and anxiety in acquiring a new language. It suggests that an “affective filter” acts as a psychological barrier, either aiding or hindering language assimilation based on the learner’s emotional state. In VR, where embodiment and realistic avatars play a crucial role, the affective filter takes on new significance. A supportive, immersive VR environment can lower this filter by boosting learners’ confidence and reducing anxiety, thereby facilitating more effective language acquisition. Conversely, if VR scenarios fail to engage learners emotionally or if the avatars and environments feel inauthentic, the affective filter may rise, impeding language learning progress. This interplay highlights the importance of carefully designed VR experiences that not only provide contextual and visual realism but also cater to the emotional dimensions of learning, aligning with Krashen’s insights into the affective dimensions of language acquisition (Krashen, 1980).

To make education truly resonant and impactful, it goes beyond just the transfer of information. As mentioned earlier, contextualization, visualisation, and embodiment are central to learning. Nevertheless, even with these critical components, student engagement can falter if the avatar representation is lacking. Educators leverage their facial expressions in traditional settings to add emotional depth and highlight crucial learning points. Similarly, a believable avatar with realistic facial expressions can significantly enhance the learning experience in a VR setting. However, if the avatar’s expressions seem unnatural or lacking, it creates a disconnect, clashing with our real-world expectations (habitual patterns) and potentially diminishing the educational impact.

Technological possibilities still limit facial expressions and embodiment in VR avatars. However, progress over the last decade has shown that the technological peak is far from being reached, and it is for the reasons mentioned (such as social presence, believability and potential for collaborative learning) that developments
in this area will continue (Suzuki et al., 2017; del Aguila et al., 2021). Integrating eye-tracking technology as a standard could be one of the options (cf. Geraets et al., 2021).

3.1 Methodology

Our study explored the effectiveness of interactive VR environments as mediums for English language instruction. Each lesson was deliberately crafted around a specific language teaching principle, integrating unique VR features such as embodied experiences, role-playing immersion, and specially designed environmental affordances. We included 32 university students, aged between 19-25, in our sample. Although the course targeted humanities students, those already majoring in English studies were excluded. The prerequisite for participation was a minimum CEFR English proficiency level of B1. Due to the sizable cohort of 32 students, they were subdivided into eight seminar groups, each containing four students. This smaller group size ensured lesson quality. The course was conducted during the first eight weeks of the Autumn semester in 2021, with each session spanning approximately 50 minutes. Before the first lesson, participants underwent a 10-15 minute training session to familiarise themselves with the VR equipment and mitigate potential anxiety. This training encompassed essential VR skills such as teleportation, interaction with virtual objects, and methods to prevent cybersickness. Oculus Quest 2 HMDs, powered by Qualcomm® Snapdragon™ XR2 Platform and equipped with Adreno 650 GPU and 6 GB RAM, were used for the VR sessions.

Within the scope of this chapter, we will elaborate on three core lessons. The first two sessions utilised Engage, a widely recognized commercial platform. In contrast, the third lesson was conducted on the eDive platform, a proprietary system developed at Masaryk University, specifically tailored for this course. A rigorous lesson plan was in place for each session, ensuring that all involved instructors maintained consistency, adhering strictly to the designed curriculum. Emphasis was placed on creating lesson plans that balanced pedagogical excellence with an immersive VR user experience.

3.1.1 Lesson 1 – The moon

The first lesson commenced with a 6-minute ice-breaking activity designed to familiarise participants with each other. The virtual environment mimicked the Moon. Students were presented with various virtual objects to hone their vocabulary and argumentative skills. The task was to select one object they would bring
to the Moon and construct a compelling argumentation for their choice. Subsequently, students shared their arguments with their peers.

Figure 3.1: Sample of the environment from Lesson 1 – The Moon

3.1.2 Lesson 2 – The court

The subsequent lesson transported students to a virtual courtroom setting. Initially, students delved into vocabulary and verbs pertinent to legal proceedings. Following this foundational phase, a fictitious neighbourhood dispute was introduced. Students paired off, assuming the roles of attorneys, collaboratively crafting their defence strategies for their assigned clients. After finalising their arguments, they presented their ideas to the teacher, who presided as the judge.

Figure 3.2: Sample of the environment from Lesson 2 – The Court
3.1.3 Lesson 3 – Villa Stiassni

The lesson occurred in a virtual recreation of Villa Stiassni, situated in Brno. This digital rendition of the villa was equipped with interactive objects that, when engaged with, revealed texts and narratives about the Stiassni family’s history. As students roamed and explored the villa, quizzes tested their recall and understanding of the information they encountered. Concluding the lesson, students were tasked with retelling the Stiassni family’s story in their unique narrative.

In the concluding segment of the course, students were required to pen a reflective piece, spanning 1-3 pages, detailing their experiences with English learning within a VR context. For this study, we adopted a qualitative approach, focusing on phenomenological experiences, and undertook an analysis of 32 written reflections.

The main research question was:

“How do students reflect on their experience of learning in virtual reality?”

The secondary research question was:

“What are the pedagogical aspects and implications of virtual reality in English language learning?”

To address these questions holistically and extract in-depth insights from the collected data, we advocate for the use of thematic analysis (Braun & Clarke, 2021). Since our primary interest was understanding personal reflections and experi-
ences, the data collected is qualitative. Thematic analysis, a qualitative analytic method, is suitable for discerning patterns and themes in students’ VR education reflections. Moreover, thematic analysis, with its iterative coding process, facilitates a deep dive into the data, ensuring that subtle intricacies are not overlooked. Braun and Clarke (2006) recommend the following procedure for Thematic Analysis: familiarising yourself with your data; generating initial codes; searching for themes; reviewing themes; defining and naming themes; producing the report.

First, we familiarised ourselves with the data by thoroughly reading the students’ reflections on their VR experiences and taking notes. We then identified and coded vital phrases from each reflection that captured its essence. This deeper analysis revealed consistent codes grouped into three preliminary research themes. After defining the scope of each theme, we gave them appropriate names to convey their significance. These themes were analysed concerning relevant pedagogical theories central to this research. To further illustrate our findings, we included direct quotations from the VR lesson participants, which are italicised for emphasis. The following section describes the 3 main themes of VR education.

3.2 Results

3.2.1 Context and environment: Unpacking the role of VR in contextual language education

A pivotal consideration for implementing VR in education is the precise contextualization of the lesson regarding location and situation. VR as a multisensory technology augments conventional teaching methods by enabling learning within a deeply immersive audio-visual context. Throughout the research, distinct virtual environments were designed to enrich vocabulary, conversational abilities, and the pragmatic facet of the foreign language within a relevant context. The goal was to transcend mere theoretical understanding of situations, offering students tangible experiences instead. Therefore, we opted for virtual scenarios that would be challenging to recreate within the confines of a traditional classroom.

“I see the main benefits of teaching in VR in the possibility to offer what regular teaching cannot, such as excursions to different places.”

The reflections often highlighted the vibrant and interactive nature of the crafted VR environments as a primary strength of the technology.
“I considered it a big plus that the environment changed every class and it forced us to adapt our vocabulary to the actual things around us, e.g. the class in the courtroom expanded our vocabulary beautifully and directly forced us to use the newly learned words in sentences during the defence.”

The specific setting of the lesson—within a particular context, location, and educational scenario—was frequently noted by students as a critical motivator for role-play engagement. The goal of each lesson was to foster a state in which learning transpires organically. While the lessons were primarily crafted for language acquisition, the focus in the VR lesson design was predominantly on the experience itself. This shift in perspective helps redirect the student’s focus away from the awareness that they are in a learning process.

“Practising English then became a secondary goal and, let’s say, a nice bonus.”

“And this is where VR saved me, one has so many more sensations to pay attention to, so many ways to perceive the language naturally, rather than just reading textbooks and fumbling with words endlessly, and so after about 20 minutes of the first lesson I forgot I was in a class and it started to feel natural to me. So as far as I was concerned, VR reliably took my mind somewhere else and I could use the language as I normally use it outside of language lessons.”

To achieve this immersive experience, a deep level of engagement is essential. The engagement was repeatedly highlighted in the students’ reflections. We recognize that a portion of the student’s motivation stemmed from the novelty of the technology, as it is not something they interact with daily.

“I usually looked forward to the class because I had no idea what to expect, as anything is possible in virtual reality.”

Even within the educational context, VR has yet to become so commonplace that it can be labelled as a conventional teaching method. Hence, the initial excitement stemming from the technology’s novelty should be seamlessly saturated by a well-structured and captivating VR learning environment.

“The ability to change the environment, considering the topic, is inspiring (the courtroom). I’d probably say there’s a greater tendency to play the role that is required.”

In an immersive VR setting, learning is amplified by its context. VR offers the unique opportunity to craft authentic environments where skills like conversational and argumentative English prowess can be honed.
“I found the lessons generally well designed and the vast majority of them took advantage of the technology used (I particularly appreciated the incorporation of elements to add context before the courtroom argumentation exercise).”

Conventional learning methods sometimes lack this rich context, resulting in rote or superficial memorization, such as vocabulary. However, the sensation of being present within a distinct educational scenario in VR fosters a profound level of engagement. It immerses students within the subject matter and transforms them from passive information absorbers to active actors.

“I see the possibilities of virtual reality as a great positivum, it was very interesting to try out the learning directly in Villa Stiassni. It allows you to get closer to the topic. At the same time, the interactivity was very useful, because it made the teaching more interesting and engaging. One was better able to put oneself in the model situation and concentrate.”

In the lesson set on the Moon, students’ interactions with various objects in the VR environment allowed for a unique experiential learning opportunity. By discussing why they would choose specific objects for their Moon trip, students were encouraged to create relevant and meaningful associations. This method promotes a seamless integration of existing knowledge with new insights, enhancing comprehension and retention.

“From the point of view of a student who has participated in VR classes and English classes in the past, I can say that this form of teaching is much more attractive...”

The narrative framework of the scenario served a dual purpose: It provided a structured pathway for disseminating information while simultaneously offering VR participants a sensory-rich experience rooted in spatial awareness and contextual significance. In the Villa Stiassni lesson, experienced cultural nuances set against a historical backdrop, gaining a deeper appreciation of the social intricacies and relationships that shaped the Stiassni family’s existence. This immersive storytelling approach made the information more engaging and helped anchor learning in a real-world context, further enriching students’ understanding.

“I definitely count originality and fun among the advantages. We don’t sit at a desk for an hour and read boring articles about places we’ve never been, but we go there and describe what we see and experience. It’s much easier, more fun and more beneficial to students’ lives to visually experience a situation and the feelings that are evoked in us at that time or place and describe them. There is no need to make up a story, which is often more challenging than English speaking itself.”
3. Implementing Didactic Principles in VR for Language Education

The essence of a VR experience is to simulate reality, offering a level of immersion that traditional mediums cannot provide. However, as with any tool, the efficacy of VR largely hinges on the individual’s receptiveness, personal expectations, and prior experiences with similar technology. So it may be that the VR environment has the opposite effect and serves as a distractor. Consequently, it can slow down the learning process as the learner is much more focused on the scenery and less on the educational content. In other words: While many get easily entranced by the allure of virtual reality, for some, the captivating allure of the environment can unintentionally overshadow the primary educational objective.

“Furthermore, I found it challenging to focus on the language and any learning within the totally new environment.”

As students have indicated, a lack of authenticity or fidelity in the virtual environment can cause disconnect and hinder immersion. Interestingly, this seeming shortcoming has had an unexpected positive repercussion: it piqued students’ curiosity enough to make them want to visit the actual physical locations they virtually explored. This transition from virtual exploration to real-world discovery underscores the potential of VR as a conduit for deeper experiential learning.

“What I didn’t enjoy was walking through the Villa Stiassni. I liked listening and piecing together the story, but it served more as an incentive for me to visit the place in person; it wasn’t the same in VR.”

It is imperative to strike a harmonious balance to optimise the effectiveness of VR in education. The virtual environment must be visually compelling to engage learners while ensuring that the narrative and instructional content remain central. The goal is to leverage the best of both worlds — the immersive power of VR and the rich pedagogical content — to deliver an educational experience that transcends what is possible within the four walls of a traditional classroom. By embedding interactive elements and ensuring a high degree of realism, educators can truly harness the potential of virtual reality for teaching.

3.2.2 The Somatic-Cognitive Experience: Sustaining Flow in VR

In the aftermath of the VR lesson, students recurrently highlighted a unique phenomenon: a deep immersion in the learning experience to the extent that they became oblivious to the act of learning itself. It underscores the potential of VR as a medium to facilitate the absorption of educational content in a manner that feels both organic and captivating for the learner. Within this state of immersion
and engagement with the VR lessons, students further reflected that they lost track of how long the lesson lasted.

“The VR environment definitely had a wow effect on me, where I lost track of time.”

“I enjoyed the lessons and I was happy to participate in the lessons, but I always felt that the lesson went by too quickly, so I would have liked a longer lesson time.”

In virtual reality, students experience a range of engagement levels that resemble the state of flow, characterised by deep absorption and active involvement in the virtual environment. Analysing these individual experiences reveals various nuances that have implications for pedagogical strategies within VR-based education. Nevertheless, it is imperative to recognize that VR primarily functions as a medium for information dissemination to the student. When students describe their surroundings in a foreign language within a VR environment, it becomes incumbent upon the educator to calibrate the learning level. This optimal level should be sufficiently challenging to sustain the student's engagement yet not so daunting as to impede the educational progression due to undue frustration.

“Only in one of the classes did I feel quite uncomfortable, and that was when it was a court-related conversation. I didn’t know the words and I was never oriented in that area.”

“For me, it was interesting that the topics were unexpected and for some, I didn’t know the corresponding vocabulary. Especially the lesson “In Court”. I felt useless then and even found it amusing.”

The depth of immersion VR technology offers is challenging, even implausible, to emulate in conventional learning settings. Immediate visual feedback through the VR interface is pivotal, enabling students to articulate and engage more effectively with their surroundings. It, in turn, facilitates a state of flow. The immersive ambience of the VR session plays a vital role in sustaining student concentration.

“The most engaging experience for me was probably sitting in a courtroom bench and experiencing the vocabulary I had learned in a real court trial. It could certainly be simulated in a regular classroom, but it probably wouldn’t have as profound an impact.”

As previously highlighted, engagement stands out as a paramount factor for effective learning in VR. Without adequate engagement, the learning process might devolve into a passive exercise, often leading to suboptimal outcomes. VR's in-
herent interactivity and multisensory nature offer the potential for profoundly enhanced student engagement compared to traditional methods.

“Personally, the most interesting lesson for me was the last one, where we walked around a Brno villa and learned about its history by walking through ‘real’ spaces and touching various things that always told us something about the villa’s history.”

When a VR lesson is meticulously crafted to sustain student engagement, foster a flow state, and deliver educational value, it has the potential to connect traditional educational approaches with contemporary modalities seamlessly.

“The interaction with the environment was also amazing, with the ability to walk, teleport, insert objects into the virtual world, and try to talk about them. It was definitely different from the regular English lessons I remember from high school.”

The multisensory VR experience encompasses learning at the somatic-cognitive level. Engaging the learner through cognitive, motor, haptic, and affective dimensions facilitates a profound learning experience. The emotional reactions elicited by VR stimuli often act as rapid, frequently subconscious signals epitomising somatic markers. A pronounced emotional resonance from the VR environment can serve as this somatic marker, strengthening the cognitive linkage between the emotions and the educational topic. In other words, well-designed VR scenarios heighten the probability of eliciting potent emotional responses and amplifying students’ involvement.

“While ‘walking’ through the villa, I had a strong desire to physically move through the space and not use the controller. That’s how I would ideally imagine VR!”

“I somewhat accepted the VR environment as my own and a few times caught myself wanting to lean my hand on a table. Quite a funny feeling when the hand went through thin air.”

Today’s students are nurtured in a milieu where technology permeates their everyday existence. To them, navigating virtual spaces might be as intuitive as comprehending the tangible world around them.

“You slowly forget that there is a class going on and you are not playing a game.”

VR lessons offer students a deep dive into an environment rich in elements reminiscent of gaming. When learners associate VR more with gameplay than conven-
tional learning, they are more apt to achieve a flow state, fostering subconscious learning. It epitomises what educational simulations in VR can accomplish.

“Certain inconveniences emerged, whether of a technical nature (couldn’t connect, glasses ran out of battery) or minor discomfort and unease on the head, but this is still a matter of time and getting used to.”

The concluding reflection underscored the ambivalence inherent in VR technology. While VR promises transformative teaching approaches and profound immersion, its immersion and ensuing flow state remain susceptible to unforeseen technical hiccups. Such reflections reiterate the need for educators to possess foundational knowledge, enabling them to address and navigate these inevitable challenges.

### 3.2.3 Avatar: Embodying digital anonymity and reducing fear of judgment

The embodiment of an avatar in the VR lesson emerged as a pivotal facet of immersion and learning. Insights gleaned from student reflections revealed that for some, VR technology extended the privilege of donning a “mask of anonymity” through their digital personas – the avatars. While preserving identity, this digital layer offers a unique learning experience dynamic. At the same time, it is essential to mention that the embodiment process is fragile, so an inappropriately chosen avatar can become a distracting element in specific situations.

“...the anonymity we had during the classes thanks to virtual reality helped us to be less afraid to speak our opinions in English and to speak more without fear of making mistakes.”

The anonymity provided by avatars proves beneficial in educational scenarios where students might fear judgement or criticism. Such a protective layer facilitates more accessible participation, especially for those apprehensive about vocalising their thoughts. This advantage was particularly pronounced among students who were uneasy about speaking in a foreign language in front of their peers or those who were aware of physical manifestations of their nervousness, such as anxious gestures or skin flushing.

“What I perceive as probably the biggest positive about learning a foreign language in virtual reality is the ability to speak without shyness. Personally, I’m shy and I don’t like having everyone’s attention focused on me. In a virtual reality environment, it didn’t bother me as much, mainly because I knew they would never see my slowly reddening face and the frustration in my eyes.”
In the prism of socio-cognitive learning, the dynamics of social interaction and self-perception play pivotal roles in knowledge acquisition. The fear of potential negative evaluation can profoundly impact one’s motivation to learn. By distinguishing one’s real identity from its digital counterpart within the VR environment, a form of “psychological shield” emerges. It shields the student’s genuine ego from the negative sentiments that often accompany errors, providing a buffer that encourages risk-taking and exploration without fear of judgement.

“The second advantage I would like to mention is anonymity, which will make it easier for a large number of people to speak in a foreign language. A lot of people have a fear of speaking in front of people, which completely goes away in VR classes. We can put more effort and focus on the correctness of the language because it’s basically the only thing we’re dealing with.”

Any mistakes in pronunciation or grammar remained connected with the avatar. This distinction played a significant role in their learning experiences. They identified the fear of negative evaluation as a primary obstacle in their learning process. Concerns about judgement or critique from peers can hinder one’s willingness to learn.

“Anonymity allowed me to be more open and to not be a mere listener.”

The inevitability of making mistakes is central to building upon one’s knowledge through new experiences. These mistakes serve as valuable touchpoints for reviewing and refining previously held understandings. In a digital realm, where the fear of making mistakes is diminished, students may be more amenable to constructivist approaches. This environment enables them to integrate and adapt to new knowledge without the burden of potential social repercussions, such as the apprehension of peers’ reactions.

“The biggest difference between VR and reality is the lack of facial expressions. I think sometimes it doesn’t matter, mainly because of my fear of any form of teasing or negative reaction from other classmates.”

A pivotal principle in this context is self-regulation. Virtual environments, where students interact via avatars, can foster optimal conditions for introspection and managing individual learning objectives. Specifically, within these settings, students might be more predisposed to self-assessment and self-adjustment rather than being influenced by their peers.

“I’m an introvert, so when I was speaking and engaging in activities, I felt more comfortable and felt less shy than if I spoke in a regular classroom.”
As identified by students, the avatar-centric nature of VR signifies a transformative shift in their learning experiences. The act of embodying an avatar was perceived by students as a liberating process, alleviating barriers such as apprehension or the fear of mistakes and enabling more open communication. This dynamic can be conceptualised as an outward-directed imaginary vector, extending towards classmates or the educator. Conversely, another dimension reflected by students regarding the avatar encompasses an inward-directed imaginary vector, channelling communication and information reception from classmates and instructors. This perspective underscores the current limitations inherent in the technology.

“Among the limiting factors, I would certainly include eye contact as well as facial expressions or hand gestures. Given that we were avatars during the lessons, and hands or feet, let alone facial expressions, weren’t visible. I find this to be very important for mutual information exchange.”

Many students highlighted the absence of nuanced facial expressions and advanced non-verbal cues in avatar-based communication. In conventional interpersonal interactions, facial gestures and bodily cues are pivotal in transmitting information and emotional undertones. Regrettably, the facial articulations of VR avatars remain rudimentary, leading to a flat non-verbal exchange.

“In the real world, people observe cues on each other that indicate one or the other is about to speak – gestures, opening of the mouth, facial expressions suggesting that either I or he should talk. In VR, I felt incredibly isolated.”

This deficiency can hinder or decelerate comprehension among students, especially in scenarios demanding swift feedback or the interpretation of peer responses. Ultimately, such limitations can also interrupt the immersive flow inherent in VR experiences.

“I couldn’t associate a real face with the names and voices of my colleagues. The only way to visualise these people was based on the avatars we were supposed to create in the initial lessons. Later on, we no longer had those original avatars that were meant to resemble us, so I started to feel that the lessons became even more depersonalised.”

Indeed, while the utilisation of avatars in VR education heralds a revolutionary shift, the present technological limitations in emulating genuine human interactions emphasise the imperative for continued advancements to realise its capabilities fully.
3.3 **Discussion**

The research examined VR in the framework of language education with a focus on enhancing vocabulary, conversational skills, and the pragmatic aspects of language. By placing students in virtual scenarios that are difficult to replicate or recreate in traditional classrooms, the intention was to bridge experiential learning with theoretical knowledge. The main research question was: “How do students reflect on their experience of learning in virtual reality?”

Various dynamic virtual settings necessitated students to adapt and broaden their linguistic range. The immersive nature of VR and role-playing opportunities transformed the learning trajectory more naturally (Li et al., 2022). Within these virtual environments, the act of language practice shifted to a secondary position, paving the way for a more intuitive and immersive learning process (Dede, 2009).

Nonetheless, the technology of VR is not without its challenges. Although stimulating, the novelty of the technology could divert attention from core learning aims (Makransky et al., 2017). The fundamental educational objectives will not be achieved if the virtual scenario unintentionally distracts students.

The question of authenticity in VR also emerged as a notable concern. Lessons modelled on actual sites demonstrated that VR, while adept at mimicking experiences, may sometimes need to catch up in encapsulating the authentic spirit of a location. Intriguingly, this perceived gap in authenticity spurred some students to explore these actual sites post-virtual experience, positioning VR as a conduit connecting the digital environment to tangible reality.

After participating in VR lessons, students consistently highlighted their deep immersion in the educational environment (Bowman & McMahan, 2007). They often felt so engrossed that they lost track of time and became unaware of the act of learning itself. It showcases VR’s potential in keeping students engaged and enhancing their learning experience.

On the one hand, experiences within the VR environment can lead to strong emotional responses. These emotional reactions can create lasting memories, making learning more impactful (Ragan et al., 2010). Many students found the VR lessons intuitive, with the sessions blurring the lines between gameplay and formal education (Farrow & Iacovides, 2013). This integration promotes subconscious learning.

Although, there were moments when the content was too complex or unfamiliar, signalling the need for educators to balance lesson difficulty for optimal engagement and flow. Technical issues occasionally hampered the immersive ex-
experience. It underscores the importance of educators being prepared to handle such challenges to ensure consistent and effective learning outcomes. While VR presents transformative opportunities in education, it requires thoughtful design and an understanding of potential obstacles.

The use of avatars in VR lessons significantly influences immersion and learning (Bendeck Soto et al., 2020). By acting as a “mask of anonymity,” avatars allow students to maintain a sense of identity while benefiting from a unique learning environment (Jones & Shao, 2011). This anonymity boosts confidence, particularly among those fearful of speaking in foreign languages, as it hides physical reactions like blushing or anxious movements. From a socio-cognitive viewpoint, this distinction between the real self and the digital avatar acts as a buffer, shielding students from the negativity of mistakes and promoting risk-taking.

In a VR setting where students remain anonymous, the pressure and fear associated with making mistakes are reduced. This reduction in anxiety corresponds to a lower affective filter, as per Krashen's theory (Chen, 2022). When students feel less afraid of being judged by their peers, they are more open and receptive to new information and experiences. This openness enhances their ability to assimilate new knowledge, aligning with a constructivist approach to learning, which emphasises active engagement and learning from one's experiences and interactions.

Despite the advantages, there are inherent limitations to avatar-based VR learning. A significant concern among students is the lack of non-verbal cues, such as facial expressions and gestures. This absence can make communication feel impersonal and hinder understanding, especially in fast-paced interactions. Such drawbacks sometimes disrupt the immersive quality of VR lessons and make the experience feel isolated or depersonalised (Park et al., 2021).

In essence, while avatars in VR education offer revolutionary benefits, the technology’s current limitations underscore the need for continued advancements to fully harness its potential.

Virtual reality provides an immersive, multisensory experience which can be used in language education, enhancing vocabulary and conversational skills. The balance of an appropriately chosen context, complemented by spatial cognition and a somatic-cognitive experience through an avatar, seems essential for maximising the learning process. However, challenges such as distractions due to the novelty of the technology, concerns about authenticity, and the absence of non-verbal cues in avatar interactions can hinder optimal learning outcomes. Despite its transformative potential in education, VR requires thoughtful integration, recognizing both its innovative strengths and existing limitations.
The analysis identified three key parts of VR education that are crucial for better learning outcomes. These include the relevant educational context, the choice of virtual environment, and the avatars. The triad, complemented by the pedagogical principles we identified in the data, is presented in Figure 3.4.

![Figure 3.4: The triad of Pedagogical Principles of VR Education](image)

**3.4 EDUCATIONAL IMPLICATIONS**

The secondary research question was: “What are the pedagogical aspects and implications of virtual reality in English language learning?” From our data analysis, we have identified specific practical recommendations for VR education. These insights can potentially streamline the adoption of VR technology in educational settings, complementing conventional teaching methods.

- Suitable context and virtual environments can help develop the pragmatic component of language in addition to vocabulary and grammar.
• The available VR software allows VR lessons to be situated in a different location each time, and the pedagogical situations and learning objectives can be adapted accordingly.

• Technology can be very persuasive due to its multisensory nature; it is important for teachers to create educational narratives responsibly (for example, in the reconstruction of historical events).

• If the VR environment is too flat or too exaggerated, the technology will serve more as a distractor.

• The tasks in the VR lessons must be adequately set concerning the students’ skills. The VR environment supports a flow state if the task is challenging enough but not too difficult to cause frustration for students.

• In the case of deep immersion and engaging narrative, VR can help students disengage from distractions.

• Somatic-cognitive VR experience helps build meaningful associations within learning content. The consequence is better memory retention.

• An avatar serves as a shield to students’ own egos when they make a mistake because they don’t see the reaction of their classmates.

• Facial expressions of avatars are essential when students expect a reaction from their classmates or teacher. These are habitual patterns from the real world.

• The technology seems suitable for introverts, as the avatar can mask physical manifestations of nervousness, such as flushed skin.

• Students can interact with classmates (live actors) or objects (non-live actors) in VR lessons. It depends on the nature and preference of the student.

• If students do not know each other from a real class, it is appropriate to include ice-breaking activities.

• The technology can be used remotely. Students do not have to share the same physical space. It is useful at times when in-person meeting is not possible. In this case, it is helpful to have technical support available for students who may have trouble connecting to the VR lesson.

• VR environments can cause kinetosis. If anyone becomes nauseous, they should remove the headset and inform the tutor/teacher.
Some real-world classroom principles do not work in VR lessons (like taking notes on paper). New pedagogical principles and paradigms need to be created to exploit the potential of the technology (for example, digital note-taking that syncs to the cloud).

### 3.5 Conclusion

In VR-enhanced educational research, integrating context, the virtual environment, and avatars emerges as a pivotal triad. Each component plays a distinct yet interconnected role in the learning experience, influencing engagement, immersion, and instructional effectiveness.

The VR scenario, understood as the contextual underpinning, is integral to learner engagement. A relevant and tailored scenario anchors theoretical knowledge within practical, experiential contexts, bridging abstract concepts with concrete, immersive experiences.

The virtual environment, meanwhile, functions as the spatial framework in which learning unfolds. It is not merely a passive backdrop but an active contributor to the cognitive and affective processes of learning. Its design, interactivity, and alignment with the learning objectives can significantly influence the learner’s sense of immersion and motivation.

Lastly, avatars represent the interactive agents within this virtual realm. The learner’s representation and those of their virtual counterparts shape the nature of interactions, lending authenticity to the learning experience. The appropriate design and use of avatars can foster a sense of identity, boost learner confidence, and enhance communicative exchanges, particularly in language-focused VR modules.

Effective VR learning hinges on the intricate balance and integration of scenario, virtual environment, and avatar. Their interplay determines the depth, efficacy, and authenticity of the virtual educational experience.

Should further research be conducted on our initial findings related to VR in English language teaching, the following two areas would be of paramount interest. First, the potential of the VR environment to evoke strong emotional responses could be explored. We would seek to identify which VR elements most powerfully engage students emotionally and examine the relationship between these emotions and learning outcomes.
Second, the role of avatars in VR presents intriguing possibilities and challenges. A key focus would be the absence of non-verbal cues in avatar interactions. By understanding these limitations, potential design improvements might be suggested to enhance non-verbal communication.
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Implementing Didactic Principles in VR for Language Education


Chapter 4
Collaborative Learning Heights:
Hypsography Lessons in iVRs

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This chapter explores the potential of immersive virtual environments (iVE) in geography education, particularly for understanding complex topics like hypsography and contour lines. It argues that iVEs offer unique advantages in visualising spatial data and simulating geographical phenomena, which traditional teaching methods may struggle to convey effectively. The chapter details developing and testing a collaborative hypsography application designed for educational purposes. The app focuses on enhancing spatial understanding through 3D visualisations and collaborative tasks. University and high school students participated in qualitative studies to assess the app’s effectiveness. The studies revealed that while students generally found the iVE engaging and beneficial for understanding geography concepts, there were some challenges with communication within the virtual environment and the need for controller training. The participants also suggested potential applications of iVEs in other subjects like history, physics, and chemistry. Despite some limitations, such as the novelty effect and potential for motion sickness, the overall response to using iVE in education was positive. The chapter concludes by emphasising the need for further research to optimise the use of immersive virtual environments in educational settings and to explore their long-term effects on learning.

Technological development affects most fields, including geography. By utilising immersive virtual environments (iVE), we can better grasp geographical concepts, make informed decisions, and contribute to building a sustainable future (Harknett et al., 2022). Immersive VE enables us to simulate virtual field trips, visualise and analyse spatial data, gain new insights into geographic patterns, create simulations for education and training, and simulate disaster scenarios (Feng et al., 2020; Zhao et al., 2020). Immersive Virtual Environment (iVE) technology is an exciting development that is transforming our interaction with the world around us. It has the potential to revolutionise the way we learn, study and analyse spatial information in a manner unmatched by any other technological tool (Frehlich, 2020).

In the field of geography, collaborative immersive virtual environments (CIVE) are considered excellent tools for presenting phenomena that are difficult to ex-
plain using traditional teaching methods. Many geography topics, such as map projections, planetary orbits, geomorphological processes, weather fronts, and environmental issues like climate change, could benefit from incorporating iVE components and features in the learning process (Markowitz et al., 2018). Effective visualisation of spatio-temporal data, alongside 3D visualisation itself, can greatly assist in comprehending these topics. The concept of hypsography, which involves representing the elevation of the Earth’s surface, presenting the elevation of the Earth’s surface, is often considered within these subjects, alongside contours.

Despite the common usage of various types of maps, many students struggle to understand them due to various reasons (Havelková & Hanus, 2018; Atit et al., 2016; Hanus & Marada, 2016; Ooms et al., 2016; Clark et al., 2008; Rapp et al., 2007; Taylor et al., 2004; Hamilton, 1951). The primary challenge lies in visualising 3D landscapes from 2D maps (Ooms et al., 2016; Swenson & Kastens, 2011; Clark et al., 2008; Rapp et al., 2007; Boardman, 1989; Chang et al., 1985). Additionally, students often perceive 2D maps as photographs rather than representations of spatial data (Swenson & Kastens, 2011). In contrast, topographic maps require readers to visualise discrete contour line symbols, such as shapes of various landforms, slopes, or elevation differences. Understanding and interpreting these landscape structures requires a combination of spatial, logical, and mental skills beyond simply comprehending map symbols (Borres-Calle et al., 2020; Atit et al., 2016; Clarke, 2007).

In addition to visualising the 3D structure represented by 2D lines, students are expected to engage in mental transformations (Ormand et al., 2014). They must understand that continuous dimensions of elevation or latitude and longitude are categorically coded and possess the ability to imagine the slope of the surface based on the distance between contour lines (Newcombe et al., 2015). A lack of these skills can lead to a false sense of understanding. Several misconceptions have been identified among students when interpreting relief and estimating elevation. Boardman (1989) highlights the most common including confusion caused by the absence of an elevation value on a contour line, inability to interpret the space before and after numbered lines, misunderstanding the relationship between slope and distance between contour lines, and mistaking high numbers on contour lines for steepness.

The combination of 2D and 3D visualisations of contour lines in CIVE is expected to reduce or even prevent misconceptions by helping learners understand spatial relationships within the map and perform mental rotations, which are not possible with 2D displays. Not only can 3D visualisation enhance learning, but
collaborative educational tasks in iVEs can lead to better engagement, retention of learning, and memory storage (Persellin & Daniels, 2014). Various landscape models were a standard method of teaching geography before the advent of technology (Boardman, 1982; Blades & Spencer, 1986; Sandford, 1979). According to Boardman (1982), collaborating with experts in craft, design, and technology can be highly beneficial. We share the belief that in the digital era of the 21st century, immersive virtual environments (IVEs) have the potential to partly replace traditional landscape models through 3D immersive visualisations.

4.1 Application design & development for collaborative hypsography

In recent advancements in geography education, various applications have emerged with potential. However, existing resources have been somewhat inadequate in fostering truly collaborative learning experiences. We have identified specific drawbacks in applications and software designed for hypsography learning, such as Sandbox KinectSandbox and Spot Heights.

For example, Sandbox lacks collaboration features, has limited immersiveness, and requires specific hardware such as a sandbox table, scanner, and projector. In light of these limitations, we have proposed our own concept and created entirely new technological solutions for hypsography lessons in the virtual environment. Our emphasis is on collaboration, a key feature often lacking in current apps. The new concept is designed to harness the potential of an IVE while adhering to instructional design standards. From the outset, our focus has been on making the lessons illustrative, interactive, collaborative, and hands-on, incorporating principles of gamification.

To ensure the development of a precise and effective application, we formed an interdisciplinary team of specialists from various backgrounds. Additionally, we sought significant input from teachers, designers, psychologists, information scientists and students themselves. Rather than taking an existing application and adapting it for educational use, we started with a user needs analysis and spent several years developing the app to meet educational requirements (Šašinka et al., 2018). The motivation behind this approach stemmed from the entrance exams results of the Department of Geography at Masaryk University, where the error rate in hypsography topics was 86% in 2016 and 73% in 2017. This aligned perfectly with our goal of developing an application that fully utilises the potential of an IVE—not just as a novelty environment but as a means to enhance people's 3D mental representations of space.
The initial version of the application served as a proof of concept. It ran on our first virtual environment platform (Doležal et al., 2017), whereas the finalised version now operates on the newly developed eDIVE platform (Šašinka et al., 2021). The eDIVE platform was created to provide a universal space for tasks and apps across various disciplines rather than focusing solely on geography (Šašinková, 2023). The eDIVE platform is freely available under an open-source licence (LGPL-3.0), and all final scenarios (builds) are possible to download from the project web page eduincive.muni.cz. The conception of the entire project, including the way of developing the software solution, scenarios, and lesson plans, is described in Šašinka et al. (2023).

The original hypsography application included two scenarios tested in a qualitative study. These scenarios involved completing mirror signals and determining the order of flooded houses in a valley (see detailed description in Šašinka et al., 2019). The main objective was for participants to create a mental 3D representation of a 2D map to complete the tasks. After receiving feedback, participants could switch to a 3D visualisation and precisely connect the 2D map representation with its 3D counterpart. The original study, which focused on adults, provided us with the following outcomes:

- Participants appreciated the collaborative aspect, perceiving it as more efficient than individual work (Zambrano et al., 2019).
- They found the cartographical topic more engaging thanks to the iVE.
- They acknowledged that communication still posed a challenge in the iVE, but it was not deemed insurmountable.
- Some participants experienced confusion or other negative feelings, such as depersonalization or derealization from prolonged exposure to the iVE.

For the final version of the application, we focused solely on the first type of task but included more variations. We then tested it again with experienced geography teachers, who saw it as an excellent opportunity to teach the topic in a more efficient and enjoyable manner (Jochecová et al., 2022).

4.2 The final solution for hypsography learning in CIVE

After conducting rounds of user testing and receiving expert evaluations, we made further adjustments and additions to the final design of the application to enhance
the engaging experience. The environment is highly interactive and designed to facilitate smooth collaboration among 3 to 4 users.

In the final version of the eDIVE platform, we made alterations to improve the user experience. Firstly, we fixed the default flags A and B in the map, preventing students from manipulating them and simplifying the task. We also added two more tasks to the original three, providing a greater variety of challenges. To address the issue of students frequently losing flags irrecoverably, we implemented a flag resetting function after switching tasks. Additionally, we included a laser pointer to indicate the person operating a specific flag.

The app's interior is intentionally minimalistic, consisting of a room with a few chairs, a whiteboard, and a map displayed on a concrete block (Figure 4.1). This simplicity helps students focus on the task at hand without unnecessary distractions or excessive interactivity. Instructions for each selected task are always provided on the whiteboard. The map itself incorporates various features to enhance the visualisation and understanding of different hypsographic principles.

Users can switch between a basic blank contour map, an orthophoto, and a 3D visualisation of the designated area. This allows them to observe instantaneous and dynamic changes in the terrain while retaining the course of the contour lines on the 3D visualisation. Users can also adjust the equidistance of the displayed contour lines, which aids the comprehension of terrain shapes. Manipulating a slider
to change the spacing between individual contour lines and their density transformation provides a clearer representation of slope steepness, particularly when viewing the 3D visualisation. The 3D visualisation’s dynamic cross-section feature highlights the fact that contour lines delineate areas of the same height. This concept shares similarities with physical landscape models created using stacked layers, as suggested by Boardman (1982).

To navigate through the environment and manipulate objects, the standard Oculus Quest 2 controllers are utilised. Participants can move within the environment by using the teleport function, which is activated by pressing button A (Figure 4.2). To select visualisation options, the triggers on the controllers are employed. When it comes to grabbing flags, participants can utilise the grip buttons on the controllers.

Once a flag is held, participants can slide it along a line, either bringing it closer or moving it further away, by using the thumbsticks on the controllers. Furthermore, they can rotate the flag around its axis by manipulating the thumbsticks. These controller functions provide users with the necessary tools to navigate the virtual environment and interact with objects effectively.

The avatar is made from two colourful balloons with a headset on the upper balloon while the participant’s nickname is written above the head. To avoid confusion among the students, a feature signalling who holds each flag was added (Figure 4.3).
Students are assigned five distinct tasks focused on hypsography understanding.

**Task 1.** Your task is to connect points marked with the flags A and B (as seen in the video) in a way that direct visibility between all neighbouring points is ensured. You have 5 flags available, but you don't have to use them all. Place them in the map in the correct sequence and in ascending order. You can't move points A and B, but try to connect them through two highest peaks. When you are finished, press the EVALUATE button to check your solution. The correct solution is demonstrated by green rays between the points, incorrect by the red rays. First try to work on the 2D map and then switch to a 3D visualisation.
Task 2. Your task is to connect points marked with the flags A and B with as few flags as possible while every two neighbouring points are directly visible. You can’t move points A and B. First, try to work on the 2D map and then switch to a 3D visualisation.

Task 3. Your task is to connect points marked with the flags A and B in such a way that the trail has minimum superelevation and every two neighbouring points are directly visible. You can’t move points A and B. First, try to work on the 2D map and then switch to a 3D visualisation.

Task 4. Place flag number 3 on the red point. It is now the midpoint you need to consider within the task. Your task is to connect points marked with the flags A and B with as few flags as possible, while maintaining direct visibility in each two neighbouring points. You can’t move points A and B. First, try to work on the 2D map and then switch to a 3D visualisation.

Note. Remember to place flags in ascending order, considering the flag no. 3 in the middle.
**Task 5.** Place flag number 3 on the red point. It is now the midpoint you need to consider within the task. Your task is to connect points marked with the flags A and B in such a way that the trail has minimum superelevation and every two neighbouring points are directly visible. You can't move points A and B. First, try to work on the 2D map and then switch to a 3D visualisation.

Note. Remember to place flags in ascending order, considering the flag no. 3 in the middle.

![Flag Placement Diagram](image)

Figure 4.4: Example of accuracy evaluation (green = line visibility between flags, red line = no visibility between flags)

### 4.3 The Lesson Plan

The lecture commences with an engaging video clip from the Lord of the Rings movie, specifically the scene depicting the lighting of the Gondor beacons. This
clip holds significant resonance, even among the young Generation Z and digital natives. Following the video, a geography teacher conducts a frontal lecture, explaining the fundamental concepts of contour lines and map reading using concise PowerPoint slides. Additionally, the lecturer briefly introduces the application (as it is the same for both an iVE and computer screen condition) and prepares the students for the virtual environment they are about to experience. Subsequently, the students are divided into groups consisting of three to four individuals. They then proceed to complete tasks either within an immersive virtual environment using Oculus Quest 2 headsets or as control groups on a computer screen with an 80 cm diameter. Each computer screen group shares one mouse for interaction. During this phase, students actively engage with the environment at their own pace while fostering teamwork and communication within their respective groups. This allows for autonomous learning and collaborative problem-solving. Following the autonomous learning period, students participate in a group reflective discussion led by the teacher in a physical classroom setting. This discussion provides an opportunity for students to address any remaining areas of confusion, evaluate their teamwork dynamics, and reflect on their overall experience with the virtual environment.

By combining both traditional teaching methods and the application’s immersive learning experience, we aim to strike a balance between leveraging the benefits of iVR technology and maintaining the value of established teaching approaches.

4.4 **Empirical Studies**

4.4.1 **Procedure**

To ensure that the extensive efforts invested in the design and development process were effective, we sought to gather substantial feedback and data. For this purpose, we conducted three qualitative studies, aiming to comprehensively assess the experience of our target users.

The first pilot study involved university students majoring in teaching. A total of 9 university students participated in this initial study. Subsequently, we conducted two additional studies specifically targeting high school students. One study was conducted with a group of 8 students from a Civil Engineering High School who attended a geography seminar as an after-school activity. The other study involved an entire class of first-year high school students, comprising 16 participants from a secondary grammar school.
In these studies, we examined the entire lesson concept, which combined a frontal lecture with a collaborative exercise in various environments, with a particular emphasis on the preference for immersive virtual environments. Following the lesson, we gathered participants’ thoughts, insights, and comments on the virtual environment and its features. Additionally, we engaged in discussions with them regarding other potential applications of immersive virtual environments during lectures. The feedback collection was conducted through focus groups, semi-structured interviews, and questionnaires, depending on the specific study and participant preferences.

By conducting these qualitative studies, we aimed to gather comprehensive and diverse feedback from our target users. This feedback not only helped us evaluate the effectiveness of the lesson concept but also provided valuable insights for further improvements and identified potential applications of immersive virtual environments in educational settings.

4.4.2 Results

This chapter provides an overview of the outcomes obtained from testing the application and conducting user studies. Throughout the individual experiments, the procedure underwent changes due to the lack of detailed controller training provided to university students. Although the students found the controllers intuitive and the environment easily controllable, they suggested the need for more precise instructions regarding task procedures, goals, and environmental manipulation. This requirement stemmed from the novelty of not only the technology but also the design and didactics involved. Without proper guidance before and during the experience, the students could easily become distracted or confused.

Consequently, we decided to provide high school students with more information, specifically controller training, as some of them encountered initial difficulties. However, the majority of high school students managed to handle the controllers successfully on their first attempt. Younger students also faced no issues in understanding the tasks, and the given time was sufficient for them. Some students expressed a preference for more tasks and shorter task descriptions, as they tended to skip instructions and consequently become confused while attempting to complete assignments.

All university students believed that the collaborative use of this application would benefit children in their learning process. They suggested that groups should not exceed four members, with an ideal count ranging from two to three children per group. The students did not mind collaborative work; in fact, most of
them preferred it as working alone would be monotonous. However, one student expressed a preference for collaboration in a traditional classroom setting (although they found it preferable to remote collaboration on individual computers during remote learning within COVID-19 restrictions). Additionally, this collaborative approach allowed all students to try out the application's features and participate in the work, including those who might be less motivated or proactive. Randomly assigning groups ensured a more equitable distribution and prevented students from working solely with their closest schoolmates. As observers, we noticed that students diligently attempted to complete the tasks, despite occasional distractions and initial fascination with the immersive virtual environment, which occasionally led to minor delays or confusion (e.g., losing flags).

Notably, students across all groups did not engage equally, but this discrepancy seemed to stem from personal preferences rather than a lack of opportunity. Usually, one or two students emerged as leaders who spoke the most and managed the group, while others focused on completing the assigned tasks. The students also felt more motivated, perhaps because they could see each other in the iVE, and communication was easier without the need for written notes.

Regarding **avatars and their communication**, students expressed varying opinions. Some students had no issues with the absence of facial expressions or the avatars’ slight resemblance to human figures. A few suggested that providing more facial details would be helpful, while others argued that the current schematic representation preserved anonymity, which they considered an advantage. The rest of the students missed facial expressions, particularly when the application froze, as they were unable to immediately discern what was happening. Although they did not offer specific solutions, they emphasised the necessity of addressing this problem before implementing iVE lessons in education. Students also expressed a desire for some form of interaction among avatars, such as tactile responses during high fives or victory dances.

Both groups of university students agreed that the **3D visualisation** was highly beneficial for understanding concepts, with the orthophoto option receiving appreciation as well. They found the “play-like” concept and interactivity to be effective for learning, and the introductory movie served as a motivating factor for children’s engagement. However, the university students believed that using such a setting would be more advantageous after prior exposure to the concept of hypsography. Similarly, they recommended initially using the 2D map as it proved more useful for practising contour line reading, because if students started immediately with the 3D visualisation, they would be able to correctly finish the task without understanding contour lines whatsoever.
Students from the Civil Engineering High School found the 3D visualisations significantly more helpful than regular lectures. They appreciated the opportunity for active participation, which prompted them to think more deeply about the topics. On the other hand, students from the secondary grammar school did not feel as strongly about the educational benefits but found the experimental lecture format more interesting. Nevertheless, all groups expressed appreciation for the 3D visualisation and the ability to view it from different perspectives.

We were also curious to learn about the students’ ideas regarding further beneficial uses of iVEs in various subjects and classes. They frequently mentioned descriptive geometry, history (utilising the time axis to explore historical places and study war strategies), physics, physical education, and chemistry. Overall, all the students displayed enthusiasm, finding the application more enjoyable than traditional lectures, regardless of their assigned groups. They appreciated the incorporated features, and their feedback was primarily positive, immediately during or after the lessons. Despite the challenges associated with integrating VE into education, these results provide promising evidence that change is indeed possible.

4.5 Conclusion

The potential learning benefits of the application are currently being assessed through extensive quantitative research. If proven effective, immersive virtual reality (iVR) could be a valuable solution for enhancing the understanding of certain topics, particularly for students with limited 3D imagination. The engaging nature of iVE lessons has the potential to motivate students of all abilities to learn. However, it is important to note that the use of immersive virtual environments in education is not necessary or suitable for all subjects. It is crucial to consider whether the options provided by the immersive environment can be easily accessed and experienced in the real world. Overusing iVEs in education may lead to the exclusion of students who experience motion sickness. Additionally, the impact of an iVE on communication development remains unresolved.

These findings offer valuable insights into the effectiveness of the app in improving students’ understanding and collaboration in geography lessons, as well as areas for further improvement. To fully utilise the potential of virtual environments in classrooms, a thoughtful approach is necessary. This may include providing controller training, especially for first-time users, and implementing appropriate introductions and incentives to engage students in different class procedures. We conducted further quantitative research based on the insights from this qualitative
study. In our subsequent quantitative study, we successfully reduced disruptive behaviour and increased student engagement by promising iVE gaming sessions after completing the tasks. However, it is important to note that the novelty effect of immersive virtual environments may fade over time.

Comparing these results with the findings from the initial qualitative study on the original hypsography application, it is evident that certain aspects of the immersive virtual environment are applicable across different demographics. Even young students prefer collaborative work over individual work and find hypsography more exciting in the immersive environment. While communication in the virtual environment was not considered significantly problematic by most students, there was no consensus, and the absence of facial and other expressions was identified as a significant limitation. The ideal representation of avatars in the virtual environment remains an area that requires further research. Importantly, none of the participants in the current studies reported feelings of disorientation or other negative effects upon returning to the real world, potentially due to their shorter exposure time in the virtual environment. Although motion sickness is often associated with immersive virtual environments, this application has successfully mitigated most of the factors that induce sickness. Out of approximately 250 students who participated in all the experiments combined, only two reported slight discomfort at the end.

In conclusion, our exploration of immersive virtual environments in geography education on an example of hypsography has yielded promising results in enhancing students’ learning experiences. However, as technology continues to advance rapidly, further research is needed to fully harness the potential of these innovative tools. By embracing new advancements and refining our approaches, we can unlock more effective, engaging, and inspiring educational experiences not only in the field of geography but across various subjects.
4.6 References


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Chapter 5
Implementing Collaborative iVR into Libraries

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This chapter explores the integration of immersive virtual reality (iVR) into library services, mainly focusing on its role in education and collaborative learning. The chapter examines how libraries, especially in the Czech Republic, are evolving to include VR technologies, thereby enhancing learning and offering new interactive experiences. Two English VR lessons were conducted to evaluate current possibilities and challenges in implementing VR in libraries. The study identified vital aspects such as librarian competencies, the evolution of librarian roles, educational competencies required for VR, librarians’ attitudes towards technology, and the readiness of institutions to introduce VR services. It concludes that while there are challenges in implementing iVR in libraries, such as technical and financial constraints and space limitations, there are also significant opportunities. iVR can transform libraries into dynamic learning hubs, fostering creativity, teamwork, and user engagement, especially among younger generations.

5.1 Introduction

Libraries are vital places that respond to current social and technological trends, providing the latest technologies to the public (Smith, 2019). One of these technologies is virtual reality (iVR), which is becoming an essential part of libraries. Whether public, academic or community, libraries already have an established infrastructure, allowing them to reach out to communities that would otherwise not have access to new technologies (Vijayakumar & Vijayan, 2011). In the Czech Republic, libraries are noteworthy for their dense network, with approximately 1 700 inhabitants per library (Tutar, 2021). Libraries go beyond traditional book services and increasingly focus on supporting local communities (Dewe, 2016; Aabø & Audunson, 2012) and education (Borrego, 2015; Xue et al., 2023). With decreasing costs, libraries can now offer a variety of VR options to users, providing different devices, from simple models like Google Cardboard to advanced devices such as Oculus Rift or HTC VIVE (Lee et al., 2020).

In the realm of education, iVR is used as part of library services in diverse ways – from facilitating virtual visits to different locations to actively participating in sci-
entific programs. This approach allows students to immerse themselves in an authentic virtual environment, providing a more immersive and interactive learning experience. iVR can serve as a primary platform for specific activities where users continuously interact and communicate within the virtual environment. Moreover, academic libraries offer students access to VR labs, enabling them to generate content in a virtual reality environment and conduct research. This active involvement allows students to participate in the creation process, hone their iVR skills and gain hands-on experience (Horban et al., 2022).

With the development of VR technologies, we can expect to see the expansion and diversification of library service delivery models to better meet users’ needs (Koukopoulos & Koukopoulos, 2018). Still, there are hurdles to overcome, such as technical difficulties, the high costs associated with acquiring and maintaining VR equipment, a lack of standardisation, and the need for training for librarians. Harnessing the potential of VR requires careful planning and investment. Studies examining the potential and challenges of implementing VR into libraries show that VR can enhance access to information, support education and research, and increase user engagement. Technical issues and lack of standardisation present challenges. Libraries need to invest in infrastructure and provide training for their staff. Academic libraries, in particular, must equip their librarians with new competencies (Malgard et al., 2022).

Our research focuses on the implementation of iVR in the network of libraries on the integration of iVR within the library network, utilising libraries as the infrastructure for remote collaborative education. We explored both opportunities and barriers in implementing VR in libraries. Harisanty (2022) argues that library users appreciate the opportunity to explore VR technologies, yet there is room for improvement in using VR for research and educational purposes. Designated spaces for iVR use can reduce barriers and reduce discomfort associated with using VR technology in public areas (Frost et al., 2020). Virtual reality is finding its way into academic libraries to provide new ways to support learning. By leveraging virtual reality, libraries can create interactive and immersive environments for students and academic staff, enhancing learning experiences (Suen et al., 2020). iVR in libraries finds application in various models, such as open spaces for the general public, closed labs for demonstrations and testing, flexible spaces for groups, and lending iVR equipment and kits to developers. This diversity of models shows the myriad of ways iVR can be implemented in libraries (Casucci et al., 2019). In the educational context, VR proves valuable for skills training and simulating different situations, especially for crisis librarians (Dumas et al., 2022). Immersive virtual reality also brings new opportunities to support learning and allows libraries to create engaging learning experiences. In academic
settings, VR implementation varies based on accessibility, target user groups and purpose. Adapting to the specific needs and constraints of individual libraries is crucial when introducing VR technologies.

Immersive Virtual Reality develops information literacy and promotes critical thinking. For example, utilising an application designed as a detective game allows students to absorb information without feeling pressured (Smith, 2019). The collaborative use of virtual reality in education provides new opportunities for interaction and sharing between students and teachers across physical distances. However, the implementation of this technology in libraries remains an ongoing challenge (Hamad & Jia, 2022). It is imperative to ensure access to appropriate equipment and equip staff with the necessary skills and knowledge (Dahya et al., 2021). Libraries must prioritise the provision of suitable equipment and software tools for VR, ensuring their staff have the skills and expertise to proficiently manage and support these technologies. Collaborative VR presents a substantial opportunity for libraries to improve their services and increase user value.

5.2 Methodology

This paper used a qualitative research method known as Research through Design (RtD), focusing on design processes and addressing specific design problems. In the context of this research, both a focus group and interviews were employed to gain a deeper understanding of the research problem and gather diverse perspectives. Focus groups facilitate participant interaction, diverse viewpoints and stimulating discussion, while interviews enable individual reflection and the exploration of complementary viewpoints. These methods contribute to generating new ideas, solutions and a more profound understanding of the studied topic (Zimmerman, 2014).

The research aimed to assess the viability of collaborative (or synchronous) immersive virtual reality for libraries. Specifically, two English VR lessons were successively employed to investigate the current possibilities and limitations in implementing VR in libraries. To achieve this, an experimental method was used to introduce the virtual reality service in various institutions. The selected institutions were chosen based on their diverse practices and approaches to service delivery. The research was conducted in collaboration with the Jiří Mahen Central City Library (KJM), the experimental library Na Křižovatce, the local library in Tišnov, and the Central Library of the Faculty of Arts of Masaryk University. Additionally, the Znojmo Grammar School, as a specific type of involved institution, also participated in the project.
Two methods were used in the research to gain a better understanding of the issues under study: focus groups and interviews. These approaches allowed us to obtain more in depth and diverse participant information. Both methods were conducted in a semi-structured format, offering flexibility throughout the process, facilitating discussion of crucial aspects of the topic, and providing space for participants to engage in deeper reflection. Focus groups were used to compare the experiences and opinions of employees from various institutions regarding collaborative virtual reality. An individual interview with a librarian from KJM, who did not participate in any focus groups, supplemented the perspectives, attitudes and reflections on the experimental implementation.

The implementation was divided into two phases. In the initial phase, employees of the participating institutions were introduced to VR technology, and both hardware and software were prepared. Subsequently, the first synchronous English lesson took place. In addition to direct observation, interviews were conducted with the participants. Based on the findings from this phase, a guideline for working with VR was created for employees of the participating institutions, among other things. In the second phase, another synchronous English teaching session occurred, with the difference that employees could follow the guidelines. For the experimental implementation, it was necessary to ensure correct parameters in the individual libraries and the high school. This included adequate facilities, technology, supervising librarians/teachers, and students, i.e. lesson participants. To ensure the experiment’s success, allocating suitable space in each institution was necessary. The Faculty of Arts Library and Tišnov Library already had dedicated space for using technology, including virtual reality. The Jiri Mažen City Library provided a club room, the Na Křižovatce Library offered all its facilities, and the Znojmo Grammar School made a classroom available.

To implement virtual reality, Oculus Quest 2 headsets (Oculus Quest 1 in the case of the library in Tišnov) were used, and the necessary equipment, such as headsets and spare batteries, were provided. Each headset was prepared with a critical application used to run the experiment. Two apps, Vila Stiasni and Quality of Life, developed within the EduInCIVE project, were employed. In the experiment’s initial phase, the Vila Stiasni app was used for an English lesson in a virtual architectonic monument setting. In the second phase, the Quality of Life app was chosen.

The experiment required responsible staff (librarians or teachers) to provide the virtual reality service in the institutions. Training these staff members effectively to run the experiment was necessary. The selection of participants (voluntary
students) for the experiment was done purposely and based on the capabilities of the participating institutions.

The research had two phases, spaced two months apart. After each VR session, a focus group was conducted, accompanied by individual interviews with the responsible staff. The interviews were then transcribed accurately to preserve the statements’ precision. The coding and data analysis were conducted using the dedicated tool Atlas.ti. The analysis of library readiness focused on various aspects, including the transformation of librarians’ role in virtual reality, their new responsibilities in implementing the service, training needs, and staff attitudes. Another aspect examined was the institution’s readiness to introduce the new service. Sub-categories related to the library’s technological equipment, the institution’s conceptual adaptability, technical infrastructure, user needs, financial requirements, and the benefits of the new service were identified. The institution’s readiness was evaluated by assessing these areas, and potential challenges and obstacles were identified.

5.2.1 INITIATING THE EXPERIMENT:
FIRST PHASE AND LESSON PROGRESSION

The first phase of the investigation focused on securing suitable spaces, coordinating timing across institutions, and reaching out to potential participants or students. Each institution had unique requirements necessitating tailored approaches. To secure experiment space, considerations included room availability and booking procedures. The Library Na Křižovatce faced limitations, requiring the experiment to occur outside of regular hours. The Jiří Mahen Library and the Znojmo Grammar School scheduling flexibility. Besides space considerations, ensuring internet connectivity was crucial, given the wireless Oculus Quest headsets’ reliance on an internet connection. The Jiří Mahen Library and the Grammar School in Znojmo encountered network connection challenges, resolved with solutions such as obtaining a new network address and the assistance of IT staff during hardware setup.

The initial lesson focused on the history of Brno’s architectural monument, Villa Stiassni. An interactive application allowed students to explore the villa and discover its history. The lesson included collaborative activities in which students reflected on their acquired knowledge. Before the lesson, preparation included familiarising the participants with the headset, controllers and virtual environment. The session, lasting approximately 40 minutes, was led by a tutor experienced in collaborative virtual reality education.
Following the session, a Zoom-based online focus group with participating staff discussed the implementation and their attitudes towards technology in libraries.

Based on the data and experiences of the first experiment phase, a document with recommendations for swiftly implementing immersive collaborative virtual reality services in libraries was created. It offers practical guidelines for librarians and responsible staff, to implement the service quickly. The recommendations are divided into several sections, covering administrative provisions, technical support, internal communication, user instructions, and inter-institutional communication. The document serves as a clear guide, aiding in the implementation and ensuring the proper functioning of the Immersive Collaborative Virtual Reality service in libraries.

5.2.2 The second phase of the experiment

The second phase of the experiment aimed to enhance the approach based on lessons learned from the initial phase and avoid repeating previous errors. Key preparations focused on resolving internet connectivity issues experienced by some institutions in the first phase. Temporary solutions, such as using the mobile data of the staff responsible, were implemented in the Na Křižovatce library and the grammar school in Znojmo. Furthermore, a communication channel was created between the institutions and the lecturer to improve coordination.

In this phase, another application, “Quality of Life”, was employed for teaching English on the topic of social geography. Participants were provided with thematic maps that assessed the quality of life in different areas. Some institutions also witnessed a change in lesson participants. The lesson flow mirrored the previous phase, with a follow-up Zoom-based focus group for reflection after the lesson.

5.3 Results

5.3.1 Librarian competencies for virtual reality services

Introduction to virtual reality for responsible personnel

Familiarity with virtual reality among library staff was often linked to the institutional context. For example, at the Tišnov library and the Central Library of the Masaryk University, Faculty of Arts, staff members already had a basic understanding of the new technology. They further developed their competencies
Implementing Collaborative iVR into Libraries through user training and collaboration with researchers. In contrast, staff members at other libraries, such as the KJM and the Na Křižovatce Library, had more indirect familiarity with VR. In these cases, the staff had limited experience and were not actively working with the technology. The teacher from Znojmo Grammar School had sporadic experiences with VR but lacked a deeper understanding of the technology. The institutional context significantly influenced the staff’s level of experience with VR.

The evolution of the librarian’s established role

Introducing librarians to virtual reality brings a change in their roles and responsibilities. Librarians need the appropriate competencies to work with VR, providing services and leading education in virtual reality. In certain libraries, such as the one in Tišnov and the Central Library of the Faculty of Arts, Masaryk University, librarians have transformed and acquired technical and lecturing competencies for working with VR. They organise workshops and clubs focused on technology, allowing users to learn new skills. Librarians can pursue competency acquisition in various ways, including self-study, participation in training courses, and attendance at conferences. Embracing new activities and roles requires flexibility, a willingness to step out of their comfort zone, and active engagement in new projects. Motivating librarians to develop their professional skills and supporting them in overcoming obstacles is essential. Community involvement can help librarians in their tasks and strengthen the connections between the library and the community. The transformation of the librarian’s role and the integration of VR in libraries require technical competence and the ability to address new challenges while developing professional skills in alignment with users’ needs.

Educational competence of librarians for collaborative VR learning

In the pursuit of necessary competencies, it is necessary to emphasise the education of librarians in virtual reality and its collaborative applications. Librarians in Tišnov and at Makerspace (division of Faculty of Arts Central Library, Masaryk University) not only manage the technology but also actively explore the potential of VR through educational events. Examples include a painting lesson in a 3D environment and collaborating with theatre studios to convert the theatre into a virtual space. The librarian in Tišnov organises educational events for children and teenagers focused on technology. At KJM, a librarian leading English clubs has gained competencies in non-formal education applicable in other areas of library services. The experimental implementation affirms librarians’ ability to organise and lead educational activities using VR and its collaborative potential.
presence of the right software and hardware environment is critical for achieving successful outcomes.

LIBRARIANS’ ATTITUDE TOWARDS TECHNOLOGY AND THE INTRODUCTION OF THE SERVICE

Librarians’ views on VR may vary depending on technical and financial capacities as well as user needs. For instance, librarians at Makerspace see VR as an opportunity to introduce new services that meet user needs and innovative environments. At KJM, librarians recognise VR’s potential as a tool for transforming the library into an educational hub, emphasising the educational value of VR in connecting experience and learning. Although the Tišnov library has adapted VR technology, its current educational use does not align with its envisioned context. The Znojmo Grammar School expresses a positive view of VR, seeing its potential in teaching and motivating students. In contrast, the Na Křižovatce library maintains a neutral stance, viewing VR more as a marketing tactic for the library.

5.3.2 THE INSTITUTION AND ITS APPROACH TO TECHNOLOGY

INSTITUTIONAL TECHNOLOGY READINESS

Libraries are evolving into hubs of advanced technologies incorporated into the services provided to users. The Makerspace provides students with extensive access to innovative technologies, including virtual reality, 3D printing and a plotter. In Tišnov, the library offers virtual reality, 3D printers and educational robots. The Jiri Mahen Library actively explores and tests new technologies while collaborating with other libraries. The Znojmo Grammar School utilises a 3D printer for teaching in school clubs. However, the Na Křižovatce library has yet to adopt new technologies. Despite differences, all institutions have the potential to engage in collaborative learning through virtual reality.

CONCEPTUAL ADAPTATION OF THE INSTITUTION

Creating a suitable space in the library is essential for the successful implementation of virtual reality as a service. It does not have to be a separate area, but it must be adequate and safe for users. Examples of well-established virtual reality spaces include The Makerspace and the Creative Workshop in Tišnov. The Na Křižovatce Library has limited space, and it is unclear whether it is suitable for collaborative VR. The Jiří Mahen Regional Library has potential, but finding a convenient location for the service may be challenging. The grammar school has sufficient space within its classrooms or school library for collaborative VR.
The technical infrastructure of the library

The technical infrastructure in the library is crucial for offering modern services and meeting user expectations. This involves ensuring quality internet connectivity, data backup, virus protection, and technical support. Research participants expressed concerns about the difficulty of preparing and managing the technical infrastructure for virtual reality services. The “EduInCIVE” project enables institutions to use collaborative virtual reality but requires adequate technical support from the library. Having some support from the institution could ease the workload on librarians and enhance confidence in the successful implementation of the new service.

End-users’ needs

Implementing VR in an institution requires tailoring the service to a specific type of institution, such as academic libraries or public libraries. Librarians must ensure the technology meets current regulations and standards, receives regular updates for safe use, and assess both the risks and benefits of the new technology. Providing users with necessary information and instructions is crucial, with special attention to health risks associated with virtual reality. Users, whether in academic or public libraries, bear responsibility for using the technology, while librarians must also ensure proper equipment functioning and compliance with usage rules. Maintaining equipment hygiene and cleanliness is essential to maintain a safe working environment.

The financial aspect of setting up the service

In addition to the physical space, it is essential to consider the financial costs associated with implementing a collaborative virtual reality service in libraries. Acquiring equipment can be expensive, although prices are gradually decreasing with the advent of more affordable models. Institutions can explore programs like the Public Library Information Services (PLIS) initiative, which supports libraries in innovating their services through new technologies. Seeking funding through grant programs or participating in projects outside the educational environment are also viable options. While implementing these services can pose financial challenges, various strategies exist to overcome obstacles and secure funding.

Costs versus benefits for service deployment

The introduction of collaborative virtual reality services in libraries may seem to have a low perceived value compared to the financial cost. This problem is linked
to the limited human resources in libraries, where the time required to run such a service outweighs the effort involved. The evolving role of librarians emphasises educational possibilities with new technologies, integrating tech education into institutional services. To run the service effectively, there is also a need for sufficient VR equipment, demanding additional financial investment. Balancing these factors and assessing costs versus benefits is crucial when implementing a collaborative virtual reality service.

5.4 **DISCUSSION**

**The critical role of the librarian**

Implementing virtual reality (VR) in informal collaborative learning can be technically challenging for librarians. Their enthusiasm and positive attitude towards VR play a vital role in evolving the library as an educational centre. With a proactive approach and support for VR, the library can become an innovation centre providing new learning opportunities and strengthening its educational role. Successful implementation of VR depends on the librarian's technical competence and willingness to learn continuously. Suen et al. (2020) emphasise that librarians must have sufficient skills to effectively implement new technologies, including VR.

**Potential overload on librarians**

As the librarian's responsibilities grow due to the expanding tasks associated with VR administration, there is a risk of overload. To alleviate this, strategies can be employed. One option is to transfer some of the technology responsibilities to the community so librarians can focus on their core tasks and professional development. Community members with the right expertise could actively manage the library's technology infrastructure (Lessic & Kraft, 2017), possibly through volunteer work (McCarthy, 1996). However, this approach may pose challenges in accountability and might not achieve the intended collaborative element.

**Support librarians in service management**

Consider creating a regular newsletter, inspired by Eisenberg (1995), focusing on collaborative learning applications. The newsletter would contain information about available apps and software tools for teaching, news, tips and links to training. Its purpose would be to encourage discussion, experience-sharing among staff, and serve as a guide for librarians learning about VR use in education. The
Implementing Collaborative iVR into Libraries

A newsletter would allow for feedback from librarians on VR learning applications, which would help to optimise the service provided. Leveraging librarian input is key to the effective use of collaborative VR in informal learning.

Benefits of introducing VR technology into libraries

The use of virtual reality in libraries offers significant advantages. Its intuitive nature makes VR efficient and convenient for both users and librarians. A wide range of collaborative and educational applications support interactive and fun learning. VR transforms libraries into dynamic and interactive learning environments, encouraging active student engagement, creativity and teamwork. It provides an authentic, stimulating environment for learning and discovery, enhancing educational programs, expanding access to information, and supporting innovative teaching methods. VR brings new opportunities in information and media education, data visualisation and interactive learning approaches in libraries (Smith, 2019).

Reaching potential users

The implementation of virtual reality and collaborative learning brings marketing benefits to libraries. Embracing a modern and innovative image attracts current and potential users, especially the younger generation. This strengthens the library’s identity as a contemporary educational space. Implementing collaborative VR is especially advantageous for smaller libraries seeking to connect with new users, particularly the younger demographic (Beheshti, 2012).

Education in leisure activities

Libraries offer an ideal setting for informal learning and developing a virtual reality perspective. Collaborative VR brings an interactive element to casual learning styles, making the subject more engaging. Research in public libraries has shown that VR can support learning for those with non-traditional learning styles. Librarians appreciated the “learning by doing” and interactive approach. VR is perceived as an innovative and effective means to support learning and knowledge acquisition in the library environment (Monge & Frisicaro-Pawlowski, 2014).

Potential constraints on service deployment

Implementing collaborative virtual reality in libraries and schools can be a complex process that faces several challenges. Some of these challenges include:
• Spatial constraints: each institution has limited spatial options that may affect the implementation of VR. Ensuring the environment’s safety and minimizing user risks is essential (Suen et al., 2020). If sufficient physical space cannot be allocated, alternatives such as adapting seated positions or providing equipment for home use can be considered (Wang et al., 2017).

• Limited budget: the financial costs associated with implementing VR can be a significant barrier, especially for institutions with limited budgets. It is essential to strategically plan and allocate resources for technology acquisition, service provision and technical support. Collaboration with companies, grant programs and subsidies can help reduce the financial burden.

• Service reach limitation: lack of available VR headsets may restrict the service’s accessibility to users. Acquiring a sufficient number of headsets is crucial to effective service delivery. Consideration of the age range of users is also essential for service design (Lee et al., 2020).

• Despite these challenges, there are manageable solutions. Libraries and schools can look for alternative solutions, work with external partners, use grants and subsidies, or adapt the service to suit specific constraints. Strategic planning and investments in technology, staff, and infrastructure are essential for the successful implementation of collaborative VR in libraries and schools.

5.5 Conclusion

All surveyed institutions, including libraries, can integrate online synchronous informal learning through virtual reality into their services. However, successful implementation requires careful consideration of libraries’ diversity, financial capacity, and conceptual alignment. Institutional readiness hinges on critical factors such as designated space, technology costs, service reach, and the qualifications of librarians delivering the service.

When introducing a new service, libraries must thoroughly assess factors influencing its success, including space availability, motivated staff, financial resources, and seamless integration into existing library programs. This careful analysis ensures that collaborative virtual reality becomes a meaningful addition to library services.

In general, it is possible to formulate the following recommendations that a library should take into account if it decides to implement immersive collaborative reality for educational purposes in its service portfolio:
• **Providing space** – Space is essential for working with iVR. The ideal option is a specific room, but rooms typically used for educational events can also be used (or adapted). Ensuring the room has a good quality internet connection and is secure is critical. The handset-wearing user should have sufficient space for their education.

• **Securing funding** – Virtual reality involves considerations of space, technology, and librarian time costs. Financial support can come from the institution or through grants, but it’s crucial to assess the service’s sustainability once external funding concludes.

• **Having a dedicated person**, typically a librarian, is crucial for the practical implementation of the service. Various models of task or service dedication exist, but the essential factor is the librarian’s interest in service management and their willingness to undergo systematic training.

• **Service provision** – Working with iVR is a service that the library can provide, following information service design principles with regular evaluation and improvement. Time requirements for collaborative use should be carefully considered to avoid overlap with other library activities. Ensuring synchronicity with other educational actors is crucial.

• **Lesson delivery** – For effective lesson delivery, the library should have methodologies, procedures, or shared sets of good practices to offer an adequate learning experience. Availability of individual lessons or applications is essential. A desktop version for librarians to monitor the class and intervene if needed enhances the learning process.
5.6 References


5. Implementing Collaborative iVR into Libraries


This book comprehensively explores immersive virtual reality (iVR) in educational settings. At the beginning, the stage for the book is set by detailing the objectives of the “Education in Collaborative Immersive Virtual Environment” (EduINCIVE) project. It emphasises the creation of the eDIVE platform, designed for collaborative education in immersive virtual reality. The project mainly focuses on developing software tailored to specific educational needs, particularly in language and geographic education. The text highlights the criticality of considering the limitations and strengths of iVR, advocating for a balanced and critical approach to technology adoption. The intent is to complement rather than replace traditional educational methods, with a strong emphasis on creating a user-centric experience that adapts to the unique capabilities of iVR.

Chapter one provides a comprehensive introduction to the fundamentals of iVR, tracing its evolution from the 1960s and its growing role in various domains, particularly education and research. The chapter defines iVR, discusses achievable degrees of immersion, and categorises VR experiences based on user interaction and application. It delves into the spectrum of iVR use, from individual experiences to collaborative environments, and discusses the nuances of group dynamics in virtual settings. The chapter also critically examines the application of iVR in research, exploring its use as a tool for simulation, as a novel medium, and as a research subject. The chapter concludes by emphasising the need for tailored research approaches to maximise the benefits of iVR while acknowledging its inherent limitations.

Chapter two explores various theoretical frameworks underpinning the use of iVR in education. It discusses pragmatism and the embodied mind, emphasising active, holistic learning experiences. Constructivism’s role in understanding VR’s educational impact is examined, highlighting how VR can aid in building new mental models. Behaviorism’s focus on measurable outcomes and short-term interventions is contrasted with design thinking’s user-centric, iterative development approach. This chapter also touches on logocentrism, which prioritises the quality of the virtual experience itself. This theoretical exploration underscores the multifaceted nature of VR in education, pointing to the need for diverse approaches in research and application.
Chapter three presents a case study of a semester-long English language course conducted in iVR. It explores the transformative potential of VR in language education, focusing on creating immersive, context-rich environments that enhance traditional learning methods. The chapter discusses how VR facilitates a deeper understanding of language through somatic-cognitive experiences, contextualised learning, and the role of avatars in reducing anxiety and fostering engagement. The study also highlights challenges such as the distraction potential of VR, issues with authenticity in virtual environments, and limitations in avatar communication. The methodology involves thematic analysis of university students’ reflections on their virtual learning experiences, providing valuable insights into the effectiveness and areas for improvement in VR-based language education.

Chapter four focuses on the application of iVR in teaching hypsography, a complex geographical concept. It details the development of a specialised iVR application for hypsography lessons, emphasising its collaborative and interactive design. This chapter discusses empirical studies conducted with university and high school students to evaluate the application's effectiveness. Key findings include the engaging nature of collaborative tasks in iVR, the effectiveness of 3D visualisation in understanding geographical concepts, and the challenges associated with non-verbal communication in avatars. The study suggests integrating iVR with traditional teaching methods for a more balanced educational approach and calls for ongoing research to optimise the use of iVR in geography education.

The final chapter, Chapter five, explores the integration of iVR into library services, focusing on its potential to revolutionise collaborative education. The chapter discusses the increasing adoption of iVR in libraries, its diverse applications, and the challenges faced, such as technical difficulties, costs, and librarian training. The research methodology includes qualitative methods like focus groups and interviews with library staff. The chapter highlights the transformation in librarians’ roles due to iVR, the importance of institutional readiness for technology adoption, and the benefits and constraints of implementing iVR services in libraries. The chapter concludes with recommendations for successful iVR implementation in libraries and anticipates the continued growth of VR technologies in library services.

The book offers a nuanced and comprehensive exploration of iVR in educational contexts, presenting insights, challenges, and recommendations for effectively leveraging this emerging technology in learning and teaching environments.