Learn Reading in a Fairy Tale: Design Guidelines for Immersive L2 Reading Competency Self-Learning

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Abstract: Learning to read and speak a second language (L2) is a complex process that benefits from engaging, multimodal experiences—especially for young learners in multilingual educational contexts. With the increasing availability of affordable immersive technologies, new opportunities arise for designing digital applications that support language acquisition. This paper presents design guidelines and a prototype for an immersive virtual reality (VR) application that fosters the development of reading and speaking competencies of German as L2. The prototype targets young learners with basic German reading proficiency and is designed for self-learning. Following a Design Science Research (DSR) approach, the application was iteratively developed and evaluated. The VR environment combines gamification elements with AI based speech feedback and multilingual support to promote independent practice. Initial user feedback and expert evaluation indicate high motivation and usability potential. The resulting design guidelines offer a transferable foundation for future VR-based language learning tools.

Keywords: Virtual Reality, Language Learning, Reading Competency, L2, Immersive Learning, Speech Recognition

1 Introduction

In the context of increasing international mobility and multilingual classrooms, the demand for effective and accessible methods for learning German as a second language (L2) continues to grow. In 2023 alone, Germany recorded a net immigration of approximately 663,000 people [St25a], many of whom arrived with children requiring language support to participate fully in the education system. In addition, nearly 470,000 international students [St25b] were enrolled at German universities during the 2023/2024 academic year, further emphasizing the importance of scalable language learning approaches.

This paper focuses on young learners of German as L2. These learners typically possess basic German knowledge and benefit from methods that support vocabulary development, reading fluency, and pronunciation. To address these needs, immersive virtual reality (VR) technologies offer promising potential by combining interactive, game-like experiences with structured language learning.

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Recent advancements in widely available immersive hardware, particularly in consumer-grade virtual reality (VR) headsets, open new opportunities for digital language education. Modern devices such as the Meta Quest now offer sufficient screen resolution and interactivity to support detailed visual perception of letters and texts—an essential prerequisite for reading acquisition.

This paper addresses the following research question: *How can an immersive virtual reality application be designed to integrate modern technologies for fostering reading and speaking competencies in self-directed learning scenarios, supporting learners of German as a L2?*

The foundation for this work was laid in the context of a master's thesis by one of the authors. Using a Design Science Research (DSR) approach, Design Guidelines (DG) and a functional Meta Quest prototype were developed and evaluated, demonstrating the feasibility of immersive language support for young learners.

2 Theoretical Background

This research takes a cross-disciplinary approach, connecting language learning with an immersive solution driven by an AI based information system regarding speech recognition.

2.1 Reading Competencies

Various approaches have been proposed to improve reading competencies. One common method is *repeated reading aloud*, in which learners read a text multiple times under the supervision of a tutor until a high rate of correctly read words is achieved. Another method involves *reading aloud in unison*, where a tutor and a learner read the text simultaneously [To06; Tr07].

These two methods can be combined to form a cooperative learning strategy known as *paired repeated reading*, or *reading tandems*. This method can be adapted to different contexts and learning environments. The reading tandem model described by [Tr07] builds upon the foundational work of [To06] and expands it by introducing the idea of a "reading championship" between classes to draw analogies with sports training. The effectiveness of reading tandems is further confirmed by [Va24].

2.2 German as a Second Language

In second language acquisition, multiple factors influence the learning process, including the learner's age, environment, duration of exposure, cognitive predispositions, and motivation. For example, children who begin acquiring German before the age of three tend to follow developmental patterns similar to monolingual learners. In contrast, children starting at age six or later often show distinct learning trajectories [La09].

Older learners may also develop *hidden difficulties*, relying on avoidance strategies—such as omitting difficult words or staying silent—which can lead to an overestimation of their actual speaking competence [La09].

2.3 Immersive Applications for Learning

Virtual reality (VR) has a long history, beginning with the first head-mounted display (HMD) developed by Ivan Sutherland in 1968 [Su68], which was capable of displaying a 3D scene responsive to head orientation. Since then, VR technology has evolved considerably, offering new educational opportunities [Ra20].

VR can increase learner motivation through immersive experiences compared to traditional media [Bo25], and it enables intuitive communication of complex phenomena [Kr22].

It is well established that enriching textual content with images improves learning outcomes [LL82], and media selection significantly affects learning [Ko91]. In language learning, photographs can support authentic learning experiences [Ba15]. Research has shown that specialized immersive VR platforms can positively impact vocabulary acquisition in second language learners, often outperforming traditional classroom settings [Le19]. Immersive applications for language learning are now available on the market [Gl24], and this work contributes a novel design-oriented approach to that growing domain.

This theoretical foundation informs the design of our prototype, which combines these pedagogical principles with immersive technology.

3 Research Approach

In this section we take a closer look into the process which guided our research. DSR is employed as a methodology to help during prototype creation to flesh out the most important design guidelines for the creation of immersive learning environments to teach L2.

3.1 Iterative process

The DSR methodology is often employed in information systems research [He04], especially in the case where software artefacts are in the focus. The iterative way of the software development process fits naturally to the cyclic nature of DSR.

3.2 DSR Framework Sonnenberg und vom Brocke

The fit is even better in special application with the evaluation focused framework from [SB12]. Fig. 1 shows our research steps in alignment with this framework.

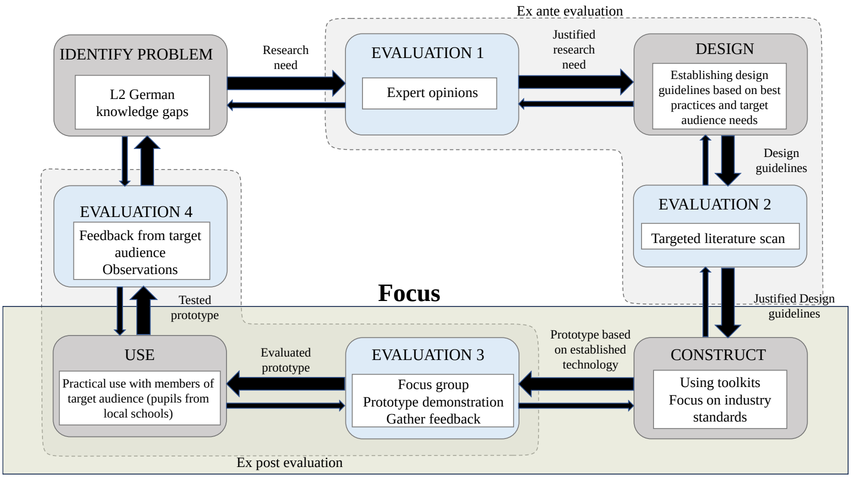

Fig. 1: Researchprocess guided by [SB12]

Our research targets one DSR cycle centering on the development of an immersive virtual reality software prototype aiming to derive design guidelines. This artefact gets heavily evaluated before and after its construction. We run through the whole cycle with a focus on (Construct) and (Use) starting with the problem identified as insufficient knowledge of the german language for L2 learners. The problem gets validated (Evaluation 1) by the opinion of two experts. The next step involves the creation of design guidelines (Design), which are justified by literature. Then the instantiation as a software artefact (Construct) took place. Afterwards this prototype was evaluated by a focus group (Evaluation 3). A usage phase (Use) was conducted with a group of pupils from different schools. As pupils are part of our target audience, this phase generated lots of insights in the form of direct feedback and indirect observations (Evaluation 4).

3.3 Experimental Validation

The phases Evaluation 3 and Evaluation 4 contained hands-on experiments. In total 18 participants, see Tab. 1, interacted with the HMD and experienced the software prototype for between 10 and 20 minutes, one participant stopped immediately due to simulation sickness. By direct questioning during and after their immersive software test we gathered concrete feedback. More insights for improved future use were collected by the authors during the experimental setup.

Additionally, we asked the participants of Evaluation 3 to fill out a questionnaire to gather more insights. The questions were designed to elicit qualitative feedback on the prototype's usability, effectiveness, and overall user experience. The participants were asked to rate various aspects on a scale from 6 to 1, including accessibility, simplicity, efficiency, robustness, functionality, suitability, UI interaction, advantage of VR, interactivity, readability, navigation, aesthetic, and immersive environment. Furthermore, open questions addressed their opinion on virtual reality, whether they would recommend the prototype for learning German, if the prototype motivated them more than traditional learning methods, which additional functions they would like to see, what advantages or disadvantages the prototype has compared to traditional learning, and whether they would prefer the prototype over a mobile app or computer program.

The participants comprised three distinct groups: university students from various academic backgrounds, professionals working in fields relevant to language education and technology (including visual arts education, cognitive science, language pedagogy, and computer science), and students from secondary schools and international colleges preparing for the German university entrance qualification (Abitur). This diverse composition ensured feedback from both the target demographic of young learners and experts who could provide professional insights into the educational and technical aspects of the prototype.

Participant	Occupation	Gender	Age group	Evaluation
#1 - #10	pupil	female	10 - 14	4
#11	pupil	male	10 - 14	4
#12	visual arts educator (BA)	female	20 - 24	3
#13	cognitive science expert (BA)	female	20 - 24	3
#14	computer science expert (MA)	male	20 - 24	3
#15	pupil	female	20 - 24	3
#16	language pedagogy educator (BA)	female	25 - 29	3
#17	student	female	30 - 34	3
#18	marketing project manager (Business graduate)	male	40 - 44	4

Tab. 1: Overview of the participants ordered by age group

4 Results

The research endeavor yielded two main kinds of insights. On one hand we derived practical guidelines on how to design an immersive virtual reality to foster L2 learning and on the other hand we obtained prescriptive knowledge from the instantiation.

4.1 Guidelines

The selection of the design guidelines (DG1–DG5) followed a structured process. Initially, we conducted semi-structured expert interviews (Evaluation 1), during which practitioners highlighted challenges and effective strategies in L2 learning with immersive media. Based on these discussions, preliminary guidelines were formulated during the design phase. In the final step before implementation, we conducted a targeted literature review using keywords such as “immersive language learning”. We screened studies for empirical evidence of effectiveness and pedagogical relevance. Guidelines were included if they appeared in both expert input and literature. The resulting design guidelines are: *DG1 Gamification*, *DG2 Immediate Feedback*, *DG3 Immersiveness*, *DG4 Interaction* and *DG5 User-centric Design*.

DG1 Gamification is the core idea behind adding an additional dimension of motivation to the language learning process [RS18]. It contains reward as a central part to ensure a high motivation.

DG2 Immediate Feedback after reading enables faster correction and repetitions of problematic words, supporting more direct learning [Sh08].

DG3 Immersiveness has been shown to create a stronger sense of presence, potentially reducing external distractions and enabling deeper engagement with language learning [HWL21].

DG4 Interaction fosters self-efficacy and positively anchors language learning. Active and individual dealing with the concrete scenario enables knowledge and competency [St06].

DG5 User-centric Design is necessary to achieve an accessible application without barriers and usability itself can be seen as a measurement of quality seen by the users [BKM91]. A design with the user in focus could reach L2 learning as an engaging and motivating process by addressing user’s special needs and preferences otherwise their acceptance will be low [Mi15]. In the realm of immersive virtual reality an important issue regarding usability is the occurrence of cybersickness [CKY20]. This should be avoided by all means, otherwise even the best software becomes useless. Our approach differs from traditional software engineering guidelines by requiring specialized adaptations for both the VR platform and young L2 learners. While standard guidelines address desktop/mobile interfaces, our approach demands VR-specific considerations: larger interactive elements with generous hit boxes for hand tracking, gesture-based 3D interactions, and cybersickness prevention through careful motion design. For the target age group, the design requires age-appropriate visuals, simplified navigation, and multilingual scaffolding—recognizing that young L2 learners need simultaneous support for both language comprehension and VR interaction, unlike general guidelines that assume adult users with established digital literacy.

4.2 Prototype

The instantiation was implemented with the help of the Unity Framework (2022.3.38f1) with the deployment target Meta Quest 3. The 3D-models for Little Red Riding Hood and for the wolf were handcrafted in Blender, the forest was created by hand, supported by the Unity Terrain Tool, other 3D-models, like trees, flowers and the house were taken from the asset store. The application integrates two service endpoints, one for speech recognition and another for textual translations. The speech recognition webservice is a self-hosted Python Flask web application powered by the model wav2vec2-xlsr-53-espeak-cv-ft [Fa25] (see [XBA21]). For the textual translation the translation service from Google was utilized [Go25]. The overall architecture as shown in Fig. 2 consists of the VR application running on the HMD, the cloud endpoint for translation and the local webservice for speech recognition. Spoken full texts were generated in advance and packaged with the application. The text was adapted from [Gr25].

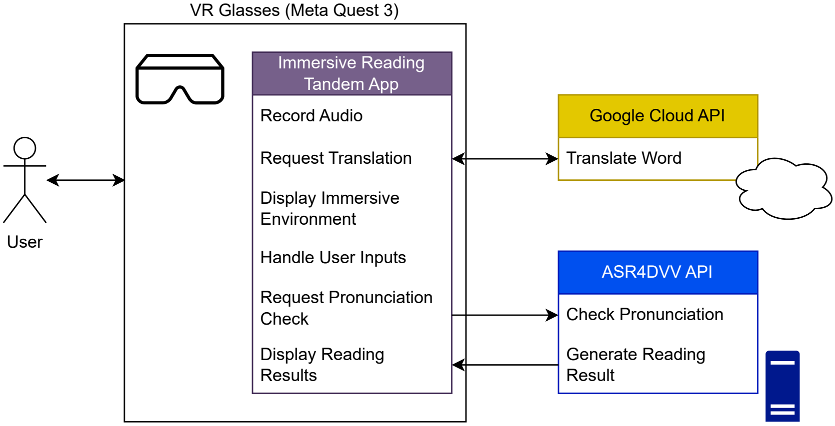

Fig. 2: The communication architecture

The process after taking the HMD and starting the application is as follows: the initial scene shows a purple universe where a book is flying towards the user and halting right in front of the user. This book is designed like a storybook and contains a menu on the left-hand side and some usage hints on the right-hand side. When the start button is pressed the screen fades to black and when it fades back in a forest from a fairy tale appears. The content of the book has changed and Little Red Riding Hood is visible in the background, as can be seen in the screenshot from the working prototype in Fig. 3. The target text to be read is on the left side in the book. Below the text are control buttons to let the app read the text (speaker symbol), to caption the own reading (microphone symbol) and the arrow to progress to the next scene. This arrow is initially inactive and gets enabled as soon as the text is read correctly. On the right-hand side are usage hints as before, except they changed according to the new context. Moreover, there is a button (German or British/ American flag) to switch translation of the usage hints and the last button with the home symbol enables the returning to the initial scene.

The first insights came during the phase of creating the prototype. The prototype was designed to be easily extendable, for instance additional scenes are added by simply extending a list container with text to be read. The speech recognition service needs to be external, due to the weak hardware resources of the standalone HMD. For the same reason

Fig. 3: A still image from the prototype featuring the storybook

the overall performance for the application runtime needed to be monitored all the time during development. The translation for individual words is implemented webservice based. This integration turned out to be oversized as it would have been sufficient to use hard coded lookup tables. This would eliminate one external dependency and increase robustness. Another learning from the implementation concerns certain template blueprints like these from the XR-Interaktion Toolkit. They are a good solution to get quickly productive, however, in the long run they are not the best solution for interaction elements, custom designed buttons allow better support for the respective target user group.

Even more insights resulted from the many evaluations ex post. The room for improvement is huge, as can be seen from the sheer number of suggestions: At first it was meant as a design feature increasing authenticity, however the historic font is not helpful for learning to read better, for instance the letters M and W are hardly distinguishable. In general, the software is not yet fully bug free, buttons had to be repeatedly interacted with before there was a reaction. A restart helped often but caused irritations. More robust software was mentioned as a necessity. The AI based speech recognition took too long (longer than 3 seconds), which broke the user flow. A loud environment induced further recognition problems. Another irritating bug from the speech recognition led to even higher frustration which was the false attribution of singular words as read wrongly. This was even more frustrating for people who tried to reach a flawless reading result. Regarding interactive tasks there should be more of them, and clear instructions are missing about when the interactive task should be completed. This task is not easy to recognize exactly, especially if only reading the text. A feature enabling the return to the previous scene was demanded. Equally requested in order to prevent frustrations was a feature to go the next scene if the text passage was to often read wrongly. More languages, other stories, difficulty levels, and the focus on only the wrongly spoken words in the case of repeated reading are other suggested improvements. Let the application only read single words on demand to train especially the wrongly spoken words was requested as well. The actual percentage of the correctly read words should be visualized. Finally, an encouraging message should appear as soon as the user has read a sufficient number of words correctly.

Some suggestions were neutral: Background music was suggested. The prototype cannot replace school lessons or other specialized apps for vocabulary learning but can be of additional use. This prototype is not for absolute L2 beginners, there must be a basic language level. The feature for letting the entire text get read aloud by the application was used often. However, the reading speed was rather fast and the participants themselves tried to read as fast. In the beginning it was unclear to the participants that it is necessary to correctly emphasize the words. Speaking clearly alone was not sufficient. The storybook was located by the participants themselves too far away which unnecessarily decreased the usability.

Positive feedback was given as well: The participants experienced a high motivation for reading correctly. They enjoyed reading the same text section multiple times until they got it correctly. There was positive excitement while waiting for the results from the speech recognition. Technology enabled interactivity and interactive tasks like the visual environment increased motivation. Participants alluded to a positive influence on fun from the environment and positively mentioned the design decision to mark misread words as blue instead of red. The application enables independent learning without the need of assistance. A useful application scenario would be the usage by tutorial groups. The immersive surrounding would not be a distraction but a useful motivation, especially because of less movement in the background during the reading task. As a positive side effect could this prototype help teaching children how to use VR. A part of the participants were L2 learners and their speaking competencies improved over the utilization of the prototype. The participants noticed it in general as an exciting prototype which is good for learning languages. A statement was "it felt very cool and real when the book came flying in the universe".

Indirectly we made many observations which led to a better understanding regarding the practical usage of the immersive learning application. The technical setup is dependent on network connections to speech recognition and translation service, thus it needs to be taken care of the infrastructure. A hardware specific issue occurred during the very first contact with the HMD. Most female participants from Evaluation 4 have worn their hair loose, which complicated the adjustment of the straps on the HMD. Partially a blurry vision was experienced, which could be adjusted by eye distance setting. The play area needs to be big enough for safe and free interaction. During the experiment it was very loud, which originated from other sources, and this made it difficult to hear and speak. The level of difficulty was to high, it seldom happened that participants passed the first level. The usability of the buttons was not optimal, delayed or no reaction created frustrations. Some connection problems occurred, the wireless network was not so stable, which led to some delays. It was difficult to support the participants, since the inside view of the headset was not visible to observers from the outside.

4.3 Matching the Design Guidelines with the Prototype

DG1 is achieved by highlighting the correctly read words in green color and by enabling the next stage of the story only after a decent amount (70 percent) of the words had been read correctly.

The prototype enables *DG2* through the integration of an AI based speech recognition service. Directly after reading the recorded audio and the corresponding text is sent to this service. It matches every word from the reference text with the learners' spoken words and returns, for each word, wether it was spoken correctly or not.

DG3 is a key benefit from the usage of closed virtual reality headsets. However, even then there are many subtle nuances regarding the grade of immersion. For instance the prototype offers hand tracking as a more natural interface which has a positive impact on immersion. The application itself does not have to be photorealistic, although this might help, more important is the authentic environment with three-dimensional objects, as they are involved in the prototype.

DG4 is enabled in multiple ways. Firstly, the act of reading in the L2 is the central task and activity. Moreover, the storybook is a grabbable object and interaction point. Additionally, later in the scenario, the learner must fulfill an interactive task and pick flowers.

The language learner is specifically addressed by an intuitive user interface and an additional localization in a native language. Both aspects fulfill *DG5*. One additional aspect to make this application available without barriers is its careful design regarding cybersickness. The user is not in motion all the time, only red riding hood moves gently through the woods, and when the scene changes a dimming effect is used to enable a smooth transition between different virtual locations reducing the risk of cybersickness. Additional factors minimizing this risk are the six degrees of freedom which are provided by the chosen HMD and a high framerate which was permanently ensured during the development process.

5 Discussion

Although the design guidelines are specifically addressed by the instantiation, the experiments have shown that there is even more potential for improvement. For instance, *DG5* could be even more pushed forward by bigger controls which are easier to use. Sometimes we observed difficulties regarding the usage of these buttons. Increasing the size of the hitboxes could improve the usability.

One major issue concerns speech recognition speed and quality. The model is from 2021, thus there should be better trained models, yielding better speech recognition quality. The self-hosted service runs at a development computer with a standard desktop computer equipped with a graphics processing unit (GPU). Therefore, the utilization of more decent hardware could improve the response time. However, a faster response time may not be mandatory, the positive excitement during the waiting for the results was a positive aspect. The environmental noise is not easily addressable. Although it would be possible to add closed headphones, they make the setup bulkier. Additionally, class room settings would not work with all pupils interacting at the same time with their HMD. The acoustic interferences would disturb the speechrecognition. If possible, a quiet environment is the best solution. To overcome this issue, if there are more silent working spaces available at school, an idea would be to let fast workers in the class go to the quiet rooms in order to use the headset as a reward.

One participant experienced cybersickness at the very beginning. Directly after the start of the prototype the storybook flies towards the learner, who is surrounded by a purple universe without any fixed anchor. This animation could appear overwhelming and could be left out to minimize the risk of cybersickness.

Especially in scenarios with shared devices there are issues with an initial HMD adjustment, which must take place for every person to avoid blurry appearance inside the HMD. In the special case of long open hair HMDs with knob-based strap adjustment are helpful. Before going into the application there could be a special setup scene.

To improve external support for the learners it would be of help to stream the HMD-content to a separate display. This could be done over a fast wireless connection or over a cable connection. But it makes an additional computer necessary and increases the requirements towards the infrastructure.

The young target group created many challenges, VR headsets are not recommended below 10 years as stereoscopic vision is in its development, the head size and the eye distance is usually smaller, which makes adjustments more difficult. With Meta headsets in particular there is an account issue, in the United States there are even no accounts allowed below the age of 13.

Regarding existing digital learning settings, like mobile apps or serious games, where equal learning outcomes regarding reading competency could be achieved, this immersive approach enables a new way of learning, which extends the space of possible knowledge acquisitions and therefore helps to find more entry points for differentiation [RH24].

6 Conclusion

This research contributes specific design guidelines and a wealth on insights regarding the practical utilization of an immersive L2 learning application.

Another DSR cycle is planned for the future. It is not yet decided in which direction it is finally heading. However, there are many interesting opportunities: One possible direction is vocational schools inducing a scenario change. The usage of a production machine in an industrial setting could be of high practical need. This scenario is especially useful in the case of skilled labor shortage and the recruitment of foreign workforce. Another scope would be the change from L2 to L1 speech therapy for learning correct pronunciation, the target group gets even younger, which is problematic, the scenario may stay, but the text needs to be more visual for nonreaders. In a therapeutic sense there could also be a focus on attention deficit hyperactivity disorder. The closed HMD could be helpful in the reduction of problematic distractions and in the fostering of concentration.

Looking to the future, more powerful mobile devices can be expected and the integration of speech recognition is feasible, this could, for instance, be achieved by GGML, a lightweight inference library for local deployment [NGs24]. This framework transfers currently only in python available machine learning models into native environments and enables mobile utilization of machine learning. More recent language models and a careful adjustment regarding the recognition decisions could improve the felt speaking performance. A technical 100% recognition rate is not reachable but with user motivation in mind it should be possible to make it look perfect as soon as the learners reach a sufficient performance.

Mobile hardware specifications affect the visual capabilities and an interesting future research question would address the influence of the level of realism on the learning outcome of L2 learning.

A limitation in this exploratory study is the small number of participants which makes quantitative results difficult. Future studies should emphasize empirical measurements regarding cybersickness, immersion and learning success. A further interesting quantitative research topic would be trust in AI inside an immersive setting.

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