

Augmented reality technology in learning German as a foreign language: technological and didactic aspects

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Abstract. This paper explores the application of augmented reality (AR) technology for developing foreign language professional communication skills in learning German. The study involved creating a virtual tour of architectural landmarks in Kyiv related to German architects, with AR elements like QR codes linking to textual, visual and video information and 3D models. The technological and didactic requirements for implementing AR were determined. Students prepared informative materials and tested the tour. The results of the questionnaire confirmed the motivational effect and expanded content from AR. Some difficulties were the dependence on gadgets and software. AR elements facilitated remembering terminology in context. The approach allows combining speciality content and language learning. AR technology can potentially enhance the learning process, but further research on methods is needed.

Keywords: augmented reality, virtual tour, German language learning, foreign language professional communication, QR codes, 3D models

1. Introduction

The search for innovative educational technologies is crucial for improving learning efficiency in the modern world. New technologies can help increase information assimilation, professional knowledge acquisition, abstract thinking development, and finding creative solutions. Such technologies should utilise information technology's vast capabilities to transform traditional learning approaches, changing how learning content is presented and studied.

Emerging technologies like virtual reality (VR), augmented reality (AR), and mixed reality (MR) can alter people's perception of reality. Virtual reality immerses users in an entirely artificial digital environment. Mixed reality seamlessly blends real and virtual objects. Augmented reality overlays virtual enhancements onto the real world, extending it with symbolic, audio, visual or animated information [4].

AR technology enables quickly finding and obtaining multilayered data about real objects, represented symbolically and interactively in 3D. This fundamentally changes processes in complex fields like manufacturing and personnel training. AR systems give employees contextual

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hints, simulating products from components. AR efficiently improves qualifications through on-the-job interactive learning. Applying such technologies in higher education professional training can enable cutting-edge learning methods embedded in research and discovery [10].

Studies have examined using AR to build skills in language learning, especially English. AR was found to save time in searching words, help remember vocabulary, and link language to real-world contexts [11]. However, more research is needed on using AR to learn other languages like German. This paper explores applying AR technology for developing foreign language professional communication competence in learning German.

2. Research methods

The study utilised several research methods:

- Theoretical analysis of scientific publications on AR's impact on education, specifically language learning, determined current knowledge and refined the research focus.
- The descriptive method outlined the background, process and results of the research.
- The experimental trial tested AR elements' effectiveness in learning German through student participation in group work, preparing and using materials in a virtual tour.
- A questionnaire with 39 student respondents assessed the virtual tour's impact on motivation, content, language, and technology.
- Generalisation drew key conclusions and implications from the study results and analysis.

The research process involved:

- Selection of architectural landmarks in Kyiv related to German architects for a virtual tour.
- Identification of information resources for students to prepare the tour using AR elements.
- Students developed tours using a map and QR codes linked to textual, visual, and video materials.
- Students tested peers' tours and completed a questionnaire on the experience.
- Results were analysed to determine AR's effects on German language learning and requirements for implementation.

The methods provided qualitative and quantitative data on AR technology's potential for enhancing professional foreign language competencies. The experimental trial and questionnaire offered insights into students' perspectives.

3. Literature review

The technology of AR is not only increasingly used in various industries and fields of science, but attempts have already been made to apply it in the educational process. This mainly occurs in foreign universities and is reflected in many scientific publications. In particular, according to Kaya and Bicen [7], AR applications can be used in almost any educational environment, and their use in the educational process increases the level of students' knowledge.

According to Bower et al. [3], AR can cause a profound transformation of modern education. Overlay multimedia in the real world to see via web devices such as phones and tablet devices means that information can be made available to students anytime and anywhere. Scientists believe that this can also reduce students' cognitive overload.

Santos et al. [12] identified AR technology's benefits, including real annotation, contextual visualisation, and haptic visualisation. Scientists substantiate these advantages with several latest theories – multimedia learning, experimental learning and the theory of animation visualisation.

In the context of our study, the developments of scientists and practical teachers on the use of AR in the study of foreign languages are of particular interest. In particular, Godwin-Jones [6] focuses on the links between AR and modern theories of foreign language learning, which emphasise localised, 12 contextual learning and semantic connections with the real world. The researcher considers this possibility using mobile games created using the ARIS platform (AR and Interactive Storytelling), a free, open-source game editor of the University of Wisconsin. From his point of view, there are various ways for teachers to use AR because studying the language in connection with expanded digital spaces is advisable.

Liu and Tsai [8] focused on building written writing skills in English at Taiwan universities using AR through the use of multimedia documents (such as photographs and videos) in the process of learning English with computer support to improve students' language skills, which are necessary for their written assignments (writing an essay).

Akçayır and Akçayır [1] investigated the students' attitude to using AR applications in learning English, particularly for learning new vocabulary. According to the results of the study, they found that the technology saves time by simplifying the search for a new word. In addition, AR programs help students remember words. The authors indicated that the problem students encountered during the study was recognising the QR code. According to students, the small screens of mobile phones make it difficult to use them in teaching and learning a language.

Considering the search by scientists for ways to intensify the study of foreign languages and the insufficient development of this problem in terms of the use of AR technology in general and in the study of foreign languages, in addition to English, where some attempts have already been made [2], the question of using AR technology in the process of learning foreign languages is relevant and requires a separate study. In addition, as the analysis of the above works shows, the application of AR technology in the study of English is mainly concentrated on the study of vocabulary, which limits the use of this technology because its potential is much greater.

4. Result and discussion

The process of gaining knowledge usually requires different methods and tools for working with information, depending on the technological possibilities and basic didactic and pedagogical models. The development of cognitive didactics has led to the emergence of a new concept of learning based on considering how people process information. At the same time, primary attention is paid to cognitive, structural, and process components of learning, such as thinking, perception, and problem-solving. In the training process aimed at obtaining new knowledge, cognitive structures should change, considering motivational and affective factors.

When considering the application of augmented reality technology in students' learning of a foreign language in general and in the development of foreign language professional communication skills, we proceeded from the fact that it is necessary to identify and take into account the technological and didactic requirements for organising this type of learning.

As for technological requirements, first, each student must have gadgets to perform tasks with installed, functionally suitable software to process the AR elements chosen as aids in learning German. A significant obstacle that would make such work difficult or even impossible could be insufficient Internet access. Care should, therefore, be taken to ensure a stable internet connection. Before planning AR technology in the classroom, the teacher should verify the existence of augmented reality objects on the chosen topic and their availability (free internet access, etc.). In addition, having different options for working with selected objects – real-time, asynchronous timing – will allow the teacher to practise variation in tasks and thus diversify the course.

Providing specific didactic requirements for including AR elements is equally essential for their effective use in developing foreign language professional communication skills. Regarding professional communication, it is clear that this involves enriching students' vocabulary with domain-specific terminology. Therefore, one of the didactic requirements is to have a basic knowledge of a foreign language as a basis for students to perform AR technology tasks precisely for the stated purpose. The basic skills of the other field are also needed to engage students in work envisaged namely the basic skills of learning a foreign language using Internet resources, on which AR can be built. On the part of the teacher, an atmosphere of immersion in a foreign language environment should be created, and strategies for developing productive speech should be provided. This means that the tasks and the organisation of the student's work should be designed in such a way as to stimulate the students' independent production of dialogical and monological speech based on the elements of AR. A very important condition for the development of professional communication is the adequate choice of the topic of the session, which should be more or less related to the students' speciality. The thematic orientation of the content of a particular session, in turn, influences the choice of AR elements. In this context, we also emphasise the careful design of each task so that students understand the complexity of speech activity as an integral part of their future professional work.

New technologies, which are becoming more accessible today, contain new didactic potential regarding the possibilities of working with information while studying specific topics [14]. In particular, the study of a foreign language is impossible without the inclusion in the educational material of linguistic and geographical information related to the country of the language being studied, its traditions, the specific historical or cultural influence of the representatives of this country and the reflection of all these aspects in the student's native country or city. Since it is not always possible to carry out a real excursion to a specific region or a particular attraction, and sometimes this is impractical due to lack of time, there is the possibility of a virtual excursion that can thematically present the contents of the excursion regardless of time, logistic and human resources. The essence of modern cognitive excursion didactics is the orientation to independent actions, which accelerates acquiring knowledge. In addition, due to its specificity, the excursion has a positive, motivating effect [13]. This can increase motivation to learn a foreign language, leading to higher learning efficiency.

Based on the above considerations, we created a virtual excursion for German language

students as a basic organisational and informational complex. We implemented the use of such a complex in the study of German by students, for example, the topic “Traces of German architects in the history of Kyiv”. It is worth noting that since Kyiv is an attractive city for German-speaking tourists, several virtual tours in German have already been developed. In particular, this is the Reisen Kiew project of the Kiewer Stadtführer, which covers the most famous historical monuments of the Ukrainian capital. However, we invited students to consider the outstanding sightseeing objects of the city from a different angle, namely, as indicated in the topic, the contribution of German architects to their design and construction.

At the initial stage, the selection of objects for a virtual tour was carried out. For this purpose, a number of materials were analysed regarding historical objects in the territory of the city of Kyiv, as a result of which the following architectural monuments were selected:

1. *St. Volodymyr's Cathedral*. The construction of the cathedral began in 1862 and lasted 40 years. Its construction involved several architects and painters. In 1853-1859, the prominent architect of German origin, Ivan Strom, designed the St. Volodymyr's Cathedral; architects P. Sparro, A. Beretti and V. Nikolaev amended the design. Later, German engineer Berengardt was involved in solving technical problems.
2. *St. Sophia's Cathedral*. The cathedral, built in 1037, was destroyed several times. In 1736-1740, the Ukrainian architect of North German origin, Johann Gottfried Schedel, reconstructed the main bell tower. He also built a stone wall around the St. Sophia's Monastery, successfully combining Western-style elements with elements of the Cossack Baroque and folk motifs.
3. *Kyiv Pechersk Lavra*. Until 1745, the architect and engineer Johann Gottfried Schedel worked on the construction of the Kyiv Pechersk Lavra bell tower, which became one of the best bell towers in Eastern Europe of the 18th century. Schedel developed a project in a transitional style from baroque to classicism. The bell tower of the Assumption Cathedral was built according to his design in the form of an octagonal four-tier tower with a height of 96.5 meters.
4. *St. Andrew's Church*. The foundations of St. Andrew's Church were built according to the design of J. G. Schedel; however, the design of the temple itself, submitted by him, was not approved. Carved details of the iconostasis according to sketches and drawings by F.-B. Rastrelli, created by the master (J. Domash, A. Karlovsky, M. Manturov, D. Ustars, H. Oreidah, J. Zunfer), among which there were several Germans. German master Johann Friedrich Grot led installation work.
5. *National Opera of Ukraine*. After the old theatre building burned down in 1896, an international architectural competition for designing a new opera house was announced. More than twenty well-known architects from different countries – Italy, Germany, Russia and France – attended the competition, and the winner was the project of the architect of German-Baltic origin, Victor Schröter, a representative of the rational direction of eclecticism in architecture. The new city theatre was built from 1898 to 1901 in rationalist, baroque, and neo-Romanesque styles.
6. *Klov Palace*. The architects J. G. Schedel and P. I. Neyelov built the Klov Palace in 1756. The German painter and jeweller Benedict Friedrich performed many works, particularly

the painting of the ceiling in the large hall of the Klov Palace. The German garden master Johann Blech worked on the Klovsy garden.

7. Kyiv Polytechnic Institute. Famous architects, including Germans and Austrians, participated in the competition for construction projects at the Polytechnic Institute, particularly Benoit, Gauguin, Kitner, Kobelev, Pomerantsev, Tsender and Schröter. The jury recognised the best project of Professor I. S. Kitner under the motto “Prestissimo” (“Very Fast”). The construction of six university buildings in the Romanesque style began on August 30, 1898, and was completed in 1901.

After determining the content of the future virtual tour, that is, the selection of the outstanding architectural structures of Kyiv associated with the work of German architects, engineers and decoration painters, information resources were identified that students could use to prepare and conduct a virtual tour. Providing students with assistance in information resources was determined, on the one hand, by the desire to reduce the time for them to complete the task since local history aspects are only part of the German language classes, and, on the other hand, to limit the amount of information for processing by directing it to specific subtopics. In addition, interactivity, a variety of materials and multimedia play an essential role in creating a virtual tour. Another important aspect that we were guided by was the understanding that when integrating information into a virtual tour, we should respect copyrights, that is, use only those publicly available sources or those for which a permit is granted.

First, students were offered the job of processing a digital map of Kyiv since the maps provide an understanding of the integrity of the territory with objects located on it and possible connections between them, form a sense of scale and improve spatial orientation. Using digital maps, students can easily create virtual sightseeing tours, combining sightseeing objects with routes according to certain signs: the chosen topic, the chronological period, the place of a historical event, the sequence of location, and the logic of movement. In our study, we used the Google Maps application to create a virtual tour map. One of the advantages of this tool is the ability to position the excursion object on the map using built-in search tools based on addresses. Coloured markers were superimposed on automatically identified points on a digital map to conveniently identify each virtual tour object (figure 1).

The main task of students was to develop their excursions based on the use of the proposed map. At the same time, each group selects one of the characteristics for building the route. As already noted, the virtual tour was to maximise the achievement of the main goal, particularly the deepening of the study of the German language by acquaintance with architectural monuments built with the participation of German architects. In this case, the informative part about the objects of the virtual excursion had to combine text, photo and video information into a single, complementary information case formed using AR technologies. Guided by these requirements, access to the necessary information on mapped architectural monuments should be provided throughout the tour. One of the ways to obtain information quickly and conveniently in various forms is by using modern mobile devices capable of reproducing multimedia information concentrated on various web pages. An important issue remains the search for the correct information and quick access.

Students were asked to solve this problem by creating a system of QR codes that provide information support for a virtual tour, providing quick access to information about a particular

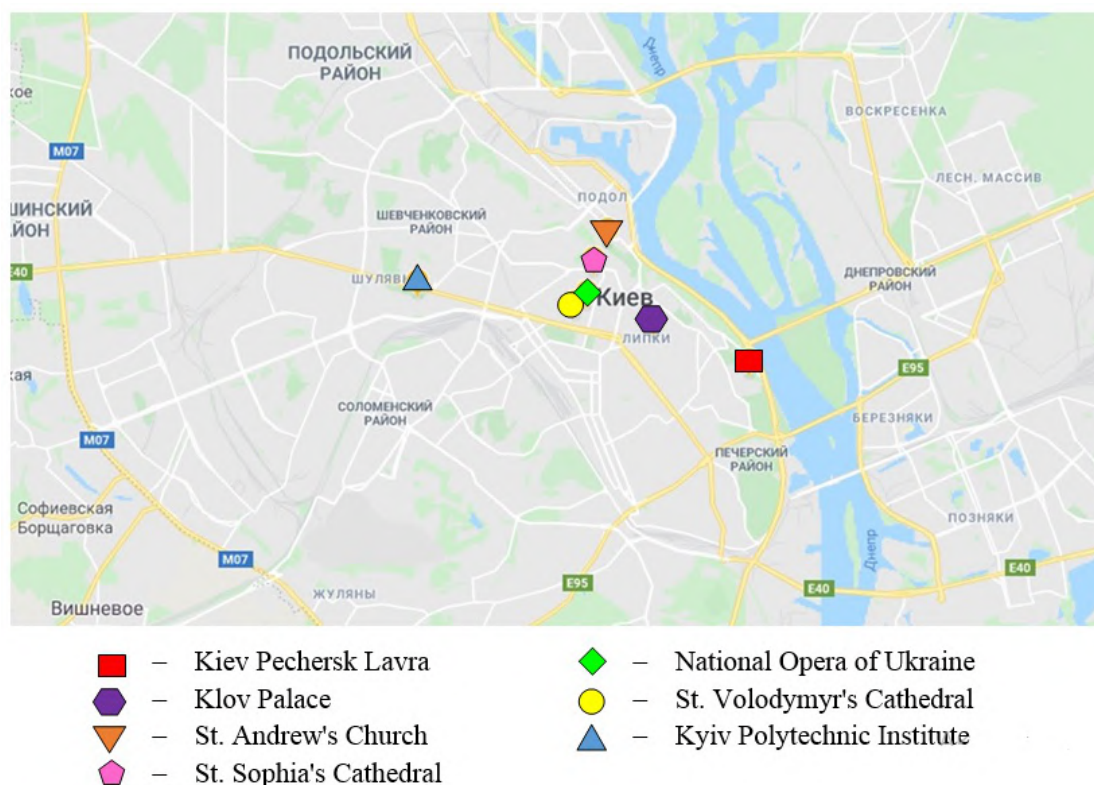


Figure 1: Digital map of Kyiv with printed objects proposed for a virtual tour (Google resource).

object of the tour in different forms. It is known that a QR code can be generated for textual information, a URL, an e-mail, a phone number, etc.; special scanners easily and stably recognise it and provide quick access to the encoded information.

To this end, students first processed open Internet resources with text, photo and video information about the objects of the excursion, selected the most successful of them, and then, using QR-code generators, formed the corresponding set of codes. An example of a set of QR codes for information about one of such objects of the excursion, the bell tower of the Kyiv Pechersk Lavra, is shown in figure 2.

The primary condition for preparing textual information should be in German. One of the sources that students used for this purpose was the open electronic encyclopedia Wikipedia (figure 3). This approach had a double effect since students, on the one hand, processed German sources in the process of searching and selecting the necessary information, and on the other hand, created the opportunity to receive extended information in German about objects during the virtual tour for her “visitors”, which were students from other groups.

However, for many people, information in the form of a graphic image is more informative than text. In particular, many facts can be presented more fully and clearly in the photograph than in words. Therefore, in a virtual tour, the use of images is critical. For the images to be used in a virtual tour, they must be presented in digital form. The range of such images can be



Figure 2: A set of QR codes with text (a), graphic (b) and video (c) about the bell tower of the Kyiv Pechersk Lavra.



Figure 3: A fragment of a web page with textual information about the bell tower of the Kyiv Pechersk Lavra, access to which is generated by a QR code.

very diverse, ranging from simple photographs to interactive maps, managed panoramic images, 3D images and the like. Image types such as satellite images are also well suited for inclusion in virtual tours. The use of mobile devices in conducting virtual excursions with access to images about the object has significant advantages compared to providing these images in print, primarily due to the possibility of increasing images, changing their brightness and contrast, and making even small details visible. When preparing virtual excursions, students sought to provide access through a QR code not to individual images about the object but to a collection of photographs that would allow them to get the most out of a particular architectural landmark (figure 4). For this purpose, students used the resources of Google Images, Wikiway and the like.

The advantage of video resources is that the presentation of information on the corresponding excursion space is almost realistic and relatively uncomplicated. Like photographs, especially panoramic photographs, films and videos very closely convey the atmosphere of real visits to

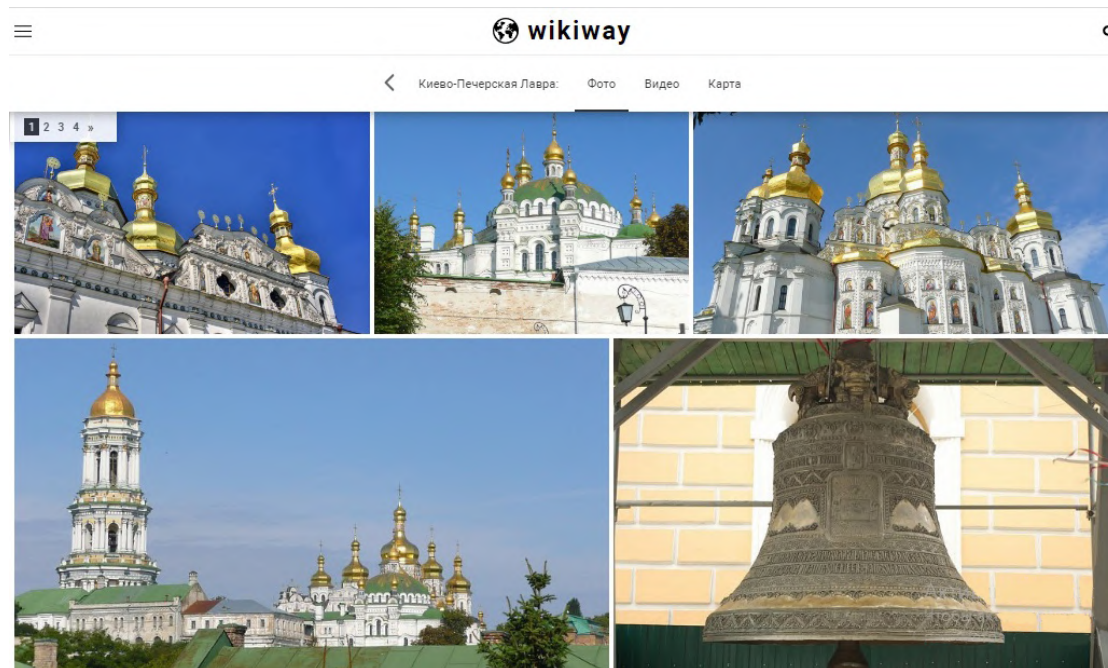


Figure 4: A fragment of a web page with graphic information about the bell tower of the Kyiv Pechersk Lavra, access to which is generated by a QR code.

places of excursion objects. In addition, in the case of using video, there is visual perception and perception of information by ear.

On this basis, when designing virtual excursions, students integrated thematic films and videos by linking to video portals such as YouTube and Vimeo. An example of a link to the corresponding video fragment encoded by a QR code is shown in figure 5. Topically relevant videos can be quickly found using targeted keyword searches. As with photographs, we must also respect copyrights regarding videos and films.

It is worth noting that the communication of the group members during the preparation of the virtual tour also contributed to the formation of teamwork skills among students and allowed them to develop communication skills in foreign languages. In addition, working together on one topic and intending to achieve a common goal, students learned from each other to build sentences of different types with the correct word order, learned conversational vocabulary options, and trained pronunciation of individual words and phrases.

Upon completion of the development of virtual tours of each group, they were tested by students who did not take part in their preparation. After passing these excursions, a questionnaire was proposed to assess the effectiveness of a virtual excursion with elements of AR in studying the German language. This questionnaire contained questions grouped into four blocks: motivational, informative, linguistic and technological. 39 people attended the survey. The results of the answers to the questionnaire are shown in table 1.

The survey results indicate that virtual excursions with elements of AR aroused interest among students, which manifested itself to different degrees and in different aspects when



Figure 5: A fragment of a web page with video information about the bell tower of the Kyiv Pechersk Lavra, access to which is generated by a QR code (Reisen Kiew).

studying the German language. In particular, this approach has most positively affected the substantive aspect of this process. A high percentage of students (76.9%) noted that AR elements provided them with extended information about the excursion objects presented.

It is gratifying to note that the level of positive answers in the technological unit was also relatively high (58.1%), which indicates students' readiness for new forms of organising the study of a foreign language. However, some aspects of this process caused quite serious technological difficulties. In particular, 61.5% of students could not fully use the capabilities of the proposed elements of AR due to insufficient technical characteristics and an inappropriate software set for their smartphones.

An undoubtedly positive result of using virtual tours is the desire expressed by 79.5% of students to learn German, including in this way. Therefore, teachers should use the influence on the motivation to learn a foreign language, which is created through AR elements in the educational process.

Another confirmation of the advisability of using elements of AR in studying a foreign language is the low level of positive answers to the questions of the linguistic block of the

Table 1
Results of answers to questionnaire questions.

Question	Response rate, %	
	Yes	No
Motivational block	66.7	33.3
Did the virtual tour contribute to the desire to learn German?	79.5	20.5
Are you ready to continue learning the language this way?	66.7	33.3
Have you been encouraged by the existing elements of AR to the in-depth study of information in German about the excursion objects presented?	53.8	46.2
Content block	77.8	22.2
Have elements of AR provided you with enhanced information about the excursion objects presented?	76.9	23.1
Did German videos provide an understanding of the information about the object of the excursion?	74.4	25.6
Were the text materials sufficient to obtain information on the topic of the tour?	82.1	17.9
Linguistic block	53.8	46.2
Did the information presented in the form of elements of AR make it easier for you to understand excursion materials in German?	61.5	38.5
Did elements of AR help to understand the meaning of new words in context?	56.4	43.6
Did the augmented reality elements help you remember the terms?	43.6	56.4
Technological block	58.1	41.9
Were there new ways for you to obtain additional information using QR codes?	71.8	28.2
Have you possessed sufficient skills in using smartphones to receive information presented as elements of AR?	64.1	35.9
Did the specifications and software set of smartphones make it possible to fully utilise the capabilities of the proposed elements of AR?	38.5	61.5

questionnaire. This indicates that the general level of students' linguistic knowledge is relatively low and, therefore, needs to be improved, including through the search for new approaches and forms of learning a foreign language.

Thus, the use of AR technology contains great potential for the formation of a holistic, realistic view of objects outside the classroom. Owing to the student's independent actions and his emotional impression when perceiving the educational object, an active approach to the educational content to the student occurs, which leads to better assimilation and longer memorisation of knowledge.

Improving training effectiveness and longer memorisation of the studied content is achieved through higher motivation for learning and active and direct interaction with a real educational object based on AR technology. Since there are different types of students depending on the channel of perception of information (audials, visuals, kinesthetics, mixed types, etc.) [5, 9, 15, 16], thanks to the holistic representation of objects based on AR technology, a higher level of assimilation of educational information and the formation of multimodal representations can be achieved.

One further aspect of our research was to compare the feasibility and relevance of applying other elements of augmented reality technology in addition to the ones above when students learn German in their field of study. This is due to the desire to optimise the professionalisation of German language learning. The most involved in content and thematic content in the information materials and augmented reality technology elements reviewed are the specialities of Tourism, Architecture, and History. Regardless of the speciality or specialisation, it is common for them to be able to create models of professional communication in a foreign language, relying on augmented reality elements. In doing so, we have considered that speech activity encompasses more than just linguistic competence. In order to bring training closer to real-life professional situations, we paid attention to the development of sociolinguistic and pragmatic competence, which can be facilitated by AR technology.

We consider the proposed application of AR technology in the study of German by tourism students to be appropriate for the following reasons. The range of available high-performance mobile devices with integrated cameras allows for the increasing use of AR, specifically in the travel industry. Therefore, tourism managers and guides should be trained to organise and direct guided tours and prepare and provide virtual tours or virtual demonstrations of individual sites with appropriate descriptions or commentary. Now, tourists can bring their smartphone to a sightseeing location that interests them and get information about it while walking around the city. Of course, this is possible with a downloaded app. In the future, such services will be extended to foreign tourists, who will purchase individual tours, partly use the services of a guide, and partly act on their own.

The study programme in Architecture includes the history of architecture, construction of buildings and structures, basic design, architectural design, reconstruction and restoration of monuments, and architectural details. For this reason, the study of German in terms of professional communication was built around the vocabulary of these issues. At the same time, the thematic features of the field of architecture are better revealed by studying German with the help of illustrations of architectural structures and their details, which can be achieved through AR.

The history specialisation is quite multifaceted. It covers the study of eras, events, commemorative dates and prominent figures in various public spheres. Much of this information, presented through AR, can also be a rational basis for the development of communicative skills, in particular professional communication skills in German.

In addition to the AR elements discussed above, we also used 3D models in our research, which extended to the tourism, architecture, and history majors. Such photos and videos are a good way of illustrating the learning material. They contribute, on the one hand, to deepening the perception of the object itself and, on the other hand, to immersion in a foreign-language environment (provided there is a text or caption).

We have chosen a 3D model of the famous Pergamon Altar of the same name in Berlin's museum for use in German teaching. Freely available on the Internet, the model provides an overview of this historic architectural monument (figure 6) and makes it possible to see all the desired details clearly, if necessary (figure 7).

Thanks to the different "access points" to the object, there is an opportunity to use the potential of AR further to develop both monological and dialogical foreign language communication skills. In order to increase the level of monological communication, we used a number of tasks.

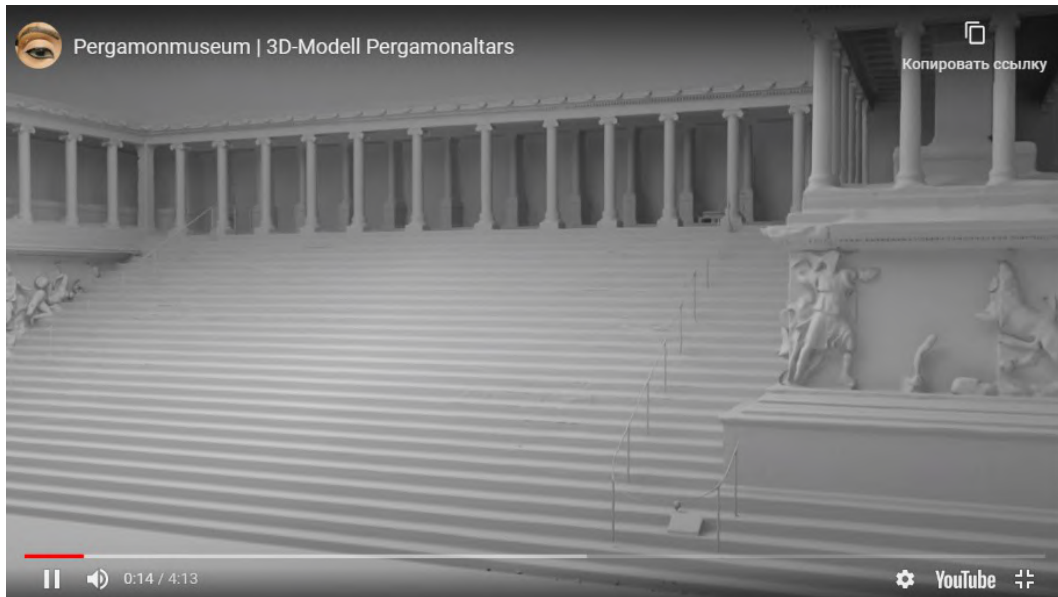


Figure 6: General view of the Pergamon Altar (3D model).

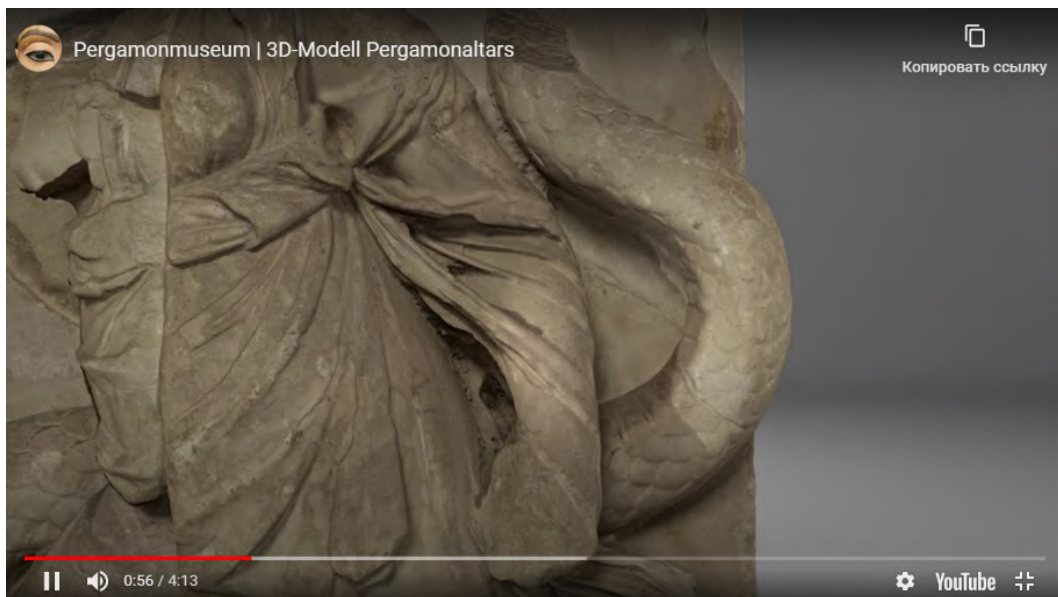


Figure 7: One part of the Pergamon Altar (3D model).

Some of them are:

- describes the Pergamon altar as a whole, focusing on its scale, form, construction and material,
- suggests as to the functional purpose of such a structure,

- describes one of the details in more detail,
- to give a German-language demonstration of a 3D model of the Pergamon Altar with clear timing.

We developed the skills of dialogical communication by carrying out, among other things, the following tasks:

- clarify individual details about the Pergamon altar,
- find out the professional opinion of the person you are talking to about this historical landmark,
- discusses the details of the building, presented in the form of a 3D model.

Communicative tools were used to organise the learning communication based on the 3D model, which was made possible by visualising the 3D model. In particular, students exchanged opinions and answered questions by visually highlighting individual elements of the building.

Depending on the educational programme, there were some differences in the results of the tasks. For example, tourism managers were more inclined to produce longer sentences and reactions with less specialised vocabulary. On the other hand, the architecture students paid more attention to architectural details. Their sayings were rich in terminology, detailed, though less so, and their sentences were simple. The history students showed a similar tendency; that is, they constructed their remarks more simply and used many terms, but of course, it was from their science field.

It is worth noting that the 3D model as an AR element offers access to specially prepared and visualised, unchanged information. Interactive interaction with this type of reality is not foreseen, which limits the development of foreign-language professional communication accordingly.

A positive influence is activating the existing foreign language communication skills, which is achieved in two opposite ways. On the one hand, through the student's relaxed feeling of being in the country whose language he or she is learning. The situation contributes to the student's need to talk. On the other hand, since the duration of viewing augmented reality elements in the form of videos and 3D models is usually short, this time constraint puts gentle pressure on the students, "pushing" them to engage in the speaking process.

At the same time, using the 3D model is possible in the classroom and in students' independent learning. As with other elements of AR, working with the 3D model allowed students to process the task at a comfortable pace, focusing on an aspect, side or detail of the object that is of particular interest or difficulty.

The main problem of using AR technology when learning a foreign language by organising virtual tours, in our study, as in other cases of using digital information, is the dependence on the technical infrastructure and software. Since each student used his smartphone with different technical characteristics and his own software set, sometimes this led to problems with receiving and reproducing information in accordance with the used technology. Most of these problems were related to ensuring stable access to the Internet, improper operation of QR scanners and the lack of some software installation skills.

AR technology requires appropriate methodological didactic reorientation, which will create the opportunity for students to independently organise research, collect, evaluate, process and

present information, apply complex hypertext structures, develop network thinking, and work within flexible, group, project-oriented forms of training.

5. Conclusions

In the course of the study, a number of advantages of using AR technology in the study of the German language were identified. In our opinion, such advantages can be used in the process of learning other foreign languages, in particular:

We developed the skills of dialogical communication by carrying out, among other things, the following tasks:

- Due to the integrity of the representation of the studied object, the student can get a complete picture of it and then learn, for example, a larger amount of new lexical material since memorising new words, especially terminology, takes place faster and remains in memory longer when new words are not used in isolation, but in context.
- Based on the application of AR technology, students can familiarise themselves with objects that are unique or inaccessible due to spatial remoteness (for example, are located in another country), which will help them understand the essence or purpose of these objects and remembering the vocabulary associated with them, which it would be much more difficult to use other information sources.
- Faster memorisation of new vocabulary is also facilitated by the parallel presentation of information cases and selected objects for study, allowing students to receive extended information using AR technologies quickly.
- The use of AR technology, particularly in the form of a virtual tour, which involves working in a group, allows students to develop communicative foreign language skills.
- AR technology can be a good tool for learning a foreign language because it allows the student to learn at his own pace. The assimilation of new knowledge and skills takes place based on previous knowledge of the language, the level of which, as shown by pedagogical practice, is very different even within the same academic group.
- Professionalisation of foreign language learning by integrating domain-specific terminology into the relevant language course by illustrating augmented reality objects and their elements.
- The interdisciplinary potential of augmented reality technology will make it possible to combine the study of some content aspects of students' future speciality with studying a foreign language and create the basis for a better career start for young professionals, including in foreign or multicultural environments.

The augmented reality elements that can be used in the process of formation and development of foreign language professional communication skills can be various types of text, graphic and photo/video information integrated into the learning process by using specially generated QR codes as augmented reality tags as well as freely available 3D models.

Based on our review of the possibilities of applying AR technology in developing foreign-language professional communication skills, we identified several technological and didactic requirements for including AR elements in this process.

Technological requirements include:

- availability of gadgets for students to carry out the tasks,
- the installation by students of the necessary software to process the selected AR item,
- ensuring stable access to the Internet,
- availability and accessibility of augmented reality objects on the chosen item
- possibility to work with these objects both in real-time and asynchronous time mode.

The didactic requirements include:

- basic knowledge of a foreign language as a basis for students to perform tasks on the use of AR technology,
- the formation of basic skills for learning a foreign language using Internet resources, based on which the work with AR can be built,
- organisation of immersion in a foreign language environment,
- using strategies for the development of productive speech,
- thematic orientation of the content from the field of specialisation,
- development of specific tasks for understanding the complexity of speech activity as an integral part of the professional functions of a specialist.

Since learning any foreign language in the aspect of developing communicative skills of foreign language professional communication has a number of common features, the results of our study can and should be used in learning other foreign languages as well.

At the same time, further research is needed better to understand the transfer of knowledge through virtual and AR and develop appropriate methods for using these technologies. In particular, it is advisable to compare augmented and virtual reality technologies with traditional teaching methods and other latest information processing tools and study and compare various methods that offer augmented and virtual reality.

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