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VIRTUAL REALITY TECHNOLOGIES AND THE DEVELOPMENT OF THINKING SKILLS AMONG PRE-SERVICE PRIMARY SCHOOL TEACHERS

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Abstract. Technology is rapidly developing, directly impacting the educational process. Traditional teaching methods are inferior in effectiveness to these innovations. The focus, engagement, and desire of future teachers to apply certain systems in their professional work are changing. The use of virtual reality technologies inspires students to try their hand at learning and teaching. They evaluate this new direction in digital pedagogy through the prism of their emotions and feelings. Therefore, the relevance of this study lies in understanding how such technologies develop the thinking processes of students, who in a few years will themselves apply them in their teaching practice. A competency-based and student-centered approach allowed us to focus on the development of professional competencies and student independence. During the fifth (third-year) semester of the 2024–2025 academic year, an experiment was conducted with study participants in program 6B01301 “Pedagogy and Methodology of Primary Education” at O. Zhanibekov South Kazakhstan Pedagogical University. The control group (n=24) studied using a standard syllabus. The experimental group (n=24) used a virtual reality platform to compare, analyze, classify, systematize, process, and generalize information across a range of topics. The quasi-experimental design of the study revealed before-and-after changes in both groups. Descriptive statistics, paired Student’s t-test, independent samples t-test, and Cohen’s d-test were used to analyze the data. Results showed positive changes in thinking skills in both groups. The experimental group achieved larger gains and a substantial within-group effect size (Cohen’s $d = 1.751$). The post-test differences between the two groups did not reach statistical significance ($p = .226$), indicating that virtual reality should be considered a valuable complementary instructional tool rather than a replacement for traditional teaching methods.

Keywords: virtual reality, Google Expeditions VR, future teachers, thinking skills, teacher education, digital technologies, cognitive development, professional training

Introduction

Virtual reality technologies can be used to develop the thinking skills of future primary school teachers. Students learn to analyze various learning situations and solve various problems in the learning process. This helps them to

be confident in performing complex tasks, in addition, students learn to express their thoughts openly and clearly, explain their conclusions and make informed decisions. The development of thinking skills of future primary school teachers using virtual reality is a relevant topic for pedagogical research. According to researchers, such technologies help improve the quality of education. Logical analysis, identification of inconsistencies, formulation of specific opinions and decisions, and consideration of the application of the results obtained in different situations are the basis of this study. The theoretical basis of this article is the structure and content of the concepts of “virtual reality” and “technology”.

The study of the possibilities of using virtual reality technologies to develop the thinking skills of future primary school teachers is an important scientific topic. This study demonstrates their importance in the modern educational process. With the help of virtual reality technologies, it is possible to gradually develop the ability of future primary school teachers to think in real and virtual environments [1]. This increases their motivation and activity in the learning process. These technologies create the necessary conditions for the full mastery of the educational material. The potential of virtual reality technology in improving teachers' thinking skills has been studied in various studies.

In order to use virtual reality technologies in the learning process, they must be constantly studied and compared with other technologies. For this reason, this study considered and discussed the role of virtual reality technologies in education. For example, in order to meet the needs of students, it is necessary to conduct comprehensive research on the development of thinking skills using virtual reality [2]. These technologies must be used effectively. It is also very important to take into account the development of technologies in various areas of social life. This can interest students and improve their thinking skills. The use of presentations, multimedia technologies, interactive whiteboards and other visual aids helps to simplify and make the learning process more interesting. It has been observed that students perceive and remember virtual reality faster than traditional methods. These achievements confirm the rapid development and demand of virtual reality technology.

Virtual reality technologies help students apply their knowledge to their daily lives. They improve not only digital literacy, but also functional literacy [3]. The issue of factors influencing students' transition from outdated educational platforms to new ones remains very relevant. Based on this, it can be concluded that virtual reality technologies can facilitate the learning process and support different learning styles. Through virtual learning, students can create a comfortable environment. In such an environment, students can improve their thinking skills and self-confidence. Students can overcome the constraints of time and space. This may explain the great interest of future primary school teachers in using their thinking skills with such new technologies. Currently, virtual reality technology is not new. Students and teachers have a certain understanding of what it is and how to use it. This is because virtual reality technology is widely used in the entertainment industry [4]. A recent systematic review by AlFajrani et al. found that virtual reality is widely perceived as an effective educational technology

with high levels of user acceptance. The authors concluded that immersive VR environments facilitate learner engagement and represent a promising innovation for professional education and training [5]. Society has formed a positive attitude towards VR, and the process of introducing it into education is not new.

Virtual reality technology is gradually being introduced into various fields: medicine, industry, and education. Due to its unique technical capabilities (3D visualization of objects, modeling of situations), this technology has begun to be integrated into the educational process [6]. Therefore, virtual reality technology is developing every day. Therefore, it is very important to study the chronology of the development of virtual reality technology and its results (positive and negative) in education. Only then can we discuss its effectiveness and application [7].

Virtual reality creates immersive digital environments that allow learners to interact with simulated objects and educational scenarios in ways that are difficult to achieve through traditional instruction.

Kazakhstan's adherence to a digitalization policy is affecting the education system. Imangalikova and Zhumataeva [8] emphasize the introduction of new technologies. This directly affects the development of society and the quality of training future teachers.

Ayasheva and Nurkenova discussed the role of digital literacy in Kazakhstan [9]. They identify new generation technologies as an effective way to develop language skills and increase student interest.

Some authors note the advantages: students' interest in using interactive platforms, the development of critical thinking and active interaction between project participants. However, there are also disadvantages: insufficient knowledge of teachers on how to use innovations, poor Internet connection and poor technical equipment.

Teachers and students understand that the learning process cannot be completely digital. Traditional methods have their own importance and need. Virtual reality technologies in foreign language teaching can support interactive learning, individualized instruction, and active student engagement. First, anything new is always attractive, giving students a new incentive to learn. Second, visual learning materials are always perceived as more interesting and more convincing when combined with audio. This helps to memorize learning materials, thereby increasing motivation to learn. Third, tasks can be adapted to the student's learning pace, which allows for individualized learning.

The model of combining virtual reality with goals, content and methods requires further research. This may include digital and pedagogical environments that contribute to the development of communication skills and learner engagement increases.

The perception of digital pedagogy by future foreign language teachers was studied. The experiment described in the article showed that by the beginning of 2023, students' digital literacy had increased. The new generation is mobile, technologically savvy, and ready to master digital technologies [10].

The following trends emerge from the above studies:

- sufficient digital competencies allow for more effective use of virtual reality;
- learning outcomes are possible only in a blended learning format, where innovation or traditional classroom teaching does not dominate.

The aim of our study was to experimentally determine the effect of virtual reality on the development of thinking skills during the professional training of future primary school teachers. To achieve the research goal, research question was developed:

(RQ) To what extent does the use of virtual reality technologies affect the development of thinking skills of future primary school teachers compared to traditional teaching methods?

Materials and Methods

The methodological basis of the study is based on competency-based and student-centered approaches. These approaches consider students as active participants in the educational process and subjects of professional development.

The study was conducted from November 2024 to January 2025 at the South Kazakhstan Pedagogical University named after O. Zhanibekov. Forty-eight third-year students studying in the program 6B01301 “Pedagogy and Methodology of Primary Education” participated. Participants were divided into control ($n = 24$) and experimental ($n = 24$) groups.

To achieve this goal, a quasi-experimental design with pre-test and post-test measurements was used. The control group received traditional instruction, and the experimental group introduced virtual reality technology into the learning process. Archived Google Expeditions virtual tour materials were used as the virtual reality resource in this study. Although the original Google Expeditions application was officially discontinued by Google in 2021, its educational virtual tour content remains accessible through archived educational repositories and Google Arts & Culture resources. These immersive virtual tours enabled interactive exploration of educational objects and environments through 3D visualization, providing students with simulated learning experiences that supported the development of observation, analytical thinking, and the ability to establish cause-and-effect relationships. During the lessons, students in the experimental group participated in the analysis of virtual objects, explained educational situations, found solutions to problematic issues, and discussed their results.

The study consisted of three stages. In the first (exploratory) stage, the initial level of students’ thinking skills was assessed. In the second (formative) stage, the experimental group explored immersive virtual environments based on archived Google Expeditions educational materials, including natural landscapes (forests, mountains, and volcanoes) and historical and cultural heritage sites such as the Pyramids of Giza and the Mausoleum of Khoja Ahmed Yasawi. They analyzed the observed objects and phenomena, interpreted their characteristics, established cause-and-effect relationships, and discussed their potential

application in primary school educational practice. Then, the group discussed cause-and-effect relationships and their application in primary education with the teacher. As part of the practical tasks, future teachers created lesson excerpts based on the virtual tour materials. They asked questions, performed comparison tasks, classified and summarized information to develop critical thinking in primary school students. One of the main objectives of the study was to develop ways to introduce virtual reality into the primary school curriculum. Particular attention was paid to the development of analytical, logical and creative thinking, the ability to make pedagogical decisions and the ability to apply the acquired knowledge in professional situations. The third (control) stage included final testing and comparison of performance indicators between the control and experimental groups.

In the control group, similar topics were covered using traditional teaching methods. Students worked with textbooks, presentations, illustrations and video resources. They completed tasks on the analysis and discussion of case studies, answered the teacher's questions and participated in group discussions. The course material was the same as in the experimental group, but virtual reality technology was not used.

Before and after the experiment, participants took a diagnostic test. This test assessed the thinking skills of future primary school teachers. The test consisted of 20 tasks divided into four blocks (Table 1).

Table 1. Diagnostic tasks for assessing the thinking skills of future primary school teachers

Indicator	Task description	Assessment criteria	Scale
Information analysis	The student was presented with a pedagogical situation related to teaching primary school students. They had to identify a problem, identify causes, and suggest possible solutions.	Problem definition, logical analysis, and validity of conclusions	1–5 points
Comparison and classification	The student compared two ways of explaining learning material or two learning situations, identifying their similarities, differences, and application features.	Completeness of comparison, accuracy of classification, validity of conclusions	1–5 points
Generalizing and formulating conclusions	Based on the presented materials (text, images, virtual tour), the student formulated the main conclusions and recommendations for the learning process.	Ability to generalize, logical conclusions, integrity of the answer	1–5 points
Making pedagogical decisions	The student was presented with a problem situation that required him to choose the most effective pedagogical solution from his primary school experience.	The validity of the decision, its practical application, and the justification of the choice	1–5 points

Note. Each indicator was rated from 1 to 5 points, where 1 point corresponded to a low level of skill and 5 points to a high level. The final score was calculated as the average value for all diagnostic tasks.

IBM SPSS Statistics 28 was used to process and analyze the data. After calculating descriptive statistics for each indicator studied - means and standard deviations, a paired Student's t-test was used (first a paired test, then a test for independent samples). The analysis was carried out separately for each component of thinking skills ("information analysis", "comparison and classification", "generalization and formulation of conclusions", "pedagogical decision-making"), as well as for the integral score calculated as the average value of all diagnostic tasks. Cohen's d indicated the practical significance of the experiment. The statistical significance level for all analyses was $p < .05$.

Results

A comparative analysis of the performance of the control and experimental groups (before and after) was conducted to assess the impact of Google Expeditions educational materials on the development of thinking skills of prospective elementary school teachers. The results are shown in Table 2.

Table 2. Changes in thinking skills performance in the control and experimental groups

Indicator	Control group before (M±SD)	Control group after (M±SD)	Experimental group before (M±SD)	Experimental group after (M±SD)
Information analysis	2.75 ± 0.68	2.92 ± 0.65	2.75 ± 0.68	2.96 ± 0.62
Comparison and classification	2.75 ± 0.68	3.08 ± 1.02	2.83 ± 0.82	3.38 ± 0.65
Summary and conclusion	3.17 ± 0.70	3.33 ± 0.56	3.13 ± 0.61	3.46 ± 0.83
Decision making	3.50 ± 0.51	3.63 ± 0.65	3.50 ± 0.51	3.75 ± 0.61
Total score	3.04 ± 0.41	3.24 ± 0.43	3.05 ± 0.40	3.39 ± 0.39

Note: M - mean; SD - standard deviation.

Positive dynamics were observed in both groups, which confirms the impact of the educational process on the development of students' thinking skills. More pronounced changes were recorded in the experimental group. The greatest increase was observed in the "Comparison and Classification" indicator (from 2.83 to 3.38 points). In the control group, the increase in this indicator was not so noticeable (from 2.75 to 3.08 points). A similar trend was observed in other components of thinking skills.

Changes were observed in the integral indicator. In the experimental group, it increased from 3.05 to 3.39 points (+0.33). In the control group, the increase was from 3.04 to 3.24 points (+0.20). These results indicate that the use of virtual reality may support the development of thinking skills during teacher education.

The effectiveness of the technology is also evident from the analysis of changes in thinking skills scores in the two groups. Table 3 shows the differences between the pre-test and post-test results.

Table 3. Paired Student t-test results in the control and experimental groups

Indicator	Experimental group t(23)	p	d	Control group t(23)	p	d
Information analysis	-2.460	.022	0.502	-2.145	.043	0.438
Comparison and classification	-4.033	.001	0.823	-2.326	.029	0.475
Summary and conclusions	-2.892	.008	0.590	-1.696	.103	0.346
Decision making	-2.769	.011	0.565	-1.813	.083	0.370
Overall indicator	-8.579	< .001	1.751	-4.389	< .001	0.896

Note. Cohen's d is the effect size; $p < .05$ indicates a statistically significant difference between pre- and post-test scores.

Positive changes were observed in both the control and experimental groups. The changes were more pronounced in the experimental group. In contrast to the control group, which recorded statistically significant improvements only in the "Information Analysis" and "Comparison and Classification" dimensions, the experimental group showed significant changes in all components of the thinking skills studied.

The most significant changes were found in the "Comparison and Classification" dimension ($t(23) = -4.033$, $p = .001$, $d = 0.823$). This is an indication of a large effect size. The total thinking skills score in the experimental group showed a significantly larger effect size ($d = 1.751$) compared to the control group ($d = 0.896$). The results indicate that the use of Google Expeditions educational materials has a clear positive effect on the development of thinking skills in future elementary school teachers. However, to fully assess the differences between groups, additional between-group analysis of the final results was conducted.

Table 4. Comparison of the final results of the control and experimental groups (Independent Samples t-Test)

Indicator	Control group (M±SD)	Experimental group (M±SD)	t(46)	p	Cohen's d
General thinking skills score	3.24 ± 0.43	3.39 ± 0.39	1.226	.226	0.354

At the end of the formative phase of the study, the experimental group showed a higher mean score on the general thinking skills measure ($M = 3.39$; $SD = 0.39$) compared to the control group ($M = 3.24$; $SD = 0.43$). A t-test for independent samples showed that the differences did not reach statistical significance ($t(46) = 1.226$, $p = .226$).

The detected effect size ($d = 0.354$) indicates a small practical advantage for the experimental group. This value cannot be interpreted as a complete advantage of virtual reality over traditional teaching methods in this model.

The lack of statistically significant differences between the groups may be due to several factors. First, both groups were involved in an educational process aimed at developing thinking skills. This situation caused a positive dynamics of indicators regardless of the learning format used. Second, the relatively small sample size ($n = 48$) may have limited the statistical power of the analysis and reduced the likelihood of detecting significant differences between the groups. Third, the duration of the experiment may not have been sufficient to achieve a clear effect of virtual reality.

Discussion

The results demonstrate the educational potential of virtual reality learning activities based on archived Google Expeditions educational materials. This potential is realized in the development of thinking skills of future primary school teachers. The experimental group that used this technology achieved positive results in analyzing and interpreting data, as well as in the ability to compare and generalize information. These skills are very important for future teaching in primary schools in the region. In addition, the total score for thinking skills showed a high effect size ($d = 1.751$). The practical significance of the changes that occurred in the formative period of the study is noted.

It should be noted that no significant differences were observed between the groups. It is impossible to conclude that virtual reality is superior to traditional teaching methods. The research question was partially confirmed: there is a positive attitude towards the use of virtual reality in the training of future teachers.

Virtual reality provides more visual content as an educational tool. This interactivity establishes connections between the phenomena being studied and creates favorable conditions for participation in thinking processes and the learning process.

These results are consistent with the results of research on virtual reality technologies. In addition to improving understanding of the educational material, critical thinking is also developed. Such thinking is very important for finding ways to teach young students.

Significant changes in the experimental group were recorded on the indicator "Comparison and Classification" ($t(23) = -4.033$, $p = .001$, $d = 0.823$). This result reveals the unique properties of the Google Expeditions educational materials. During virtual interaction, differences are visually displayed, and knowledge is systematized by comparing one object with another. Three-dimensional visualization allows you to identify similarities and classify them in a certain order.

Statistically significant changes were observed in the indicators of information analysis, generalization and formulation of conclusions, as well as pedagogical decision-making. These results show how virtual reality affects individual cognitive processes. While working with virtual excursions, students analyzed phenomena and discussed the causes and consequences of processes. Their findings identified possible applications of the material learned in primary school educational practice. Such activities contribute to the development of

skills in interpreting information and applying it in a professional context.

It is worth noting that the positive dynamics were observed not only in the experimental group, but also in the control group. The development of thinking skills was influenced by the educational process as a whole. In the control group, significant improvements were recorded only in individual indicators.

The practical significance of the study lies in the possibility of using virtual reality technologies as an additional tool for training future primary school teachers. These virtual tools are used not only to increase the visual appeal of educational materials, but also to develop the analytical skills of future teachers.

The limitations of the study include a limited sample size of students from one university. In addition, the study covered only one semester of study and did not allow assessing the long-term impact of using virtual reality. In addition, the study only studied the Google Expeditions educational materials, and the educational potential of different virtual reality solutions may vary.

Future research opportunities include expanding the sample size, extending the duration of the experiment, and conducting comparative studies of different virtual reality platforms. It is also possible to study the impact of virtual reality not only on thinking skills, but also on digital competence and the readiness of future teachers to use innovative technologies in teaching.

Conclusion

The purpose of this study was to study the impact of virtual reality technology on the development of thinking skills of future primary school teachers. For this purpose, archived Google Expeditions educational materials were integrated into the instructional process. The results show that virtual reality is associated with positive dynamics in the development of the studied skills in the control and experimental groups. The most pronounced changes were recorded in students from the experimental group who studied using virtual excursions on the selected platform.

The data obtained indicate a comprehensive development of the thinking skills of students in the experimental group. These changes are primarily associated with the ability to structure information, determine the characteristics of objects and establish logical connections between the phenomena under study. These skills allow us to consider virtual reality technology as an effective tool to support the analytical work of future teachers.

In conclusion, the results of the study can be used to improve the content of teacher training and develop digital educational resources.

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БОЛАШАҚ БАСТАУЫШ СЫНЫП МҰҒАЛІМДЕРІНІҢ ОЙЛАУ ҚАБІЛЕТІН ВИРТУАЛДЫ ШЫНДЫҚ ТЕХНОЛОГИЯСЫ АРҚЫЛЫ ҚАЛЫПТАСТЫРУ

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Аңдатпа. Технология қарқынды дамып келеді, білім беру процесіне тікелей әсер етеді. Дәстүрлі оқыту әдістері бұл инновациялардан тиімділігі жағынан төмен. Болашақ мұғалімдердің белгілі бір жүйелерді кәсіби жұмысында қолдануға деген назары, қызығушылығы және ұмтылысы өзгеріп жатыр. Виртуалды шындық технологияларын пайдалану студенттерді оқу мен оқытуда өз күштерін сынап көруге шабыттандырады. Олар цифрлық педагогикадағы бұл жаңа бағытты өз эмоциялары мен сезімдері тұрғысынан бағалайды. Сондықтан, бұл зерттеудің өзектілігі мұндай технологиялардың бірнеше жылдан кейін оларды өздерінің оқыту тәжірибесінде қолданатын студенттердің ойлау процестерін қалай дамытатынын түсінуде жатыр. Құзыреттілікке негізделген және студентке бағытталған тәсіл бізге кәсіби құзыреттіліктер мен студенттердің дербестігін дамытуға назар аударуға мүмкіндік берді. 2024–2025 оқу жылының бесінші (3-курс) семестрінде Ө. Жәнібеков атындағы Оңтүстік Қазақстан педагогикалық университетінде 6B01301 – «Бастауыш білім берудің педагогикасы мен әдістемесі» білім беру бағдарламасы бойынша білім алатын студенттердің қатысуымен эксперимент жүргізілді. Бақылау тобы (n=24) стандартты оқу бағдарламасын пайдаланып оқыды. Тәжірибелік топ (n=24) әртүрлі тақырыптар бойынша ақпаратты салыстыру, талдау, жіктеу, жүйелеу, өңдеу және жалпылау үшін виртуалды шындық платформасын пайдаланды. Зерттеудің квазиэксперименттік дизайны екі топта да бұрын және кейін өзгерістерді анықтады. Деректерді талдау үшін сипаттамалық статистика, жұптастырылған Студенттің t-тесті, тәуелсіз үлгілердің t-тесті және Коэннің d-тесті пайдаланылды. Нәтижелер екі топта да ойлау дағдыларындағы оң өзгерістерді көрсетті. Тәжірибелік топ үлкен жетістіктерге және топ ішіндегі айтарлықтай әсер мөлшеріне қол жеткізді (Коэннің $d = 1,751$). Екі топ арасындағы тестілеуден кейінгі айырмашылықтар статистикалық маңыздылыққа жетпеді ($p = .226$), бұл виртуалды шындықты дәстүрлі оқыту әдістерін алмастырудың орнына құнды қосымша оқыту құралы ретінде қарастыру керектігін көрсетеді.

Тірек сөздер: виртуалды шындық, Google Expeditions VR, болашақ мұғалімдер, ойлау дағдылары, мұғалімдерді оқыту, цифрлық технологиялар, когнитивті даму, кәсіби дайындық

ФОРМИРОВАНИЕ МЫШЛЕНИЯ БУДУЩИХ УЧИТЕЛЕЙ НАЧАЛЬНЫХ КЛАССОВ С ПОМОЩЬЮ ТЕХНОЛОГИЙ ВИРТУАЛЬНОЙ РЕАЛЬНОСТИ

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Аннотация. Технологии развиваются стремительно. Они оказывают прямое влияние на образовательный процесс. Традиционные методы обучения уступают по эффективности этим инновациям. Меняются фокус, вовлеченность и желание будущих учителей применять те или иные комплексы в своей профессиональной деятельности. Использование технологий виртуальной реальности вдохновляет студентов попробовать свои силы в обучении и преподавании. Они оценивают это новое направление в цифровой педагогике через призму своих эмоций и чувств. Поэтому актуальность данного исследования заключается в понимании как такие технологии развивают мыслительные механизмы студентов, которые через несколько лет сами будут применять их в своей практике преподавания. Компетентностный и личностно-ориентированный подход позволил сосредоточиться на развитии профессиональных компетенций и самостоятельности обучающихся. На пятом (3 курс) семестре 2024-2025 учебного года с участниками исследования по программе 6B01301 – «Педагогика и методика начального образования» Южно-Казахстанского педагогического университета имени О.Жанибекова был проведен эксперимент. Контрольная группа (n=24) обучалась по стандартному силлабусу. Экспериментальная группа (n=24) использовала платформу виртуальной реальности, где сравнивала, анализировала, классифицировала, систематизировала, обрабатывала информацию и обобщала предметы определенного характера между собой. Квазиэкспериментальный дизайн исследования раскрыл изменения что были до и после в двух группах. Для обработки данных использовались описательная статистика, парный t-критерий Стьюдента, t-критерий для независимых выборок и коэффициент эффекта Коэна. Результаты показали положительную динамику навыков мышления в обеих группах. Экспериментальная группа показала более значительные результаты и существенный размер эффекта внутри группы (коэффициент Коэна $d = 1,751$). Различия между двумя группами после тестирования не достигли статистической значимости ($p = 0,226$), что указывает на то, что виртуальную реальность следует рассматривать как ценный дополнительный инструмент обучения, а не как замену традиционным методам преподавания.

Ключевые слова: виртуальная реальность, Google Expeditions VR, будущие учителя, навыки мышления, педагогическое образование, цифровые технологии, когнитивное развитие, профессиональная подготовка

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