Specific features of the use of augmented reality technologies in the process of the development of cognitive component of future professionals' mental capacity

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V V Osadchyi[1], K P Osadcha[1], H B Varina[1], S V Shevchenko[1] and I S Bulakh[2]

[1] Bogdan Khmelnitsky Melitopol State Pedagogical University, 20 Hetmanska Str., Melitopol, 72300, Ukraine
[2] National Pedagogical Dragomanov University, 9 Pyrohova Str., Kyiv, 01601, Ukraine

E-mail: osadchyi@mdpu.org.ua, okp@mdpu.org.ua, varina_hanna@mdpu.org.ua, shevchenko_svitlana@mdpu.org.ua, i.s.bulakh@ukr.net

Abstract. Ways of development and modernization of modern higher education are largely determined by the scientific and technological progress. The article is devoted to the current issue of the augmented reality technology use in professional education. The paper analyzes foreign and domestic experience of the use of augmented reality technologies as a means educational, research and project activities implementation. The author also describes the benefits of the augmented reality technologies use for the curricula design. Taking into account the reorganization of the educational process due to pandemic isolation, caused by COVID-19, the issue of the identification of AR technologies impact on the development of cognitive component of future specialists' mental capacity is becoming extremely relevant especially in the conditions of adaptive and blended learning. The paper, in a structured way, describes the experience of introducing the augmented reality elements in the process of developing cognitive component of future professionals' mental capacity. The ascertaining and formative stages of the empirical research were carried out during 2020 on the basis of Bogdan Khmelnytsky Melitopol State Pedagogical University. Relevant interdisciplinary research is a logical construct of cooperation between leading scientists of the Department of Psychology and the Department of Informatics and Cybernetics of Bogdan Khmelnytsky Melitopol State Pedagogical University. The structure of the study includes the main scientific developments in the context of the research work, performed at the expense of the General Fund of the state budget: "Adaptive system for individualization and personalization of professional training of future specialists in blended learning". Based on certain psychological and pedagogical determinants of the AR technologies use for the development of cognitive component of the future specialists' mental capacity, we have proposed the implementation of interactive technologies at three levels: competence-oriented, structural-cognitive, emotional-reflexive, on the example of doing the course "Introduction to Specialty (Psychology)" in the conditions of distance learning. According to the results of an interdisciplinary research, it was found out that students gained skills which are necessary for their adaptation to a new intellectual and educational environment. Due to positive qualitative and quantitative changes in the cognitive structure of personality there was an increase in the first-year students' mental capacity in its main components (the level of attention stability and selectivity, short-term memory span and analytical thinking, level of development of special qualities necessary for mental capacity, formation of mental capacity culture).

1. Introduction

The processes of socialization, education and professional activity in the conditions of society transformation are accompanied by an unprecedentedly rapidly changing information infrastructure in everyday and business life. The current phenomenon of modern society is a continuing formation of new knowledge and competencies. Human existence in various communicative areas requires permanent mastery of new ways of communication and interaction at all levels. Technological innovations affect almost all areas of human activity; they are especially important and relevant in the field of education. The Digital Agenda of Ukraine 2020 states: "Rapid and profound consequences of the transition to "digitalization" will be possible only when "digital" transformation becomes the basis of Ukrainian society, business and government institutions, when it becomes a commonplace and everyday phenomenon, becomes our DNA, our key agenda on the path to prosperity, will be the basis of Ukraine's well-being" [1]. Digital literacy (or digital competence [2–5]) is recognized by the EU as one of the key competences necessary for a full-quality life and human activity, so in the Law "On Higher Education" [6] it is stated that the formation of information and communication competence is a compulsory one.

Modern higher education, as an important part of the future professionals' resourceful personal and professional development, is focused on the formation of a specialist of a new format – capable of professional self-realization in the conditions of revolutionary digitalization and technological breakthrough. Higher education cannot exist without the introduction of new technological modifications. Among the most noticeable trends in modern learning technologies, augmented reality occupies a leading position. The use of modern technologies in the organization of educational activities and implementation of competency-based approach allow not only to study current computer technology, but also to organize the learning process in such a way that the study of innovative technologies is accompanied by their integration into personal information, communication and competence environment. Accordingly, the issue of integrated implementation of augmented reality technologies while using a competency student-centered approach is quite relevant [7–22]. Formation of cognitive component of mental capacity is a key element in the context of the development of future specialists' professionally important qualities and competencies.

The aim of the study is to analyze the features of the integrative use of augmented reality technologies in the development of the cognitive component of the mental performance of a future professional in the context of adaptive learning.

2. Literature review

Mixed reality technologies have become highly popular in higher education in recent years. Projects of modeling the elements of augmented reality are actively implemented in the educational process in foreign and domestic higher educational institutions. Analyzing the current study, done by C.-H. Chen, regarding the introduction of augmented reality technologies in the educational process in higher education we came to the conclusion that a teaching method, based on AR games through the integration of AR technology and digital games, is quite interesting and innovative one. It promotes students' learning and facilitates the research of metacognitive and motivational factors of multimedia learning. Based on the implemented approach, the author has designed a contextual mobile learning system with tips for the personality's cognitive structure development. The results of the research allow us to state that digital games play an important role in promoting affective and motivational states in multimedia learning and in the development of future professionals' cognitive abilities [23]. A multifactor study, done by R. Sitharan, N.T. Kian, N. Mai, H.T. Yeen-Ju, M. Syahmi Abd Aziz and K.S. Bin Dollmat demonstrates the possibilities of implementing a competency-based approach in line with the integration of different learning technologies, namely virtual reality,

augmented reality and holograms. Using the process of MOOC development as a case study, the authors made an attempt to reveal some factors and barriers to creating a cohesive and holistic learning experience of using these technologies [24].

The presentation of ARETE (Interactive Educational System for Augmented Reality) allows us to have a new look at the technological progress in the development of interactive tools for the content of augmented reality (AR). The authors demonstrate modern capabilities of the ARETE system, which corresponds to human-oriented practices of interaction design and has considerable impact on the interactive, multi-user and multilingual technologies. In the research structure, researchers demonstrate positive impact of ARETE system implementation and the educational value of AR for mastering English language, developing STEM skills (science, technology, engineering and mathematics), which provides a positive behavior support in educational institutions (PBIS) [25].

Research works of the Ukrainian scientists demonstrate the priority of implementing augmented reality technologies in the design of project activities in higher education. It is considered to be a determinant of creative self-development, self-realization of project executors, as it develops cognitive activity and various future professionals' life competencies. Researchers emphasize that the augmented reality program for the implementation of educational projects helps to: enhance students' interest in educational material; develop new competencies; increase motivation for the autonomous educational and cognitive activity; intensify educational activities and mental capacity; form a positive motivation for personal and professional growth; create conditions for the development of future specialists' professionally important personal qualities [26].

Considering personality's cognitive structure and individual features of thinking processes as an important condition for constructive implementation of the concept of adaptive learning, the scientists in their empirical research works substantiate the prospects and priorities of using VR and AR technologies as a special information environment, which is used according to the identified dominating thinking type of students. The authors emphasize the prospects of using the proposed model in the educational process of educational institutions. They demonstrate the benefits of these technologies in terms of implementation and support of new teaching and learning strategies, as well as for the improvement of the future professionals' learning outcomes on the example of such courses as "Algorithms and Data Structures", "Computer Graphics and 3D Modeling", "Scheme of Engineering", "Computer Architecture" [27].

Modernization and digitalization of the higher education system in the context of pandemic limitations does not go beyond the attention of domestic researchers. Thus, mobile Internet devices (MID) – multimedia mobile devices that provide wireless access to information and communication Internet services for collection, organization, storage, processing, transmission, presentation of all types of messages and data become a part of the distance education optimization by means of the use of leading learning tools (on the example of Bachelors of Electromechanics). The authors describe the main possibilities of using MID in the sphere of education in order to ensure equal access to education, enhance personalized learning, provide instant feedback and evaluation of learning outcomes, stimulate mobile learning, productive use of time spent in the classrooms, promote a creation of mobile learning communities, support of localized learning, and continuing professional development. They restrict a gap between formal and non-formal learning, minimize disruption of education in conflict and disaster areas, help students with disabilities, improve the quality of communication and institution management, and maximize economic efficiency [28].

Taking into account a wide range of possibilities of augmented reality technologies use in the process of developing cognitive structure of personality, increasing cognitive motivation, researchers demonstrate the possibility of introducing elements of augmented reality into the structure of kinesthetic learning or "Learning by Doing". The researchers presented a

study of this concept by demonstrating an initial prototype system, which was developed and implemented on the basis of adaptive learning methodology in the AR application, with the prospect of the future use of intelligent agents [29].

Thus, summarizing theoretical, methodological and empirical research done by leading experts in the field of design and implementation of augmented reality technologies in the educational space of higher educational establishments, we can say that the perspective research area is the integrative use of augmented reality technologies in the structure of competence-based, practice-oriented and adaptive concept of education reorganization [30]. At the same time, the identification of AR technologies impact on the personal construct and professionally important qualities of future specialists is relevant and poorly studied issue so far. Under the conditions of the adaptive and blended learning, the issue of AR technologies impact on the development of cognitive component of future specialists' mental capacity is a relevant research area.

3. Research background

The problem of increasing students' mental capacity in the conditions of blended learning, and identification of their cognitive structure specific features in solving intellectual problems in the process of training is extremely important. Working capacity, as a state of the system "man-machine", was analyzed in studies dealing with the rationing of optimal time parameters of students' activity, which can maintain a high productivity level in certain microperiods. To solve this problem, scientists used indicators of physical and mental health, preparedness, level of development of professionally important personal traits, conditions of activity. The level of the highest capacity (its optimal level) is determined by the following features: employment period reduction (transition from rest to a high level of capacity); the highest indicators of system functions (reaction rate, signal processing, etc.); the most economical bioenergy costs; long-term preservation of working capacity (increase of endurance); adequacy of body's reactions to external actions; the easiest adaptation, regulation of functions and automation of skills [31]. Changes in capacity can be caused by various factors: fatigue caused by prolonged work in the information space; emotional and physical state; external environmental conditions [32]. Along with this, the researchers pay more attention not only to the personal features but also to the emotions, impact of emotional stress on the assimilation of information. They are organically linked to thinking and, thinking, as a mental process, is a combination of intellectual and emotional activities. Analyzing theoretical achievements of scientists, based on the analysis and generalization of the scientific outcomes, we have identified 4 main criteria for mental capacity:

(i) development of cognitive processes (the level of students' cognitive processes functioning, ability to perceive and select information in accordance with the purpose of mental activity, ability to highlight main issues, analyze, compare, provide rational for their thoughts and actions, memorize necessary material),

(ii) emotional and motivational activity while performing intellectual actions (desire for knowledge, initiative in performing intellectual tasks while maintaining emotional stability, activity and productivity),

(iii) subjectivity, objectivity, regulation in the implementation of mental actions (person's ability to initiate, carry out mental activity independently and persistently, evaluate it independently and critically, and take responsibility for one's own actions),

(iv) intellectual activity effectiveness (completeness of mental actions, focus on the intellectual activity performance).

Based on all mentioned above, we can say that we view students' mental capacity as their integrative ability to perform purposeful intellectual activity, provided by the development

of cognitive processes. Summarizing and systematizing the above mentioned scientific achievements, we have identified the specific features of the development of cognitive component of students' mental capacity (figure 1).

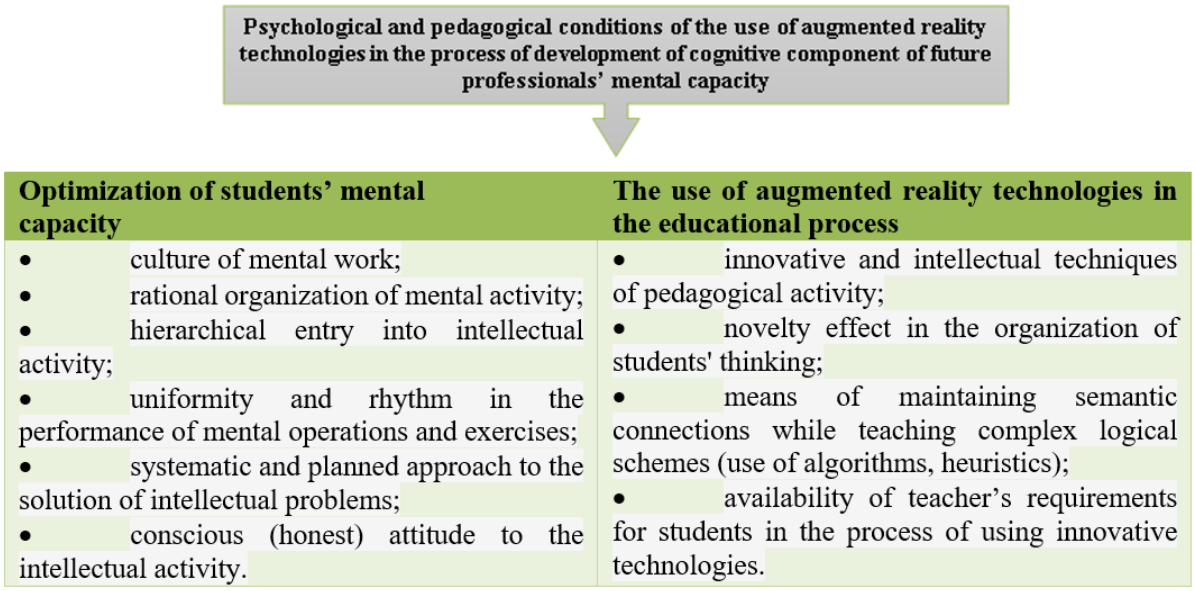


Figure 1. Psychological and pedagogical determinants of AR technologies implementation in the process of teaching disciplines on the Moodle platform.

Taking into account the psychological and pedagogical conditions of AR technologies introduction in the educational process in higher educational establishments, in order to form a cognitive component of future professionals' mental capacity, we have analyzed the possibilities of implementing elements of AR technologies at three levels: competence-oriented, structural-cognitive, emotional-reflexive.

At the competence-oriented level, the experimental group students (n=30) were offered to search for an independent solution of problem-based tasks using AR technologies:

1. Design of a professional profile with the creation of a structural model of a modern psychologist. To fulfill this task, students were asked to use the following AR applications:
   - Pose Maker Pro - 3D art poser app – an application for creating characters, it is used as a guide for drawing physical image of people, for designing illustrations or framing individual visual objects.
   - D3D Sculptor - 3D modeling – a tool for creating digital sculptures and objects, it combines 3D modeling, texturing and drawing. D3D offers tools for creating a 3D model or other manipulation with a digital object as if it is made of real substance.

   With the help of appropriate applications, students were able to independently create an image of a modern psychologist, reflecting even the nonverbal behavioral components – posture, facial expressions, and gestures. Based on the created image, students described psychologist's personal, professionally important qualities in a particular field of psychology, analyzed the peculiarities and conditions of work, and demonstrated the algorithm for performing the assignment.
2. Construction of the design model of modern psychologist's office:

- Myty AR – an application which allows you to create a 3-D model, project or collage of any room, office, workspace.
- Floor plan – Home improvements in AR – Wodomo 3D – using this program students can see in augmented reality (AR) the result of virtual changes made to their workspace. Interaction with augmented reality begins with the creation of a 3D plan of the project model. The user sends a request to the application where the characteristic points are located, simply by pointing them at the camera screen. There is no need for the tape measure, the application automatically measures all dimensions, and reproduces the exact plan of the room project in 3D. Due to augmented reality, the user can gain an exciting experience of what the final product can be.
- Home AR Designer – an application for interior design in augmented reality. Convenient 3D models of furniture, space with the possibility of adjustment. By controlling high-quality 3D models, users themselves create their dream workspace in augmented reality. In the application there aren't any markers or objects floating in the air! Augmented reality from Project Tango is the absolute accuracy of surface recognition.

Using appropriate AR technologies, future psychologists have the opportunity not only to demonstrate creativity in designing their future workplace, but also with the help of 3D spacious structures they can visualize the relevant licensing standards for the establishment of modern psychological services.

3. Construction of personal and professional growth trajectory:
   - Remente: Self Help, Mental Health and Improvement – a universal application that acts as a life-coach, and allows you to plan, monitor and regulate personal plans, actions and emotional states. This application includes:
     (a) goal setting guidance to help students to achieve life and professional goals on the path to their self-improvement,
     (b) day planner, which contains a list of tasks for the day, as well as long-term goals and objectives for self-development and professional growth,
     (c) life assessment tool that provides an overview of life priorities for an active lifestyle development,
     (d) reflective journal, which explains what affects mood, motivation, emotions and well-being,
     (e) gallery of professionally designed goal plans that the students can use for their personal and professional growth. Personal growth and professional development can be achieved only by creating good life goals and positive intrinsic motivation.
   - Pockets Goal – an easy-to-use application that allows students to make a complete plan of achieving educational and professional goals through a well-thought-out task. In the application, students can create a new goal, set necessary deadline to achieve it, then a countdown system starts functioning and it clearly shows the time left for the plan implementation. In any vital life and professionally important categories, the users can safely set both short-term and long-term goals, and with the help of Pockets goal students can achieve the desired outcomes in the required time.

The use of appropriate mobile applications with AR component in the process of solving new intellectual tasks or project activities at different stages of learning the discipline "Introduction to Specialty (Psychology)" allows students to immerse themselves in a new information space that stimulates independence, creativity, readiness to solve non-standard practice-oriented tasks. All these applications are focused on the visualization process stimulation and immersion in the future professional activities.

At the structural-cognitive level, students were offered AR simulators, aimed at the cognitive processes activation, development of attention stability, analytical thinking and logic. They expand short-term memory span and increase endurance and mental capacity:

- CubeAR: 3D and AR Maze is a maze game with 3D and AR game modes with new interesting mechanics. The application has 10 different cubes, each of them has its own unique texture and the complexity of passing the maze. In the game you need to roll the ball on all sides, going from point A to point B. Each next level is more difficult than the previous one. It stimulates interest to pass the maze. CubeAR is an educational puzzle game; it develops logical thinking, memory, fine motor skills, stimulates the speed and stability of attention.
- AR Sandbox is a block-based augmented reality game. The application has all necessary tools to create everything that can be visualized or imagined. The user will be able to see their creations as if in the real world. This game stimulates the development of creativity, creative thinking, attention span and planning skills.
- NeuroNation is one of the best applications of the year according to the official version of the Google Play Store. The users can effectively improve brain functions through interactive research by the German research project NeuroNation. Appropriate interactive application promotes the development of memory, intelligence, and logical thinking, it increases concentration. The advantages of this application are: 27 interesting interactive activities and personalized courses; detailed report on personal and cognitive strengths and weaknesses; personalized interactive trainings based on the latest scientific discoveries; comparative analysis with a certain age group, normalization and interpretation of individual successes.

At the emotional-reflexive level, students were offered to perform tasks using interactive technologies for self-analysis, self-reflection and assessment of the current emotional state, levels of personal and professional development. The appropriate level provides an opportunity to summarize the impact of AR technologies on the development of cognitive component of future specialists' mental capacity:

- Reflectly is a personal journal and diary that works on the basis of artificial intelligence and allows you to cope with negative thoughts, analyze personal and professionally important events, and strengthen a positive attitude to activities and learning. It also helps to stabilize emotional states and mood and cope with destructive feelings. This application is based on the principles of positive psychology, self-actualization and cognitive behavioral therapy.

Comprehensive three-level implementation of interactive AR technologies in educational activities stimulates the development of positive motivation and cognitive activity, increases interest in learning and project-based tasks, promotes emotional satisfaction with visualization and created products on the way to professional self-realization, readiness to perform tasks in modern technological progress. The proposed model of AR technologies use in the process of future specialists' professional training promotes the development of mental capacity and endurance.

4. Experimental results of research

Taking into account the peculiarities of educational process reorganization, caused by the transition to distance learning in the conditions of pandemic isolation, the empirical study was conducted in two stages. The first ascertaining stage was carried out in the first half of 2020 – from March to May, 2020. The first-year students, who were studying distantly, but without the introduction of augmented reality technologies, participated in the ascertaining stage of the

research. The second, formative stage, was implemented in the second half of 2020 – from October to December, 2020. As a part of the formative research, first-year students were offered to perform tasks of the same discipline, but with the introduction of augmented reality elements, in order to develop the cognitive structure of mental capacity of future professionals. According to the results of the ascertaining research of the cognitive component of mental capacity, the indicators of the development of students' cognitive processes have been identified. The obtained results are presented in table 1.

Table 1. Quantitative indicators (%) of levels of development of a cognitive component of the first-year students' mental capacity ($n = 58$).

Levels of cognitive processes development	Selectivity of attention	Stability of attention	Analytical thinking	Short-term memory span
High	29,47	9,12	17,90	11,93
Medium	43,85	52,63	61,05	69,12
Low	26,68	38,25	21,05	18,95

As we can see from table 1, taking into account the indicators of the level of attention selectivity, 43.85% of students demonstrated a medium level of the development of attention selectivity. It indicates their ability to select relevant information and ignore insignificant and incidental issues, to distinguish objects by essential and non-essential features. These students also demonstrated the ability for the partial generalization and schematization, and it somewhat reduces the level of their intellectual and cognitive activity. 29.47% of respondents are dominated by a high level of attention selectivity. They are able to distinguish objects by essential features, to generalize and schematize them, as well as to find some images in the background. These are those first-year students who completed the task quite well and demonstrated sufficient indicators to perform intellectual activities which require the use of this feature of attention.

But there were also students who showed a low level of attention selectivity (26.68%). They are not always able to choose necessary items from the proposed material, they distinguish items only by the insignificant features, and therefore they have some problems performing intellectual tasks. This result may be related to a state of strong emotional experience, external obstacles that lead to the disappointment of a respondent.

After processing the data of "Dot Cancellation Test (Bourdon Test)" technique we obtained results on the level of development of the first-year students' attention stability. The majority of students (52.63%) demonstrated a medium level of the attention stability. These students are able to focus their attention on a particular subject, without being distracted and becoming less focused. But this situation takes place only in the case the students are motivated enough and if the features of these subjects are attractive for students and stimulate their curiosity. Personal activity is also important. This allows us to state that according to this indicator they have a sufficient potential to successfully master the high quality knowledge and productivity.

According to the results of the corresponding method, it was found that 38.25% of first-year students demonstrated a low level of attention stability. They tend to be distracted by other bright objects; they can change their purposeful activity and experience certain problems when performing long, monotonous and complex mental activity.

In the process of diagnosis it was found that 9.12% of respondents are characterized by a high level of attention stability. It indicates their ability to maintain a high degree of concentration of attention for a long period of time. These students are aware of the importance and significance

of mental tasks even working in the unfavorable conditions. It is the main prerequisite for the intellectual productivity and mental activity of students.

The research results, obtained by "Research of analytical thinking" technique, successfully demonstrate that the majority of first-year students (61.05%) are diagnosed a medium or satisfactory level of analytical thinking. This indicates that they are able to make logical conclusions in case of attractiveness and significance of intellectual activity, which allows them to successfully carry out various activities, including mental ones.

According to the results of quantitative analysis of empirical data, it is established that 21.05% of respondents demonstrated a high level of this indicator, which is manifested in the effective solution of mental problems based on logical conclusions. They also have an ability to plan their activities, find specific solutions to problems, they have a desire to search. While solving mental tasks these first-year students are able to split information into separate components, carry out a comprehensive analysis of both of these components and initial information, select several options for their solution, carry out an analysis and objective evaluation of each option. They solve complex problems more efficiently and faster than others, make logical conclusions even in the absence of information, and view the problem from different perspectives, so they are able to find the best solution.

Unfortunately, in the course of research low results on the specified characteristic of thinking have been also revealed. In particular, 16.14% of the respondents showed a low and 1.76% – a very low level of analytical thinking. They experience significant difficulties in drawing logical conclusions while solving intellectual problems, they are unable to theorize, find causal relationships between phenomena, they don't have skills to make reliable assumptions about the most likely scenarios, to effectively restore necessary information by logical reasoning, which affects the process of mental activity and its effectiveness.

"Research of short-term memory span" technique was aimed at the identification of students' short-term memory span. It showed the following results (table 1). The majority of first-year students (69.12%) demonstrated a medium level of short-term memory span, showing the ability to memorize and reproduce only relevant, interesting, necessary information and expressive features of some subjects. Therefore, taking into account that modern educational process is associated with a large mental load, they have some potential opportunities for successful mental activity. 11.93% of respondents have a high level of this type of memory. They are able to memorize a large amount of intellectual information, quickly retain and reproduce it, which ensures high productivity of mental activity. Despite this, 18.95% of students showed low results on this indicator. Respondents experience difficulties perceiving information, memorizing and reproducing the material, they are motivated to memorize only a small amount of information, and need systematic memory training.

Assessing the effectiveness of creating psychological and pedagogical conditions for developing mental capacity, based on the integrated implementation of AR technologies in the educational process, it should be noted that we have noticed some positive changes after the research work has been conducted (table 2).

Thus, table 2 demonstrates the outcomes of the research work, and it shows a positive dynamics of changes in the conditions associated with the effectiveness of the learning distantly and implementation of AR technologies (experimental group students mention that with the use of interactive technologies their classes have become more informative and meaningful, they have changed their perception of a teacher and the requirements). In particular, students emphasize that they have become more conscious of their intellectual activity (due to the motivation for learning), they acquired skills of rational organization and planning of their mental activity, and most importantly – mastered basic techniques and methods which help them perceive, process and internalize learning material.

The organization of appropriate research work, based on the above mentioned changes

Table 2. Psychological and pedagogical conditions of the development of mental capacity of first-year students of experimental ($n = 30$) and control ($n = 28$) groups as a result of the introduction of AR technologies in the educational process.

No	A list of conditions	Assessment in Experimental group (before)	Assessment in Experimental group (after)	Assessment in Control group (before)	Assessment in Control group (after)
1	The novelty effect in the organization of students' thinking	3	4.5	3	3
	Means of maintaining semantic connections when teaching complex logical schemes	4	4	4	3.5
	Innovative-intellectual pedagogical activity	4	4	4	4
	Availability of teachers' requirements	3	4	3	3.5
	Friendly and highly intelligent relations between students and teachers	4.5	4.5	4	4
	General atmosphere in the university	5	5	5	5
2	Culture of intellectual activity	2	4	2	2.5
	Hierarchical entry into intellectual activity	4.5	4.5	4.5	4.5
	Uniformity and rhythm in the performance of mental operations and activities	4	4	4	4
	Systematic and planned approach to solving intellectual problems	3.5	4	3	3
	Rational organization of mental activity	3.5	4	3.5	3.5
	Conscious attitude to intellectual activity	3	4	3	3.5

in psychological and pedagogical conditions, had a positive impact on the indicators of all components of experimental group students' mental capacity. In particular, we identified significant changes in the indicators of stability and selectivity of attention. According to the results of the experimental work, there was an increase by 20.01% and 23.34% in the number of

the experimental group students with a high level of stability and selectivity of attention (from 13.33% to 33.34%, and from 26.66% to 50.00%) and with a medium level (from 53.33% to 60.00% and from 40.00% to 43.33%) respectively. There is a decrease by 26.68% (from 33.34% to 6.66% in both cases) in the number of students with a low level of these indicators. Students developed the ability to identify certain objects, summarize and schematize them. They demonstrated the ability to find definite images in the background, gained skills that allow them to successfully master knowledge in the university, perform intellectual tasks and productively organize their mental activity. Thanks to research work conducted, students became more able to maintain a high intensity of attention for a long period of time, to realize the importance and significance of mental tasks, even in unfavorable conditions, which is the main prerequisite for intellectual productivity, learning and mental activity of students. Instead, changes in these indicators in the control group are less significant and noticeable.

Implemented components of AR technologies have contributed to the development of students' short-term memory span. In particular, the number of experimental group students with a high level of short-term memory increased significantly (by 23.34%) (from 13.33% to 36.67%) and the percentage of first-year students with a low level of short-term memory decreased (by 13.34%) (3.33% instead of 16.67%). So, the implemented measures allowed students to perceive and reproduce the material more easily, they became more able to memorize a large number of elements, without using the techniques of semantic organization of the material, which provides prompt retention and conversion of data to long-term memory and high level of productivity of mental activity. Consequently, students have gained more opportunities to carry out a successful learning process. The results of the control group on this indicator have insignificant dynamics.

The implemented measures contributed to the development of students' analytical thinking. In the experimental group there is a positive dynamics of change, which is manifested in an increase (by 20.00%) in the percentage of students (from 16.67% to 36.67%) who have high levels of development of the specified parameter, a number of those, having a medium level, has increased by 3.33% (from 50.00% to 53.33%).

In addition, due to the change of approach to solving practice-oriented and project tasks, we identified students with a very high (3.33%) level of analytical thinking. The percentage of respondents with a low level of this parameter is only 6.67% (instead of 30, 00%). Thus, first-year students acquired skills that contributed to the development of analytical thinking, their ability to operate with data, theorize, and find cause-and-effect relationships between phenomena. While performing their mental activity, they began to use different methods of splitting the information into separate components, comprehensively analyzing them, identifying several options for the best solution, analyzing and objectively evaluating each separate option. They began to solve complex problems more effectively, learned to draw logical conclusions even feeling a lack of information. It allows students to successfully master various activities, including learning ones. Instead, in the control group, the results remained almost unchanged.

As it can be seen from table 3, students of the experimental group demonstrated a significant increase of the quantitative indicator of a high level of cognitive component of mental capacity. This indicates the mobilization of students' mental processes, formation of skills necessary for the successful performance of intellectual tasks. These students also showed an increase in the development of critical thinking, perseverance and independence in assessing their capabilities in the process of mental activity fulfillment. They showed productive performance of intellectual tasks, they are fluent in the amount of educational material, capable of generalizing and systematizing it, and it allows them to successfully study in a higher educational establishment. In order to identify the correlations between the levels of development of cognitive component of future professionals' mental capacity we used Spearman's rank correlation coefficient, which was calculated by the formula:

Table 3. Quantitative indicators (%) of the levels of development of mental capacity of experimental group students ($n = 30$) and control group students ($n = 28$) before and after the formative experiment.

Level of mental capacity	Cognitive component in Experimental group (before)	Cognitive component in Experimental group (after)	Cognitive component in Control group (before)	Cognitive component in Control group (after)
High	16.67 (5)	36.67 (11)	14.29 (4)	17.86 (5)
Medium	50.00 (15)	56.67 (17)	53.57 (15)	57.14 (16)
Low	33.33 (10)	6.66 (2)	32.14 (9)	25.00 (7)

$$r_s = 1 - \frac{6 \cdot \sum(d^2)}{N \cdot (N^2 - 1)}$$

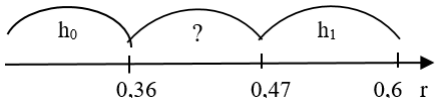
where d – difference between the ranks of two variables for each respondent; N – a number of respondents. So, let's calculate the empirical value r_s:

$$r_s = 1 - \frac{6 \cdot 1760}{30 \cdot (30^2 - 1)} = 1 - \frac{10560}{26970} = 0.6$$

We determine the critical values of the coefficient rank correlation coefficient for the number of subjects $n = 30$.

$$\begin{cases} r_{cr} = 0.36 & \alpha \leq 0.05 \\ r_{cr} = 0.47 & \alpha \leq 0.01 \end{cases} \tag{1}$$

$$r_s > r_{cr} \alpha \leq 0.01$$



Thus, hypothesis H_0 is rejected, hypothesis H_1 is accepted. In other words, it can be argued that the indicators of the cognitive structure and the levels of mental performance are positively related to each other – the higher the level of development of the cognitive component, the higher the indicators of the general coefficient of mental performance. According to the mathematical calculations, the reliability of the obtained empirical data and conclusions is established, and it is determined that the corresponding quantitative and qualitative changes presented by the results of the formative research are not accidental.

5. Conclusions and prospects for further research

Our research allows us to emphasize a high degree of relevance and demand for the use of new technologies in the field of higher education, as well as to state that AR technologies are being

actively implemented in the educational component of higher educational institutions. Due to the unprecedented speed of development and implementation of information and communication technologies in all spheres of human activity, domestic universities are actively using the latest learning formats. It doesn't only improve the quality of education but also increases future professionals' competitiveness in the global labor market. The process of introducing new learning formats is not only in demand but also interdependent. On the one hand, students are interested in any technological innovations in education, and in the framework of scientific work, educational and project activities they actively use various applications with AR technologies. On the other hand, teachers are well aware of the latest developments in AR technologies, use online systems in their work and are ready for further implementation of relevant information and communication technologies in the educational process of higher educational establishments. According to the results of an interdisciplinary study on the use of augmented reality elements in the process of organizing learning activities on the distance learning platform Moodle, it was found out that students gained skills necessary for their adaptation to a new intellectual and educational environment, they became more optimistic, using basic adaptive mechanisms. Due to these changes there was an increase in the level of development of main components of first-year students' mental capacity (the level of stability and selectivity of attention, short-term memory span, development of analytical thinking, level of development of special qualities required for mental activity, formation of students' mental work culture and skills of their mental activity organization), which allows them to successfully carry out intellectual activities in higher educational establishments. Thus, the obtained data make it possible to state the feasibility and high efficiency of the introduction of AR technologies in the process of developing future professionals' mental capacity. It can be stated that AR technologies, being actively modernized day by day, have a huge potential for the future prospects of higher professional education.

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