

PAPER • OPEN ACCESS

The peculiarities of the usage of AR technologies in the process of hardiness of future professionals

To cite this article: V Osadchyi *et al* 2021 *J. Phys.: Conf. Ser.* **1840** 012059

View the [article online](#) for updates and enhancements.



240th ECS Meeting ORLANDO, FL

Orange County Convention Center Oct 10-14, 2021



Abstract submission due: April 9

SUBMIT NOW

The peculiarities of the usage of AR technologies in the process of hardiness of future professionals

V Osadchyi, H Varina, N Falko, K Osadcha and T Katkova

Bogdan Khmelnsky Melitopol State Pedagogical University, 20 Hetmanska Str.,
Melitopol, 72300, Ukraine

E-mail: osadchyi@mdpu.org.ua

Abstract. One of the main challenges of today is to increase the resilience of individuals to stressful environmental factors and preserve the quality of life and efficiency. Hardiness is a psychological phenomenon, the essence of which is a productive way out of the crisis towards personal growth. Taking into account the effectiveness of information and technological progress, the issue of internalization of AR technologies in the process of training a competitive, viable specialist who is able to mobilize and self-realize internal potential resources is vital. The scientific article analyzes the possibilities of using innovative AR technologies in the process of developing the hardiness of the future specialist on the basis of the implementation of competence and subject-personal approach to the introduction of AR technologies in the educational process in the system of higher education. The article describes the experience of integrated implementation of elements of augmented reality in the program of development of hardiness - Hardiness Enhancing Lifestyle Program based on the concept of BYOD. According to the results of the obtained empirical data the efficiency of using innovative AR technologies in the structure of mobile applications in the process of development of the components of hardiness of the personality of the future specialist is proved. Prospect for further research is the development of a methodology for integrated implementation of AR technologies in the practice of higher education in order to optimize the training of future professionals.

1. Introduction

Unrestrained social and economic as well as informational and technological development of society increasingly requires the ability to take advantage not only of adaptive potential, but also of reserve regulatory resources from each of us. Modern pandemic conditions of the society existence [51], the growing role of remote interaction of the subjects of labour pose more and more challenges to man as a subject of his own life. The subjective qualities of the personality that determine its hardiness are increasingly valued. Studies show that vitality and hardiness interact with activity, a person's ability to make independent decisions, professional and academic success, faith in his own strength, ability to cope with difficulties, stressful situations, maintain his health and psychological well-being. An integral feature of the current situation is the process of globalization, which affected all spheres of public life and the higher education system. Global transformations of all aspects of society and the higher education system lead to increased demands on individual resources [14]. To meet the requirements of innovative social development, it is necessary to have certain personal attitudes, qualities and values that would allow full participation in innovation processes – high potential for self-realization, resilience to frustration, the ability to turn problem situations into positive experiences, willingness to change



patterned behavioral stereotypes, tolerance for uncertainty, developed motivation for self-improvement and innovation, etc.

Current trends in the digitalization of education and the transformation of the competency approach involve the active implementation of innovative information and communication strategy for higher education. The corresponding innovative strategy determines not only the search for adaptive, resourceful IT technologies, but also the development of new competencies of modern specialists [8]. One of the key competencies of a modern specialist is the ability to implement hardiness as the ability of the subject to find a degree of compliance with existing conditions, determines a person's protection from various threatening influences associated with human perceptions of his ability to implement successfully the behavior necessary to achieve expected results, to overcome the negative effects of the environment and realize the potential of man in a competitive space [23]. The impact of pandemic trends on the process of self-realization and training of future professionals has led to a global reorientation from the “subject-subject” relationship to the realization of the ternary process space “subject – information environment – subject”. The field of higher education actively uses the advanced achievements of scientific and technological progress in many areas of human activity and, in particular, the achievements of information technology, proving the feasibility of their use in the educational process. The digital revolution, which has spawned smart connected devices and explosive data growth, is boosting productivity and opening up opportunities for higher education. Today, the future specialist is not limited by the lack of information, but the complexity of its understanding and application – in other words, we need a new type of interface. The most promising solution is augmented reality [9], [10]. Accordingly, taking into account the spread of augmented reality technologies and changes in the competency approach in the process of training future professionals, the issue of internalization of AR technologies in the process of training a competitive, hardiness specialist capable of mobilizing and self-realization of internal potential resources is vital.

The purpose of our interdisciplinary study is to determine the functional impact of AR technologies on the proprium of hardiness of the future specialist in the training process.

2. Literature review

Analyzing the hardiness as an integrative phenomenon, it is necessary to pay attention to its various aspects and manifestations, the structural components of this phenomenon. Based on the definition of the diversity of life as well as various manifestations of such a quality as resilience, we can talk about the multifaceted phenomenon of hardiness. Applied research has identified a personal construct of “hardiness”, which characterizes the degree of individual ability to withstand a stressful situation, maintaining internal balance without reducing the success of the activity [17].

Studies by Salvatore R. Maddi and Suzanne C. Kobasa have shown that hardiness is a personal characteristic that is a general measure of a person's mental health and reflects three life attitudes: involvement, confidence in the ability to control events, and willingness to take risks ([29], [36]). In addition to these attitudes, “hardiness” includes such core values as cooperation, trust and creativity. A high level of hardiness contributes to the assessment of events as less traumatic and successful coping with stress. Indicators of hardiness are a set of characteristic features, according to which we can conclude about the development of this personality trait [31]. The authors include genetic predispositions, immune system parameters and neuroendocrine response to stress (Christyn L. Dolbier [38], Robert R. Cocks [21], Jenn A. Leiferman [21], Alse M. Sandvik [4], Sigurd William Hystad [25], Terry Martyn Phillips [49], Julian Francis Thayer [49], Bjørn Helge Johnsen [25]), strength and speed of response of the sympathetic nervous system on stress (Suzanne C. Kobasa [29], Salvatore R. Maddi [36], [37], Mark C. Puccetti [45]), cardiovascular reactivity in response to stress (Richard J. Contrada [6]). The individual psychological (social and psychological) indicators of hardiness should be identified and grouped as follows: cognitive (locus of control, critical thinking and creativity, optimal response to criticism; divergent thinking, predictive abilities, search activity, effective assessment of the situation, its perception as a challenge, rather than threats), emotional and volitional (stress resistance, purposefulness, emotional stability, ways of emotional self-regulation), behavioral indicators (effective

behavior patterns, constructive coping strategies, coping style, task-oriented rather than emotional experience, readiness for action, social communication skills such as active listening, confident demandingness, flexibility and independence in decision-making (Roos Delahajj [20], Anthony W. K. Gaillard [20], Salvatore R. Maddi [37]). Most researchers of hardiness agree that this phenomenon embodies in addition to psychophysiological, individual, social and psychological indicators, certain characteristics of personal and semantic level, level of values and motivation [38]. A hardiness personality is characterized by a positive outlook, increased subjective assessment of quality of life, the search for meaning as the leading goal of life, and the search for meaning in a given situation, a high level of awareness of his own interests, values and meanings [57]. An important factor in the development of human hardiness is the ability to have his own personal potential [29].

Based on the research of Velly Ndlovu and Nadia Ferreira about the actualization of the development of psychological resilience as a dominant component of professional adaptation, the question of finding adaptive and innovative ways to develop the hardiness of the individual is quite relevant [41].

In the context of digitalization and informatization of the modern cultural and sensory environment, the priority is to find ways to use augmented reality technologies in the process of professional and personal development of the future specialist [52].

Analyzing the work on the introduction of AR technologies in the educational environment ([26], [28], [30], [32], [33], [39], [40], [43], [48], [47], [53], [54], [59]) it should be noted that the growing popularity of augmented reality technology and interest in it, at the moment, is due to researches that justifies the prospects for use augmented reality technologies by expanding the production sphere and creating completely new areas and opportunities for education. Among the main arguments are: the ability to design thematic databases with visualized data, capable of working with different operating systems and devices; the emergence of crowd sourcing platforms for the creation of augmented reality content by users, the creation of new computer systems.

A significant number of modern researchers (Pietro Cipresso [16], Irene Alice Chicchi Giglioli [16], Hsin-Kai Wu [13], Hsin-Yi Chang [13]), pay special attention to the integrative processes of introduction of AR technologies in the system of higher education. Scientists study the process of introducing innovations in virtual development, augmented reality in the psychological and pedagogical structure of training future professionals, the formation of professionally important qualities, professional competencies. Wilma Lorena Gavilanes López, Blanca Rocio Cuji, Maria José Abásolo and Gladys Lorena Aguirre Sailema analyze the degree of technological acceptance of educational contents enriched with Augmented Reality (AR) by university students, mainly if these contents have been designed by some students to others. Researchers have scientifically substantiated the relevance of implementing the Technological Acceptance Model (TAM) using Augmented Reality in University Learning Scenarios [35]. Especially innovative in the coaxial realities, according to Hsin-Yi Chang, Hsin-Kai Wu and Ying-Shao Hsu [13], Matt Bower, Cathie Howe, Nerida McCredie, Austin Robinson and David Grover [8], is the integrated combination of traditional pedagogical technologies and models with innovative technologies of augmented reality, in order to optimize educational activities and increase the effectiveness of research activity of students.

Analyzing the scientific trends of the introduction of AR technologies in the process of training and formation of hardiness and stress resistance of the individual, it is necessary to pay attention to the research of Cristina Botella, Rosa M. Baños, Helena Villa, Conxa Perpiñá and Azucena García-Palacios [7]. Scientists have substantiated the effectiveness of the use of virtual and augmented reality in the process of correction and treatment of claustrophobic phobia, proposed a technology for the development of stress and hardiness of the individual. In turn, Oliver Baus and Stéphane Bouchard [5] emphasize the effectiveness of the use of feedback, technological video games with augmented reality in the formation of stress resistance and the development of a constructive coping strategy of behavior in a stressful situation.

According to the analysis of existing scientific and practical developments on the introduction of AR technologies in the competency and subject-integrated approach to training future professionals, in the

existing digitalized realities of higher education the issue of studying the applied impact of augmented reality technologies on the development of professional competencies, on the example of vitality.

3. Empirical introduction of AR technologies in the process of development of hardiness of future specialists in the conditions of modern higher school

This study was conducted within the scope of joint research work of teachers and students (future psychologists and computer scientists). Methods used in the research process are: method of analysis of theoretical sources, studying of advanced psychological and pedagogical experience of foreign and local scientists on the implementation of competency and personality-oriented approach in the educational process in the system of higher education, development of hardiness in training, generalization of the conceptual issues of the research; design and modeling of technological and empirical construct of introduction of AR technologies in the process of development of hardiness of future specialists.

The theoretical construct of our study is the analysis of priority opportunities and mechanisms for the usage of AR technologies in the process of developing the hardiness of the future specialist in the system of higher education. AR applications are used to combine a wide range of virtual learning resources with the real environment, thus improving the opportunities for internalization of theoretical and practical experience, influencing the personal and professional resources of future professionals [42], [44]. Augmented reality is a technology that allows computer programs to create and identify a virtual layer of information with any marker or object in the real physical world [11]. The role of the marker can be played by any graphic visual object, to which virtual objects of different formats can be added using special software. Jeremy N. Bailenson, Kim Swinth, Crystal Hoyt, Susan Persky, Alex Dimov and Jim Blascovich [3] found that the simulation of experience in augmented reality directly affects human behavior in the real world. In the study, the authors came to the idea that augmented reality technology can change the way you behave: how you walk, how you turn your head, how you approach a problem, how you communicate with other people. It is interesting to note, however, that the augmented reality scheme of coping strategy of human behavior remains even after the end of the session in augmented reality. Accordingly, the created effects and auras in augmented reality affect the neural connections in the human brain and are projected onto consciousness, which allows a person to feel and perceive objects in augmented reality as close as possible to real ones. AR technology has the following psychological and pedagogical advantages in the development of sustainable coping strategies for the behavior of future professionals:

1. *Accessibility.* AR can make education more accessible and mobile. AR does not require special equipment; learning resource using AR is implemented using such available to most target audience technology tools as a tablet or smart phone.

2. *Involvement.* Learning with the use of AR is personality-oriented, it allows to realize individual abilities. Interactive, “playful” learning with the use of AR motivates students, increases their interest in self-development and finding resource opportunities for self-realization [15].

3. *Cooperation.* Students' learning activities and their ability to learn are formed, including through participation in joint groups and communities. AR's extensive interactive activities encourage students to work together, develop soft-skills, resilience to frustration and choose constructive behavioral strategies in stressful professional situations.

4. *Interactivity.* AR creates a multidimensional space for self-expression, allows individuals to explore the world and their own potential in an interactive way. Students achieve the best results in learning through visualization and full immersion in certain cases, which allow in the closest to the reality situation to analyze and choose the appropriate behavioral strategy. Thus, the use of AR provides an opportunity to develop professionally important qualities and develops the ability to be resilient and competitive in a changing world.

5. *Integrity.* AR technology opens up new opportunities for learning theory and training practical skills. The practical combination of virtual and real experience enriches the personality-oriented activities of students. The display of the simulated space and the effect of one's own participation in virtual events make AR technology a relevant psychological and pedagogical tool, universal for all age

groups and at all levels of education. AR has the potential to make the process of internalizing theoretical and practical life and professional competencies more effective, as it promotes the integration of knowledge with reality.

Currently, there is a sufficient number of platforms (AR libraries) designed to create AR applications. Among them are such as Vuforia, ARToolKit, Kudan, Catchoom, WikiTude, LayAR, BlipparEON Reality, InfinityAR and others [19]. Let us consider the functionality of some of them and evaluate the feasibility of their usage in the development of hardiness of the future specialist.

The most common application is Qualcomm's Vuforia, which has paid and free versions and provides developers with a wide range of tools for creating augmented reality objects. Vuforia's functionality allows not only scanning several real 2D and 3D objects at the same time, but also to identify them, as well as play additional elements through a set of specifications and view a virtual display of the desired object, which may even be out of sight. When recognizing objects, the application allows you to use data stored on a mobile device or in cloud storage. Thus, this platform provides opportunities for individual personality-oriented approach in the process of developing hardiness, because it is the individual who can independently regulate the time and place of using certain markers. A set of open source ARToolKit software libraries allows you to get an augmented reality interface by tracking camera pre-known markers of objects, their subsequent recognition and playback in 3D with a mobile device. ARToolKit supports a large number of operating systems, free software environments, implementations for each of which are available on all platforms [22]. Thus, the accessibility and mobility of the program using expands the possibilities of its implementation within the competence approach in training future professionals. The HP Reveal platform, being an updated version of the AR library Aurasma, combines AR and IoT (Internet of Things) technologies. The principle of HP Reveal is similar to the widely used technology for recognizing QR codes. Using the camera of a mobile device, GPS, Bluetooth, Wi-Fi, accelerometer and gyroscope, the application identifies various objects from the surrounding space. Then, with the help of visual interactivity, files of various formats (graphics, audio, video, etc.) are superimposed on these objects and the received objects, called auras, are transferred to the screen of the mobile device. The wide-ranging use of the updated platform allows bringing objects and forms as close as possible to reality, which can be combined into thematic cases and form sustainable personal qualities [58]. Analyzing the possibilities of using AR libraries in the process of modernization of the educational space of higher education, special attention should be paid to the technological principles of using AR technologies in the implementation of competence approach and development of professionally important personality traits, for example (table 1).

Table 1. Technological possibilities of using AR technologies in the process of developing the hardiness of the future specialist.

Subtechnology	Example	Solution description	Components of personal hardiness
Graphic output technologies	Augmented reality helmet Augmented reality glasses	With the help of computer vision technology, self-inclusive and compact devices with built-in sensors and cameras allow to analyze the space around the user, to form a map of space for orientation in it. Most glasses are equipped with voice and movement recognition, they can be controlled without using your hands. Images are projected on spectacle lenses or special mini-displays, there is no need for additional labels to	The use of helmets, glasses and an augmented reality optical system allow to implement situational, personality-oriented cases that affect the development of hardiness personality structures: – cognitive structure (creativity, divergence of thinking, prognostic abilities); – emotional and volitional structure (stress resistance, emotional self-regulation);

Subtechnology	Example	Solution description	Components of personal hardiness
		generate content. There are binocular (Hololens, DAQRISmartGlasses, Meta 2) and monocular (GoogleGlass, Vuzix M3000) models of glasses and helmets.	– behavioral structure (readiness to solve professionally important tasks, flexibility of behavior, tolerance to uncertainty
	Augmented reality system – an optical element	Optical system for creating holograms. Can be used as a basic element of an augmented reality helmet, i.e. the creation of holograms.	
Motion capture and photogrammetry technologies	3divi gesture recognition system	Hardware platform for developing interactive applications based on body tracking and face recognition TVico and SDK for gesture and face recognition (Nuitrack). This is a solution for tracking the position of the body at 19 points and gesture recognition, which provides the capabilities of the Natural User Interface (NUI) for Android, Windows and Linux operating systems.	These technologies help to improve the physical and mental health of the future specialist, successful adaptation in stressful situations with the level of transadaptation associated with self-determination and self-realization of the individual. The use of these hardware platforms with augmented reality allow to implement the principles of physiological and psychological feedback, which stimulates the manifestation of the insight effect, introspection and the formation of constructive resilient coping strategies of behavior
	TauTracker	Gloves. Motion capture technology for virtual and augmented reality applications, 3D simulators, providing the user with the best immersion due to high accuracy of capture and the absence of restrictions associated with shading tracked objects and accumulated error. TAU tracker is created on the basis of its own magnetic inertial technology, with sensors located on the human body to transmit the coordinates of various parts of his body in a virtual reality system. This avoids using cameras, solving the problem of blind spots and cumulative error (in inertial tracking systems) and ensures maximum immersion of the user in virtual reality	
	Ntech Lab	A set of high-precision photogrammetric algorithms based on flat video streams. Algorithms provide verification of persons, identification of persons, determination of age and sex,	

Subtechnology	Example	Solution description	Components of personal hardiness
		recognition of emotions. Based on algorithm data, the following products have been created: FindFace Enterprise Server SDK (platform for face recognition based on client scripts)	
	The Psycho	Outside-in tracking and tactile feedback system to ensure high simulation reliability.	
	Vision Labs	LUNA SDK Enterprise is a face recognition and analysis system that provides efficient and accurate processing in images and video streams, and can run on a variety of operating systems and platforms. LUNA SDK Enterprise consists of several modules, each of which solves certain tasks. FaceEngine is a module that contains basic functions and algorithms for face detection and retrieval of descriptors; LivenessEngine is a module that allows to distinguish the face of a real person from an image or video; TrackEngine is a module for tracking faces and choosing the best frame from the stream.	
Applied technologies for education	ISP Platform	Platform solution for the creation and implementation of hard and soft skills simulators with the functionality of network interaction, behavioral data analytics, language recognition and analysis, object libraries, etc.	An important cognitive component of the hardiness of the individual is the developed prognostic abilities and critical thinking. These platforms and simulators provide an opportunity to train practical professionally important skills and internalize theoretical knowledge and practical experience. This allows to form a set of resilient behavioral markers that increase the opportunities for effective professional self-realization of future professionals, for example: – ability to solve complex specialized problems and practical problems;
	hrvr.Academy Platform	A platform solution for learning with the help of interactive simulations in virtual reality. A full-fledged ecosystem has been created, consisting of modular educational simulations in virtual reality with an AI system for providing feedback on learning outcomes and a web portal with standard LMS functions. Ability to adapt scripts	
	PraxisVR	Training simulators and simulators in virtual reality for hard and soft skills)	

Subtechnology	Example	Solution description	Components of personal hardiness
	X-Reality Conference room	Virtual reality training simulators and simulators for hard and soft skills. Virtual space interaction system with motion recognition, user gestures when using widely available VR equipment and visual space reproduction of behavior and reactions in a multi-user network mode. Users see each other, interact with each other through XR-avatars (projections of a real person) and reproduce the user's face on the uploaded photo in 3D.	<ul style="list-style-type: none"> – ability to apply knowledge in practical situations; – knowledge and understanding of the subject area and understanding of professional activity, readiness to take responsibility for decisions within professional activity; – skills in using information and communication technologies; – ability to make informed decisions, analyze activities;
	Luden.io	A platform for creating interactive VR visualizations to promote knowledge to the general consumer. In the game form in VR-format, certain knowledge is conveyed to the target audience, stimulating the continuation of the process of learning through the positive emotional coloring of the process.	<ul style="list-style-type: none"> – ability to generate new ideas, to make non-standard solutions in problem situations (creativity); – interpersonal skills, ability to tolerant behavior; – ability to analyze and systematize the results obtained, to formulate reasoned structured conclusions and recommendations, to inform about the results and recommendations provided;
	UniVRsity Platform	A platform for creating online courses using VR / AR technologies, which allows the user to assemble a training course with VR / AR elements without special programming skills. The platform is open, contains script designers, is implemented within the digital project “Virtual University 4.0”.	<ul style="list-style-type: none"> – ability for personal and professional self-improvement, learning and self-development; – ability to apply methods of emotional and cognitive regulation of the psychological state and activity

Software and hardware for working with three-dimensional images to create training VR / AR lessons for trainers EON Reality and software for creating educational kits Virtualis are the examples of platforms for AR simulators. The platforms for creating educational AR content are Amazon Sumerian, BrivoVR, Engage, Visible, The AVR Platform from EON Reality (consists of three separate products – Creator AVR, Virtual trainer and AR Assist), SecondLife, VRLively, Vrchat and High Fidelity. Marketplaces for educational AR content are Zspace and Hologate. In the professional and educational segment, the introduction of these technologies in terms of creating accessible tools for users and supplementing with interactive visual AR content can increase learning efficiency, provide continuing professional education, implement a healthy approach, the formation of hardiness as a dominant component of future professionalism [56].

The ways of applying augmented reality technologies in education are reflected in the methodology of MARE (Mobile Augmented Reality Education). The proposed MARE structure consists of three hierarchical layers: basis, functions and results [46]. It is based on the analysis of different ways of learning from theoretical knowledge to the development of practical skills. Whatever the theory of learning is adopted in an educational institution, for example, associative and reflexive theory of learning

or the theory of problem-based learning, the main criterion for acquiring knowledge is application in practice for high school. The functional level depends on the individual approach and actions of the learner and his interaction with educational resources.

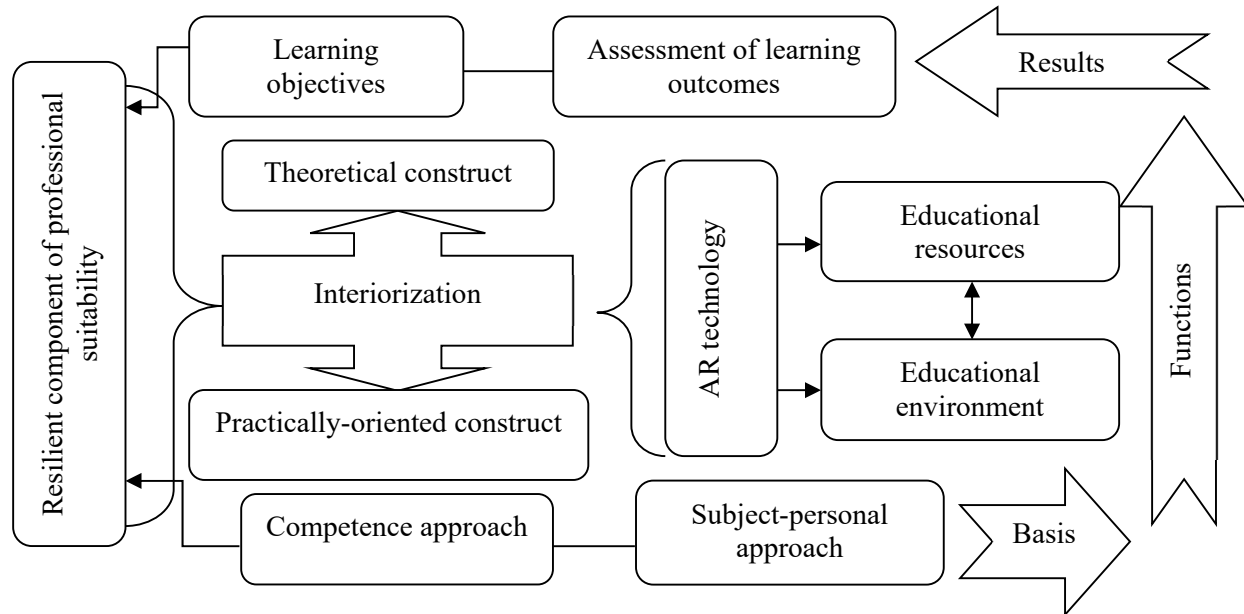


Figure 1. Scheme of implementation of competence and subject-personal approach to the introduction of AR technologies in the educational process in the system of higher education (the basis of the MARE methodology).

As can be seen from the above diagram (figure 1), the fields of augmented reality (AR) technologies include primarily educational resources. These resources and their combination, which comprise the educational environment, are designed to fill the gaps between the required competencies and learning outcomes and contribute to the internalization of theoretical and practical experience on the path to professional suitability and competitiveness [56]. In the corresponding scheme AR technologies act as an interiorizing link, which provides an opportunity to bring the theoretical and practice-oriented construct of professional training to the realities of life, which affects the development of hardiness of the individual. Focusing on this model of complex integration of AR technologies in the process of professional training and development of hardiness of future specialists (psychologists), an interdisciplinary study was implemented on the basis of Bogdan Khmelnytsky Melitopol State Pedagogical University. The purpose of the study is to investigate the constructive use of AR technologies in the process of developing the hardiness of the individual, as the dominant construct of the professional and personal component of training future professionals. The study was conducted with future psychologists. The total number of the sample is 70 people; the sample is randomized, formed on the principle of stratification. The corresponding research consisted of ascertaining and forming stages. As part of the ascertaining stage, a diagnostic survey was conducted using the Google form. Respondents in the online mode had to pass the test of hardiness by Salvatore R. Maddi (adaptation of Dmitrii A. Leontev and Elena I. Rasskazova [34]).

The formative stage of the research was implemented within the scientific and practical online course “Modern practice-oriented technologies in education”, which includes a module “Innovative ICT in psychology: the experience of implementing augmented and virtual reality in psychological practice”. As part of the formative research on the basis of the online course, an integrative combination of the standardized Hardiness Enhancing Lifestyle Program (HELP) [2] and the augmented reality construct was implemented. Considering hardiness as a key personal variable that mediates the impact of stressors on physical and mental health, as well as the success of the individual, it can be formed in the process

of mastering the profession, stimulating independence, voluntary activity, responsibility, teaching future professionals to manage their emotions, behavior and ability to mobilize in difficult life situations. The corresponding program also included elements of development of the general stress resistance of the person, methodologically presented in the form of five-R model of Roger S. Ulrich, Robert F. Simons, Barbara D. Losito, Evelyn Fiorito, Mark A. Miles and Michael Zelson [61]: Recognition – understanding of the possible reasons and sources of stress; Relationships – identification of the sources of support and people who can come to the rescue; Removal – elimination of stressors and their management; Relaxation – the use of relaxation techniques (breathing exercises, meditation, massage, imagination); Re-engagement – repetition of immersion in stress by desensitization [24]. The program to increase the resilience of the individual was divided into appropriate blocks [27], which are presented in figure 2.

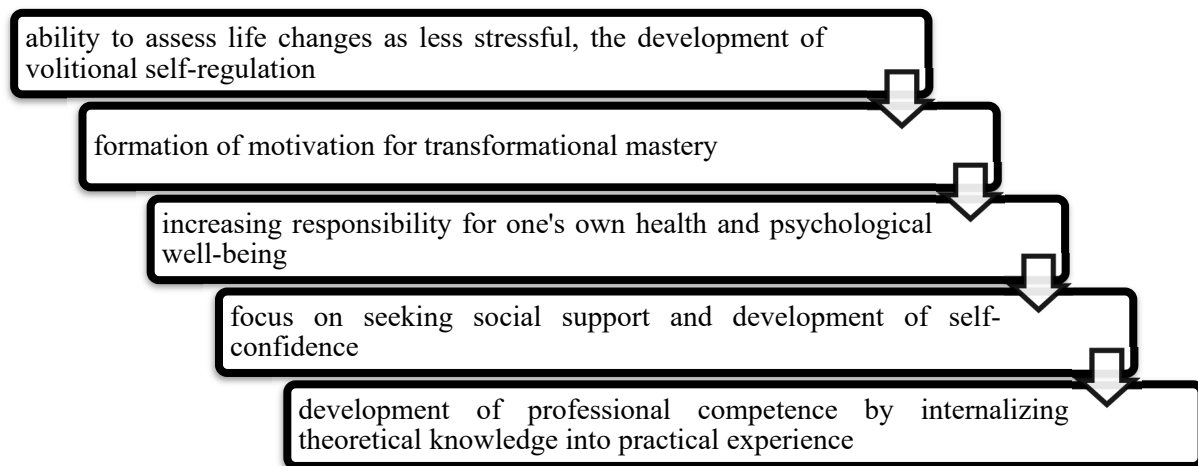


Figure 2. Features of the Hardiness Enhancing Lifestyle Program, HELP.

In our study, we emphasize the unity of traditional training technologies and innovative AR technologies. The peculiarity of the scientific and practical online course is not only individual and group psychological support in the implementation of the Hardiness Enhancing Lifestyle Program, HELP using Zoom, Google Meet, Skype platforms, but also the inclusion of mobile learning elements using augmented reality technology:

- creation and application of QR-codes as hyperlinks for navigation on them by means of mobile devices;
- creating auras of images that connect a static image with video with a help of free installed augmented reality program on a mobile device;
- use of interactive 3D markers for educational purposes by independently adding subject content to the already developed content;
- creating and conducting online surveys to update knowledge, consolidate the studied material, check the level of assimilation of material, reflection without the use of special equipment with remotes (only a gadget with an augmented reality application, a computer with Internet access and a projector). These elements are used to deepen the study of material, visualization of objects, increase individualization and interactivity of the Hardiness Enhancing Lifestyle Program, HELP.

According to the implemented BYOD concept (“Bring Your Own Device”), when organizing classes with the help of mobile learning technology, respondents can use their own gadgets with the necessary software installed [50]. The organization of classes with the use of mobile learning technology with elements of augmented reality can be carried out both individually and in groups. The choice of the appropriate concept is justified by the possibilities of individual, personality-oriented approach, the availability of implementation.

According to Salvatore R. Maddi's three-component model of hardiness, we analyzed the possibilities of using ergonomic and accessible Google Play content with elements of augmented reality.

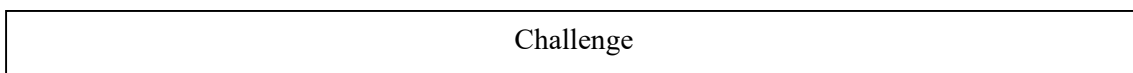
Commitment	
NeuroNation – exercises for the brain	NeuroNation brain training is an endless improvement of achievements: <ul style="list-style-type: none"> – Improve memory – Increase concentration – Increase intelligence, concentration and attention – Development of logical thinking Features: <ul style="list-style-type: none"> – 27 interesting exercises and personalized courses – Detailed report on the strengths and weaknesses of the respondent – Personalized training based on the latest scientific discoveries – Comparative analysis with a certain age group and interpretation of individual successes
Diaries of Therapy Sintylapse	At the moment, the application contains 4 diaries with elements of additional reality. The Diary of Wishes will help to find more joy every day, with the Diary of Fears you can realize the insignificance of fears of change, the Diary of Emotions will help to get rid of negative thoughts and fix positive moments from life, and using the Diary of Thanksgiving you can find truly pleasant things in your life.
AR ARLOOPA Inc. Augmented and Virtual Reality Apps	The application focused on generating augmented reality elements. Leader in the augmented reality revolution with 3 main AR functions, marker-based scanning, marker-free tracking. The application uses a yang learning resource.
Diarize	Motivational diary with elements of augmented reality is a tool for the development of inner motivation, goal setting, values and self-development. The application includes: <ol style="list-style-type: none"> 1. Diary of success. Based on these parameters, the application calculates the effort and displays personal performance in the form of graphs. The diary gives significant motivation to maintain and improve the pace of self-development, lifts the mood and self-esteem, reminds of priorities. 2. Plan. Now planning is much easier and faster, thanks to the new methodology “Spontaneous planning”. Achieve what you want without burdening yourself with tight deadlines and other horrors of time management. 3. Habits. Connect a new habit to the priority areas of life, thanks to this application. 4. Balance wheel. Estimate the current situation using a pie chart. After the assessment you will be able to get recommendations based on used methodology. The diary will tell you what you need to do and what to pay attention to become happier. By reevaluating your life in the future, you will be able to see progress clearly. 5. Statistics of activity and progress. It will reflect your efficiency in achievements and spheres of life in detail. Statistics are simple and informative. Thanks to this, looking at the current results, you will be able to achieve great results in the future. 6. Challenges 7. Management of spheres of life

	8. Management of activity levels
PFSscanner Bonus	<p>Online psychodiagnostic service</p> <p>The mobile application PFSscanner Bonus (psychological face scanner) is a convenient mobile tool that allows you to perform automated psychodiagnostics of personality on a photo in a couple of seconds. By downloading and installing PFSscanner Bonus on your mobile device, you will be able to get objective information about your individual psychological characteristics. Periodic use of PFSscanner Bonus makes it possible to track the dynamics of positive or negative changes, adjust tactics of behavior, plan daily activities, choose the best ways of personal development.</p> <p>PFSscanner Bonus allows you to diagnose the following features:</p> <ol style="list-style-type: none"> 1. Emotional stability 2. Interaction with the environment 3. Flexibility 4. The pace of behavior 5. Moral normativeness 6. Sociability 7. Adaptation potential



NeuroNation Ease: Mindfulness & Meditation	<p>Personal and effective application for emotional self-regulation.</p> <ol style="list-style-type: none"> 1. Reduction of fatigue and learn how to prevent stress before it occurs. 2. Focus on important events. 3. Development of constructive coping strategies of behaviour, psycho-correctional work with anxiety, worry and panic attacks. 4. Help in preventing depression.
Paint Draw AR Vaytricks	<p>In this application, the respondent can draw in 3D space using augmented reality. This program is aimed not only at drawing. It supports many features:</p> <ul style="list-style-type: none"> – promotes the development of self-control and emotional self-regulation; – acts as an art-therapeutic tool; – develops spatial thinking and memory.
feel better - Mood & CBT therapy	<p>The application promotes the development of self-control, self-reflection and emotional stability. The application is built on the principles of behaviorism, cognitive and behavioral therapy, contributes to the formation of constructive goals, the development of positive thinking and personal growth</p>
eQuoo: Emotional Fitness Game	<p>An exciting game “Choose your adventure”, which increases emotional readiness and teaches new psychological skills, helping to increase your level of resilience in real life.</p>
Pocketcoach - Anxiety Helper	<p>Self help for anxiety, stress and panic based on CBT, mindfulness and ACT (Acceptance and Commitment Therapy). Pocketcoach is a digital coach for more happiness and less stress. When you feel anxious, about to have a panic attack, have trouble sleeping or feel restless, Pocketcoach offers scientifically validated techniques and self-help programs. Just download the Pocketcoach app for free and step by step, you learn how to be more resilient and less stressed.</p>
Timia	<p>Timia is the world's number one application for regulating emotions through behavioral geometry, designed to manage stress, reduce anxiety symptoms and train memory and attention, based on sensory stimulation and innovative psychological techniques, the use of geometric shapes, colors , which</p>

	<p>contributes to the stabilization of self-esteem and development of resilience. Timia is an ideal psychological supplement designed for people with little experience in mental health, but it can also be used by therapists. During the action in the Timia application, you are first asked to take a personality test, after which the number of sessions will be determined, an activating image will be presented, asking you to visualize for 10 seconds the worst scene of the problem you encountered. Then perform a breathing exercise with geometric shapes, which helps to regulate the sympathetic system, which was activated after the visualization of the activating image.</p>
--	---



Expeditions AR	<p>Google Education Initiative is an application that allows you to conduct cognitive virtual tours. Inside there are many different experiences: there are 360-video tours, there are adventures in VR, there are trips to various objects, such as a meandering volcano in augmented reality. With the help of the application, a person develops the belief that everything that happens to him contributes to his development through knowledge, which is internalized from experience - no matter positive or negative.</p>
CubeAR: maze 3D & AR	<p>CubeAR is a maze game, with 3D and AR game modes with new interesting mechanics. In the application there are 10 different cubes, each with its own unique texture and the complexity of passing the maze. In the game you need to roll the ball on all sides, passing from point A to point B. Mazes and each subsequent level is more difficult than the previous one, which adds interest to the passage of the maze. Also, CubeAR is an educational puzzle game, it develops logical thinking and memory. The game promotes self-control and strengthens the skills of constructive decision-making in changing conditions.</p>
Reality Hacker VR	<p>Project VisoR is built on the idea of using computational transformations on augmented reality (AR) and virtual reality (VR) devices to view the world in ways you never thought possible! Reality Hacker allows binocular rivalry experiments with all of its computational lenses, and also gives you the ability to rotate/flip your view of the world along the XYZ axes (mirror view, upside down, etc). Use retinal rivalry with the color space permutations to see “impossible colors.” The application promotes creativity and emotional intelligence.</p>
SuperBetter	<p>SuperBetter increases resilience which is the ability to stay strong, motivated and optimistic even in the face of change and difficult obstacles. Playing SuperBetter reveals the potential for overcoming difficult situations and achieving the most important goals.</p>

Figure 3. Technology for implementing mobile applications with AR technology in the Hardiness Enhancing Lifestyle Program, HELP.

The Hardiness Enhancing Lifestyle Program, HELP with AR technology elements, described in accordance with Salvatore R. Maddi's three-component model of hardiness (figure 3), includes practice-oriented cases. Relevant cases affect the cognitive, emotional, volitional and behavioral structural components of the personality, which, when integrated, form the resilient potential of the personality of future professionals.

From January to May 2020, with the help of the Moodle platform, a scientific-practical online course “Modern practice-oriented technologies in education” was introduced. This course was first implemented online as part of the BYOD concept in connection with the pandemic environment of

education. The module “Innovative ICT in psychology: the experience of implementing augmented and virtual reality in psychological practice” was implemented in the structure of the relevant course. The corresponding module combined Hardiness Enhancing Lifestyle Program and components of mobile applications with AR technology (figure 3). The course was monitored and feedback was provided through the Moodle platform, the Zoom program. The psychodiagnostic survey was conducted using the Google form. Respondents were also asked to conduct a self-analysis of the effectiveness of the Hardiness Enhancing Lifestyle Program with augmented reality elements using the SafeDiary mobile application [55].

In order to evaluate the effectiveness of the integrative implementation of the Hardiness Enhancing Lifestyle Program, HELP using AR technology a repeated diagnostic study was conducted with Google Forms. The results of correctional and post-correctional activities are presented in figures 4, 5.

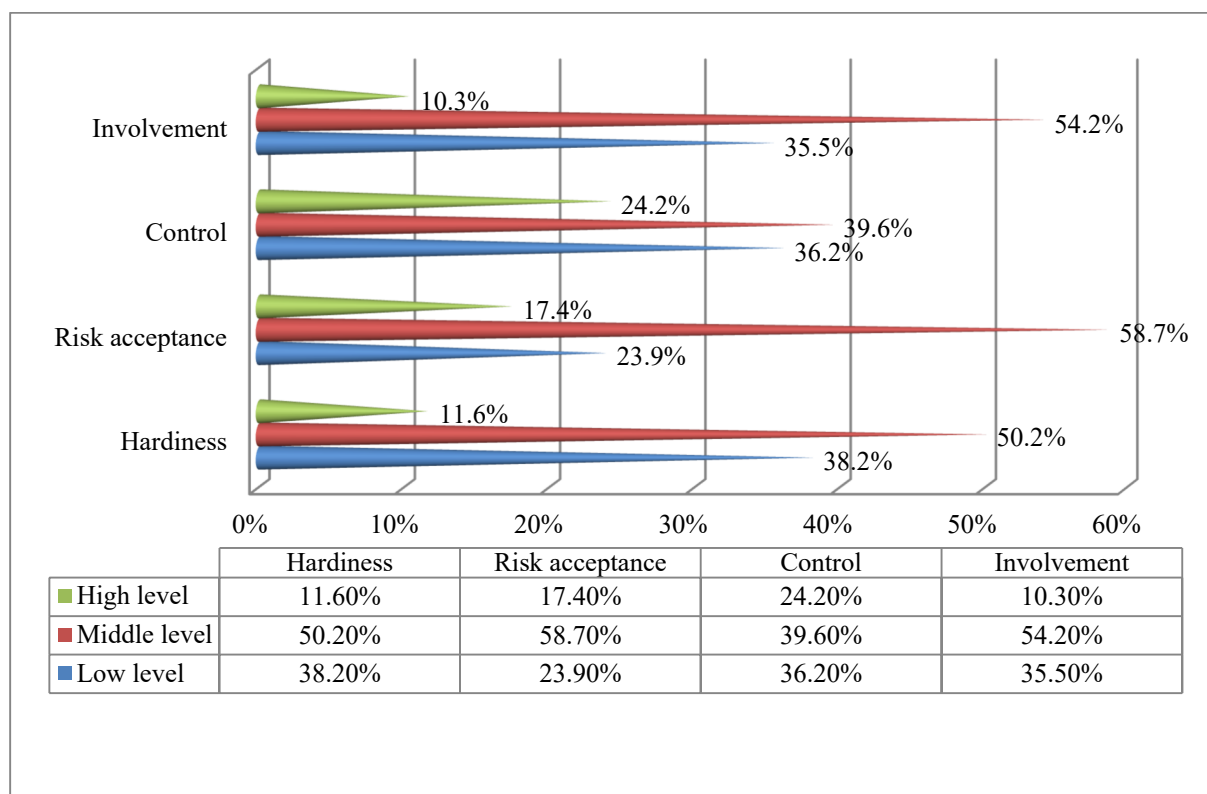


Figure 4. Indicators of the development of the components of the vitality of the individual before the implementation of the program with elements of augmented reality.

After the implementation of the Hardiness Enhancing Lifestyle Program, HELP using AR technologies, according to the obtained data, a significant increase in the development of components of hardiness was revealed. To determine the significance of the changes that occurred after the implementation of the program with elements of AR technology, we used the G-criterion. The G criterion is intended for establishment of the general direction of shift of the investigated feature. First, we formulate hypotheses. H_0 : the significance of shifts in the typical direction does not exceed the significance of shifts in the atypical direction. H_1 : the significance of shifts in the typical direction exceeds the significance of shifts in the atypical direction.

After the implementation of the program, the absolute number of respondents with a high (29.7%) and medium (61.2%) level of overall hardiness increased. Also, the results of correlation analysis revealed that at $n = 108$ typical shift is positive. Negative shifts are 32.

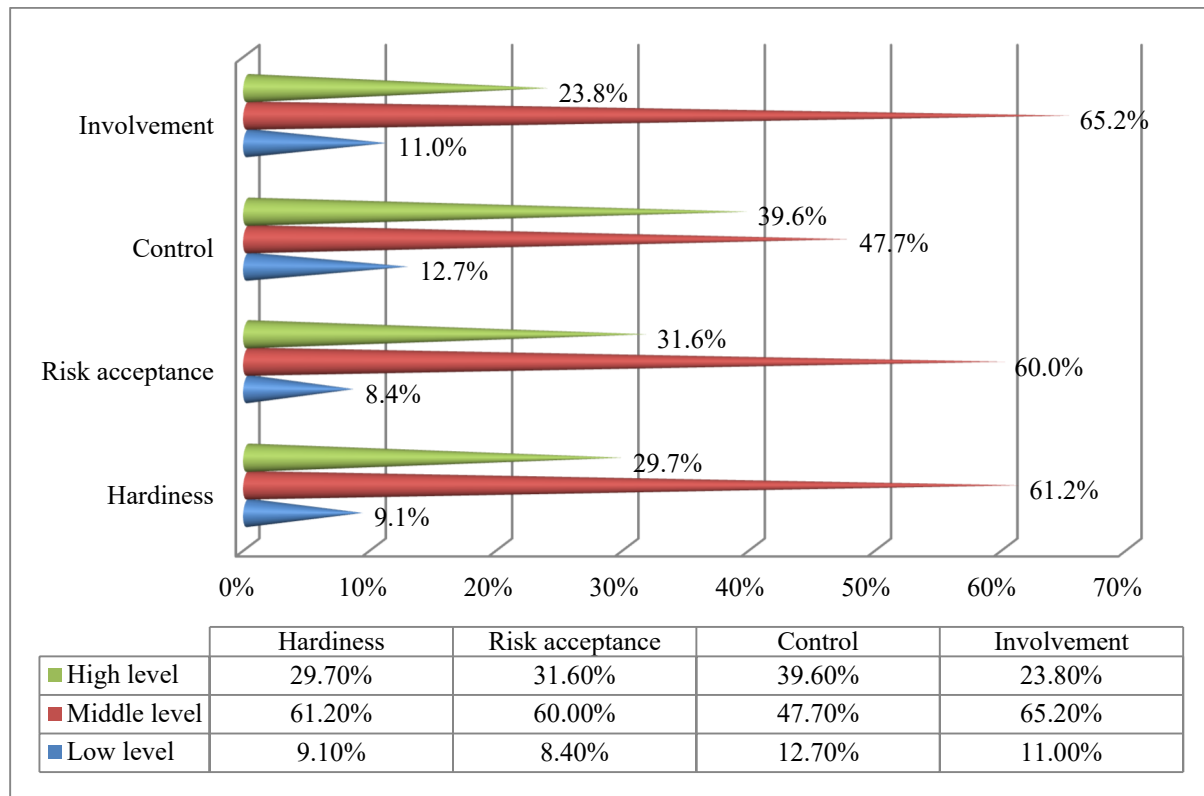


Figure 5. The dynamics of development of the components of vitality of the individual after the implementation of the program with elements of augmented reality.

$$G_{crt} = \begin{cases} 45 (\rho \leq 0,05) \\ 42 (\rho \leq 0,01) \end{cases}, G_{emp.} - \text{the number of atypical shifts, i.e. } G_{emp.} = 32, G_{emp.} < G_{crt}.$$

Accordingly, H_0 is rejected and H_1 is accepted. Thus, positive changes have been confirmed as a result of the implementation of the Enhancing Lifestyle Program, HELP with augmented reality component. The increase in indicators on the scale of “involvement” indicates an increase in motivation for self-realization, the desire of respondents to self-realization and self-improvement, constructive use of internal resources and internalization of experience. The dominance of medium (47.7%) and high (39.6%) levels on the scale of “control” after the implementation of the Hardiness Enhancing Lifestyle Program, HELP with elements of AR technology indicates the development of emotional self-regulation skills, updating the search for ways to influence the results of stress change, as opposed to falling into a state of helplessness and passivity. The percentage on the scale of “risk acceptance” also increased significantly – medium level (60%), high level (31.6%). Accordingly, respondents have increased motivation for the process of transformation and mastery of their own emotional states, based on openness to the new, willingness to act actively in a stressful situation (the use of resilient coping strategies); strengthening the immune response through mental and physical mobilization; strengthening responsibility and care for one's own health; search for effective social support that will contribute to the process of transformation of self-mastery, through the development of communication skills. Thus, in the process of interdisciplinary research proved the effectiveness of integrated use of Hardiness Enhancing Lifestyle Program, HELP and AR technologies in the process of developing the hardiness of the future as a dominant component of effective professional self-realization.

4. Conclusions and prospects for further research

The analysis of available sources allows us to define hardiness as a system of personal beliefs that promotes the willingness of the subject to participate in situations of increased complexity, control them,

manage them, be able to perceive even negative events as experience and successfully cope with them [12]. Based on this, we can talk about the features of a resilient personality as a holistic system of interaction with the world. A resilient person is a person who has resilient beliefs (involvement, control, risk), who leads a resilient lifestyle (maintains his physical and mental health), uses resilient coping to overcome stressful and difficult life situations [1]. The main components of the concept of hardiness are considered to be strong character, sense of purpose, optimism. Hardiness, based on individual and personal (natural) properties (extraversion, spontaneity, introversion and anxiety), which are based on innate features of the nervous system and mediate social activity, is more manifested in the ability to create personally meaningful meaning of life and reality. Hardiness, as a characteristic that reflects the ability of the subject to find a degree of compliance with existing conditions, determines a person's protection from various threatening influences associated with human perceptions of the ability to successfully implement the behavior necessary to achieve expected results, overcome negative environmental influences [18]. Psychological phenomena such as optimism, dispositional hope, integrity of the locus of control, high self-esteem, focus on the present and the future play an important role in a person's positive assessment of his life and his choice of productive strategies in crisis situations. As part of the implementation of competency and subject-oriented approach, in accordance with the concept of BYOD, Hardiness Enhancing Lifestyle Program, HELP with elements of AR technology was introduced in the scientific and practical online course "Modern practice-oriented technologies in education", which includes a module "Innovative ICT in psychology: experience in implementing augmented and virtual reality in psychological practice". According to the results of the obtained empirical data the efficiency of using innovative AR technologies in the structure of mobile applications in the process of development of components of hardiness of the personality of the future specialist is proved.

Prospect for further research is the analysis of the results of integrated implementation of AR technologies in the practice of higher education in order to optimize the training of future professionals of a "new format" who are capable of competitive self-realization in a changing information transformation.

Acknowledgements

The interdisciplinary research was conducted as part of research work that was carried out 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" (the state registration number 0120U101970).

References

- [1] Abdollahi A, Panahipour S, Tafti M A and Allen K A 2020 Academic hardiness as a mediator for the relationship between school belonging and academic stress *Psychology in the Schools* **57** 823–32 URL <https://doi.org/10.1002/pits.22339>
- [2] Allred K D and Smith T W 1989 The hardy personality: Cognitive and physiological responses to evaluative threat *Journal of Personality and Social Psychology* **56** 257–266 URL <https://content.apa.org/doi/10.1037/0022-3514.56.2.257>
- [3] Bailenson J N, Swinth K, Hoyt C, Persky S, Dimov A and Blascovich J 2005 The Independent and Interactive Effects of Embodied-Agent Appearance and Behavior on Self-Report, Cognitive, and Behavioral Markers of Copresence in Immersive Virtual Environments *Presence: Teleoperators and Virtual Environments* **14** 379–93 URL <https://doi.org/10.1162/105474605774785235>
- [4] Bartone P T, Valdes J J and Sandvik A 2016 Psychological hardiness predicts cardiovascular health *Psychology, Health and Medicine* **21** 743–49 URL <https://doi.org/10.1080/13548506.2015.1120323>
- [5] Baus O and Bouchard S 2014 Moving from Virtual Reality Exposure-Based Therapy to Augmented Reality Exposure-Based Therapy: A Review *Frontiers in Human Neuroscience* **8**

- 112 URL <https://doi.org/10.3389/fnhum.2014.00112>
- [6] Betensky J D and Contrada R J 2010 Depressive symptoms, trait aggression, and cardiovascular reactivity to a laboratory stressor *Annals of Behavioral Medicine* **39** 184–91 URL <https://doi.org/10.1007/s12160-010-9176-6>
- [7] Botella C, Baños R M, Villa H, Perpiñá C and García-Palacios A 2000 Virtual reality in the treatment of claustrophobic fear: A controlled, multiple-baseline design *Behavior Therapy* **31** 583–95 URL [https://doi.org/10.1016/S0005-7894\(00\)80032-5](https://doi.org/10.1016/S0005-7894(00)80032-5)
- [8] Bower M, Howe C, McCredie N, Robinson A and Grover D 2014 Augmented Reality in education – cases, places and potentials *Educational Media International* **51** 1–15 URL <https://doi.org/10.1080/09523987.2014.889400>
- [9] Brengman M, Willems K and Van Kerrebroeck H 2018 Can't touch this: the impact of augmented reality versus touch and non-touch interfaces on perceived ownership *Virtual Reality* **23** 269–80 URL <https://doi.org/10.1007/s10055-018-0335-6>
- [10] Burov O Yu, Kiv A E, Semerikov S O, Striuk A M, Striuk M I, Kolgatina L S and Oliynyk I V 2020 AREdu 2020 – How augmented reality helps during the coronavirus pandemic *CEUR Workshop Proceedings* **2731** 1–46
- [11] Carmigniani J, Furht B, Anisetti M, Ceravolo P, Damiani E and Ivkovic M 2010 Augmented reality technologies, systems and applications *Multimedia Tools and Applications* **51** 341–77 URL <https://doi.org/10.1007/s11042-010-0660-6>
- [12] Cash M L and Gardner D 2011 Cognitive hardiness, appraisal and coping: comparing two transactional models *Journal of Managerial Psychology* **26** 646–64 URL <https://doi.org/10.1108/02683941111181752>
- [13] Chang HY, Wu HK and Hsu YS 2013 Integrating a mobile augmented reality activity to contextualize student learning of a socioscientific issue *British Journal of Educational Technology* **44** E95–E99 URL <https://doi.org/10.1111/j.1467-8535.2012.01379.x>
- [14] Cheng YH, Tsai CC and Liang JC 2019 Academic hardiness and academic self-efficacy in graduate studies *Higher Education Research & Development* **38** 907–21 URL <https://doi.org/10.1080/07294360.2019.1612858>
- [15] Chin KY, Wang CS and Chen YL 2018 Effects of an augmented reality-based mobile system on students' learning achievements and motivation for a liberal arts course *Interactive Learning Environments* **27** 927–41 URL <https://doi.org/10.1080/10494820.2018.1504308>
- [16] Cipresso P, Giglioli I A C, Raya M A and Riva G 2018 The Past, Present, and Future of Virtual and Augmented Reality Research: A Network and Cluster Analysis of the Literature *Frontiers in Psychology* **9** 2086 URL <https://doi.org/10.3389/fpsyg.2018.02086>
- [17] Corso-de-Zúñiga S, Moreno-Jiménez B, Garrosa E, Blanco-Donoso L M and Carmona-Cobo I 2017 Personal resources and personal vulnerability factors at work: An application of the Job Demands-Resources model among teachers at private schools in Peru *Current Psychology* **39** 326–36 URL <https://doi.org/10.1007/s12144-017-9766-6>
- [18] Creed P A, Conlon E G and Dhaliwal K 2013 Revisiting the Academic Hardiness Scale *Journal of Career Assessment* **21** 537–54 URL <https://doi.org/10.1177/1069072712475285>
- [19] del Amo I F, Erkoyuncu J A, Roy R, Palmarini R and Onoufriou D 2018 A systematic review of Augmented Reality content-related techniques for knowledge transfer in maintenance applications *Computers in Industry* **103** 47–71 URL <https://doi.org/10.1016/j.compind.2018.08.007>
- [20] Delahaij R, Gaillard A W K, van Dam K 2010 Hardiness and the response to stressful situations: Investigating mediating processes *Personality and Individual Differences* **49** 386–90 URL <https://doi.org/10.1016/j.paid.2010.04.002>
- [21] Dolbier C L, Cocke R R, Leiferman J A, Steinhardt M A, Schapiro S J, Nehete P N, Perlman J E and Sastry J 2001 Differences in Functional Immune Responses of High vs. Low Hardy Healthy Individuals *Journal of Behavioral Medicine* **24** 219–29 URL <https://doi.org/10.1023/A:1010762606006>

- [22] Dos Santos A B, Dourado J B and Bezerra A 2016 ARToolkit and Qualcomm Vuforia: An Analytical Collation *Proceedings - 18th Symposium on Virtual and Augmented Reality, SVR 2016* pp 229–33 URL <https://doi.org/10.1109/SVR.2016.46>
- [23] Eschleman K J, Bowling N A and Alarcon G M 2010 A meta-analytic examination of hardiness *International Journal of Stress Management* **17** 277–307 URL <https://psycnet.apa.org/doi/10.1037/a0020476>
- [24] Hofman N L, Simons R M, Simons J S and Hahn A M 2019 The Role of Emotion Regulation in the Relationship Between Trauma and Health-Related Outcomes *Journal of Loss and Trauma* **24** 197–212 URL <https://doi.org/10.1080/15325024.2018.1460528>
- [25] Hystad S W, Eid J, Johnsen B H, Laberg J C and Bartone P T 2009 Psychometric properties of the revised Norwegian dispositional resilience (hardiness) scale *Scandinavian Journal of Psychology* **51** 237–45 URL <https://doi.org/10.1111/j.1467-9450.2009.00759.x>
- [26] Kaiser R, Schatsky D 2017 For more companies, new ways of seeing *Deloitte Insights* URL <https://www2.deloitte.com/us/en/insights/focus/signals-for-strategists/augmented-and-virtual-reality-enterprise-applications.html>
- [27] Karagiannopoulou E and Kamtsios S 2016 Multidimensionality vs. unitary of academic hardiness: An under explored issue...? *Learning and Individual Differences* **51** 149–56 URL <https://doi.org/10.1016/j.lindif.2016.08.008>
- [28] Kiv A E, Shyshkina M P, Semerikov S O, Striuk A M and Yechkalo Yu V 2020 AREdu 2019 – How augmented reality transforms to augmented learning *CEUR Workshop Proceedings* **2547** 1–12
- [29] Kobasa S C, Maddi S R and Kahn S 1982 Hardiness and health: A prospective study *Journal of Personality and Social Psychology* **42** 168–77 URL <https://doi.org/10.1037/0022-3514.42.1.168>
- [30] Kolomoiets T H and Kassim D A 2018 Using the Augmented Reality to Teach of Global Reading of Preschoolers with Autism Spectrum Disorders *CEUR Workshop Proceedings* **2257** 237–46
- [31] Kowalski C M and Schermer J A 2018 Hardiness, Perseverative Cognition, Anxiety, and Health-Related Outcomes: A Case for and Against Psychological Hardiness *Psychological Reports* **122** 2096–118 URL <https://doi.org/10.1177%2F0033294118800444>
- [32] Kramarenko T H, Pylypenko O S and Zaselskiy V I 2020 Prospects of using the augmented reality application in STEM-based Mathematics teaching *CEUR Workshop Proceedings* **2547** 130–44
- [33] Lavrentieva O O, Arkhypov I O, Krupskiy O P, Velykodnyi D O and Filatov S V 2020 Methodology of using mobile apps with augmented reality in students' vocational preparation process for transport industry *CEUR Workshop Proceedings* **2731** 143–62
- [34] Leontev D A and Rasskazova E I 2006 *Test zhiznesteikosti (Vitality test)* (Moscow: Smysl) p 63
- [35] López W L G, Cuji B R, Abásolo M J and Sailema G L A 2019 Technological acceptance model (TAM) using augmented reality in university learning scenarios *Iberian Conference on Information Systems and Technologies, CISTI, 2019 – June* URL <https://doi.org/10.23919/CISTI.2019.8760784>
- [36] Maddi S R, Harvey R H, Khoshaba D M, Fazel M and Resurreccion N 2009 The Personality Construct of Hardiness, IV: Expressed in Positive Cognitions and Emotions Concerning Oneself and Developmentally Relevant Activities *Journal of Humanistic Psychology* **49** 292–305 URL <https://doi.org/10.1177%2F0022167809331860>
- [37] Maddi S R, Matthews M D, Kelly D R, Villarreal B J, Gundersen K K and Savino S C 2017 The Continuing Role of Hardiness and Grit on Performance and Retention in West Point Cadets *Military Psychology* **29** 355–358 URL <https://doi.org/10.1037/mil0000145>
- [38] McCalister K T, Dolbier C L, Webster J A, Mallon M W and Steinhardt M A 2006 Hardiness and Support at Work as Predictors of Work Stress and Job Satisfaction *American Journal of Health Promotion* **20** 183–91 URL <https://doi.org/10.4278%2F0890-1171-20.3.183>
- [39] Midak L, Kravets I, Kuzyshyn O, Baziuk L and Buzhdyhan K 2021 Specifics of using image

- visualization within education of the upcoming chemistry teachers with augmented reality technology *Journal of Physics: Conference Series* In press
- [40] Mintii I S and Soloviev V N 2018 Augmented Reality: Ukrainian Present Business and Future Education *CEUR Workshop Proceedings* **2257** 227–31
- [41] Ndlovu V and Ferreira N 2019 Students' psychological hardiness in relation to career adaptability *Journal of Psychology in Africa* **29** 598–604 URL <https://doi.org/10.1080/14330237.2019.1689468>
- [42] Osadchy V V, Chemerys H Y, Osadcha K P, Kruhlyk V S, Koniukhov S L and Kiv A E 2020 Conceptual model of learning based on the combined capabilities of augmented and virtual reality technologies with adaptive learning systems *CEUR Workshop Proceedings* **2731** 328–40
- [43] Osadchy V V, Valko N V and Kuzmich L V 2021 Using augmented reality technologies for STEM education organization *Journal of Physics: Conference Series* In press
- [44] Osadchy V V, Varina H B, Osadcha K P, Prokofieva O O, Kovalova O V and Kiv A E 2020 Features of implementation of modern AR technologies in the process of psychological and pedagogical support of children with autism spectrum disorders *CEUR Workshop Proceedings* **2731** 263–82
- [45] Ouellette Kobasa S C, Maddi S R, Puccetti M C and Zola M A 1985 Effectiveness of hardiness, exercise and social support as resources against illness *Journal of Psychosomatic Research* **29** 525–33 URL [https://doi.org/10.1016/0022-3999\(85\)90086-8](https://doi.org/10.1016/0022-3999(85)90086-8)
- [46] Proskura S L, Lytvynova S G, Kronka O P and Demeshkant N 2020 Mobile Learning Approach as a Supplementary Approach in the Organization of the Studying Process in Educational Institutions *CEUR Workshop Proceedings* **2732** 650–64
- [47] Rashevskaya N V and Soloviev V N 2018 Augmented Reality and the Prospects for Applying Its in the Training of Future Engineers *CEUR Workshop Proceedings* **2257** 192–7
- [48] Rashevskaya N V, Semerikov S O, Zinonos N O, Tkachuk V V and Shyshkina M P 2020 Using augmented reality tools in the teaching of two-dimensional plane geometry *CEUR Workshop Proceedings* **2731** 79–90
- [49] Sandvik A M, Bartone P T, Hystad S W, Phillips T M, Thayer J F and Johnsen B H 2013 Psychological hardiness predicts neuroimmunological responses to stress *Psychology, Health and Medicine* **18** 705–713 URL <https://doi.org/10.1080/13548506.2013.772304>
- [50] Semenikhina E, Drushlyak M, Bondarenko Y, Kondratiuk S and Dehtiarova N 2019 Cloud-based service GeoGebra and its use in the educational process: The BYOD-approach *TEM Journal* **8** 65–72 URL <https://doi.org/10.18421/TEM81-08>
- [51] Semerikov S, Chukharev S, Sakhno S, Striuk A, Osadchy V, Solovieva V, Vakaliuk T, Nechypurenko P, Bondarenko O and Danylchuk H 2020 Our sustainable coronavirus future *E3S Web of Conferences* **166** 00001 URL <https://doi.org/10.1051/e3sconf/202016600001>
- [52] Semerikov S, Striuk A, Striuk L, Striuk M and Shalatska H 2020 Sustainability in Software Engineering Education: a case of general professional competencies *E3S Web of Conferences* **166** 10036 URL <https://doi.org/10.1051/e3sconf/202016610036>
- [53] Shepiliev D S, Semerikov S O, Yechkalo Yu V, Tkachuk V V, Markova O M, Modlo Ye O, Mintii I S, Mintii M M, Selivanova T V, Maksyshko N K, Vakaliuk T A, Osadchy V V, Tarasenko R O, Amelina S M and Kiv A E 2021 Development of career guidance quests using WebAR *Journal of Physics: Conference Series* In press
- [54] Skorenkyy Yu, Kozak R, Zagorodna N, Kramar O and Baran I 2021 Use of augmented reality-enabled prototyping of cyber-physical systems for improving cyber-security education *Journal of Physics: Conference Series* In press
- [55] Sun J C Y and Rueda R 2011 Situational interest, computer self-efficacy and self-regulation: Their impact on student engagement in distance education *British Journal of Educational Technology* **43** 191–204 URL <https://doi.org/10.1111/j.1467-8535.2010.01157.x>
- [56] Valko N and Osadchy V 2020 Education individualization by means of artificial neural networks

- E3S Web of Conferences* **166** 10021 URL <https://doi.org/10.1051/e3sconf/202016610021>
- [57] Weigold I K, Weigold A, Kim S, Drakeford N M and Dykema S A 2016 Assessment of the psychometric properties of the Revised Academic Hardiness Scale in college student samples *Psychological Assessment* **28** 1207–19 URL <https://doi.org/10.1037/pas0000255>
- [58] Wu HK, Lee S WY, Chang HY and Liang JC 2013 Current status, opportunities and challenges of augmented reality in education *Computers & Education* **62** 41–9 URL <https://doi.org/10.1016/j.compedu.2012.10.024>
- [59] Zelinska S O, Azaryan A A and Azaryan V A 2018 Investigation of Opportunities of the Practical Application of the Augmented Reality Technologies in the Information and Educative Environment for Mining Engineers Training in the Higher Education Establishment *CEUR Workshop Proceedings* **2257** 204–14
- [60] Zinonos N O, Vihrova E V and Pikilnyak A V 2018 Prospects of Using the Augmented Reality for Training Foreign Students at the Preparatory Departments of Universities in Ukraine *CEUR Workshop Proceedings* **2257** 87–92
- [61] Ulrich R S, Simons R F, Losito B D, Fiorito E, Miles M A and Zelson M 1991 Stress recovery during exposure to natural and urban environments *Journal of Environmental Psychology* **11** 201–30 URL [https://doi.org/10.1016/S0272-4944\(05\)80184-7](https://doi.org/10.1016/S0272-4944(05)80184-7)