RESEARCH ON THE DEVELOPMENT OF PROFESSIONAL NAVIGATIONAL COMPETENCE OF FUTURE SHIP NAVIGATORS BY MIXED REALITY SIMULATION TECHNOLOGIES

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Abstract. Continuous and rapid development of professional information, the emergence of new mechanisms, technologies require professional education to accelerate the content and development of new pedagogical technologies that guarantee the training of a specialist who has practical competencies at the time of training completion. The article states that professional navigational competence is a dynamic and multidimensional concept. The content changes in accordance with the processes taking place in society and the field of navigation. The article describes the results of an experimental study on the implementation of the method of future navigators' professional navigational competence formation with mixed reality simulation technologies. The following criteria of formation of professional navigational competence are distinguished: motivational, cognitive-content, activity, evaluation-reflexive ones. The study was conducted on the basis of the Kherson State Maritime Academy, in the experimental group 114 cadets were involved, in the control – 112 ones. For the sake of objectivity of the experiment and the reliability of the results of the study, we tried to achieve that the experimental and control group were the most typical and equal in the initial parameters: age, number, sex and level of training. In order to study the formation of professional navigational competence and, accord-

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ingly, to conduct an experimental study determined its levels of formation, criterion-level apparatus. Pearson's chi-squared test was used to confirm the absence of statistical differences between control group and experimental group. The data of the experimental research are analyzed, which testify to the efficiency of application in the educational process of institutions of higher maritime education of mixed reality simulated technologies on the example of Kherson State Maritime Academy. The study of the formation of future navigators' PNC by the motivational, cognitive, activity and evaluation-reflexive criterions is showed at the beginning of the experiment, where the nature of motives had almost the same orientation in all the study groups, after implementation of its methods the indicators increased significantly at high and good levels in the EG and decreased in satisfactory level.

The results of the experimental work allow to conclude that the proposed model of the development of professional navigational competence of future navigators with simulated mixed-reality technologies allows to optimize the process of professional training and contributes to the effective formation of professional navigational competence of maritime specialists.

1. Introduction

Ongoing and rapid development of professional information, the emergence of new digital technology, ICT requires professional maritime education to rapidly update the content and development of new pedagogical technologies that guarantee the training of a maritime professional who has practical competences at the time of completion of training. The problem of professional competence's formation of future ship navigators is the training of a specialist who has a high level of professional training, thorough knowledge of professional-theoretical and general professional disciplines, developed professionally important qualities, a high level of digital competence, and who is able to work independently and creatively. Therefore, the need for the professional navigational competence (PNC) formation of future ship navigators has arisen, which is conditioned by the justification and implementation of certain pedagogical conditions. In connection with this, a necessary step is to raise the quality standards of the future navigators' training, who must be ready to work using various information in digital form, be able to choose effective forms of ship management for the safety of navigation, be responsible for management decisions. Require-

ments for the content of maritime education are determined by the regulations of the International Maritime Organization (IMO). The problem of improving the quality of maritime professional education has become urgent in connection with the implementation of the Manila Amendments of Standards of Training, Certification and Watchkeeping of Seafarers in 2010. The 2010 Manila Amendments specified the minimum requirements for the skills at three levels of responsibility: management, operation, ancillary level, conditioned the implementation of the provisions of the amendments by enhancing the practical orientation of the educational process through the development of practical skills on simulators, regulated the use of modern electronic training methods. With the transition to new indicators of the quality of maritime education, which recognized competence, the problems of enhancing the practical orientation of professional education, the organization of productive independent work, the use of modern digital technologies in the educational process. In the system of higher education, the search for new well-directed professional practically oriented forms of training has begun, which aims to effectively ensure the formation of professional competencies of future maritime specialists on the basis of electronic, blended learning, continuous education, use of simulation technologies, simulators of augmented, mixed and virtual realities.

2. Analysis of recent research and publications

Analysis of the psychological and pedagogical literature has made it possible to establish that the modern theory and practice of higher pedagogical education has accumulated some experience, which covers various aspects of professional and pedagogical training of future ship navigators, the problem of professional training of future navigators is quite profound. The following issues have been investigated: implementation of blended training in the training of maritime specialists (Voloshinov S.) [3], formation of information culture of future navigators (Sherman M., Bezbach O.) [2], formation of professional competence in the process of study professional disciplines (Sokol I.) [8], formation of technical competence of navigators (Mussorina M.) [6], formation of foreign language competence and readiness for communication (Barsuk S., Yurzhenko A.) [1; 9]. But despite the researchers' attention, the formation of PNC by simulated mixed reality (MR) technologies remained.

In order to study the formation of PNC and, accordingly, to conduct an

experimental study to determine the levels of its formation, it is necessary to determine the criterion-level apparatus. Based on the content of training, taking into account professional requirements, we distinguish the following criteria for the formation of PNC: motivational, cognitive-content, activity and evaluation-reflexive one.

Thus, the objective of our article is coverage of the results of a forming pedagogical experiment on the formation of PNC of future ship navigators by mixed-reality simulation technologies.

3. Experimental study of future ship navigators' professional competence formation by mixed reality simulation technologies

The working hypothesis of the study is the assumption that the formation of PNC of future ship navigators will be improved if they implement the content, forms and methods of application of technologies that underlie the structural model of PNC formation of future navigators by means of MR simulation technologies and proposed pedagogical conditions. Pedagogical conditions for the formation of future navigators' PNC are: the development of professional thinking; introduction into the system of professional training of future ship navigators using the facilities of "KSMA Virtual Reality Vessel", development of teachers' digital competence.

3.1. Components of future navigators' PNC

In accordance with the content of PNC of future navigators, we have identified the following components:

1) motivational and personal one;
2) cognitive one;
3) procedural activity.

In order to study the problems and prospects of organizing the process of PNC formation of future navigators using MR simulation technologies, at the final stage of the experiment, diagnostics of PNC formation of future navigators was performed according to certain criteria. Conducting an experiment allows you to check the effectiveness of the proposed conditions in the educational process, to compare the importance of factors and to choose effective and optimal ones for certain pedagogical tasks. The theoretical analysis of the psychological and pedagogical literature on the problem of formation of PNC of future

navigators using MR simulation technologies has allowed to make assumptions that confirmed the need for experimental work, since in the professional pedagogy the application of MR simulation technologies is insufficiently studied, and also in connection with the effectiveness of the pedagogical conditions we have developed and with a view to implementing them in the practice of future navigators.

Taking into account the general requirements and methodological base of the research (competence, activity, systematic approaches), the purpose, tasks, stages and methods of experimental and experimental work were determined. The purpose of the pedagogical experiment is to test the validity of the theoretical provisions of the thesis and working hypothesis, pedagogical conditions for the formation of PNC of future navigators by simulation MR technologies in the process of training on the basis of the developed model. The experiment was done in the specific implementation of the educational process with the aim of forming PNC of future navigators by MR simulation technologies in the process of studying professional disciplines and checking the effectiveness of the proposed pedagogical conditions.

Experimental work has a complex character, and its main methods were determined by questionnaire, pedagogical observation, methods of expert assessments, summarizing the results of the study. Mathematical statistics methods were also used to determine the reliability of the data obtained [4].

3.2. Control and experimental groups distribution

Based on the topic of the study, future navigators were selected to participate in the experiment. For the experimental study, a parallel experiment was selected, which involved two groups: control and experimental one. The number of participants in the experimental verification in the control and experimental groups was 226 cadets, which provides the probability of statistically significant indicators of the effectiveness of PNC formation of future navigators by MR simulation technologies. The study included 112 control group cadets and 114 experimental group cadets.

For the sake of objectivity of the experiment and the reliability of the results of the study, we tried to achieve that the experimental and control

group were the most typical and equal in the initial parameters: age, number, sex and level of training.

Comparison of the distributions of CG and EG cadets prior to the beginning of the experimental training was performed according to the cadets' success rates (carrying out control works), which gave reason to claim that their distributions are approximately the same (Table 1).

Table 1

Distribution of future ship navigators by performance level

Groups	Number of cadets			
	Satisfactory	Good	High	Total
CG	64-57,14%	31-27,68%	17-15,18%	112-100%
EG	3-55,26%	30-26,31%	2-18,42%	114-100%

Clearly, the distribution of future ship navigators by performance level is presented in Figure 1.

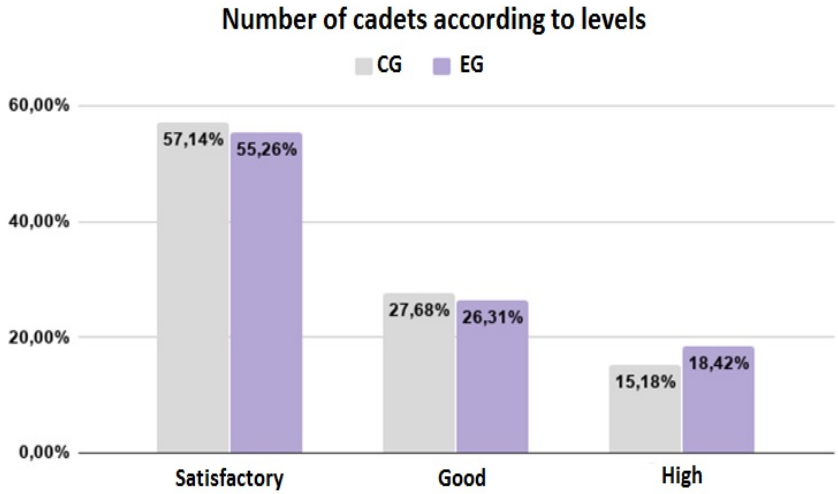

Figure 1. Histogram of cadets distribution (in percent) by level of cognitive component formation

3.3. Pearson's chi-squared test

We use Pearson's chi-squared test (χ^2) to confirm the absence of statistical differences between CG and EG. This test is used to compare the distribution of objects of two sets, subject to the following requirements: samples are random, independent, and the members of each sample are independent of each other [1]. Pearson's chi-squared test is effective in detecting differences in two samples of different volumes and does not require a clear definition of random distribution and other parameters. Calculate the value of ζ^2_{ex} by the formula [4, p. 101].

$$\zeta^2_{ex} = \frac{1}{n_1 n_2} \sum_{i=1}^{3} \frac{\left(n_1 Q_{2i} - n_2 Q_{1i}\right)^2}{Q_{1i} + Q_{2i}}$$

where n_1 and n_2 are volumes of control and experimental groups, Q_{1i} and Q_{2i} is the number of CG and EG objects of the groups that go into the category of the respective state of the investigated property ($i = 1$,2,3 which corresponds to satisfactory, good and high levels). After calculations according to formula above we get $\chi^2_{ex} = 0,42$. Critical value of ζ^2_{cr} for the level of significance $\alpha = 0,05$ and the number of degrees of freedom for our case is equal to $\nu = 3 - 1 = 2$ and $\chi^2_{cr} = 5,99$. So we found out that $\chi^2_{ex} < \chi^2_{0,05}$ $(0,42 < 5,99)$, which is a testament to the uniformity of the initial states of CG and EG. To determine the effectiveness of the hypothesis, it was necessary to obtain baseline data on the levels of formation of the main components of PNC, taking into account the peculiarities of their formation, as well as to trace the dynamics of development of PNC in the studied groups of cadets. For this purpose, a test experiment was conducted using the following methods: to check the formation of the motivational and personal component, observations were made to study motivation for professional activity, the desire for independent acquisition and updating of professional knowledge, especially the self-esteem of cadets, as well as questionnaires and interviews with them; to check the formation of the cognitive component, the results of performance level were studied, control work on the main professional disciplines was analyzed; to verify the formation of the procedural and activity component, the reports of shipboard practice and the results of successful interviews with the crewing companies were analyzed.

3.4. Curriculum analysis

Solving the problems of our study, there is a need to analyze the curriculum of future navigators who receive basic higher education in the field of knowledge 0701 "Transport and Transport Infrastructure" area of expertise "Maritime and River Transport" specialism "Navigation" according to Bachelor and Master Degree. The analysis was conducted on the basis of the Kherson State Maritime Academy, which trains specialists who can work in the crews of ships. According to the current List of specialties by which the higher education institutions of Ukraine are trained, each specialty has its own cycle of normative disciplines, which is common for a wide range of such specialties. Each candidate for the position of Chief Officer, regardless of form of study (full-time or part-time), must complete a planned and structured training program designed to assist the future crewmember in achieving the standard of competence in accordance with Table A-II / 2 of International convention on Standards of training, certification and watchkeeping (STCW) [5].

The objects of study of future navigators are the processes of navigation, navigational equipment and processes, systems of its maintenance, methods of processing and placing of cargoes on ships.

Thus, the whole system of future navigators' training is based on the standards of maritime higher education in accordance with national laws in the field of education and documents of the International Maritime Organization for the training of seafarers and navigation safety (STCW Code, STCW convention etc.) and the EU Commission.

The homogeneity of the groups was determined by the fact that they had one-on-one classroom training; time spent on studying each topic was the same, control of knowledge of performance level occurred in the same conditions.

The difference was that the training in the control group was carried out traditionally: the practical and independent work of students was carried out without the systematic use of MR simulation technologies, and in the experimental group ¬– through the developed system of the use of MR simulation technologies by means of "KSMA Virtual Reality Vessels".

To carry out an experimental verification of the effectiveness of the formation of PNC in future navigators, we have developed a plan for its implementation (Table 2).

Table 2

Plan for experimental verification

Stage's name	The target of the stage	Actions
Preparatory	Preparation of scientific and methodological support	1. Identification of contradictions, problematic aspects of the future training of future navigators in higher maritime education institutions. 2. Determination of the basis of the experiment, division of the sample into control and experimental groups. 3. Preparation of scientific and methodological materials of the experiment.
Ascertaining	Study and description of the current state of the educational process regarding the formation of PNC of future navigators	1. Study and description of the current state of the educational process regarding the formation of PNC of future navigators. 2. To study the state of the educational process on the formation of PNC of future navigators. 3. Processing, generalization and interpretation of received materials. 4. Highlighting of problematic issues in the content, forms, methods, results future navigators' training. 5. Determination of pedagogical conditions, development of a structural model, methods of PNC formation of future navigators by MR simulation technologies.
Formative	Testing of MR simulation technologies by the KSMA Virtual Reality Ship	1. Testing of set of pedagogical conditions and model of formation of PNC in educational process by MR simulation technologies. 2. Carrying out primary, intermediate and final measurements of the state of PNC formation in control and experimental groups. 3. Choice of methods of statistical processing of the obtained results.
Summarizing	Experimental confirmation of the effectiveness of the introduction of MR simulation technologies for the formation of PNC of future navigators	1. Use of statistical data processing methods to ensure the validity of the survey; 2. Comparison, analysis and interpretation of results on the formation of PNC. 3. Determining the effectiveness of the hypothesis and formulating conclusions. 4. Development of appropriate recommendations.

4. Diagnostic complex for studying the development of future ship navigators' PNC

During the experiment, we relied on the criterion base of the study, theoretical understanding of the substantive characteristics and specific features of the process of formation of future navigators' PNC in the process of professional training. Diagnostic tools were selected – techniques for objective measurement of PNC of future navigators.

The application of all methods made it possible to thoroughly investigate the problem of our study, to determine all its aspects and parameters. The proposed diagnostic complex (Table 3) enables the objective measurement of multifunctional PNC of future navigators.

Table 3

Diagnostic complex for studying the development of PNC of future navigators

Criteria	Characteristics	Methods of assessment
Motivational	Conscious attitude towards professional activity	Technique «Motivation of studying at university» (T. Ilyina)
	The need for professional development	Assessment scale of students' professional and psychological moral qualities (modified method by N. Kuzmina)
	Striving for the realization of their own abilities	Determination of motivation for success (by T. Ehlers method)
Cognitive	Level of professional knowledge acquisition (performance level)	Rector control works (complex)
	Level of mastering general scientific knowledge	Performance level of session
	Communicative skills	Interview results of Marlow Navigation crewing company
	Digital skills	Questionnaire "Level of cadets' digital competence"
Activity	Formation of professional skills	Assessments for practice Document analysis (analysis of shipboard practices, reviews fromcrewing companies, results of interviews with cadets)
	Ability to make effective decisions	
	Ability to work in team	
Evaluation-reflexive	Self-examination and self-assessment of professional activity	Studying students' self-esteem (G. Kazantseva questionnaire)

Thus, in order to check the effectiveness of PNC formation of future navigators by MR simulation technologies, we have developed an appropriate plan, described the basis of the experimental verification, determined the system of independent and dependent variables, selected a set of methods for carrying out certain measurements. A theoretical justification for the experimental verification of the model developed by us was also made [7].

4.1. Motivational criterion

We investigate the dynamics of changes in the levels of formation of PNC components of future ship navigators.

The study of the formation of future navigators' PNC by the motivational criterion is showed at the beginning of the experiment, where the nature of motives had almost the same orientation in all the study groups, after implementation of its methods the indicators increased significantly at high and good levels in the EG and decreased in satisfactory level.

The results of assessment of future ship navigators' levels of PNC formation by motivational criterion before and after the experiment's forming stage is shown in the table 4.

Table 4

Assessment of levels of PNC formation by motivational criterion before and after the forming phase of the experiment

Levels	Before the experiment				After the experiment			
	CG		EG		CG		EG	
	cadets	%	cadets	%	cadets	%	cadets	%
High	7	6,25	8	7,0	17	15,18	26	22,8
Good	42	37,5	37	32,5	58	51,78	68	59,65
Satisfactory	63	56,25	69	60,5	37	33,04	20	17,55

The graphical representation of results can be seen in Figure 2.

The tables indicate that the levels of PNC formation on the motivational criterion of future navigators by means of MR simulation technologies were not the same. Thus, in the cadets of the experimental group, the indicators are significantly different from those of the cadets of the control group:

– the number of cadets with a high level (7% – 22.8%) increased

– the number of cadets with good level (60.5% – 17.55 %).

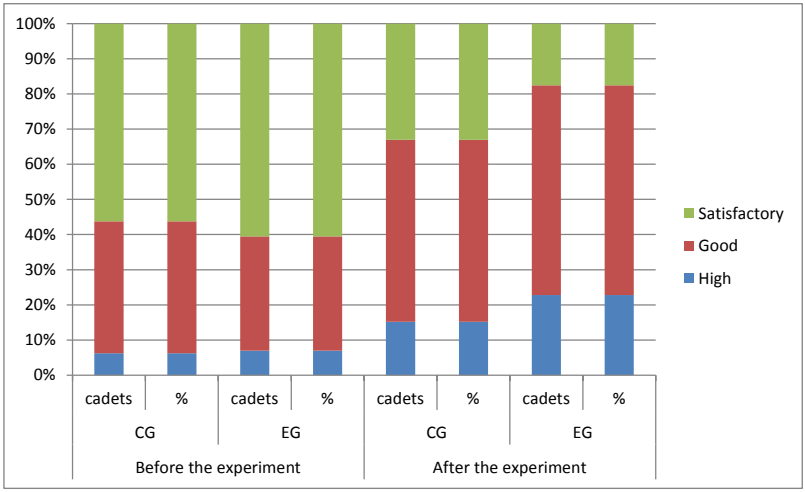

Figure 2. Graphical representation of the assessment of levels of PNC formation by motivational criterion before and after the forming phase of the experiment

In the control group there were less significant changes in the levels of PNC formation according to the motivational criterion:

– the number of high-level cadets increased from 6.25% to 15.18%;

– the number of cadets with an average level decreased from 56.25% to 33.04%;

– the number of students with a sufficient level increased to 51.78% from 37.5%.

We formulate statistical hypotheses: H_0 : the level of motivation for the formation of PNC in future navigators in the EG is not higher than in CG after the forming stage of the experiment.

H_1 : the level of motivation of future navigators' PNC formation in the EG is higher than in CG after the forming stage of the experiment.

According to the calculations χ^2_{ex} is equal to 7,73. Comparing our data $7,73 > 5,99\left(\chi^2_{ex} > \chi^2_{cr}\right)$ for $\alpha = 0,05$ we conclude that the hypothesis H_0 is declined. H_1 is accepted: the level of motivation for the formation of PNC of future navigators in the experimental group is higher than in the control group after the forming stage of the experiment for $\alpha = 0,05$.

4.2. Cognitive criterion

To assess the level of PNC formation on the cognitive criterion, the grades for the rectorial control works of professional disciplines, the level of successful completion of the session, the results of interviewing at the Marlow Navigation crewing company and the questionnaire "The level of digital competence formation of cadets".

The following indicators of the cognitive criterion were the participation of cadets in the selection of the Marlow Navigation crewing company, which together with the KSMA facilitates the organization of navigation practice by the cadets on the vessels under consideration by this company and the analysis of the level of digital competence of the cadets.

The dynamics of changes in the levels of PNC formation of future navigators by cognitive criterion is showed in Table 5.

The results of the experimental group are far from the results of control group.

Table 5

Assessment of levels of PNC formation by cognitive criterion before and after the forming phase of the experiment

Levels	Before the experiment				After the experiment			
	CG		EG		CG		EG	
	cadets	%	cadets	%	cadets	%	cadets	%
High	9	8,04	7	6,14	11	9,82	21	18,42
Good	27	24,11	27	23,68	35	31,25	44	38,6
Satisfactory	76	67,85	80	70,18	66	58,93	49	42,98

Thus, the number of cadets with a high level in CG increased from 8.04% to 9,82%, and with good level – decreased from 67,85% to 58,93%.

In contrast to the control group in the experimental group, there was a positive dynamics of indicators of PNC formation: the number of cadets with a high level increased from 6,14% to 18,42%, with an average level decreased to 42,98% from 70,18%.

The graphical representation of results can be seen in figure 3.

According to the calculations χ^2_{ex} is equal to 6,65. Comparing our data $6,65 > 5,99\left(\chi^2_{ex} > \chi^2_{cr}\right)$ for $\alpha = 0,05$ we conclude that the hypothesis H_0 is declined. H_1 is accepted: the level of cognitive criterion for the formation of

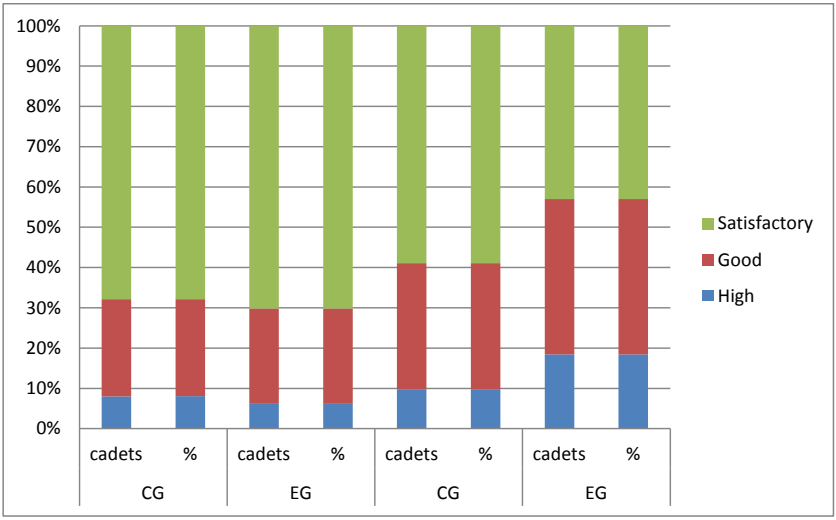

Figure 3. Graphical representation of the assessment of levels of PNC formation by cognitive criterion before and after the forming phase of the experiment

PNC of future navigators in the experimental group is higher than in the control group after the forming stage of the experiment for $\alpha = 0,05$. The cadets of the experimental group demonstrated the systematic professional theoretical knowledge, as well as demonstrated the ability to organize the development of professional thinking at the level of all components of the educational process. In the course of the experimental work, qualitative knowledge of professional terminology, processes and phenomena was formed in cadets of EG.

In CG there were insignificant changes in the indicators of the levels of PNC formation according to the indicators of the cognitive criterion, due to the fragmentary approach to the formation of knowledge on the development of professional thinking of cadets during the traditional study of professional disciplines, the lack of purposeful work on the formation of PNC.

CG students showed low knowledge of professional disciplines when writing test papers.

Most cadets were unable to properly complete the tasks of using information, analysis and synthesis, evaluation.

According to the results of the experiment, implementation of the model of future navigators' PNC formation by means of MR simulation technologies contributed to a significant increase in the level of their professional knowledge.

4.3. Activity complex

The next criterion, which was presented in the system of the diagnostic complex – activity, indicators of which were the formation of professional skills, the ability to make effective decisions and the ability to work in a team.

We summarized the estimates for shipboard practice and navigation practice reports, the crewing companies' feedback on the level of training of future navigators.

The data in table 6 indicate that the levels of formation of the process-activity component of PNC on the activity criterion of future ship navigators by means of MR simulation technologies at the end of the experiment are significantly different.

Table 6

Evaluation of levels of PNC formation by activity criterion before and after the forming stage of the experiment

Levels	Before the experiment				After the experiment			
	CG		EG		CG		EG	
	cadets	%	cadets	%	cadets	%	cadets	%
High	7	6,3	6	5,2	15	13,39	23	20,18
Good	21	18,7	26	22,8	39	34,82	52	45,6
Satisfactory	84	75,0	82	72,0	58	51,79	39	34,22

The graphical representation of results can be seen in Figure 4.

Thus, in the experimental group the indicators differ from those of the control group: the number of cadets with a high level increased (it was 5,2% – it became 20,18%) and the number of cadets with satisfactory level decreased (it was 72,0% – it became 34,22%). In the control group, there were less significant changes in the levels of PNC formation:

– the number of high-level cadets increased from 6,3% to 13,39%;

– the number of students with satisfactory level decreased from 75,0% to 51,79%;

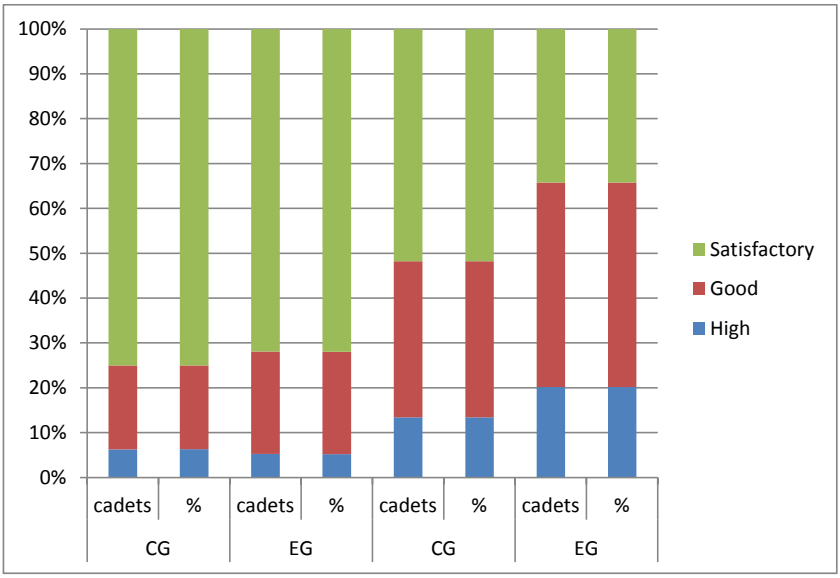

Figure 4. Graphical representation of evaluation of levels of PNC formation by activity criterion before and after the forming stage of the experiment

– the number of cadets with good level increased to 34,82% from 18,7%.

The cadets of the experimental group, unlike the cadets of the control group, demonstrated the ability to act in dangerous situations and in the presence of navigational hazards, the collective responsibility for the vessel, the ability to clearly perform and give commands. Diagnosis of the level of PNC formation according to indicators of the activity criterion showed that at the initial stage of the experiment revealed a rather low level of professional practical skills formation. The analysis of the results of the experiment's forming stage showed the effectiveness of implementation of our model of future navigators' PNC formation by means of MR simulation technologies and methods of its implementation in the process of future navigators' training. According to the calculations χ^2_{ex} is equal to 7,24. Comparing the data $7,24 > 5,99\left(\chi^2_{ex} > \chi^2_{cr}\right)$ for $\alpha = 0,05$, we conclude that the hypothesis H_0 is declined. H_1 is accepted: the level of activity criterion

for the formation of PNC of future navigators in the experimental group is higher than in the control group after the forming stage of the experiment for $\alpha = 0,05$.

4.4. Evaluation-reflexive complex

Generalized results of the levels of PNC formation by the evaluation-reflexive criterion before and after the forming stage of the experiment are presented in the table 6.

Table 6

Evaluation of equal formation of PNC for the evaluation-reflexive criterion before and after formulation of the experiment stage

Levels	Before the experiment				After the experiment			
	CG		EG		CG		EG	
	cadets	%	cadets	%	cadets	%	cadets	%
High	7	6,2	8	7	17	15,18	24	21,05
Good	38	34,0	43	37,7	44	39,29	58	50,88
Satisfactory	67	59,8	63	55,3	51	45,53	32	28,07

The graphical representation of results can be seen in figure 5.

The results of the study of the formation of PNC according to the evaluation-reflexive criterion of future navigators testify to its insufficient level

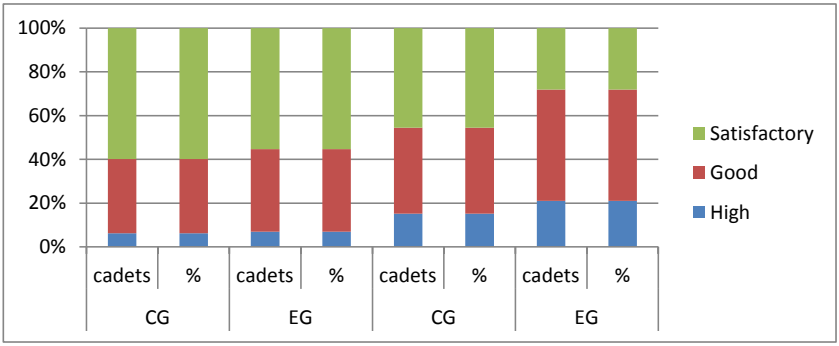

Figure 5. Graphical representation of the e valuation of equal formation of PNC for the evaluation-reflexive criterion before and after formulation of the experiment stage

at the beginning of the experiment: high (7% in EC and 6,2% – CG), good (37,7% in EC and 34% – CG), satisfactory (55,3% in EC and 59,8% in CG). It is good and satisfactory level of PNC formation according to the evaluation-reflexive criterion which increased. This indicates that the cadets have poorly developed knowledge and skills of self-examination and self-control, they have not demonstrated the ability to consciously control and predict the results of their activities. After the experiment, the data changed significantly. Thus, the results of diagnostics in the experimental group increased the number of cadets, which is dominated by a high level of PNC formation according to the evaluation-reflexive criterion (compared to the initial results – by 14%), while among the cadets of the control group this difference is only 9%. In the experimental group, the number of students with good level of PNC formation decreased from 55,3% to 28,07%. In CG, this difference is only 14,3%. The obtained indicators indicate a positive dynamics of changes in the EG – an increase in the number of cadets with a high level of PNC formation by the indicators of the evaluation-reflexive criterion (in percentage).

According to the calculations χ^2_{ex} is equal to 7,45. Comparing the data $7,45 > 5,99\left(\chi^2_{ex>}\chi^2_{cr}\right)\text{for}\,\alpha = 0,05$ we conclude that the hypothesis H_0 is declined. H_1 is accepted: the level of evaluation-reflexive criterion for the formation of PNC of future navigators in the experimental group is higher than in the control group after the forming stage of the experiment for α=0,05. The results of calculating the formation of PNC levels of future navigators at the formative stage of the experiment are presented in table 8.

Table 8

Levels of PNC formation of future ship navigators at the formation stage

Criteria	High (%)		Good (%)		Satisfactory (%)	
	CG	EG	CG	EG	CG	EG
Motivation	15,18	22,8	51,78	59,65	33,04	17,55
Cognitive	9,82	18,42	31,25	38,6	58,93	42,98
Activity	13,39	20,18	34,82	45,6	51,79	34,22
Evaluation-reflexive	15,18	21,05	39,29	50,88	45,53	28,07

The graphical representation of table is seen in Figure 6.

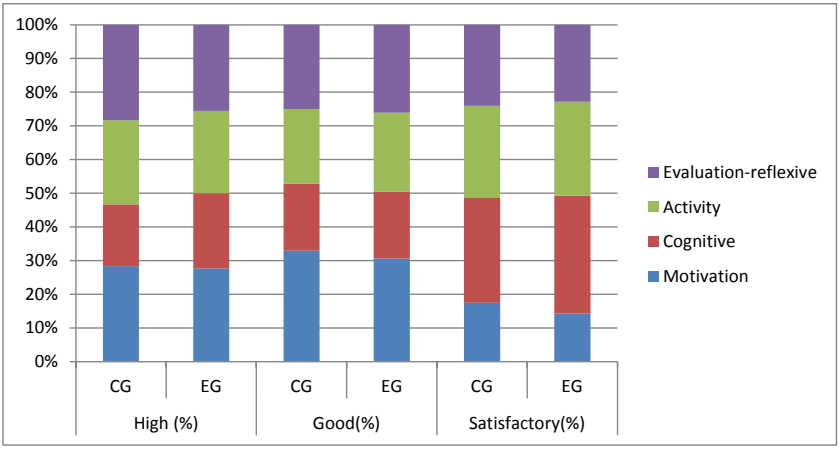

Figure 6. Graphical representation of the levels of PNC formation of future ship navigators at the formation stage

According to the obtained data, positive changes in the levels of PNC formation are observed: the transition of cadets from satisfactory to good level, from good to high level. Analyzing the obtained average results at the end of the forming stage of the experiment (Table 8), we can see that future ship navigators with a high level of formation in the experimental group increased by 14,27%, while in the control – by 6,69%. An important result of the effectiveness of the experimental work was a significant decrease in the satisfactory number of cadets (-33,75%); in the control group, such students decreased by 17,41%.

5. Conclusions

The results of the test suggest that the implementation of the model using MR simulation technologies effectively influenced on the formation of PNC of future navigators, as the level of development of each of the PNC components has acquired positive dynamics, in particular in the motivational-personal and cognitive processes of PNC. EG students demonstrated high motivation, deep professional knowledge, and practical skills. Thus, on the basis of the data obtained for all observation indicators, positive progress was made in the experimental group compared to the control group.

The results of the experiment demonstrate that the introduction of MR simulation technology cadets into the curriculum provides the opportunity to train future navigators using a professional model to provide everyone with practical skills in accordance with professional international standards. Formation of motivational-personal, cognitive, procedural-activity components is ensured through the systematic immersion of cadets in professional situations and the development of professional skills through a system of active and interactive forms of training using the latest digital technologies, among which are MR simulation technologies.

The conclusion is that our study does not exhaust all the theoretical and practical aspects of the problem of future seafarers' professional training in higher education institutions. The results obtained indicate the need for further in-depth theoretical and practical study of the prospects for the development and application of mixed reality simulation technologies in order to ensure a high level of professional training of future navigators, the development of a system of control of the ready-to-work level by means of simulation training, the development and implementation of professional skills; development of customized testing in the LMS MOODLE system. It's advisable to develop scientific and methodological support for the professional training of future navigators, taking into account perspective directions for the development of virtual and augmented (mixed) reality simulation technologies.

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