Innovative Technologies for Healthcare and Medical Education in Higher Universities in Bulgaria

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Abstract **- The article presents the possibility of significantly increasing the quality of the learning process by using innovative tools in the students' curriculum. Modern technologies have the potential to help create quality lasting knowledge in learners. An entrance test was made to establish the knowledge the students had before the training. The group of student volunteers was then randomly divided into two groups: a control group that was trained using traditional methods (giving a lecture) and an experimental group that was trained using the innovative training methodology created. A study of the acquired knowledge of the two studied groups was carried out according to a previously prepared test and knowledge assessment methodology. The degree of assimilation of new knowledge was assessed by absorption rate and a comparison was made between the studied groups of students. The study shows a significantly better acquisition of the learning material by the students whose education included innovative means of the studied subject. The obtained results show that modern innovative interactive technologies can be used in the educational process of health care students, as a supplement and continuation of classical pedagogical methods.**

Keywords **– Interactive training, health care, health professionals, educational problems.**

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1. Introduction

The development of modern interactive Internet technologies and the mass entry of multimedia into the life of a modern person gave impetus to the entry of innovative educational resources into university education in health care and medicine. This process was provoked and strengthened in the previous years, when the conditions of the global pandemic required the improvement of online learning methods. The need for distance learning has greatly increased the interest and need for high-quality educational content. The use of short educational videos, serious educational games, video presentations, online digital resources as part of the educational process leads to the improvement of accompanying teaching methods and contributes to the increase of the learner's experience, understanding of the content and improvement of knowledge.

The inclusion of modern multimedia tools in the training strengthens the interest of the learners and leads to an increase in the quality and durability of the acquired knowledge. Today's students would rather watch a 10-minute video than read 30 minutes of text [1]; interest in popular games carries over to serious educational games as a means of maintaining their attention and interest.

The university teacher is a driving force and a factor determining, to a large extent, the personally oriented education of the student. The modern educator in higher education has the responsibility to introduce learning models and learning technologies that put the student at the center of the learning process. At the same time, he is also a partner in the search for knowledge and conducting scientific research.

The modern teacher needs to include in the training interactive, educational technologies and set as his goal the support of the students in the following [2]:

- Way of learning, setting goals, and building strategies;
- A critical attitude towards innovation;

- Developing own experience and relying on it;
- Building problem-solving skills;
- Skills for carrying out research in the laboratories;
- Developing skills to work in a group, skills to be accomplices, partners, and collaborators;
- Adoption of interactivity and their inclusion in interactive technologies with the application of discussions, projects, brainstorming, situational methods, and others;
- Combining rational with creative thinking, introducing non-standard elements;
- Skills to reveal the pragmatic and health aspects of the problem;
- Preparation skills for the current and final control, self-control, and self-assessment.

Modern training must be constantly updated and improved; to comply with the changing way of learning of the modern generation of students. The use of short videos, serious educational games (SEGs), video presentations, and other digital resources in training today, should be carefully thought out and specified, and the built-in algorithm in the video, the plot of the serious game should aim to achieve a high and effective quality of the training process.

2. Related Works

Short online learning video resources can be used in online learning classes due to their strong display ability, popularity, easy understanding, and short content [3].

The videos should have the same subject content as the classroom lectures, labs, and homework, or they should supplement and enrich them [4]. Their advantage is that they are portable and can be studied at a time when the student wants and can, following his own individual learning pace.

One of the main advantages of online learning is the interactive way of learning, which stimulates the motivation to learn, increases the enthusiasm of the learners, and improves the thinking processes. The authors of [5] investigate the impact of e-learning on learning outcomes by creating a theoretical model and investigating the main influencing factors on learning behavior, improving the effectiveness of online learning, propose a strategy for optimizing feedback when using educational video tools.

Research authors [6], [7] recommend that videos should be combined and carefully selected to improve the teaching effect on learners. Today, video lessons are already becoming an interesting problem to solve, which must be approached with the necessary professionalism.

Video lessons are gradually becoming a new opportunity for learning resource developers to support the pedagogical methods of university professors.

The authors of [8] in their research on the role of video resources recommend creating labels describing the content of educational videos.

Videos can become a preferred educational medium because of their intuitiveness and appeal to their young audience. In [9], the authors investigate video training films and their effect on the educational process through thematic extraction and analysis of learner sentiments. In addition, a topic extraction model was established to achieve similarity-based video recommendations.

Modern platforms for conducting video conferences are also investigated to find applications that meet certain requirements related to the quality conduct of a real online educational process [10]. A methodology for dealing with complex problems was followed, involving four stages: concept, design, implementation, and operation.

Serious educational games are intended for purposes other than entertainment [11]. They are proving effective in medical education [12], [13] and health care education. Research [14] shows that SEGs have made significant inroads into the education of health care professionals.

The authors of [15] propose a SEG for nursing students, paying attention to the users (students), pedagogical tasks, presentation and function of the game.

3. Methodology

The use of video health care simulations in medical education is a growing trend in Bulgaria, and it is important to investigate its impact on students. The purpose of this study is to compare the effect of video-based learning and traditional practical exercises on student knowledge. The experimental study was organized using the principle of "the only difference", based on the methodology of didactic studies [16]. According to this principle, the only difference is in the experimental factor, in this case - the developed model of complex interactive methodology.

Students from the Nurse, Midwife, and Physiotherapist majors from the University of Ruse and the University of Thrace participated in the study. The principle of participation in this study is voluntary and informed. Participants fill out an informed consent form, thus avoiding possible ethical and methodological problems.

A system of criteria and indicators was created to evaluate the results of the conducted research (shown in Figure 1).

The criterion is a "characteristic" on the basis of which a judgment is made, that is, the criterion is the "qualitative side of a given result" and the "indicator - the quantitative characteristic".

In order to make a more comprehensive assessment of the qualities of a given result, each criterion is qualitatively characterized by certain characteristics and, if possible, quantitatively by indicators for the value expression of the characteristics.

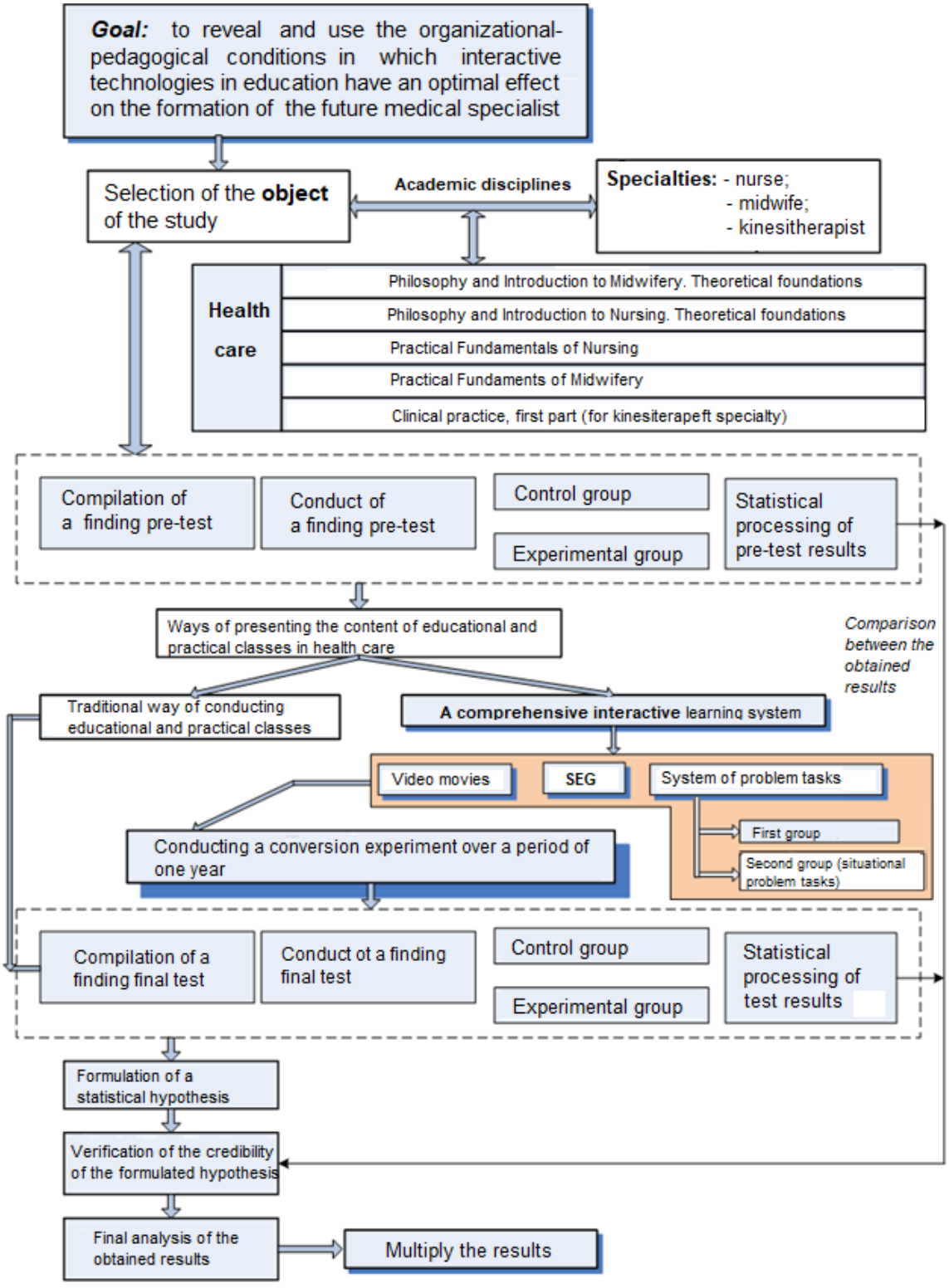

Figure 1. Organization of the empirical study of a complex interactive system for training healthcare professionals

Taking into account pedagogical research on criteria and indicators for evaluating educational results, a system of criteria and indicators for evaluating the results of the didactic experiment was developed, shown in Table 1.

Table 1. Criteria and indicators for evaluating the results of the pedagogical experiment

Criteria	Characteristic of the criterion	Indicators
I. Mastering the essential signs of the concept	1.1. Completeness of the mastered essential signs (completeness of mastering the content of the concept) - is determined by the number of mastered essential signs provided for in the educational content	Degree of concept understanding of the concept
	1.2. Completeness of learned connections	Link absorption rate
II. Level of understanding of the concept	Level of assimilation of the essential signs of the concept	Absorption rate of essential signs at a given level

Two groups of participants (Table 2) were created on a voluntary and random basis - an experimental group (EG, 115 students), in the training of which videos were included, and a control group (CG, 110 students), trained according to classical pedagogical methods. The selection of students from whom the sample was drawn is carried out according to the same candidate student procedures, according to the law on higher education. These stated facts show that the research is correctly constructed for the experimental and control groups.

A piece of knowledge in didactics is considered mastered if K>=0.7 (K - coefficient accounting for the mastering of knowledge) [17].

The students participating in the study one course are from the module "Practical foundations of nursing care" - "Practical foundations of nursing and midwifery care - care for patients with somatic diseases". The teacher sets each task by first reviewing the relevant content of the film. Then, they create a problematic situation and engage the students in a conversation to develop it into a learning problem. The learning problem is solved using all of the steps in the problem-solving methodology. Students create a hypothesis and provide evidence by referring to the content of the films. Some of the tasks use role play. The decision reached by the students is part of the summarizing thesis of the lesson.

Table 2. Distribution of participating students in the pedagogical experiment

Experimental Group					**Control Group**				
Specia-lty	**Midwives**		**Nurses**	**Kinesi-therapist**	**Specialty**	**Midwives**	**Nurses**		**Kinesi-therapist**
University	Ruse University "Angel Kanchev"	Thrace University Stara Zagora	Thrace University Stara Zagora	Ruse University "Angel Kanchev"	University	Thracian University of Haskovo	Ruse University "Angel Kanchev"	Thracian University of Haskovo	Ruse University "Angel Kanchev"
Number of students	17	25	50	23	**Number of students**	25	22	50	13
	42		50	23		25	72		13
Number of participants in the EG: 115					**Number of participants in the CG: 110**				
Total number of participants in the experiment: 225									

Due to the increased interest and desire of the students, educational videos have been made available to them for independent work and preparation for the semester exams.

To evaluate the results of the tests performed by the participants in the experiment, the absorption rate coefficient K is used [17]:

$$K_{ind} = \frac{\sum_{i=1}^{N} l_i}{i.N} \quad (1)$$

where:

N - Number of students examined by the test;

l_i- Number of learning characteristics mastered by the i-th student;

l – Number of learning characteristics provided on the curriculum.

The short educational video film presented in the article was created by professors at Ruse University "Angel Kanchev", Faculty of Public Health and Health Care, Bulgaria [18]. The video is well-planned, it follows clear and concise sequence of steps for effectively demonstrating the intradermal injection procedure. Figure 2 to Figure 7 show moments of the nurse's actions when administering an intradermal injection. This educational video, along with numerous other short videos, was used in the e-learning of health care students during the COVID pandemic. As of July 10, 2023, this educational video film has 17,023 views (since 16.05.2015).

Figure 2. Checking the suitability of the medication, color, and clarity

Figure 3. Drawing medication from an ampoule

At Ruse University "Angel Kanchev", Bulgaria, other video educational resources have been created and have been used in e-learning during the COVID pandemic: muscle injection; intravenous injection; intravenous infusion; internal obstetric palpation; obstetric mensuration; rational management of childbirth; special outfit for eyes, nose, oral cavity and ears; bathing, swaddling and dressing a newborn; hygienic toilet according to the "dry bathing" method; most commonly used instrumentation in obstetrics and gynecology practice and others.

Figure 4. Cleaning the area of the middle part of the forearm with an alcohol swab

Figure 5. Inserting the needle into the epidermis and slowly injecting the medication

Figure 6. View of the 0.5 cm papule forming when the medication is inserted

Figure 7. Disposition of used materials in designated areas

A serious medical educational game has been created to help the training of nurses and midwives. This resource has the form of a quiz and can be used both during the semester and during exam preparation. In this type of educational games, a question is asked on each slide and possible answers are suggested. A certain number of points are also awarded, which depend on the complexity of the question and the time used to give an answer. The game has a competitive nature and can be played together with colleagues.
Figure 8 shows the suggested answers, the time left for the answer is given in a circle.

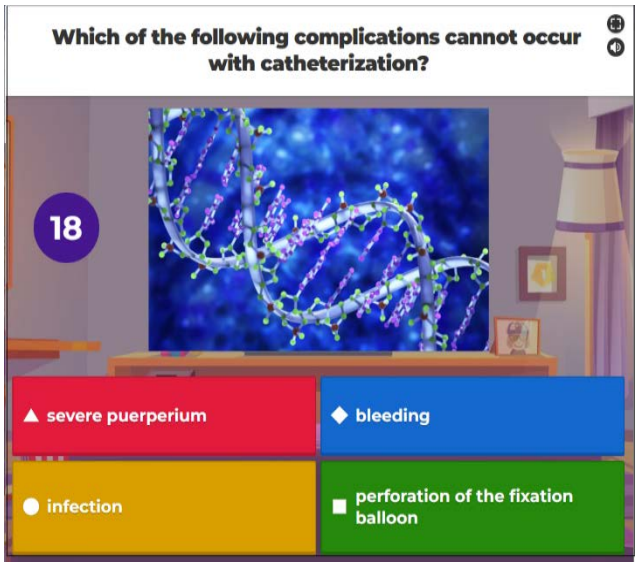

Figure 8. Question from the game test

Figure 9 shows a moment in the game where the specified response time has expired and no response is given. The correct answer to the question is shown in green. The information field shows "Time's up."

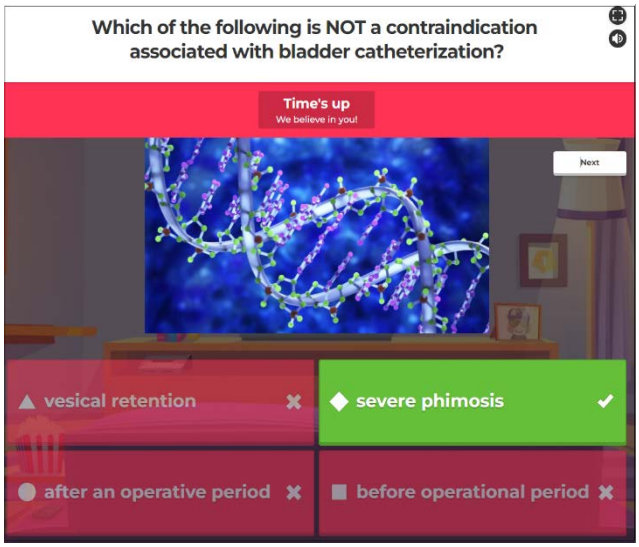

Figure 9. Response timed out

In the case of a correct answer (Figure 10) "Correct" is written in the information field, the added points are displayed, which depend on the time allotted for the answer, and the selected correct answer lights up in green.

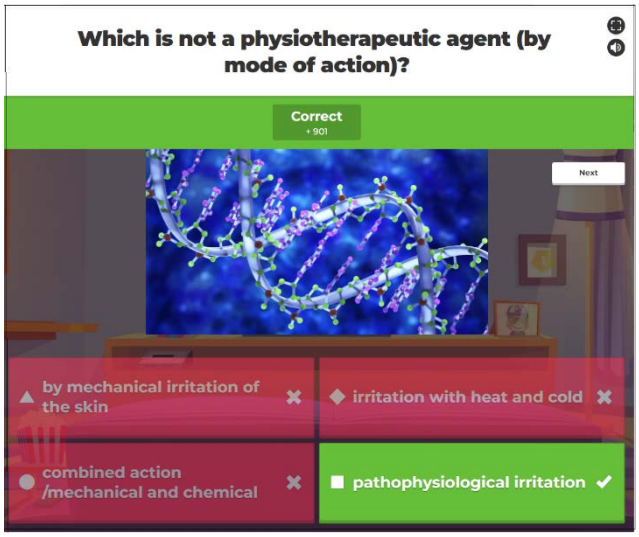

Figure 10. The given answer is correct

In the case of a wrong answer (Figure 11), "Wrong" is written in the information field, the selected wrong answer lights up in red, and the correct answer is shown in green.

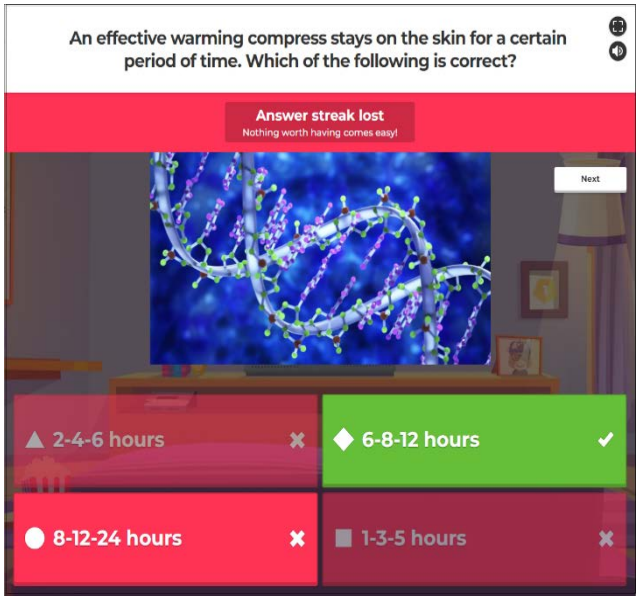

Figure 11. The given answer is wrong

4. Results

In Figure 12 the coefficient of knowledge acquisition is shown, which was obtained as a result of statistical processing from the input test taken by both the control group (CG) and the experimental group (EG).

All students in the experimental group and the control group have an average value of the coefficient of knowledge acquisition significantly lower than 0.7. This means that, for both CG and EG, unassimilated knowledge about nosocomial infections and the main physiological indicators is registered.

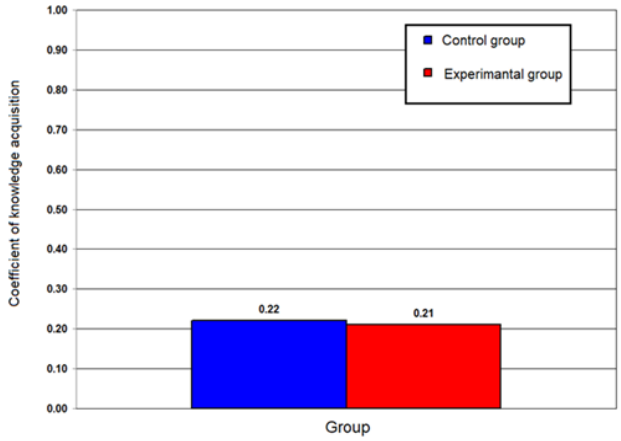

Figure 12. Absorption rate of the incoming test made by the control and the experimental group

The didactic test was prepared to check and evaluate the assimilation of the basic concepts. The tasks are constructed in a way that allows to estimate the absorption coefficient for the specific task, and the concept is formed of three tasks (each with a different elemental composition) and they determine the basic knowledge on "Health care".

The tasks are intended to check reproductive level.

The results of the test for the experimental group with an absorption coefficient of 0.21, and for the control group - 0.22. There are no statistically significant deviations from the results for both groups - EG and CG. It can be concluded that the two groups have statistically identical input characteristics, which is a necessary condition for a correct didactic experiment.

The lesson in the first semester in EG begins with a screening of educational films lasting 10-12 minutes on the relevant subject. The main points are discussed and the methodology [19] for conducting the practical lesson is continued. In the final part of the exercise, problem tasks are set for the students to solve, to check the acquired knowledge and skills.

In Figure 13 the results of the test for acquired knowledge at the applied and creative level on a task related to a disease of the respiratory system are shown. The first three questions aim to update knowledge from the previous semester and serve as an initial formulation of the problem. The following questions aim to solve this problem by preparing, planning, and performing the relevant medical examinations.

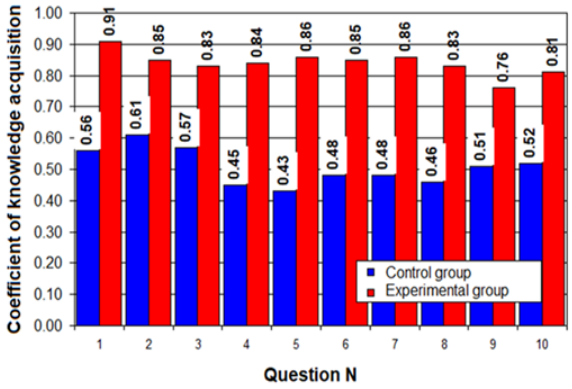

Figure 13. Results obtained from the test of acquired knowledge at the applied and creative levels

From the obtained results, it can be seen that the average value of the absorption coefficients for the individual questions for the experimental group is 1.65 times higher than that for the control group. This result is shown graphically in Figure 14.

From Figures 13 and 14 it can be seen that the impact of the complex interactive system, including training through video films and problem tasks, gives a significantly better result compared to the traditional training methodology.

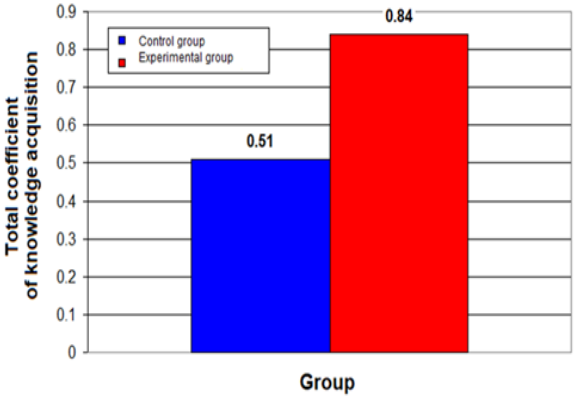

Figure 14. General results obtained from the acquired professional competence test

To statically analyze the results obtained from the research, processing with dispersion analysis was done. It was established that in the entrance test the degree of knowledge acquisition was approximately the same among the participants in the experiment, there were no statistically significant differences between the knowledge of the participating students.

The research conducted after a different type of training for the two groups (video training resources were included in the training of the experimental group, and the control group was trained using traditional pedagogical methods) showed a different degree of assimilation of the taught teaching material.

The results of the baseline test show that the K_{ind} absorption coefficient is affected by the training methodology, which is different for the control and experimental groups. This shows that the teaching methodology factor has a significant impact on learning outcomes.

The statistical processing of the obtained results was done with variance analysis.

In the static processing of the results, the following organization of the experimental data is adopted:

Controllable factors:

- specialty – denoted by A;
- teaching methodology - denoted by B;
- type of concepts (indicators) that students must master - denoted by S.

The first factor is varied at three levels:

- a1 – student kinesitherapists;
- a2 – student midwives;
- a3 – student nurses.

The second factor is varied at two levels:

- b1 – the control group where traditional training methods are used;
- b2 – the experimental group where the complex interactive training system is used.

The third factor varies on five levels:

- c1 – nosocomial infections;
- c2 – heart rate;
- c3 – arterial blood pressure;
- c4 – breathing;
- c5 – body temperature.

The output values are the learning coefficients of the individual concepts in the input test Y1 and in the output test Y2. In addition, the difference between the learning coefficients of the individual concepts in the outgoing and incoming test is given, and this outgoing value is denoted by Y3.

In Table 2 the experimental design used is shown. The number of trials for the thus chosen number of factor levels will be: N=3.2.5= 30 trials.

Table 2. Experiment plan

Expe-rience (№)	Factor A	Factor B	Factor C	Ex. №	F. A	F. B	F. C
1	a1	b1	c1	16	a1	b2	c3
2	a2	b1	c1	17	a2	b2	c3
3	a3	b1	c1	18	a3	b2	c3
4	a1	b2	c1	19	a1	b1	c4
5	a2	b2	c1	20	a2	b1	c4
6	a3	b2	c1	21	a3	b1	c4
7	a1	b1	c2	22	a1	b2	c4
8	a2	b1	c2	23	a2	b2	c4
9	a3	b1	c2	24	a3	b2	c4
10	a1	b2	c2	25	a1	b1	c5
11	a2	b2	c2	26	a2	b1	c5
12	a3	b2	c2	27	a3	b1	c5
13	a1	b1	c3	28	a1	b2	c5
14	a2	b1	c3	29	a2	b2	c5
15	a3	b1	c3	30	a3	b2	c5

In a graphic form, the obtained results are shown in Figure 15. It shows that levels a2 /midwives/ and a3 /nurses/ have practically the same influence, and better than level a1 /kinesitherapist/. Specialties a2 and a3 show the same success rate when conducting the entrance test, which differs from that of specialty a1 /kinesitherapist/.

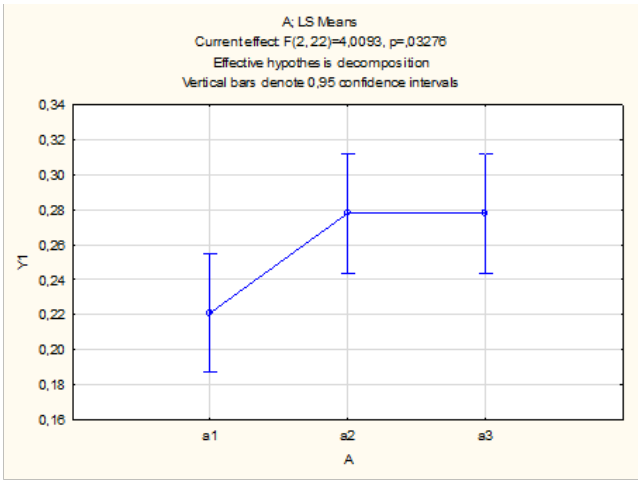

Figure 15. Influence of the factor A /specialty/ on the parameter Y1 /coefficient of absorption from the incoming test/

In a similar way, the influence of the factor B /learning methodology/ - control group b1 and experimental group b2 on Y1 / absorption coefficient from the incoming test/ was determined and the obtained results are shown in Figure 16. Accordingly, it can be concluded, that the success rate at both levels of factor B is the same, i.e. this factor has no effect. The lack of influence in this case indicates that both the control and experimental groups have the same entry level of understanding the concepts.

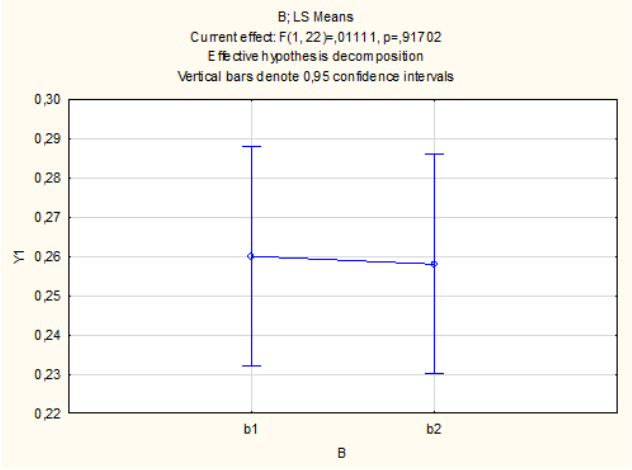

Figure 16. Influence of the factor B /training method/ on the parameter Y1 /coefficient of absorption from the incoming test/

The influence of factor C /type of concepts/ is graphically shown in Figure 17. It can be seen that factor C - these are the studied concepts (c1, c2, c3, c4 and c5) has an influence on parameter Y1, as the biggest influence there is the c1 level - nosocomial infections, and the lowest is the c5 level - body temperature measurement.

Nosocomial infections are a more specific subject that is poorly studied in secondary school, while temperature measurement is a more familiar issue for students.

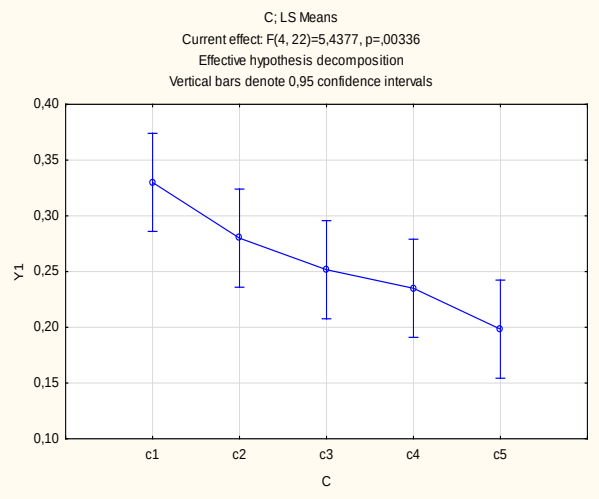

Figure 17. Influence of factor C /type of concepts/ on parameter Y1/coefficient of learning from the incoming test/

Graphically, Figure 18, 19, and 20 show the influence of the three factors A/specialty/, B/learning methodology/ and C/type of concepts/ on the absorption coefficient of the individual observed concepts Y2 when conducting the exit test.

It can be seen that the highest success rate is at the a2 level of factor A /specialty/ (midwives), followed by the a1 factor level (nurses) and the lowest success rate is at the a2 factor level (kinesitherapists). Nurses and midwives study these concepts in the academic disciplines for a much longer time than kinesitherapists study Clinical Practice 1, because Clinical Practice 1 is an introductory course for kinesitherapists.

Figure 19 shows the two values for factor B /training methodology/. The first level is marked with b1 and refers to the control group, where traditional training is conducted on the specified topic. The second level, denoted b2, refers to the experimental group, where training is carried out using an interactive complex training system for medical and health professionals, developed for the purposes of the present study.

The acquisition rate of separate concepts using the interactive complex system is 1.47 times higher than the traditional learning method.

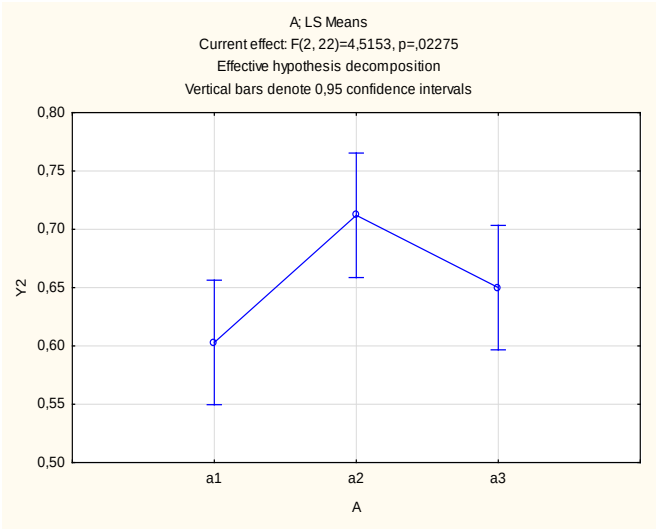

Figure 18. Influence of the factor A/specialty/ on the parameter Y2 /coefficient of absorption from the exit test /

From Figure 20 it can be seen that the highest success rate is at levels c1 (nosocomial infections) and c2 (pulse), and it is practically the same. This dependence is explained by the fact that the mentioned topics are less familiar and more interesting to students, which is a prerequisite for greater interest on the part of students and deeper study. The other topics related to arterial blood pressure, respiration, and body temperature involve the acquisition of more difficult terminology and this explains the lower success rate in these topics.

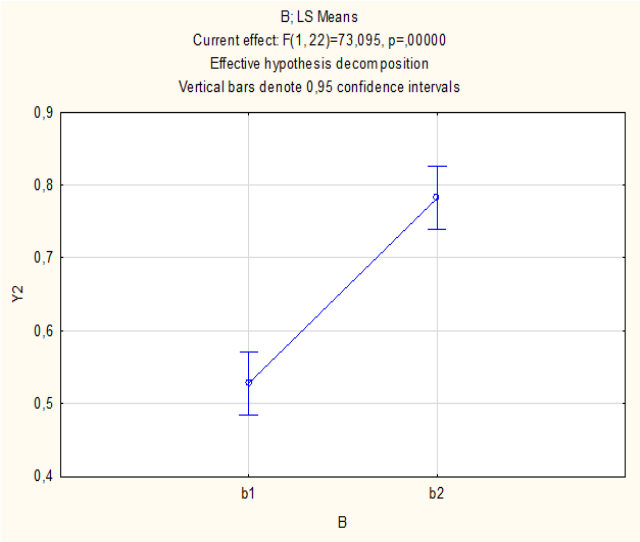

Figure 19. Influence of the factor B /learning method/ on the parameter Y2/coefficient of learning from the exit test/

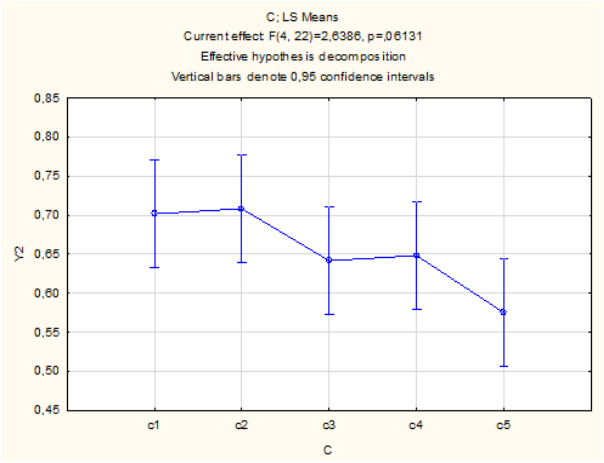

Figure 20. Influence of the factor C on the parameter Y2 /absorption coefficient from the exit test/

An examination of the differences between the acquisition coefficients of individual concepts in the incoming and outgoing test is carried out with parameter Y3 /difference between the acquisition coefficients of individual concepts in the outgoing and incoming test/.

In order to better account for the influence of the various factors in the success rate of the control and experimental groups, the parameter Y3 /difference between the learning coefficients of the individual concepts in the outgoing and incoming test/ is introduced. It represents the difference between the performance of students in the control and experimental groups, which is shown on the entrance and exit tests. Figure 21, presents the influence of factor A /specialty/ on the parameter Y3 /difference between the learning coefficients of individual concepts in the outgoing and incoming test/.

It can be concluded that all three specialties have an influence, but a1 (Kinesitherapy specialty) and a3 (Nurse specialty) have a lesser degree of influence. Factor a2 /specialty Midwife/ has a greater influence. Midwives in the experimental group were trained using the complex interactive system.

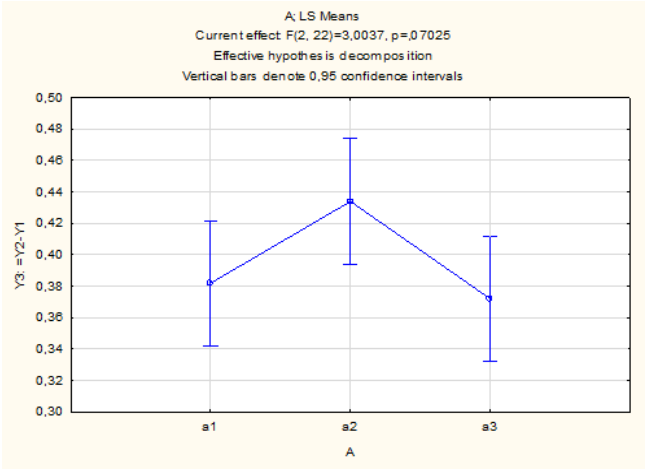

Figure 21. Influence of the factor A/specialty/ on the parameter Y3/difference between the learning coefficients of individual concepts in the outgoing and incoming test/

From the graph in Figure 22, it can be seen that the influence of level b2 is almost twice that of level b1. In practice, this means that the experimental group has almost twice the success rate in learning the material compared to the control group.

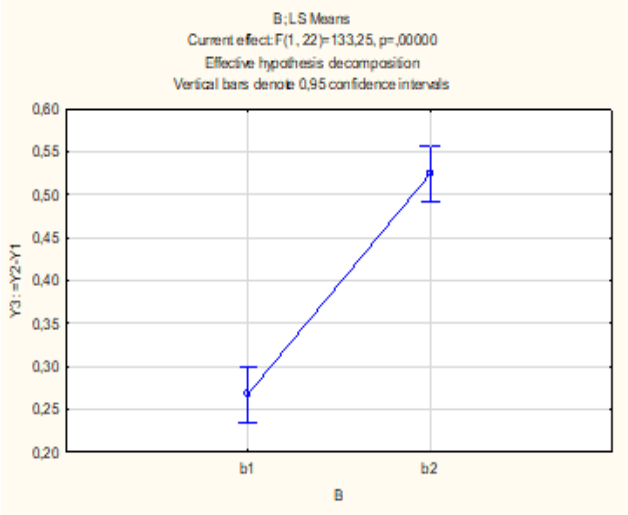

Figure 22. Influence of the factor B/teaching methodology/ on the Y3 parameter/difference between the absorption coefficients of individual concepts in the outgoing and incoming test /

From the graph shown in Figure 23 it can be seen that the levels c1, c2, c3, c4 and c5 practically have the same influence on Y3/difference between the learning coefficients of individual concepts in the outgoing and incoming test/. This can be explained by the fact that for the medical and health specialists in training, the topics presented in the individual educational and practical classes are of the same degree of difficulty.

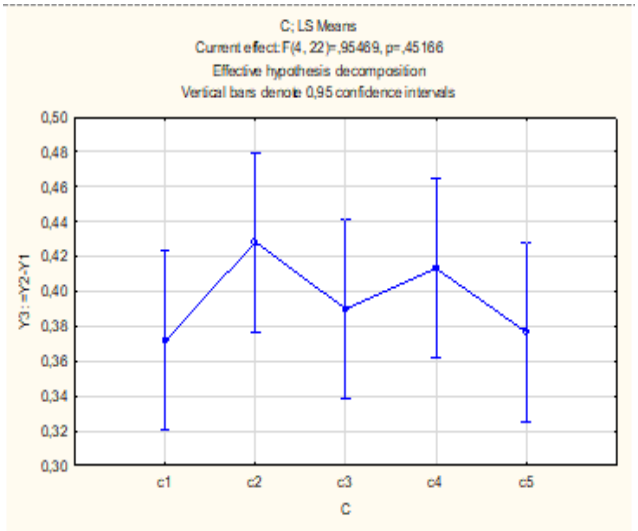

Figure 23. Influence of the C factor on the Y3 parameter /difference between the absorption coefficients of individual concepts in the outgoing and incoming test/

5. Conclusion

Today's students represent a distinct generation that remains constantly connected to information, possesses the ability to rapidly process and analyze vast amounts of data, and consequently, they have high expectations for the inclusion of cutting-edge technologies in their education. This is a challenge for teachers from higher education institutions, who must constantly integrate innovations in their lectures.

The article presents the impact of the use of innovative educational technologies in university education in Bulgaria, professional field "Health Care".

The students are divided into two groups, one group is trained according to traditional pedagogical methods, and the other group is trained according to an innovative methodology, which is carefully prepared for teaching the studied curriculum. Total number of participants in the experiment is 225 students (experimental group of 115 and control group of 110 students). For the correct conduct of the experiment and to guarantee the reliability of its results, an input test was conducted, which did not establish significant differences between the two studied groups (0.21 absorption coefficient of the experimental group, and 0.22 of the control group). The conducted research shows a significant increase in the quality of the learned learning material in the group of students taught with the innovative methods.

The obtained results show a 1.65 times more effective learning of the studied educational material than students whose education includes interactive technologies. This gives reason to conclude that the use of innovative modern methods in health care education in university education is effective and should be implemented after precise construction of educational resources.

The research carried out includes a limited number of participants, and in the future the described research could be conducted with the participation of more students, for example participants from other universities in Bulgaria, which train students from the professional field of "Health Care", will be also included. Additionally, a variety of SEGs can be included in the training of the experimental group, for example simulations of real clinical situations, virtual reality; digital resources, and other modern technological means, which, integrated in an appropriate pedagogical way in the educational process, can increase its quality.

Today, students want to be active participants in their education, which, if well conducted, can turn them into knowledgeable and capable specialists, offering and arguing their solutions on the researched issues.

The successful realization of the future healthcare specialists is guaranteed by a modern educational process skillfully combining traditional, and modern innovative training methods.

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