The Use of Simulation Models and Game Scenarios in the Study of Radio Engineering Systems by Higher Engineering Students

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Abstract

One of the ways to make learning process more effective is to use the hobbies and activities specific to children. Nowadays the teenage obsession with computer games is comparable to an epidemic. A hypothesis suggests that the students' enthusiasm for computer games can be used to their advantage. The game is widely used as a means, form and method of training and education. Unlike traditional methods, the uniqueness of the game consists in the fact that it allows to grasp not only the conceptual and informational content of the problem, but also the methods of activity in a certain sphere, norms, rules, role structure of activity, experience of social behavior. The article brought out the pedagogic methodology for teaching higher education students the discipline "Information Security in Wireless Communication Systems" with the use of game scenarios and simulation models. The discipline deals with the operation, deployment and configuration of wireless communication, navigation and control systems in such a way as to ensure the required level of information security. Practice shows that the development of students' competencies in this discipline requires high efficiency of the teaching methods used. Usage of the teaching method, which combines interactive methods of scenario planning, didactic games, inverted class and brainstorming was described.

Keywords: interactive teaching methods, gaming pedagogical technology, scenario training, simulation models, radio engineering systems, higher education, Flipped Class, brainstorm.

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1 Introduction

In most countries, the age of 18 years (21 in some countries) is officially considered the beginning of adulthood. However, modern scientists get more and more evidence that the end of adolescence may be at a later age. According to neuroscientists, the whole process of growing up is associated with changes in the human brain. Adult characteristics have changed markedly in recent decades. In most countries, as a result of the recent sociocultural changes, a longer period of maturation is observed, and the third decade of human life is included in it [**Choi14**]. The culture is changing, which has an impact on the process of raising children. The patents' experience loses the value it once had. Such a cultural transformation blurs the psychological boundaries between childhood and adulthood.

Researchers from different countries described a number of adult «children» who prefer to avoid independence, adulthood and taking responsibility for their lives [**Sza11**]: "kidults" (literally translated from English - kid-adult), «boomerang children» (young people who, after graduating from school, in accordance with the previously established tradition, first try to live independently, but then rather quickly return to the parental home), "twixsters" (from «twixt- between, i.e. a person who is between the states of childhood and adulthood, usually either unemployed, or often changing their jobs in the hope of finding both highly paid and interesting one). In Italy, these young people are called "bamboccioni" (big doll boys), in England – "sponge" and "basementdweller" (because they are often given room as a temporary shelter in the basement of the house), in Germany "nesthocker" (a word that does not have a direct translation and is derived from «nest» and «hock» - crank, support), in other words, « nestling, not departing from the nest», in Japan - hard and straightforward – "parasitesingle" (lonely parasites).

After analyzing the data, the researchers stated that only adults who are at least 30 years old could be considered truly adults. They also note that in the near future many countries will to shift the norms of adulthood and readjust the health and education systems.

One of the ways to take into account the identified trends in the learning process is to use the hobbies and activities specific to children [**Car18**]. Nowadays the teenage obsession with computer games is comparable to an epidemic. A hypothesis suggests that you can use the students' enthusiasm for computer games to their advantage.

The game is widely used as a means, form and method of training and education. The game method is an active learning method. Unlike traditional methods, the uniqueness of the game consists in the fact that it allows to grasp not only the conceptual and informational content of the problem, but also the methods of activity in a certain sphere, norms, rules, role structure of activity, experience of social behavior [**Bap15**]. The game is valuable because the learning is implicit and entertaining. Although it is the implicit nature of training in the game that causes many to doubt the didactic possibilities of the games [**Kaz05**].

Game forms in training are used not only in educational institutions, but also adopted by various corporations. So, game methods are used as a tool for recruiting, team building and staff adaptation to the work performed. For example, IKEA uses a gaming test for compatibility of a potential candidate with a company's mission as a primary "dropout". The study, conducted for the Harvard Business Review, showed that often people who did not demonstrate a desire to control something in life often prove to be good managers in the game, which means that it is also a way to create personnel reserve.

The BOSCH company uses the game-test on the knowledge of its equipment used in car repair shops. The game is freely available on the site for everyone. The players who have earned the best result are given a coupon for training with certification in the corporate training center. This allows the company to attract the most trained people in the primary selection, reducing time and labor in subsequent phases. At the same time, such a method allows in some way to reduce the influx of unnecessary people to the training center.

As a tool for adaptation in the workplace of the game uses the company TWiga. The company has created corporate theaters and creative competitions to realize the potential of its personnel. There is even a "Back to School" project.

A wide network of US stores "Giant Eagle" uses computer simulators in specially equipped rooms to train cashiers in the safe execution of everyday operations. Such innovations have contributed to reducing the number of recurring work injuries, and also reduced the level of stress among employees.

The game learning method can be implemented in the form of various games, in particular, in the form of computer games. The emergence of computer games is logical, since the games are adequate to the models of culture. It is the culture of the information society that has created such a tool for the development of reality, like computer games. Over the past ten years, a whole subculture of computer game lovers has emerged, including

periodicals for gamers, clubs, network communities, and a kind slang. The use of the hobby of modern youth in computer games can lead to an increase in the effectiveness of their learning [**Kur15**].

2 Task

The Institute of Information Technologies and Telecommunications of the North-Caucasus Federal University conducts training of specialists in information technologies in general, and in particular specialists in the field of telecommunications and communications, information security, etc. and the whole of Russia is the transfer of knowledge to students, the development of their skills and competencies in working with wireless communication, navigation and control systems.

The authors of this paper teach bachelors in the field of information security. In the standard of training bachelors in this area there are disciplines "Electrical Engineering", "Electronics and Circuit Engineering", "Mathematical methods of the theory of signal transmission", "Information security in wireless communication systems".

In the study of the discipline "Electrical Engineering" the issues of obtaining, converting and using electrical energy in the practice of the bachelor, covering the application of electromagnetic phenomena in various telecommunication systems, computer and office equipment are considered. The discipline "Electronics and Circuit Engineering" allows students to gain knowledge and skills in the field of creating and describing the physical principles of operation of electronic devices and devices or electronic circuits based on them. During classes in the discipline "Mathematical methods of the theory of signal transmission," students become familiar with the mathematical presentation of data in modern information systems; they study methods for transforming, recording, accumulating, processing and presenting data, methods for implementing in information systems efficient algorithms for transforming and analyzing information data.

The discipline "Information Security in Wireless Communication Systems" is based on the knowledge and skills gained in studying the above disciplines and deals with the operation, deployment and configuration of wireless communication, navigation and control systems in such a way as to ensure the required level of information security. By the time of the beginning of training in this discipline, students should understand all the physical processes and mathematical foundations of the work of individual elements of these systems.

Acquisition of knowledge and skills in the field of work with complex wireless communication systems, navigation and control is necessary to acquaint them with the structure and principles of operation of these systems. Students must master the various modes of operation of wireless systems.

The study of this discipline requires not only the availability of basic knowledge and skills, but also the ability of students to system thinking, abstract thinking. Practice shows that the development of students' competencies in this discipline requires high efficiency of the teaching methods used. This article describes the method proposed by the authors for using the game method of teaching according to certain scenarios in combination with the use of simulation models of radio engineering devices and systems for teaching students one of the sections of the discipline "Information Security in Wireless Communication Systems", which is dedicated to ensuring the availability of wireless communication channels, navigation and control in terms of interference. It also describes the results that have been achieved as a result of the use of this teaching method.

3 Development Of Methodology

Game methods belong to the group of active learning methods. Active game teaching methods can be implemented as computer, role-playing, situational games. The theoretical foundations of "active learning methods" were formulated at the beginning of the 20th century by the American philosopher and educator John Dewey. Over the course of further research in the 1960s, two main illustrative concepts emerged - the «learning pyramid» and the "Dale's cone of experience".

The cone of experience of E. Dale clearly shows the different types of educational results that can be achieved using various «media» and means for conveying the content of training (Fig. 1) [**Dia89**]. This model shows the relationship between the effectiveness of the development of the material and what options the students carry out at the time of training. From the figure it is clear that the simulation (playing) of real experience and the accomplishment of real actions have a close learning efficiency. Both of these actions are at a low level of abstraction and allow learners to memorize up to 90% of what they say and do.

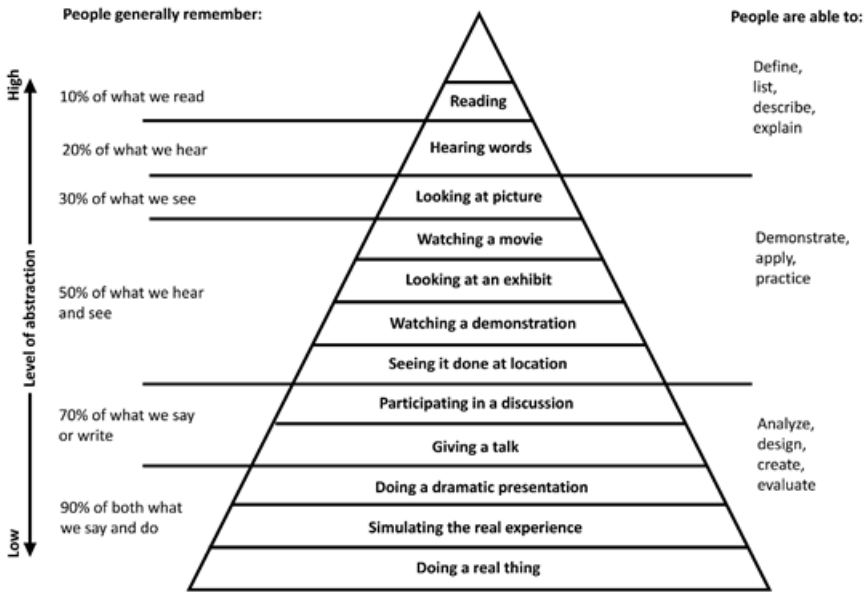

Figure 1: Dale's cone of experience

Various training methods are applied depending on the goals and objectives:

3.1 Practice

The classic and oldest teaching method. The student is engaged in real practical activities, mastering in the process of professional skills and abilities of handling equipment. In the modern education system, this method underlies internships and practices.

This training method is certainly the most effective. However, it is possible to apply this method with great limitations to solve the problem of the present study, set by the authors.

Training in the discipline "Information Security in Wireless Communication Systems" includes the study of the structure, principles of operation and modes of operation of various radio engineering devices and systems. This can be implemented using the available device samples available at the Institute. However, in this case, a number of difficulties arise. Observing the characteristics of signals from real devices transmitting and receiving radio signals requires connecting oscilloscopes to them, spectrometers, or monitoring signals using mobile radio monitoring systems. The characteristics of the listed devices for monitoring the parameters of radio signals have limitations in their capabilities. As a result, it is not always possible to visually see the processes taking place. In addition, samples of real equipment are quite expensive to purchase, resulting in a limited number and variety of equipment available for use in the learning process.

The study in practice of certain modes of operation of radio systems associated with the peculiarities of the external environment. For example, the operation of base stations of cellular communication systems must be studied in the conditions of urban development, which affects the distribution of radio signals. The work of radio-relay communication systems must be studied in conditions of uneven terrain at a distance reaching tens of kilometers. It is not possible to organize such practical work with real systems in the framework of conducting classes.

It should also be noted that the real equipment emits radio signals of different powers. For this reason, radio transmitters often require licenses from government agencies. In addition, powerful radiation can degrade the ecological state of the area, and this situation is contrary to existing trends in the area of expanding the use of green technologies [**Pan18**]. In addition, the work of students near such powerful radio transmitters without safety precautions may cause damage to their health. All of the above indicates that it is extremely difficult for the Institute to organize training of students on real equipment using the Practice method, and there is a need to look for other highly effective teaching methods.

3.2 Broadcast Material

A simple transfer of knowledge about a subject or activity from a knowledgeable person to a student. Today, this method is the main (and basic). Methods based on it include lectures, independent reading of books by

students, participation in courses and master classes of experts.

According to the cone of E. Dale's experience, this teaching method is at high levels of abstraction and is considered not the most effective: when used by students, only up to 30% of what they do, listen and speak is assimilated if interactive teaching methods are not used. This training method can be effective in conditions of strict discipline and high self-motivation of students.

As noted above, modern students increasingly behave like teenagers. They are not characterized by high self-motivation to learn. In such classes, where it is necessary to carefully listen, record and memorize, they start to get bored, and their attentiveness decreases. In addition, modern trends in the development of society and the education system in many countries, including in Russia, do not allow to maintain strict discipline in the classroom, because it is usually associated with the use of methods of coercion.

As a result, the methods of simple translation of educational material cannot be considered effective for solving the problem posed in this study.

3.3 Case Study

The point of the situation analysis methods lies in the taking typical situations from practical activities. Depending on the task, the students either analyze the situation, or analyze and formulate proposals for possible actions and scenarios which the situation follows. This group includes the so-called interactive teaching methods, in which students turn into active participants from ordinary listeners. Such training methods are more effective than the second group and allow students to absorb up to 50-70% of the information.

One of the most effective teaching methods of this kind is brainstorming. The group of students is assigned a task that needs to be solved jointly. Each student offers possible solutions to the problem or improves a solution proposed by another student. This method of teaching assumes that students have already mastered a sufficient amount of theoretical material, allowing them to propose solutions to the problem and evaluate the effectiveness and applicability of these methods based on the conditions of the task.

The considered teaching method is effective in accomplishing the goal of developing student teamwork competencies.

Another learning method related to this group is the Flipped Class. The bottom line is: when conducting traditional classes, the teacher explains the material of a certain complexity in lectures, practical classes and laboratory work. Students learn this material, but when doing independent work, they may encounter more complex material or tasks for which the algorithms for solving them were not considered in the classroom. Often the schedule of the educational process is planned so that students do not have enough time to consult the teacher on emerging issues. Flipped Class is designed to eliminate this problem.

Students independently study the theory and algorithms for solving typical problems. Then students try to independently carry out practical tasks of varying degrees of complexity. In the classroom, students ask the teacher questions that have arisen in the process of independent practical tasks. The teacher helps students to solve complex problems with which they cannot cope on their own.

When using this pedagogical method, there is a shift in activity towards students: they talk and do more, and the teacher moderates the process, puts the students in a situation where they solve problems themselves.

Both considered methods are quite effective pedagogical methods, each of which has its own advantages. For the development of teaching methods in this article it is proposed to combine the "Brainstorming" and "Flipped Class" and use them together with other methods.

3.4 The Game

Since ancient times, people, especially children, studied in a game environment. Game training technology refers to the so-called "non-formal education", in which students performed some actions and learned in the process of some natural adolescent activity [**Tup18**].

Gaming teaching methods as a preparation for professional activity were first used in the USSR. The business-like game aimed at solving production problems was carried out in 1932 by Maria Birshtein and was called "Production restructuring due to a drastic change in the production program". However, group exercises for developing solutions in conditions that mimic reality are not widespread [**Ren18**]. Examples of this type of games are the organizational-activity games of G. P. Schedrovitsky or policy exercises actively discussed by renowned foreign researchers Richard Duke and Jan Clubbers. Role-playing games that are used to simulate typical professional situations or to work out an employee's workplace model are much more common.

Currently, didactic games are relevant - this is a type of training sessions organized in the form of training games which implement a number of game principles and differ by the presence of rules, a fixed structure of game activity and an assessment system [**Ren18**].

Scenario planning is another relevant learning method that belongs to the group of game methods. Scenario planning is divided into two types.

In the first case, scenario planning is a definition of an action strategy in a confrontational situation between several participants or groups of participants who have their own plans for the development of the situation, and their interaction with each other is determined by the proposed promotion strategy [**Ren18**]. This method of scenario planning is associated with the implementation of the task-targeted learning strategy, where the scenario actually describes the plan of conducting the lesson, and the training is associated with the students understanding and accepting the task proposed by the teacher, developing and attempting to implement ways to solve it.

In the second case, scenario planning is presented as a way to operationalize some of the previously described large-scale action strategy [**Ren18**]. Then the scenario is no longer associated with the implementation of the project, but with the identification of a situation of action that arose after the introduction of the project (large-scale strategy) in the field of public discussion and analysis. This method of scenario planning is adequate to the problem learning strategy. Here, when organizing a search for ways out of the indicated problem, the teacher first "throws in" their project, and then acts in accordance with the previously thought out options for possible results of analysis and discussion by students of the proposed project.

The methodology developed in this article combines the use of a number of game methods: the proposition is to combine didactic games with scenario planning and using simulation models of radio engineering devices and systems for teaching students one of the sections of the "Information Security in Wireless Communication Systems" discipline [**Ard18**]. The authors hypothesize that such a combination of pedagogical methods will allow a number of competencies to be developed more effectively in students [**Ren18**].

The use of simulation models allows to generalize and systematize the knowledge gained in the study of the disciplines "Electrical Engineering", "Electronics and circuitry" and "Mathematical methods of the theory of signal transmission". When using simulation models of radio engineering devices and systems, students develop the skills to apply previously learned positions of electrical engineering, electronics, and circuitry to problems from the professional field.

For training students in the discipline "Information Security in Wireless Communication Systems", Matlab engineering computing environment and simulation models of various technical devices and wireless communication systems in the Simulink environment are used. The skills of working with these software environments develop students' ability to apply system, application and special purpose software, tools, languages and programming systems to solve professional problems [**Pav17**].

The use of simulation models of wireless communication, navigation and control systems allows to get rid of the limitations arising from the use of real devices and systems described in the training.

The use of simulation models in training allows to obtain a number of advantages:

– access to the simulation model can be provided at each workplace of the student; the restriction of the number of available real devices and systems is eliminated (Fig. 2);

– files of simulation models can be placed in a distance learning system [**Kus14**], and students can perform tasks according to methodological materials remotely on their personal computers;

– simulation models allow to change the parameters and characteristics of the studied systems in a wide range, it will not affect the change in the environmental situation and will not harm the health of students (Fig. 3);

– imitation models contain submodels, have levels of a hierarchy of elements that cannot be simultaneously displayed on the screen, this develops abstract thinking in students (Fig. 4);

– means of observation allow to represent the values in any range of time and amplitude scales, which is not always possible to achieve by using real equipment;

– simulation models allow to replace some blocks of systems and explore the results of these actions (Fig. 5);

– simulation models allow to investigate the effect on radio signals by third-party radio systems and the effects of various interference, which is difficult to implement in real conditions.

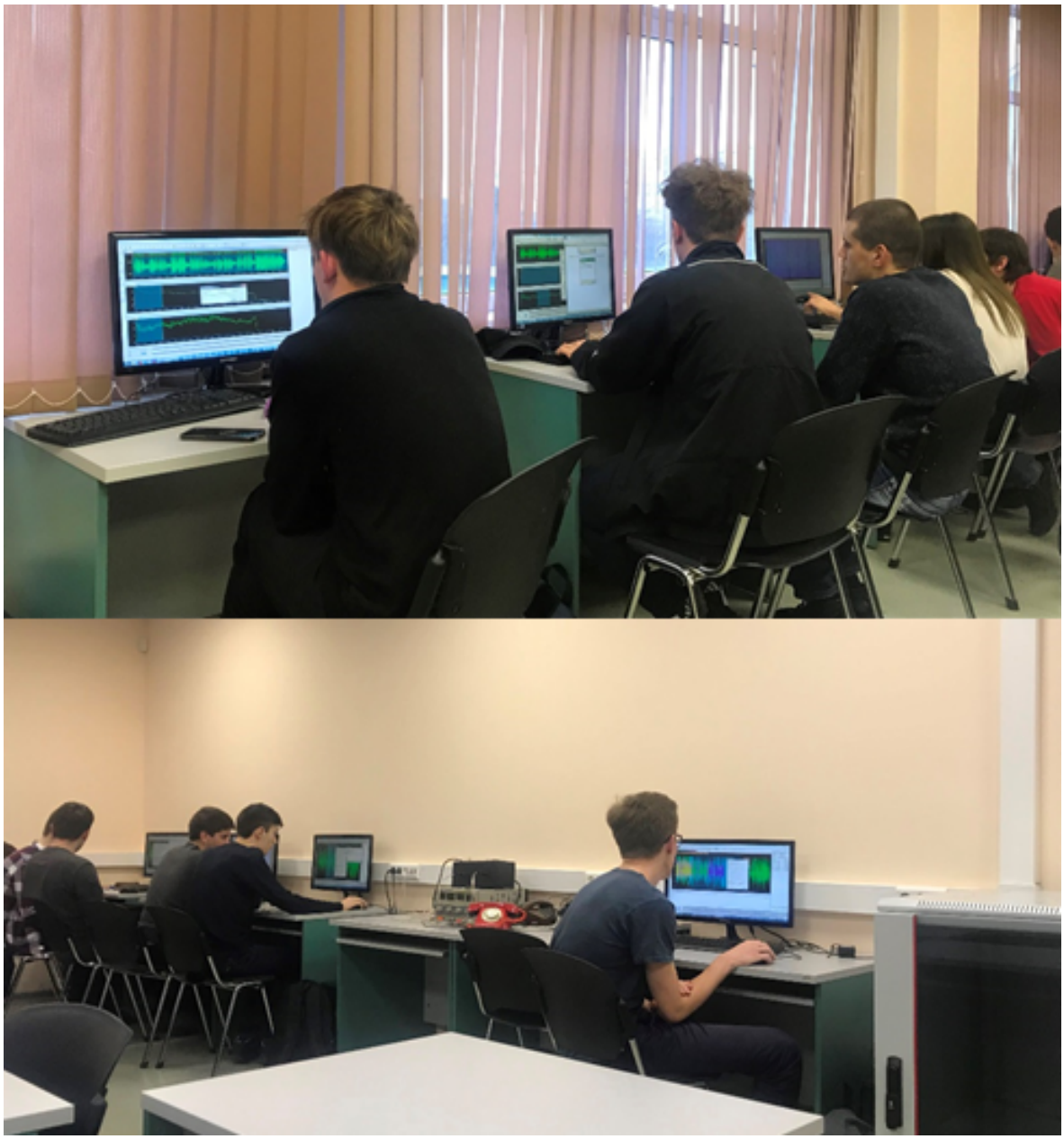

Figure 2: Students work with simulation radio systems models

Fig. 2 shows photographs of students working simultaneously with the same simulation model of a radio-technical system. In this case, the number of available workspaces is determined only by the number of computers. In the case of conducting lessons with real systems, their number would be significantly fewer.

Fig. 3 shows the spectrum of a powerful high-frequency radio signal, which was formed in a simulation environment. To emit a real signal with such parameters, a license from the controlling state authority is required. In addition, people working close to equipment of such power requires special safety knowledge from them to not put their health at great risk.

Fig. 4 shows a simulation model, some blocks of which are also simulation models containing many elements. Within the framework of the "parent" model, these submodels are represented as blocks. However, by double-clicking any of them, a new window of the Simulink model will open, which will contain submodel elements connected to each other. Thus, models can contain other models, and the number of such levels of embedding is not limited. This allows students to develop abstract thinking, taking the logic of the subsystems of various levels into account.

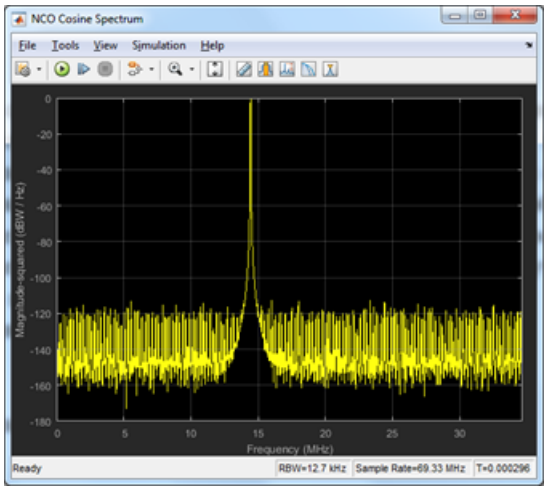

Figure 3: High-frequency signal that can harm the ecology

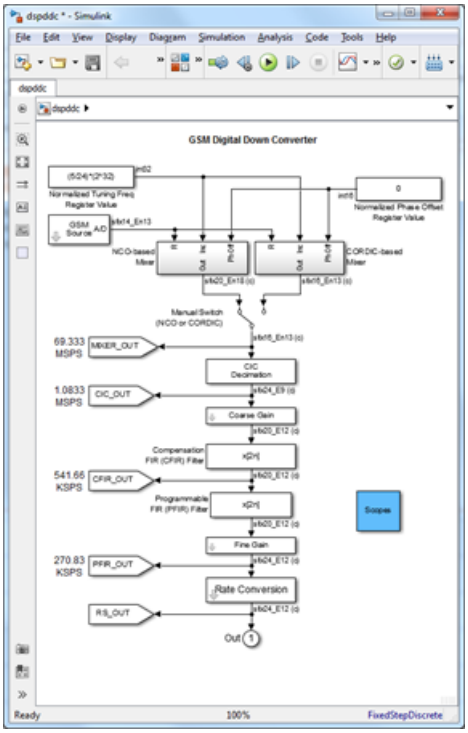

Figure 4: GSM Digital Down Converter simulation model that holds subsystems

The authors developed the following script to train the students. Laboratory work is carried out in educational subgroups of 12-15 people, so the subgroup is conveniently divided into 3 teams of 4-5 people. Teams are offered the following roles:

1. Information transfer team.
2. Information receive team.
3. Radio signal interference providing team.

Further, the scenario includes three game situations:

1. Ensuring the transmission and reception of data over a wireless communication channel with specified parameters in the conditions of a natural electromagnetic interference background.

2. Ensuring the transmission and reception of data over a wireless communication channel under the conditions of intentional interference, which is set with the specified parameters.

3. Ensuring the transmission and reception of data via a wireless communication channel under conditions of intentional interference where the parameters of signals can be arbitrarily chosen by teams within specified ranges.

The plan of the first game situation is following. The first team of students assembles a model of the information transmission system in the Simulink environment. The task of the team is to create and adjust the model so that it follows the conditions of exposure to the natural background of electromagnetic interference and takes into account the attenuation of the distance dependent radio signal [**Lin18**]. The task of the second team is to assemble and adjust the model of the radio receiver, which allows to receive signals from the transmitter created by the first command. The third team models the interfering system of the communication channel. The teacher provides the structural diagram of the simulated systems. The operating parameters of all three technical systems are also predetermined and described in the assignments given to students. After the system models are ready, the teacher checks their performance according to a given method. All three systems are combined into one model and then the signal is checked in different modes by the receiving system.

If everything works correctly, the teams move to the second game situation. It includes several iterations of one script. The teacher instructs the third team to input certain values of the parameters of the electromagnetic interference system. Generated interference interacts with the transmission of the signal generated by the conditions of the first game situation. In this case, the interference parameters are only known to the third team. The task of the first and second teams is to coordinate the parameters of the transmission and reception systems that would allow to transfer the radio signal in the event of interference [**Ore17**]. Students are limited in choosing the characteristics of a system with a maximum transmitter power and a frequency band allocated to a radio signal. However, they are free to choose how to modulate the signal, the data transfer rate and how to select and filter the signal [**Pas18**]. When students successfully modify the models of the transmitter and receiver of signals for communication, the teacher gives the third team new data to form interference and the game situation repeats. After the students have established effective interaction between the teams and learned how to quickly select the parameters of the transmitting and receiving systems to successfully transfer data in conditions of intentional interference, the teams move to the third game situation.

Within the third game situation, teams are given the opportunity to independently choose the modes of system operation, taking the indicated limitations into account. The first and second teams must agree on a strategy for changing the parameters of the receiving and transmitting systems so that the actions of the third team do not interfere with the process of transmitting information. The task of the third team is to formulate different types of interference in such a way that the first two teams fail to transfer data [**Zhu18**]. This game situation assumes that teams 1 and 2 need to transfer the agreed amount of data in the allotted time. The task of team 3 is to prevent them from doing this.

All results of game situations are recorded. At the end of each situation, a discussion is held on why in some cases the signal was successfully transmitted and received, and not in others.

For each game situation 1-2 training sessions are given depending on the complexity of the used device models. Thus, the entire scenario takes from 3 to 6 lessons.

As a rule, a teacher conducting scenario training according to the described method uses the help of 2-3 assistants who supervise students and make notes about their activity during the work and the correctness of the proposed ideas and actions taken.

4 Results

The method of teaching students of a higher education institution, developed and described in this paper, is aimed at the effective development of the competencies that the discipline "Information Security in Wireless Communication Systems" should develop in students. This is a general professional competence (GPC-3) - the ability to apply the propositions of electrical engineering, electronics and circuitry to solve professional problems; as well as professional competence (PC-2) - the ability to use software systems, applications and special tools, languages and programming systems to solve professional problems. Pedagogical methodology allows to consolidate and put the knowledge gained by students in lectures from the subjects and the knowledge and skills gained in the study of related disciplines into practice.

Moreover, when performing game tasks and preparing reports on the results, students develop other competencies envisaged by the curriculum to some extent. These are the following common cultural competencies:

– CC-6 - the ability to work in a team, tolerantly perceiving social, cultural and other differences;

– CC-7 - the ability to communicate in oral and written forms in Russian and foreign languages to solve problems of interpersonal and intercultural interaction, including in the field of professional activity;

– CC-8 - ability for self-organization and self-education. General professional competence is also being improved (GPC-1) - the ability to analyze physical phenomena and processes to solve professional problems. Also

at the lessons following the described methodology, professional competence (PC-11) is developed - the ability to conduct experiments according to a given technique, process and evaluate of the error and reliability of their results. Some development is gained in the professionally-specialized competence (PSC 2.1) which is the ability to conduct a joint analysis of the functional process of the object of protection and its information components in order to determine the possible sources of information threats, their probable goals and tactics.

To assess the effectiveness of the development of each of the listed competencies, the authors developed a test block. The students of the two focus groups underwent entrance testing, in which the level of development of each of the listed competencies was accessed. One focus group of students was trained using traditional pedagogical technologies and simulation models in the Simulink environment. The second focus group of students was trained using the developed pedagogical methodology of scenario planning and simulation model usage. Despite the fact that the criteria for evaluating the development of competencies and the adequacy of the developed test tasks to these criteria require independent assessment and improvement according to the best practices, i.e. [**Bap16**] and [**Simj14**], the first results showed that the effectiveness of training the second focus group increased by an average of 22% for two core competencies and 10% for additional competencies. That is an impressive result.

5 Discussion

Olga Petrovna Pankratova, Head of the Computer Science Department at the North-Caucasus Federal University shared her approaches to assessing the effectiveness of introducing pedagogical methods. With Ekaterina Aleksandrovna Konopko, Associate Professor of the Computer Science Department at the North-Caucasus Federal University, authors had many fruitful discussions in the process of working on the material.

6 Conclusion

Usage of the teaching method developed and described in this article, which combines interactive methods of scenario planning, didactic games, inverted class and brainstorming was described. Conducted classes that follow this method allow to consolidate and put the knowledge gained by students in lectures on the discipline, as well as the knowledge and skills gained in the study of related disciplines into practice.

It is comfortable for students to study according to the developed methodology, since game including pedagogical technologies are routinely perceived by them as an activity that they like to engage in. Students do not need to write down some material for a long time. They work in a team, develop relevant competencies and try on the roles of leaders or performers in solving professional tasks. In addition, students develop a sense of professional competition, which stimulates their further development. When performing the third game situation, students already work independently most of the time. The teacher remains in the role of a moderator. This stimulates the development of students' responsibility for decisions and actions.

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