© University Press 2020
ISSN 2719-6550
ISSN online

„Journal of Education, Technology and Computer Science"
No. 1(31)/2020
www.eti.rzeszow.pl

Received: 13.06.2020
Accepted for printing: 3.08.2020
Published: 05.11.2020

DOI: 10.15584/jetacomps.2020.1.12

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Didactic Significance of Modern Simulation Programs in Vocational Education – Divagations from Own Research

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Abstract

Simulation programs in polytechnic (vocational) education have an important didactic function. On the one hand, they are a great example of modern didactic software, on the other hand, knowledge of the simulation software environment by a future graduate of a technical university increases the qualifications of the future employee and allows him to acquire an attractive profession. In the era of high requirements set by employers and competition on the education market, their knowledge seems highly justified. However, whether simulation programs, especially deterministic ones, can also act as teaching aids is not so obvious. In this article, in addition to purely theoretical considerations, will be presented stages of own research on didactic efficiency, or more precisely the impact of this group of software on the cognitive process during learning. More importantly, the didactic effectiveness was tested based on typical pedagogical research as well as by means of electroencephalographic tests using the QEEG method.

Keywords: simulation programs, electroencephalographic tests, QEEG, cognitive process, modeling

Introduction. Analysis of basic concepts

Simulation modeling has been included in the curricula of various fields of study for many years (although it does not necessarily function under that proper name). As part of vocational training at the Jan Długosz in Częstochowa and Częstochowa University of Technology, students build computer models of real or hypothetical systems developed for the teaching process. Usually theoretical elements are included in the content discussed during one course: model construction, statistical analysis of results, etc. as well as practical: programming, use of various simulation tools, etc. It is important to remember that simulation is a set of techniques and not just a single method. There is no special type of model, which may suggest the frequently quoted phrase “simulation model”. In fact, the term simulation refers to a methodology for collecting system information by observing the behavior of a mathematical model using a computer program. Three main simulation currents are most often considered, these are: simulation games, static simulation and dynamic simulation. Although each of these variants is unique, simulation games are fundamentally different from the others. The term “computer simulation” is also defined by the PWN Encyclopedia: “computer simulation, a method of reproducing real-world phenomena (or some of their properties and parameters) using their mathematical models, defined and operated using computer programs”. In short, computer simulation is the final effect of combining a physical and mathematical model. After entering data about the object and saving the calculations in the simulation program, we can make a visualization that we care about. The most useful use of simulation techniques is using complex techniques, where analytical determination of the solution is too laborious. Almost all simulations are currently carried out using the most modern IT equipment together with computer software. This problem has long been significant, especially in Polish schools and colleges, where the financial factor clearly limited the use of this group of programs. The biggest advantage of computer simulation is the ability to observe the future. It is very important because we can test this simulation without using any resources. We can control the duration of the simulation, we can trace the whole event step by step and thanks to visualization, complicated systems become easier to pick up. Thanks to the simulation, we can avoid the costs associated with improving errors and performance, we can examine the behavior of non-existent phenomena. Computer simulation also has negative aspects, i.e.: simulation design requires experience so as not to make mistakes when designing, which may be reflected in the final work result. According to the definition of simulation formulated by Naylor: “Simulation is the process of designing a mathematical and/or logical model of a real system and then conducting computer experiments on this model to describe, explain or predict the behavior of the real system…”.

Simulation programs can be divided into three main categories:

- board and fantasy games;
- simulations similar to games accidentally referring to program content;
- simulations built with a specific pedagogical intention (Bruce, 1999, p. 135).

Types of computer simulations

An additional, significant difficulty in shaping the content of the program is the variety of methodological approaches that occur under the common banner of simulation. Computer simulations can be divided according to:

- event predictability,

– stochastic – they use a pseudo-random or (very rarely) random number generator (the Monte Carlo method is particularly popular),

– deterministic – the result is repeatable and depends only on the input data and possible interactions with the outside world, e.g. an operator,

– the way time passes,

– with continuous time – time increases with constant increments, as in the simulation with discrete time, but the values of signal samples are interpolated for intermediate moments between the reading moments,

– with discrete time – time increases steadily, and the time step is optimally selected due to the resource availability of the system, its performance and the nature of the simulated object and/or phenomenon (microseconds in electrical circuits and millions of years simulating star evolution),

– discrete event simulation – time increases by leaps and bounds, but its increments are variable (the sequence of events is more important here than the actual or virtual passage of time),

– the form of the output,

– static – the result is a data set, static image, etc.,

– dynamic – the result is a process that takes place over time, e.g. animation,

– interactive – react to signals from the outside world, e.g. an operator,

– noninteractive,

– the number of computers used,

– local – processing takes place on a single computer,

– distributed – processing takes place in many computers connected in a local area network (LAN) or external, e.g. the Internet.

Due to the research nature, the simulations are divided into deterministic and stochastic. In technical education (vocational, polytechnic), we will be particularly interested in deterministic simulation. If we call the simulation putting the model in motion, it is this term that best suits deterministic simulation. The deterministic model is a useful and most commonly used model in describing many physical, biological, sociological or economic phenomena. The deterministic description can be contrasted with a probabilistic model, such as a stochastic or accidental process.

Simulation as a method of active learning process

Simulation is a method of active teaching and learning, in which you imitate reality in order to gain experiences similar to those that we implement in the real world. If teaching is to serve the assimilation of material to the maximum degree and the entire perception system of the student, student or trainee is to be involved in the cognitive process, then it is worth reaching for visual and multimedia techniques. Educational computer programs perform many cognitive, educational and didactic functions in the teaching and learning process. These functions are directly or indirectly related to learning about reality and knowledge about it, shaping the emotional attitude to the environment and training the action that causes its processing (Okoń, 1995).

According to the Encyclopedic School Dictionary, physical experience (experiment) is the induction of some phenomenon in controlled laboratory conditions, ensuring its repeatability, in order to make observations and measurements. The results obtained are the basis for a qualitative and quantitative description of the phenomenon, and are also used to explain it based on current knowledge (Cach, 2002). Experiments that are carried out during classes can be divided into two types. These are shows that can be an "experimental illustration" of the phenomenon, law or model, instrument or device discussed by the teacher. These are also laboratory exercises, which are a form of experimental research carried out by students independently (Przybylak, 2010).

Didactic programs supporting teaching can be divided into:

- programs supporting conducting experiments using a computer;
- programs supporting solving tasks in the subject using a computer;
- programs supporting theoretical lessons in the given subject;
- programs supporting checking of messages learned during lessons – control tests (Kiedrowicz, 2000).

Information technology has been included in the core curricula. It should be used as far as possible and in the process of teaching all subjects. Classes enriched with information technology provide students with the skills to properly use information sources and appropriate tools for its processing, and to understand the new possibilities provided by this technology, its effects and limitations (Sysło, 1996). It is important to emphasize the fact that simulation is a set of techniques and not a single method. There is no special model type, which may suggest a frequently cited phrase simulation model. In fact, the term simulation refers to the methodology for collecting information about the system by observing the behavior of the mathematical model using a computer program (Mielczarek, 2003, p. 133–141).

Simulation modeling is a field of knowledge that serves to deepen the level of understanding of the interactions occurring in the system and the system as a whole. It can be argued that the computer simulation method is only a means and not an end in itself. The overriding task of the course in the field of simulation should be to teach the ability to ask the right questions regarding system behavior and recognize the correct answers. Therefore, the distinction between acquiring knowledge and developing certain skills seems appropriate. Acquired knowledge should make a student skillfully introduced to the model of real world uncertainty, will feel at ease when dealing with large, complex systems, will know how to properly plan a simulation experiment to move in the maze of various solutions. However, his skills will allow him to efficiently use a selected programming tool, build a correct computer model and carry out its verification (Mielczarek, 2003, p. 134).

There are various approaches to the term “simulation” in the literature. Alternatively, concepts such as simulations, social simulations and simulation games are used. Definition problems are not the result of the method's novelty, but rather a consequence of different ways of imitating reality and different ways of using simulation in pedagogical practice. Before starting the simulation, make sure that students have the appropriate knowledge needed to analyze the simulated process and that they are ready to actively participate in it. Define the objectives of the simulation, present the scope of the topic, prepare additional texts that will engage the group in the initial search, allow you to feel the “atmosphere” of relationships between people, characteristic of specific events, and provide students with a basic set of concepts. It is the responsibility of the teacher to prepare materials with a description of the situation and roles, and to outline the situation framework. It should be remembered that the simulation is to accurately reproduce a given event or process. Therefore, it is necessary to precisely develop the rules and scenarios. Participants are not allowed to go beyond the framework created in this way – all ingenuity and activity must be used to develop the best solution in their opinion within the imposed restrictions, and not to circumvent or break them. Summary is the most important thing in simulation. Based on the experience gained during the simulation and the behavior of others, participants have the opportunity to compare and analyze what happened. This can be done in the forum, or students can be encouraged to work in smaller groups. That is what the selected literature related to didactics says, and how is it in practice? As an answer to this question, the results of own research conducted for many years and concerning generally speaking didactic effectiveness in vocational education will be presented in a form of extremely concise.

Review of author’s research

In the years 2010–2015 scientific research was conducted on the main research problem: Does and to what extent the use of deterministic computer simulations in technical education has an impact on the increase in the effectiveness of education compared to traditional didactic methods used in laboratory classes? The results of the research were included in the author’s scientific monograph (Prauzner, 2016). Pedagogical research was carried out with the help of comparative groups among technical students in traditional and experimental form using deterministic simulation software. In detailed studies statistical calculations were carried out, confirming the assumed detailed hypotheses and showing the strength of relationships between the adopted independent and dependent variables. To conclude and not go into the details of the research here, it turned out that deterministic computer simulations in technical education can be an interesting didactic proposition for those conducting the classes and in the self-education of students, of course, provided that a number of conditions are met, the quality of these programs, their algorithmic construction, etc. In subsequent years of scientific work, it was possible to continue the above-mentioned research problem in a different way by means of electroencephalographic tests. As part of EU funding, the Biofeedback Experimental Research Laboratory of the Jan Długosz in Częstochowa. To assess cognitive activity, brain electroencephalographic studies based on the EEG test and the more advanced QEEG method (brain mapping – quantitative – or "quantitative" EEG) were used. Mitsar EEG 202 measuring apparatus was used in the tests. The brain is a complex organ that regulates human activity. It consists of many different structures that play a different role in regulating behavior. In the study, signals from sensors located on the scalp were observed, i.e. signals generated at various levels of the brain structure. The reflection of the work of neurons in the form of recorded impulses can also be interpreted by specific cognitive activity occurring in the brain and typically body movement. Specific signals were extracted and subjected to computer analysis. Students performed various problem tasks in simulation software, and the apparatus measured the activity of various wave frequencies in the brain at that time. These waves are divided based on their frequency, and so we distinguish the waves: Theta, Alpha, Beta1, Beta2, SMR and Gamma. By comparing the results obtained with separate functional areas and medical literature, it is possible to determine with certain probability a specific human activity during work. It should also be mentioned that various wave frequencies also arise in humans in certain states of biological or mental activity. Conducting this research takes a lot of time for the researcher, it is also methodically complex, which is why at this point I also refer the reader to my numerous publications. In conclusion, this type of research additionally provided further data on the assessment of didactic effectiveness. These studies also allowed us to explain the differences in cognitive activity in the didactic process, but resulting not so much from the quality of the prepared materials, but from interpersonal differences resulting from the different structure and functioning of the brain in people. QEEG research will continue and the results confirm the belief that it is an interesting and non-invasive method of research, thanks to which it can be used not only in medicine, but primarily by educators and psychologists.

Figure 1. Example of QEEG tests while working with a computer

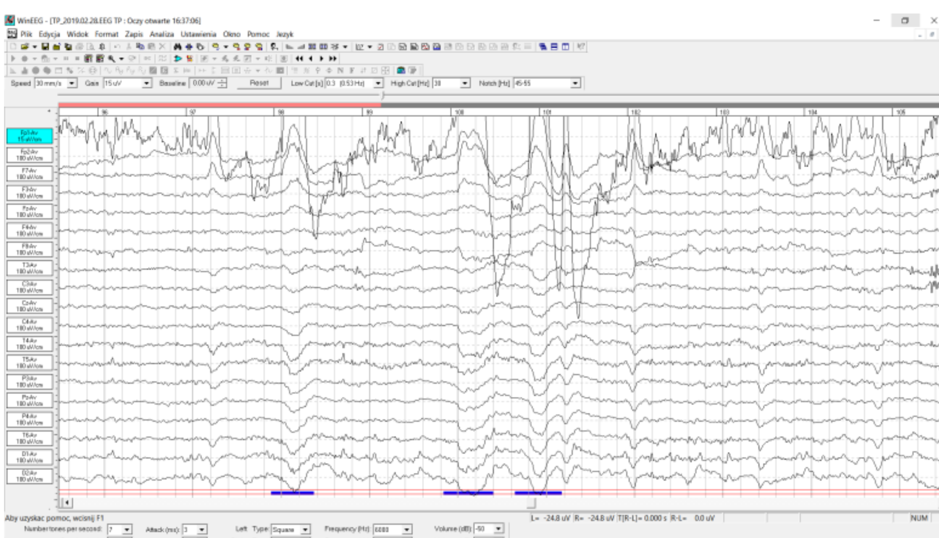

Figure 2. Example of brainwave waveform with separated artifacts (read errors)

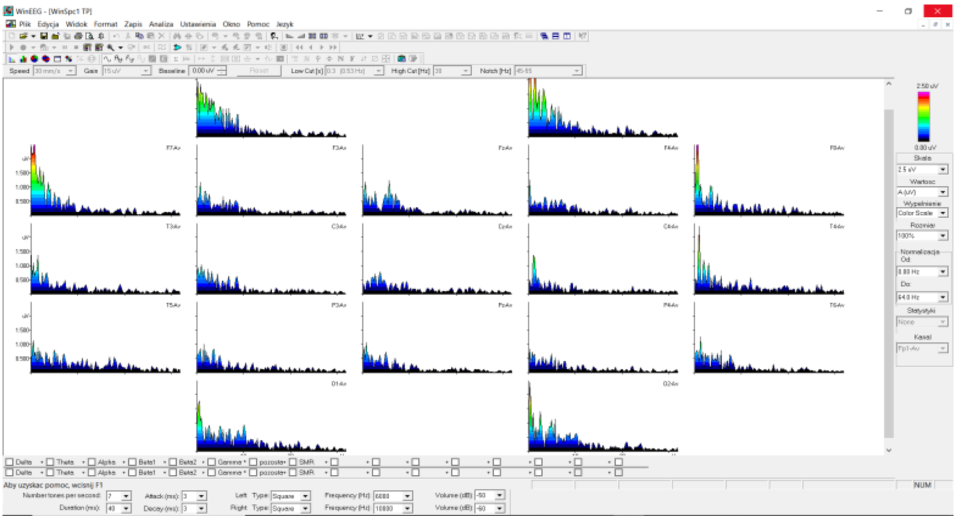

Figure 3. The course of frequency characteristics from individual sensors

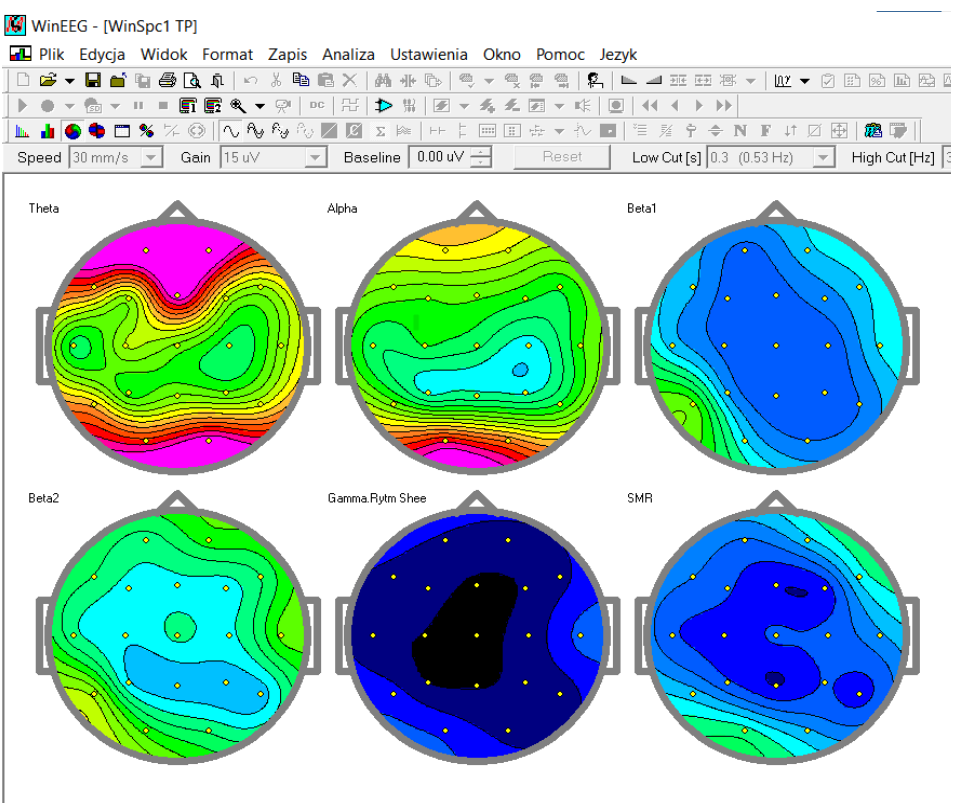

Figure 4. Visualization of the map of brain activity

Summary

The above research method is a non-invasive form of conducting scientific research. Like any research technique, it also has its drawbacks. They mainly result from insufficient resolution of measurements, because the limited number of sensors on the head affects the approximation of the results of activity of certain areas of the brain. The reliability of results is also strongly influenced by the care of processing of recorded "raw" signals that require complicated mathematical calculations. As research shows (Prauzner, 2015, p. 19), one can observe above all high activity of the waves: Beta1, Beta2 and SMR when working on a computer with simulation programs. Their location of occurrence in the brain and signal amplitude is interpreted in detail and on this basis appropriate conclusions are drawn.

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