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INTEGRATION OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN THE TEACHING-LEARNING PROCESS OF BIOLOGY WITHIN MIDDLE SCHOOL EDUCATION FROM ISRAEL

532.02. SCHOOL DIDACTICS (BIOLOGY)

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CONCEPTUAL BENCHMARKS OF THE RESEARCH

One of the priorities of the educational policies of the last years, at global level, is the integration of information and communication technologies (ICT) in the didactic process, which allows the opening of new horizons for the educational practice such as: facilitating the processes of presentation and transmission of the information, of its processing and knowledge building. This is why the education system in general and the secondary school in particular becomes an applicant for the implementation of research results related to the elaboration and development of new didactic technologies associated with ICT integration.

Recent research confirms the need to adapt the school to the 21st century or to the information age and to prepare students for a rapidly changing world. This fact implies the need to integrate technologies in the teaching-learning process in the classroom, which contributes to facilitating the development of 21st century skills [1, 2]. Hence, since 2010 the education system in Israel applies a national ICT program called "Adapting the Education System to the 21st Century". The goal of this program, but also of all the reforms in the educational system, is to lead to a profound pedagogical change that will promote the significant learning and development of the skills needed for the 21st century, by integrating ICT. Such an innovative model increases the teacher's potential towards students and his school and constantly changes his role in the classroom [2, 3].

There are numerous studies regarding the subject of ICT integration in the school. However, there is very few fundamental researches on: the influence of ICT on student outcomes in biology; the learner's opinion on the use of ICT in the learning process and the impact of information technologies on the motivation of learning and self-efficacy of students. In this context, the current paper is a totalization of the author's research on these aspects of ICT integration in teaching and learning biology in the Israeli gymnasium. And the achievement of results in the mentioned field will reflect the desired pedagogical change.

The use of ICT tools in biology lessons has many effects on the students. However, to what extent does this fact influence the results that will be reflected in the biology scores from the graduation diplomas of the gymnasium? To what extent does ICT learning influence the motivation to learn the biology and self-efficacy of students? What is the opinion of the students regarding the integration of ICT in the biology lessons? These are some of the questions that this research will try to address. The insufficiency or even the lack of studies that would aim at the impact of ICT in the discipline of Biology on the school results of students, in general, and of the gymnasium, in particular, was decisive for initiating this research and highlighted the actuality of research theme: *Integration of Information and Communication Technologies in the teaching-learning process of biology within middle school education from Israel*.

Description of the situation in the research field and identification of the research problem. Scientists from all over the world, including Israel and the Republic of Moldova, have

focused their research on the main pillars of the contemporary education system: developing curricula focused on the learners and the use of ICT in the teaching process.

The research literature addresses the subject of ICT integration in the teaching-learning process in several aspects that confirms the idea of the multidimensional influence of ICT on the student and which has been used as a basis for current research. Thus, pedagogical researchers highlight the role of the knowledge of information technologies by teachers and emphasize the importance of the correct and efficient integration of ICT in the educational process. Many researchers from Israel addressed the integration of ICT in education in various aspects: O. Avidov-Ungar and F. Arazi Cohen [4], R. Dayan and N. Magen-Nagar [2], O. Avidov Ungar and A. Forkosh-Baruch [5], A. Uphan, G. Trachtman and O. Spektor-Levy [6] investigated the factors that impede and delay the assimilation of ICT in schools and the perception of the national ICT program "Adapting the education system to the 21st century" success, and what can be learned from the successes [7]. O. Avidov-Ungar and Y. Eshet-Alkalai [8]; L. Cohen [9]; T. Shamir-Inbal and K. Yael [10] addressed and presented the systematic models for ICT assimilation in school culture. N. Magen-Nagar and T. Shamir-Inbal [11]; Y. Kolikant [1]; B. Peled and N. Magen-Nagar [12]; Y. Nissim, M. Barak and D. Ben-Zvi [13] pointed out: the profile of teachers in an ICT learning environment; role perception and teaching strategies of teachers combining advanced technologies in their lessons and the influence of the national ICT program on the changes happening in the teachers' work.

The pedagogical researches of scientists from Republic of Moldova refers to: the implementation of ICT in education as a means of modernizing pre-university education [14, 15]; the formation of professional competences of teachers [16]; the methodology of using ICT in higher education [17]; the impact of ICT on the study of school and university disciplines [18-22].

Studies on the use of ICT in teaching biology, internationally, have been conducted by G. Ezekoka [23], M. Al-Rsa'i [24], Y. Garraway-Lashley [25], A.C. Kafyulilo, P. Fisser, J. Pieters and J. Voogt [26], R. Trumper [27] and A. Šorgo, T. Verčkovnik and S. Kocijančič [28] who also examined progress in scientific literacy through the use of ICT in teaching science in general. In Israel, was studied the subject of ICT integration in science teaching. Also, researchers [29-31] studied students' opinions and perceptions of technological innovations in school and the contribution of ICT to the teaching-learning process and motivation in general, but they did not examine the integration of ICT in the teaching of biology in terms of its influence on student outcomes, a fact that adds value to this research. Russian researchers are also involved in studying the aspects of implementing information technologies in biology classes [32-36]. In the Republic of Moldova, the studies on the implementation of ICT in the educational process in biology are very few, summarizing the approach of the practical experiences in this field of some researchers [37-41].

The study of the results of national and international pedagogical researches and educational practices allowed the identification of ***contradictions***:

- between the extensive offer of educational software and technologies and the insufficient and even reserved, reluctant implementation of ICT in biology lessons due to the lack of adequate methodological and technical support for teachers;
- between the abundant use of technologies, especially the Internet, by students in everyday life and the minor implementation of ICT in their own learning process, due to insufficient pedagogical guidance;
- between educational policies offered in the field of ICT, recently intensified scientific studies, scattered technical and practical models for the implementation of ICT in the educational process in biology and the lack of an integrated pedagogical model, theoretically and methodologically grounded, in this field.

The aforementioned and the identified contradictions, highlights **the research problem**: *what are the theoretical and methodological foundations for the implementation of information and communication technologies in order to streamline the teaching-learning process of biology in gymnasium so that there is an increase in students' school results?*

The goal of the research is summarized in *theoretical justification, development and validation of a pedagogical model for integrating ICT into the process of teaching-learning biology in gymnasium, meant to contribute to the progress of students' school results*. In order to solve the research problem and reach its goal, the following **objectives** have been advanced:

- *study of educational practices for the implementation and integration of ICT in learning environments;*
- *analysis of the advantages offered by ICT and arguing the need for their implementation in gymnasia education in biology;*
- *elaboration of a pedagogical model for the integration of ICT in the teaching-learning process of biology;*
- *revealing the methodological landmarks for implementing the elaborated pedagogical model;*
- *validation through pedagogical experiment of the efficiency of the pedagogical model of integration of information and communication technologies in the teaching-learning process of biology.*

The following **research hypothesis** was advanced: by implementing the pedagogical model of integrating information and communication technologies in the teaching-learning process of biology in gymnasium, the teaching-learning process will be streamlined to the study discipline, a phenomenon that will materialize in increasing the school results of students in biology.

The methodology of scientific research included theoretical methods, practical and experimental methods. **The research period** is between 2015 and 2018 and contains four basic stages: first stage was carried out during the years 2015-2016 and was one of documentation; second stage (2016-2017) refers to the research design; third stage, the experimental one (2017-2018); fourth stage (June 2018) was intended for analysis and conclusions.

The novelty and scientific originality of the research results consists in the conceptual foundation of *the pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology* through theoretical and practical evidence that the use of ICT in teaching / learning contributes to: improving results of students in biology; increasing motivation to learn biology and self-efficacy in learning; adopting the positive attitude of students towards the integration of ICT in the process of studying biology; optimal improvement on the dimensions of significant learning.

The theoretical significance of research consists in identifying, analysing and developing theoretical landmarks regarding the implementation of information and communication technologies in the biology teaching process; determining the theoretical-methodological foundations of the pedagogical model for integrating information and communication technologies in the teaching-learning process of biology.

The applicative value of the paper consists in the elaboration and experimental validation of the set of methodological and praxiological tools included in the pedagogical model of integration of information and communication technologies in the teaching-learning process of biology. The identified, selected and capitalized landmarks contributed to the increase of the school results in biology of the students from the middle school in Israel. The research carried out allowed to demonstrate the applicability in the educational practice in the classroom, of all pedagogical and technological tools concentrated in the pedagogical model developed and validated.

The result obtained that contributes to solving an important scientific problem consists in determination of the theoretical and methodological foundations of the effectiveness of the biology educational process in the gymnasium using ICT, which led to the theoretical justification and development of pedagogical model for integrating ICT into the teaching-learning process of biology.

The implementation of the scientific results took place within the pedagogical experiment in which 145 students from the 9th grade (59 students constituted the control sample and 86 students - the experimental sample) from the Kafr Yasif secondary school were involved, Northern District, Israel. Also, in the organization and conduct of the experiment were attended by 3 biology teachers who teach in the classes involved in the experiment, an informatics teacher and the school manager.

The approval of the research results was achieved in accordance with the fundamental phases of the research, during the accomplishment of the theoretical and experimental tasks proposed by the author. The main results of the research were presented, discussed and approved at the meetings of the chair of vegetal biology and didactics of sciences within the Tiraspol State University; at 5 national and international scientific conferences.

Publications on the topic of the doctoral thesis - 8: 4 scientific articles in scientific journals (category B and C); 4 communications at conferences and scientific symposia.

CONTENT OF THE THESIS

The thesis consists of Introduction, three chapters, general conclusions and bibliography, presented on 125 pages.

The *Introduction* highlights the relevance of the research topic, describes the situation in the research field, identifies the contradictions and based on them the research problem is formulated. The research goal and objectives are also formulated here and the research methodology is presented. It also highlights the novelty and scientific originality of the research results, the theoretical and applicative significance of the investigation, the conditions for implementation and approval of the research results. At the final, the summary of the thesis sections is presented.

Chapter 1, *Theoretical aspects of information and communication technologies using in the biology didactical process*, has a theoretical character and represents a synthesis of the specialized scientific works published by various authors, which have tangencies with the research topic. It reflects the epistemological aspects of the use of ICT in education in general and in biology lessons in particular, starting with the general notion of the concept of ICT and ending with the national program in Israel for adapting the educational system to the 21st century.

According to the 12th version of the Master Document of the national ICT program, elaborated by the Ministry of Education [42], the 21st century skills include: *Use of ICT tools; ICT literacy; Critical thinking and problem solving*; *Collaborative communication and teamwork; Student independence*; *Ethical competences and network protection* [42].

In order to lead to a state in which the technology is used for assimilating innovative pedagogy and imparting 21st century skills, it should lead to a state in which the combination of information technology improves the following aspects of teaching: improving the skills of the teachers; adapting the teaching for the variant students; real-time feedback; a learning continuum in the classroom and at home; strengthening of the connection between home and school; administration that relies on the information technology.

Factors involved in the implementing of national ICT program refers to: *the organizational-administrative dimension* (school management and the supervision); *the teaching staff and the level of pedagogical knowledge* (the support of the teachers); *structure and processes within the school* (division to classes, study units, methods of teaching and evaluating); *factors surrounding the school* (Ministry of Education, supervisory bodies, local authorities etc.); *infrastructures* (hardware, software, equipment etc.) [43].

Innovative initiatives can be implemented among different categories of population capable of learning to meet unique needs. According to Nira Hativa [44], the factors that promote the successful integration of technology in the curriculum are: 1. *positive attitude of the teacher* towards the integration of technology in the teaching; 2. *successful experience* from the background in the field of technology integration in teaching; 3. the *high personal motivation* to teach well, to develop as a teacher and a personal commitment to promote student's learning; 4. *significant support from the educational institution* for the use of technology in teaching, both declaratively, verbally and financially, but also by hiring an expert for technical support; 5. good *accessibility to technology* in classroom that is expressed through the direct help of a technician in the classroom, so that the teacher does not fail and access for all students in the classroom to equipment, hardware and software to an appropriate extent; 6. *existence of a staff support group* (usually within the online network) that uses the same technology for consultation and feedback [44].

Factors that impede ICT integration are: *lack of resources and especially time allocation for the process; lack of knowledge, technological skills and competences; infrastructure gaps; technological aspects and organizational policy*. There are basic factors whose existence is essential for the successful implementation of innovation in the organization and for institutionalizing change in the system throughout the process: knowledge and skills, availability of resources and time, rewards and people managing the process [5].

Many researches show that motivation has a major effect on learning and achievements. *Studies show that combination of simulations in the teaching along with online tools increases motivation and achievements in comparison to traditional teaching*. Today, in an age which digital technologies occupy a major place in our social life, and when the technology is inseparable from the students' lives, the pressure to assimilate Educational Technologies into the study material in the classes, is gaining momentum among the education institutions.

According to constructivist theory, the learner is perceived as an active agent who creates meanings and forms incites regarding educational situations. Biology and science teaching by the constructivist approach must include conscious and implicit reference to knowledge construction by the student, that is active, regarding concepts in three fields: concepts in the field of scientific-content knowledge; concepts in process knowledge and the skills of using them: learning and research skills; and concepts regarding the power and limitations of science in light of the formation of scientific knowledge [45]. Curriculums that base on the students' performances and skills, rather than merely on their achievements, can benefit greatly from a correct combination of ICT.

The method of learning, according to constructivism and through ICT, sets the student at the centre (Student-Centred Learning), motivates him to be an inquisitive learner who can find reliable and relevant sources of information across the network and in designated databases. The computer serves the student as a cognitive tool for structuring his knowledge [46].

An ICT environment, can be used as an "object with which we think" and encourage, constructively, the teachers to make a proactive and authentic use in ICT contents. It can also promote constructivist conceptions and innovative pedagogy, in which the learned knowledge and contents are relevant to the students' world and the changing reality. The process of teaching and learning, in such an environment, can promote higher-order thinking and adaptation of relevant skills to an optimal function in the 21st century. The innovative pedagogy strives to nurture skills in three central domains: *higher-order thinking*: creativity, ingenuity, critical thinking and skill in solving complex problems; *collaborative learning skills*, personal learning, and maintaining ethics; *digital information processing skills* [47].

In fist chapter, also, was described the models and methods of teaching through ICT and specifies the tools and technologies that the teacher can use for this purpose. In the conclusions of this chapter, the actuality of the research problem is highlighted and the objectives that will lead to its solution are advanced.

Chapter 2, *Theoretical-methodological benchmarks for information and communication technologies implementation in the biology teaching-learning process*, constitutes the basic nucleus of the investigation and reflects the scientific contribution of the author. Here is presented the pedagogical model of integration of information and communication technologies in the process of teaching-learning of biology (Fig. 1).

The input cell in model includes the information and communication technologies that have revolutionized all spheres of modern life, including education. ICT, representing the technologies used for the reception, presentation and electronic distribution of information, requires from the members of the 21st century society, the information age, specific competences such as: - higher-order thinking; - collaborative work skills; - skills for handling digital and media information, which refers to information literacy, media and ICT literacy [48].

The imperative of these competences, on the one hand, and ICT, on the other, have determined the character of educational policies in most countries, including Israel, which launched the national program for adapting the educational system to the 21st century. Also called ICT national program, because it focuses on the implementation of information technologies in education, it has led to modernization of the school curriculum in general and that of biology in particular [49]. That why, it represents another input cell of model.

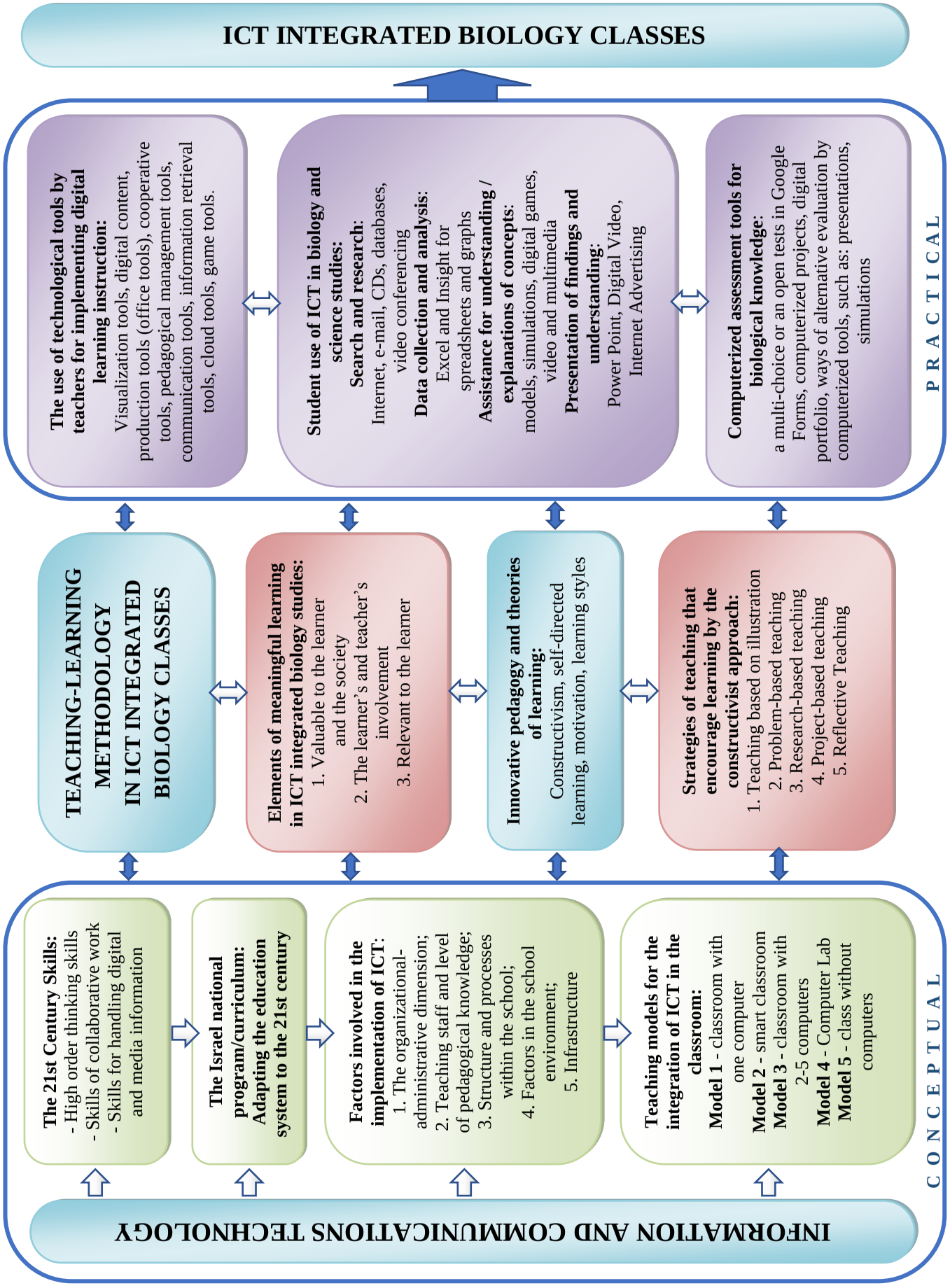

Fig. 1. Pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology

The education system in Israel aspires that all schools implement technology-based optimal pedagogy, to become a school lifestyle. However, the implementation of the ICT-based curriculum in the school depends on five factors, that complement each other and whose combination guarantees the success and achievement of the objectives of this process. Therefore, the factors involved in the integration and assimilation of ICT by the educational system, according to Ministry of Education of Israel policies: *Organizational-administrative dimension; Teaching staff and level of pedagogical knowledge; Structure and processes within the school*; *Factors in the school's environment* and *Infrastructure*, represents an important cell of model.

The guide of an ICT-based school, published by the Ministry of Education [50], describes, among other things, that the new teaching methods are aimed at developing ICT-focused education that combines traditional teaching with the technological means and services at the teacher's disposal in a lesson. There are four models of ICT integration in the classroom: 1. *Basic position of the teacher* (*Teaching Model 1*); 2. *Teacher computer connected to the internet, projector, smart tablet and computerized content* (*Teaching Model 2*); 3. *The position of the teacher (model 2) in addition with a smaller number of computer stands than the number of learners (Teaching Model 3);* 4. *The position of the teacher and additionally computers to all the learners during the lesson (Teaching Model 4);* 5. *In a class without computers, for a laptop learner*, the lesson is conducted as a frontal lesson (*Teaching Model* 5) [51].

The components of the model described above represent the conceptual benchmark for the teaching-learning methodology in biology lessons with ICT integration. This elaborated methodology is based but also requires the respect of the principles of meaningful learning, in which the subject has an active role, since it must restructure and organize information, by connecting new knowledge with previous ones. The significant learning is a learning that summon an emotional, social and cognitive experience, and its elements, addressed in the study of biology with ICT integration, are:

1. *Valuable for the learner and the society*: occurs when the learner's sense that the studied material is meaningful to them on a personal and social level (directed and self-directed learning);

2. *The learner's and teacher's involvement*: occurs when scientific and technological studies are based on constructivist approaches: students are actively, emotionally and cognitively involved in the process of knowledge building (cooperative and constructive learning), actively experimenting with methods in which knowledge and scientific researches are developed (active learning);

3. *Relevant to the learner*: it requires that the sciences and technologies curricular area, of which biology belongs, engages with current issues and problems valuable for society and the individual (authentic learning).

The theory of meaningful learning of David Ausbel has strong influences from the constructivist theory in which the true knowledge is built by the individual on the basis of his own experiences. The constructivist approach represents the core of the innovative pedagogy, which has the responsibility to train creative citizens, who face the changes, analyse and manage the information. ICT-based learning represents an innovative pedagogical infrastructure for meaningful learning in the 21st century. The concept of Innovative Pedagogy describes a flexible school structure adapted to the social, cultural, economic and technological processes of change and to changes in perception of the essence of knowledge. Innovative pedagogy defines the goals of education and the character of the learners in the 21st century education system and describes elements that should exist in school, such as: the curriculum, teaching-learning-assessment processes (including organization of time, organization of learners and team organization) and the learning environment [52, 53].

Within the innovative pedagogy, several theories such as: constructivism, self-directed learning, motivation and learning styles intersect [54]. According to her, the contents taught and the knowledge are relevant for the constantly changing reality, the teaching is adapted to the diversity of the students, it allows the evaluation and feedback in real time, the teaching-learning-evaluation process focuses on the individual and highlights the development of the learner by the self-directed learning. The informational and communicational technologies in the innovative pedagogy are: of visual multiplicity, interactive, dynamic, constantly updated, playful, linked-in, publicized in the social networks [48]. The intelligent use of ICT contributes greatly to the updating of innovative pedagogy and makes it more relevant for students.

The learning by the constructivist approach is encouraged by teaching strategies such as:

1. *Teaching based on illustration*: visual illustration in biology lessons is essential for meaningful learning.

2. *Problem-based teaching*: the learners are presented with an open problem, which must have several solutions or no solution, that solving by students will contribute to knowledge building.

3. *Research-based teaching*: students are offered an activity that develops the knowledge and understanding of scientific concepts, allows the student the opportunity to experiment looking for an answer to a significant phenomenon from his point of view.

4. *Project-based learning*: refers to learning through experiment and experience that allows for the development of 21st century skills, such as: creative thinking, active learning, teamwork, peer feedback and improving motivation for learning.

5. *Reflective teaching*: The student undergoes a process of internal evaluation training, which helps to improve his / her current performance.

The central ***methodological*** components of the pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology, are in bidirectional interaction not only with the conceptual landmark but also with the ***practical*** components. These refer to the hard and soft devices and tools available to both the teacher and the students in the teaching-learning-evaluation process.

The hardware was reflected in the ICT integration models in the classroom. These, along with the software, are decisive factors in improving the teaching-learning-evaluation processes, and the intervention program for the integration of ICT in the biology lessons includes: videos, animations, presentations, exercises and tasks on the computer [55].

Biology teachers have several categories of ICT tools that allow them to integrate it into the teaching process, these being: visualization tools; digital content, production tools (office applications); collaboration tools; pedagogical management tools; communication tools; information retrieval tools; cloud tools and educational game applications.

Regarding the students, they need to use technological tools and means in order to base and develop self-learning, because in a digital world they must learn to manipulate with essential tools for daily life and for productive work in the future. The 21st century literacy is not only reading, writing and computer skills, but also the competence to use information, knowledge and skills in relation to modern life or, as Alvin Toffler said, "The illiterate of the 21st century will not be those who cannot read and write, but those who cannot learn, unlearn, and relearn" [56]. Therefore, the tools that students use to study biology are divided, by destination, into tools for:

- search and research: internet, e-mail, CDs, databases, video conferencing;
- data collection and analysis: Excel and other spreadsheet and graphs applications;
- assistance for understanding / explaining concepts: models, simulations, digital games, video and multimedia;
- presentation of knowledge and findings, conclusions: Power Point, digital video, internet advertising.

Assessment as an important process in the educational act must also be carried out in accordance with the requirements of the information age, which requires standards and alternative assessment tools that capitalize on the skills of the 21st century, such as: open or multiple-choice tests developed using Google forms, computerized projects, digital portfolios, presentations, simulations etc.

The intelligent connection of the components of the model allows as a finality the construction of a biology educational process with adequate integration of the Information and Communication Technologies.

The developed model is characterized by *originality*, from the perspective of its specific components of the biology secondary school education from Israel, the invoked educational

policies and the relationships established between the conceptual, practical and methodological components.

The innovative character of the model is highlighted by the modern educational concepts integrated at the level of innovative pedagogy, constructivism, meaningful learning, higher-order thinking and modern teaching-learning strategies.

The adaptability of the developed model lies in the fact that the national ICT program from Israel and the specific skills of the 21st century cover most of the curricular areas, which allows its implementation in other school disciplines.

The model also has an *evolutionary character*, open to updating, dictated by the dynamic changes in the education system, by the information overload, by the numerous technological developments, but also by the evolution of the Information and Communication Technologies. This fact allows the updating at a conceptual, methodological level, but also at a practical level by easily replacing digital applications and tools with new ones, according to technological developments.

Finally, yet importantly, the model is characterized by *integrity*, due to the connections established between the modern educational imperatives (policies, curricular documents, factors involved), the strategies and methodology invoked and the technological aspects regarding the hardware and software needed by the actors of the educational process [57].

The destination of the elaborated pedagogic model is to progress an innovative pedagogy in schools by encouraging biology teachers to do an educated combination of content, digital tools and environments in the teaching-learning-evaluation process, and thus bettering the educational pedagogic methods. It is no longer possible to have a modern education system that does not integrate technologies in the learning and teaching nowadays.

The process of implementing an intervention program for ICT integration in biology lessons was realised with full collaboration of the teachers, because, when the teachers are involved in the assimilation they can cope better with the challenge of the change and evolve professionally. For this kind of involvement to be possible, the teachers and the students must be surrounded by an adequate educational environment and school system. The acquisition of innovative pedagogic-technological knowledge requires a systematic intervention, as well as a detailed planning of teacher training activities according to the needs of the school. Teaching in an ICT environment requires the teacher to use current technologies for his or her professional needs, and to combine them in the every-day life of the class. In order for the teachers to acquire the new knowledge and assimilate the ICT meaningfully, a proper training is required, basing on a local leadership of teachers, who are a part in the decision making regarding the nature of change assimilating and support in the team leading [10].

In order for the assimilation and application of the ICT integration pedagogic model in biology lessons for 9th grades in school to be meaningful, it was acted on two levels:

1. The level of the professional biology teachers: three biology teachers who teach 9th grades have participated in the experiment and in the intervention program. Guidance meetings were conducted in the school throughout the process.
2. The level of the students: students were acquainted with methods and ways of integrating ICT into biology learning and ICT-based tasks.

Chapter 3, *Experimental argumentation of the efficiency of the pedagogical model of integrating the informational and communication technologies in the process of teaching-learning of the biology and of the elaborated methodology*, refers to the pedagogical experiment carried out in the 9th grades of the Kafr Yasif gymnasium school, the northern district, Israel.

Table 1. Research participants according to classes and gender

	Control group			**Experimental group**			
Class	**9A**	**9B**	**Sum**	**9C**	**9D**	**9E**	**Sum**
Boys	17 (%56.7)	17 (%58.6)	**34 (%57.6)**	16 (%53.3)	13 (%46.4)	13 (%46.4)	**42 (%48.8)**
Girls	13 (%43.3)	12 (%41.4)	**25 (%42.4)**	14 (%46.7)	15 (%53.6)	15 (%53.6)	**44 (%51.2)**
Number of students	30	29	**59**	30	28	28	**86**
Total number of participants: 145							

The research focused on main subjects of life science content areas according to the expanded master document for teaching science and technology related to the 2016-2017 junior high school curriculum for 9th grades: needs for existence of living beings, characteristics of life; cell: structure and function; feeding: in humans, animals and plants; genetic material (genome) and a healthy lifestyle.

One of the main objectives of this research is the *validation through pedagogical experiment of the efficiency of the pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology*. Therefore, the following **research hypothesis** was advanced: by implementing the pedagogical model of integrating information and communication technologies in the teaching-learning process of biology in gymnasium, the teaching-learning process will be streamlined to the study discipline, a phenomenon that will materialize in increasing the school results of students in biology.

It was identified the research variables:

a. The independent variables examined in the research were teaching methods in two levels: the traditional method (the frontal) and the ICT level (integrating ICT in biology classes: videos, animations, presentations, tasks, digital games and chores); training content / curriculum; forms of training organization; teacher characteristics, learning conditions.

b. The dependent variables were: student achievements in the subject of biology; the students' attitudes towards integrating ICT; motivation and ability of students to study biology; meaningful learning dimensions in ICT integrated biology lessons.

In order to verify the main research hypothesis, four particular hypotheses were defined (principal one, and three additional), and they are:

Hypothesis number 1: the achievements in biology among students who learned through the ICT based method will be significantly higher than those of the students who learned by the traditional manner.

Hypothesis number 2: the motivation and self-efficacy in learning among students who studied biology in the ICT method will be significantly higher in comparison to the dimensions of motivation and self-efficacy in learning among students who studied in the traditional method.

Hypothesis number 3: students who studied biology in the ICT method will reveal more positive approaches to ICT in comparison to students who learned in the traditional method.

Hypothesis number 4: students who studied biology in the ICT method will report that the learning is more meaningful for them in comparison to students who learned in the traditional way.

Two quantitative tools have been used in the research, and they are:

A. Tests (before and after the intervention). During the research the students of both groups (the control and the experimental) had 4 tests: two mapping tests occurred before experimenting in ICT-based educational environment; and two tests occurred after using ICT, by the end of studying the relevant school units in biology for 9^{th} grade.

B. Online closed questionnaire. The questionnaire opened with an introduction explaining the research purpose. The first part examined professional and personal features. The second part was composed of 27 items, divided to three categories: **a)** motivation: capability and self-capability, (9 items); **b)** students' positions toward ICT integration in biology teaching (9 items); **c)** the meaningful learning in ICT integrated biology lessons and presenting the students' usages of ICT in class (9 items). The questionnaire included 5 reversed items. The questions were composed to be compatible to both groups (the experimental and the control), and in order to ensure reliability, the questionnaire used the *alpha Cronbach* coefficient to calculate internal consistency. The calculated data attest that the reliability of the scales in this questionnaire were in the range between α=0.721-0.858, meaning, a high level of reliability.

In table 2 are presented the results of the tests before de experiment.

Basing on the table 2, one can see that the general mean of the control group before the experiment in both tests is 76.2, higher than that of the experimental group, which its general mean in both tests is 64.4. The gap between the two groups indicates a difference in the level of knowledge among the groups, it is obvious that experimental group is at a relatively lower level

in comparison to their colleagues in the other group. These significant differences were attested with t-test for independent samples, where t(143)=3.66 and p=0.0<0.05.

Table 2. The students' achievements in biology before the experiment

	Class	First test mean, October, 2017	Second test mean, December, 2017	Test mean before the experiment	Means of both tests of each group
The control group	9th grade 1	76.4	77.7	77.1	**76.2**
	9th grade 2	77.6	73.0	75.3	
The experimental group	9th grade 3	69.1	65.1	67.1	**64.4**
	9th grade 4	66.3	65.3	65.8	
	9th grade 5	58.5	62.1	60.3	

In order to examine the first research hypothesis, the differences between the tests before and after the intervention was analysed, in five classes (control: classes number 1, 2; experimental: classes number 3, 4, 5), results of which appears in table 3 below:

Table 3. Student achievement before and after the experiment

	Achievements *before* the experiment				**Achievements *after* the experiment**			
Class No	First test October, 2017	Second test December, 2017	Average	Average for all	Third test March, 2018	Fourth test May, 2018	Average	Average for all
Control group								
1	76.4	77.7	77.1	**76.2**	77.4	73.5	75.45	**74.8**
2	77.6	73.0	75.3		76.6	71.8	74.2	
Experimental group								
3	69.1	65.1	67.1	**64.4**	75.8	77.7	76.75	**75.8**
4	66.3	65.3	65.8		75.2	76.5	75.8	
5	58.5	62.1	60.3		71.6	77.9	74.8	

There is no significant difference between averages before and after the intervention for control group (76.2 and 74.8) and significant difference between these averages for experimental group (64.4 and 75.8). For purpose to confirm it, t-test for paired samples was done in SPSS, for the control group and the experimental group.

The output of t-test for paired samples in SPSS for control group shows that, t(58)=1.336, with an p-value p=0.187>0.05, that mean there was no significant difference between students' achievements before and after intervention for control group classes.

For experimental group, the output of t-test for paired samples in SPSS shows that, t(85)=12.276, with an p-value p=0.00<0.05, that mean there is attested significant difference between students' achievements before and after intervention for experimental group.

These findings clearly attest that the assimilation of ICT in biology studies in the experimental group brought to an improvement and progress in achievements and raising the

level of knowledge of biology among the students. While on the other, the traditional learning did not affect the achievements of the control group students [58].

Regarding the *Online closed questionnaire*, there were examined the data for each 9 questions that refers to the other three particular hypotheses [59]. These three hypotheses were refuted, but important findings were obtained.

About second hypothesis, all students from all five classes, regardless of the experimental groups and control groups, reported very high rates of motivation and self-efficacy because of the ICT lessons. The reports of the participants in the control groups were based on their ongoing experiences in ICT learning, outside the intervention framework of this study. Students of class number 3 reported the highest rate 89.25% of motivation and self-efficacy, after them are the classes: number 2 (85.25%), number 1 (84.25%), number 5 (82%), and number 4 (80.50%). In conclusion, the significance of these findings in the second research question is that *all students think that the ICT lessons in biology significantly improve their motivation and self-efficacy*.

Regarding the third hypotheses, students from five 9th grades, from the experimental and control groups, expressed very positive attitudes towards the ICT learning of biology. Students of class 3 showed the most positive attitudes among all participants at the rate of 85.25%, followed by class 1 students (81.5%), followed by class 2 and 4 who showed positive attitudes at a high and similar rate of 79.75%. And finally, class 5 also showed positive attitudes at a high rate of 77.75%. To conclude, the significance of these findings is that the students, whether in the experimental group or in the control group, *have shown positive and significant attitudes towards ICT learning of the biology subject*.

On testing the fourth hypotheses, it was found that all students highly appreciated the role of ICT integration in meaningful learning in biology lessons, according to their own perception. Students of class number 3 reported the highest level of meaningful learning of all the other students from the other classes, in a rate of 88%, after which students of class 2 (85%), 1 (84.25%), 4 (82%), and finally students of class number 5 who reported meaningful learning at a rate of 80.75%. In conclusion, all students reported that *ICT biology classes are best for improving their meaningful learning.*

Above mentioned findings, based on pedagogical experiment, emphasise the efficiency of the pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology. Therefore, the implementation of the pedagogical model led to the efficiency of teaching-learning process of biology in the gymnasium ICT, which were materialized through increasing student achievement in biology, and the main *research hypothesis* was confirmed.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

1. The analysis of the advantages offered by the ICT and the argumentation of their implementation in the biology secondary education allowed to highlight the fact that there is facilitated the achievement of the innovative pedagogy, is increased the learning motivation, is developed the critical thinking, which leads to a significant (meaningful) learning, and to the training and developing of the 21st century specific skills [14, 54, 52].

2. The analysis of numerous publications related to the research topic has led to the identification of technological models for using computers in the classroom, and pedagogical models regarding the integration of information and communication technologies in the teaching-learning process of biology are missing. The researchers presented and classified different ICT tools that can be used in biology lessons, but their location and interdependence with the other components of the educational process were not shown. Therefore, *the elaboration of the pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology* was a priority objective of this research that was accomplished [57].

3. The conceptual component of the elaborated pedagogical model of integrating ICT in the process of teaching-learning of biology, influenced the afferent teaching-learning methodology, which consist the central cells of this model and determined bidirectionaly the practical component of it – the output cells, that details the ICT tools implemented in teaching, learning and evaluation processes. This methodology is modern one and is based on elements of meaningful learning that is part of innovative pedagogy and includes encouraging learning strategies, such as: problem-based learning, project-based learning etc. [57, 55].

4. It has been shown that the elaborated pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology possess the following properties: *originality*, from the perspective of its specific components of the biology secondary school education from Israel, the invoked educational policies and the relationships established between the conceptual, practical and methodological components; *innovative* character, due to modern educational integrated concepts; *adaptability* in other school disciplines; *evolutionary character*, open to updating, dictated by the dynamic changes in the education system, by the information overload, by the numerous technological developments, but also by the revolution of the Information and Communication Technologies; *integrity*, due to the connections established between its components [57].

5. The pedagogical experiment allowed to identify significant differences of 11,4 points (64,4 and 75,8) in biology achievements between tests results before and after experiment among students who learned through the ICT based method (experimental groups), and no significant difference (76,2 and 74,8) between students' achievements before and after intervention for control groups, those of the students who learned by the traditional manner, means that use of ICT has improved student achievement in the subject of biology [58].

6. The analysis of student's answers to questionnaire's questions identified that all students from control and experimental groups think that the ICT lessons in biology significantly improve their learning motivation and self-efficacy, increases the level of interest of the students and enriches the meaningful learning in biology. The student is more active and the cooperation in the learning between the teacher and the student is higher than in the not-ICT integrated learning. That why, all students, whether in the experimental group or in the control group, revealed significantly and distinctively positive attitudes toward ICT learning of biology [59].

7. ICT affects all student, from a passive student, who receives materials from the teacher, does not enjoy choice, does not live up to his potential, to an independent learner who receives appropriate learning for his needs, which allows him to live up to his personal potential. However, ICT is not a substitute for the teacher in the classroom [59].

In conclusion, the findings of the current research coincide with the importance of ICT assimilation in the teaching/learning of biology in gymnasium, mostly for teachers and students. In this point of view, the contribution of the research focuses on the powerful effects of ICT integration on the achievements, motivation, and meaningful learning in biology lessons, resulting in an improvement in all educational elements and aspects. This fact allows to highlight **the result obtained which contributes to solving an important scientific problem**, which consists in: *determination of the theoretical and methodological foundations of the efficiency of the teaching-learning process of the biology in the gymnasium through the information and communication technologies, which led to the theoretical foundation and the elaboration of the pedagogical model of integrating the information and communication technologies in the biology teaching - learning process*.

The research findings and conclusions permit to make the following **recommendations:**

For the management:

1. Forming and developing of the collaborative thinking about ICT integration as a part of the school's vision, setting of appointees to lead the assimilation that will constitutes an educational leadership in the field. Examining thoroughly the complex of factors that influence teachers' activities not only at the group level but mainly at the individual level.

2. Improving the logistical conditions within the school, in terms of technical quantity, quality, functionality, accessibility, internet connection and availability for students and teachers for teaching purposes.

3. Creation of implementation conditions for *the pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology* and for adapting it to other subjects of study.

***For the teachers**:*

1. Professional use of information and communication technologies in teaching and online activities, encouraging meaningful learning, but also training and continuing education of teachers, not only in praxiological aspect, but also methodologically, integrating ICT in the classroom.

2. Encouraging teachers to: adopt changes in teaching-assessment strategies through the implementation of ICT; training and development of a didactic approach to the efficient use of the online learning environment in the study of biology, while capitalizing on its advantages; as well as the implementation of this approach to other objects of study.

3. Valorisation of the methodology for implementing the *Pedagogical Model for integrating information and communication technologies in the teaching-learning process of biology*.

For the students:

1. Awareness of the need to train digital skills and develop learning skills through ICT.

2. Assuming by students some responsibilities related to the implementation of ICT in the educational institution. Training groups of volunteer students, who have advanced digital skills, to provide technical support in the process of integrating ICT in teaching-learning-assessment and to participate in solving specific school problems.

More suggestions for further research

In the present research, the issue of ICT implementation was examined only in the gymnasium, but it is possible to extend the research for various disciplines to the levels of primary, secondary and high school education.

In addition, the research was conducted in an Arab school in the northern area, but an investigation can be made into the peculiarities of ICT implementation in different areas of Israel.

Another direction of research may aim at a quantitative and qualitative approach to the personal conceptions, perceptions and attitudes of teachers and students towards the integration of ICT, which could promote system-wide awareness of the ways in which the mechanisms for streamlining the educational process work and their better management.

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ADNOTARE

Badarne Ghalib

Integrarea Tehnologiilor Informaționale și Comunicaționale în procesul de predare-învățare a biologiei din cadrul învățământului gimnazial din Israel

Teză de doctor în științe ale educației, Chișinău, 2021

Structura tezei: Adnotare (în limbile română, rusă și engleză), lista abrevierilor, introducere, trei capitole, concluzii generale și recomandări, bibliografie din 183 de titluri, 8 anexe, 125 de pagini de text de bază, 21 tabele, 15 figuri. Rezultatele cercetării sunt reflectate în 8 articole științifice, dintre care 4 articole în reviste științifice de categoria B și C și 4 comunicări la conferințe naționale și internaționale.

Cuvinte cheie: Tehnologii Informaționale și Comunicaționale (TIC), biologie, predare-învățare, pedagogie inovatoare, motivație, curriculum gimnazial la biologie, învățământ gimnazial din Israel, învățare semnificativă, competențe, metode didactice, metodologie.

Scopul lucrării: fundamentarea teoretică, elaborarea și validarea unui model pedagogic de integrare a tehnologiilor informaționale și comunicaționale în procesul de predare-învățare a biologiei în gimnaziu menit să contribuie la progresul rezultatelor școlare ale elevilor.

Obiectivele cercetării: studiul practicilor educaționale de implementare și integrare a TIC în mediile de învățare; analiza avantajelor oferite de tehnologiile informaționale și comunicaționale și argumentarea necesității implementării lor în învățământul gimnazial la biologie; elaborarea unui model pedagogic de integrare a TIC în procesul de predare-învățare a biologiei; dezvăluirea reperelor metodologice de implementare a modelului pedagogic elaborat; validarea prin experiment pedagogic a eficienței modelului pedagogic de integrare a tehnologiilor informaționale și comunicaționale în procesul de predare-învățare a biologiei.

Noutatea și originalitatea științifică constă în fundamentarea conceptuală a *modelului pedagogic de integrare a TIC în procesul de predare-învățare a biologiei* prin dovezi teoretice și practice conform cărora utilizarea TIC în predare/învățare contribuie la: îmbunătățirea rezultatelor școlare ale elevilor la biologie; creșterea motivației pentru învățarea biologiei și a auto-eficienței în învățare; adoptarea atitudinii pozitive a elevilor față de integrarea TIC în procesul de studiere a biologiei; îmbunătățirea optimală pe dimensiunile învățării semnificative.

Rezultatul obținut care contribuie la soluționarea unei probleme științifice importante constă în determinarea fundamentelor teoretice și metodologice ale eficientizării procesului de predare-învățare a biologiei în gimnaziu prin intermediul TIC, fapt ce a condus la fundamentarea teoretică și elaborarea modelului pedagogic de integrare a tehnologiilor informaționale și comunicaționale în procesul de predare-învățare a biologiei.

Semnificația teoretică a investigației constă în identificarea, analiza și dezvoltarea reperelor teoretice cu privire la implementarea TIC în procesul didactic la biologie; determinarea fundamentelor teoretico-metodologice ale modelului pedagogic de integrare a tehnologiilor informaționale și comunicaționale în procesul de predare-învățare a biologiei.

Valoarea aplicativă a lucrării constă în elaborarea și validarea experimentală a setului de instrumente metodologice și praxiologice incluse în *modelul pedagogic de integrare a tehnologiilor informaționale și comunicaționale în procesul de predare-învățare a biologiei*. Reperele identificate, dezvoltate și valorificate au contribuit la creșterea rezultatelor școlare la biologie ale elevilor din școala gimnazială din Israel. Cercetarea desfășurată a permis demonstrarea aplicativității în practica educațională la clasă a tuturor instrumentelor pedagogice și tehnologice concentrate în modelul pedagogic elaborat și validat.

Implementarea rezultatelor științifice a avut loc în cadrul experimentului pedagogic în care au fost implicați 145 de elevi din clasele a 9-a din gimnaziul Kafr Yasif, districtul de nord, Israel. De asemenea, la organizarea și desfășurarea experimentului au participat 3 profesori de biologie ce predau la clasele implicate în experiment, un profesor de informatică și managerul școlii. Perioada desfășurării experimentului a fost 2017-2018.

АННОТАЦИЯ

Бадарне Галиб

Интеграция информационных и коммуникационных технологий в процесс преподавания-изучения биологии в среднем образовании в Израиле

Диссертация степени доктора педагогических наук. Кишинев, 2021

Структура диссертации: Аннотация (на румынском, русском и английском языках), список сокращений, введение, три главы, общие выводы и рекомендации, библиография из 183 наименований, 8 приложений, 125 страниц основного текста, 21 таблиц, 15 рисунков. Результаты исследования отражены в 8 научных статьях, из которых 4 статьи в научных журналах категорий В и С и 4 статьи на национальных и международных конференциях.

Ключевые слова: информационно-коммуникационные технологии (ИКТ), биология, преподавание-обучение, инновационная педагогика, мотивация, гимназическая учебная программа по биологии, среднее образование в Израиле, значимое обучение, компетенции, методы обучения, методология.

Цель работы: теоретическое обоснование, разработка и проверка достоверности педагогической модели интеграции ИКТ в процесс преподавания-изучения биологии в гимназии, призванной способствовать прогрессу школьных результатов учащихся.

Задачи исследования: изучение ситуации в образовательной практике по внедрению и интеграции ИКТ в учебную среду; анализ преимуществ, предлагаемых ИКТ, и обоснование их внедрения в среднее образование по биологии; разработка педагогической модели интеграции ИКТ в процесс преподавания-изучения биологии; выявление методологических ориентиров для реализации разработанной педагогической модели; валидация через педагогический эксперимент эффективности педагогической модели интеграции ИКТ в процесс преподавания-изучения биологии.

Новизна и научная оригинальность заключаются в концептуальной основе педагогической модели интеграции ИКТ в процесс преподавания-изучения биологии с помощью теоретических и практических доказательств того, что использование ИКТ в преподавании / обучении способствует: улучшению успеваемости учащихся по биологии; повышению мотивации к изучению биологии и самоэффективности в обучении; принятию положительного отношения студентов к интеграции ИКТ в изучение биологии; оптимальному улучшению масштабов значительного обучения.

Полученный результат, способствующий решению важной научной проблемы, заключается в определении теоретических и методологических основ оптимизации учебно-методического процесса биологии в гимназии с помощью ИКТ, что привело к теоретическому обоснованию и разработке педагогической модели интеграции ИКТ в процессе обучения-изучения биологии.

Теоретическая значимость исследования состоит в выявлении, анализе и разработке теоретических ориентиров для внедрения ИКТ в учебный процесс по биологии; определение теоретико-методологических основ педагогической модели интеграции информационных и коммуникационных технологий в процессе преподавания-изучения биологии.

Практическая значимость исследования заключается в разработке и экспериментальной проверке комплекса методических и праксиологических инструментов, включенных в педагогическую модель интеграции ИКТ в учебно-методический процесс биологии. Выявленные, разработанные и заглавные ориентиры способствовали повышению школьных результатов по биологии учеников средней школы в Израиле. Проведенное исследование позволило продемонстрировать применимость в учебной практике всех педагогических и технологических инструментов, сконцентрированных в разработанной и апробированной педагогической модели.

Внедрение научных результатов происходило в рамках педагогического эксперимента, в котором приняли участие 145 учеников 9-го класса средней школы Кафр Ясифа, северный округ Израиля. Также в организации и проведении эксперимента приняли участие 3 учителя биологии, которые преподают в классах, участвующих в эксперименте, учитель информатики и руководитель школы. Период эксперимента составлял 2017-2018 годы.

ANNOTATION

Badarne Ghalib

Integration of Information and Communication Technologies in the teaching-learning process of biology within middle school education from Israel

Doctoral thesis in education sciences. Chisinau, 2021

Thesis structure: Abstract (in Romanian, Russian and English), abbreviations list, introduction, three chapters, general conclusions and recommendations, bibliography of 183 titles, 8 appendices, 125 pages of the main text, 21 tables, 15 figures. The research results are reflected in 8 scientific articles, of which 4 articles in scientific journals of categories B and C and 4 articles at national and international conferences.

Keywords: information and communication technologies (ICT), biology, teaching and training, innovative pedagogy, motivation, gymnasium biology curriculum, secondary education in Israel, meaningful learning, competencies, teaching methods, methodology.

Research goal: theoretical justification, development and validation of a pedagogical model for integrating ICT into the process of teaching-learning biology in gymnasium, meant to contribute to the progress of students' school results.

Research objectives: study of educational practices for the implementation and integration of ICT in learning environments; analysis of the advantages offered by ICT and arguing the need for their implementation in secondary education in biology; elaboration of a pedagogical model for the integration of ICT in the teaching-learning process of biology; revealing the methodological landmarks for implementing the elaborated pedagogical model; validation through pedagogical experiment of the efficiency of the pedagogical model of integration of information and communication technologies in the teaching-learning process of biology.

Novelty and scientific originality lie in the conceptual basis of the pedagogical model of integrating ICT into the process of teaching-learning biology with the help of theoretical and practical evidence that the use of ICT in teaching / contributes to: improving students' school results in biology; increasing motivation to learn biology and self-efficacy in learning; adopting the positive attitude of students towards the integration of ICT in the study of biology; optimal improvement on the dimensions of significant learning.

The result obtained that contributes to solving an important scientific problem consists in determination of the theoretical and methodological foundations of the effectiveness of the biology educational process in the gymnasium using ICT, which led to the theoretical justification and development of pedagogical model for integrating ICT into the teaching-learning process of biology.

The theoretical significance of research consists in identifying, analysing and developing of the theoretical landmarks for the implementation of information and communication technologies in the biology teaching process; determining the theoretical-methodological foundations of the pedagogical model of integration of information and communication technologies in the teaching-learning process of biology.

The applicative value of the paper consists in the elaboration and experimental validation of the set of methodological and praxiological tools included in the pedagogical model of integration of information and communication technologies in the teaching-learning process of biology. The identified, developed and capitalized landmarks contributed to the increase of the school results in biology of the students from the middle school in Israel. The research carried out allowed to demonstrate the applicability in the educational practice in the classroom, of all pedagogical and technological tools concentrated in the pedagogical model developed and validated.

The implementation of the scientific results took place within the pedagogical experiment in which 145 students from the 9th grade from the Kafr Yasif secondary school, northern district, Israel were involved. Also, in the organization and conduct of the experiment were attended by 3 biology teachers who teach in the classes involved in the experiment, an informatics teacher and the school manager. The period of the experiment was 2017-2018.

BADARNE GHALIB

INTEGRATION OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN THE TEACHING-LEARNING PROCESS OF BIOLOGY WITHIN MIDDLE SCHOOL EDUCATION FROM ISRAEL

532.02. SCHOOL DIDACTICS (BIOLOGY)

Abstract of doctoral thesis in education sciences

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