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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)

Doctoral thesis in education sciences

Scientific supervisor: **Grati Vasile**, habilitated doctor full professor

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UNIVERSITATEA DE STAT DIN TIRASPOL

Cu titlu de manuscris
C.Z.U.: ….…………

BADARNE GHALIB

INTEGRAREA TEHNOLOGIILOR INFORMAȚIONALE ȘI COMUNICAȚIONALE ÎN PROCESUL DE PREDARE-ÎNVĂȚARE A BIOLOGIEI DIN CADRUL ÎNVĂȚĂMÂNTULUI GIMNAZIAL DIN ISRAEL

532.02. DIDACTICA ȘCOLARA (BIOLOGIE)

Teză de doctor în științe ale educației

Conducător ştiinţific: **Grati Vasile,**
doctor habilitat
profesor universitar

Autor:

CHIȘINĂU, 2021

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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 182 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: Tehnologiilor Informaționale și Comunicaționale, biologie, predare-învățare, pedagogie inovatoare, motivație, curriculum gimnazial la biologie, învățământ gimnazial din Israel, învățare semnificativă, competențe necesare în secolul XXI, model pedagogic, metode didactice, metodologie, experiment pedagogic.

Scopul lucrării: fundamentarea teoretică și elaborarea unui model pedagogic de integrare a tehnologiilor informaționale și comunicaționale în procesul de predare-învățare a biologiei.

Obiectivele cercetării: Analiza avantajelor oferite de tehnologiile informaționale și comunicaționale și argumentarea implementării lor în învățământul gimnazial la biologie; Elaborarea modelului pedagogic de integrare a tehnologiilor informaționale și comunicaționale în procesul de predare-învățare a biologiei; Argumentarea 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 tehnologiilor informaționale și comunicaționale în procesul de predare-învățare a biologiei* prin dovezi teoretice și practice conform cărora utilizarea TIC în predare/învățare îmbunătățește performanțele elevilor la biologie; crește motivația și auto-eficiența în învățare printre elevi la lecțiile de biologie; determină atitudinea pozitivă a elevilor față de integrarea TIC în procesul de studiere a biologiei; îmbunătățește optimal dimensiunile învățării semnificative.

Principalele rezultate științifice înaintate spre susținere: modelul pedagogic de integrare a tehnologiilor informaționale și comunicaționale în procesul de predare-învățare a biologiei, elaborat și fundamentat teoretic; metodologia implementării modelului pedagogic elaborat; eficiența, validată experimental, a modelului și metodologiei elaborate, prin experiment pedagogic în procesul de predare-învățare a biologiei.

Problema științifică soluționată: determinarea fundamentelor teoretice și metodologice ale eficientizării procesului de predare-învățare a biologiei în gimnaziu prin intermediul tehnologiilor informaționale și comunicaționale, 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: studierea efectului produs de tehnologiile informaționale și comunicaționale implementate în procesul didactic la biologie; determinarea aspectelor teoretico-metodologice privind elaborarea modelului pedagogic de integrare a tehnologiilor informaționale și comunicaționale în procesul de predare-învățare a biologiei.

Valoarea aplicativă a lucrării este determinată de aprobarea cu succes și implementarea în procesul didactic la biologie din gimnaziu a modelului pedagogic elaborat.

Implementarea rezultatelor științifice a avut loc în cadrul experimentului pedagogic în care au fost implicați 145 de elevi din clasele a 9-a din școala gimnazială din 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 182 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 B и C 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 необходимые в 21 веке, педагогическая модель, методы обучения, методология, педагогический эксперимент.

Цель работы: теоретическое обоснование и разработка педагогической модели интеграции ИКТ в процесс преподавания-изучения биологии.

Задачи исследования: анализ преимуществ, предлагаемых ИКТ, и обоснование их внедрения в среднее образование по биологии; Разработка педагогической модели интеграции ИКТ в процесс преподавания-изучения биологии; Обоснование 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 повышает успеваемость студентов-биологов; повышает мотивацию и самоэффективность обучения у студентов на уроках биологии; определяет позитивное отношение студентов к интеграции ИКТ в процесс изучения биологии; оптимально повышает степень значимого обучения.

Основные научные результаты: педагогическая модель интеграции ИКТ в процесс преподавания-изучения биологии, разработанная и теоретически обоснованная; методология реализации разработанной педагогической модели; эффективность, подтвержденная экспериментально, модели и методологии, разработанной посредством педагогического эксперимента в процессе преподавания-изучения биологии.

Решенная научная задача: определение теоретико-методологических основ эффективности учебно-воспитательного процесса по биологии в гимназии с помощью ИКТ, что привело к теоретическому обоснованию и разработке педагогической модели интеграции ИКТ в процесс обучения изучение биологии.

Теоретическая значимость исследования состоит в: изучении влияния ИКТ, внедряемых в учебный процесс по биологии; определение теоретико-методологических аспектов разработки педагогической модели интеграции ИКТ в процесс преподавания-изучения биологии.

Практическая значимость исследования: успешное утверждение и внедрение в дидактическом процессе по биологии в средней школе педагогической модели.

Внедрение научных результатов происходило в рамках педагогического эксперимента, в котором приняли участие 145 учеников 9-го класса средней школы из 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 Galib

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 182 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, 21st century competencies, pedagogical model, teaching methods, methodology, pedagogical experiment.

Research goal: theoretical justification and development of a pedagogical model for integrating ICT into the process of teaching-learning biology.

Research objectives: Analysis of the benefits offered by ICT, and the rationale for their implementation in secondary education in biology; Development of a pedagogical model for integrating ICT into the process of teaching-learning biology; Justification of methodological guidelines for the implementation of the developed pedagogical model; Validation through the pedagogical experiment of the effectiveness of the pedagogical model of integrating ICT into the process of teaching and studying 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 / learning improves the performance of biology students; increases the motivation and self-efficacy of teaching students in biology classes; determines the positive attitude of students to the integration of ICT in the process of studying biology; optimally enhances meaningful learning.

The main scientific results: a pedagogical model of the integration of ICT in the process of teaching and studying biology, developed and theoretically justified; implementation methodology of the developed pedagogical model; the effectiveness, confirmed experimentally, of a model and methodology developed through a pedagogical experiment in the process of teaching and studying biology.

Solved scientific problem: determination of the theoretical and methodological foundations of the effectiveness of the educational process in biology in the gymnasium using ICT, which led to the theoretical justification and development of a pedagogical model for integrating ICT into the learning process of studying biology.

The theoretical significance of research: the study of the impact of ICTs introduced into the educational process in biology; determination of the theoretical and methodological aspects of the development of a pedagogical model for integrating ICT into the process of teaching and studying biology.

The practical significance of research: the successful approval and implementation of the pedagogical model in the didactic process in biology in secondary school.

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.

ABBREVIATIONS LIST

IT - Information Technologies

ICT - Information and Communication Technologies

IEA - International Association for the Evaluation of Educational Achievement

CIL - Computer and Information Literacy

RIPPLES - Resources, Infrastructure, Policy, People, Learning, Evaluation, Support

CET - Center for Educational Technology

ISTE - International Society for Technology in Education

NCES - National Center for Education Statistics

OECD - Organization for Economic Co-operation and Development

PBL - Project- Based Learning

PEA – Pedagogy Environment Attitude

SITES - Second International Technology in Education Study

SMQ - Science Motivation Questionnaire

SRL - Self-Regulation Learning

STS - Science Technology and Society

TPCK – Technological Pedagogical Content Knowledge

INTRODUCTION

The relevance of the research subject. 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.

Education is one of the most influential fields in which the state has the ability to develop quality human capital. Social changes have affected from the character of the graduate to the academic and public discourses [1]. Today we live in a digital world, surrounded and submerged in technology. The pace of technological changes and innovations increases and leads to massive changes in all aspects of our lives, including the way in which we teach and learn. Thus, many people of education argue that teachers have to deal with the challenge of integrating technology in the teaching usefully. The main reasons for this argument are: the need to adjust the teaching to the functional everyday current environment of the students, the obligation to prepare the students to function in the future world of society and work and the tremendous potential consisting in using the new technologies' abilities for advancing the learning [2]. 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 [3], [1]. 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 [3], [4].

In the 21st century, the position of the teacher is to be a facilitator of learning, working in close interaction with students, a guide and a mentor, rather than the exclusive source of knowledge [5]. Assimilation of ICT processes calls for a new point of view on our pedagogical hypotheses, and the ways of teaching and learning at schools, ICT learning environment obligates the teacher to act as a designer of the curriculums of learning and evaluation experiences to achieve defined goals adapted to students' needs. In addition to his traditional role, he is required to develop/design/adapt new learning activities integrating ICT usage, teaching that leads the student to independent learning, which begins with curiosity and the desire of the learner to solve a problem and deal with a dilemma. The learner should navigate his way through the sea of information, explore, classify, filter, evaluate data, reorganizing it, draw firm conclusions and present them clearly. The students are active partners in building the learning process; they ask interesting and fruitful questions and search for answers by themselves, they have a greater share of class time. The students take responsibility for lesson management and teaching unit management, while emphasizing the cooperation of every student in the process [6], [7, p. 8].

There are numerous studies regarding the subject of ICT integration in the school. However, there is very few fundamental research on: the influence of ICT on student outcomes in biology; the learners 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 combination of the results between the mentioned aspects 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 directly related to the impact of ICT on student outcomes in biology in general and in secondary school in particular has led to the need for 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. The significant impact of using ICT on school performance is being analyzed by O. Istrate [8] and E. Noveanu [9], from the studies conducted over the past two decades. A. Balanskat, R. Blamir, S. Kefala [10], A. Zucker [11] and D. Wagner [12], highlight the important value of ICT in the design of lessons. C. Mouza [13], N.C. Wilson [14] and S. Rockman [15] highlights the role of technologies in within colleagues collaboration, while G.K. White [16] distinguishes three aspects of ICT implementation in education: 1) network communication; 2) use of educational software; 3) facilitating interactive communication. The phenomenon of computerization of education and the use of Information and Communication Technologies in education is also researched by Russian scientists, among whom we can mention: С.А. Бешенков, Г.И. Алексеева, М.И. Шутикова [17], A. I. Razumowsky [18], Б. М. Позднеев, М. В. Сутягин, В. И. Шароватов, И. А. Куприяненко [19], В.А Старых [20] and others.

Many researchers from Israel addressed the integration of ICT in education in various aspects: O. Avidov-Ungar and F. Arazi Cohen [21], R. Dayan and N. Magen-Nagar [3], O. Avidov Ungar and A. Forkosh-Baruch [22], A. Uphan, G. Trachtman and O. Spektor-Levy [5] 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 [23]. O. Avidov-Ungar and Y. Eshet-Alkalai [24]; L. Cohen [25]; T. Shamir-Inbal and K. Yael [26] addressed and presented the systematic models for ICT assimilation in school culture. N. Magen-Nagar and T. Shamir-Inbal [27]; Y. Kulikant [1]; B. Peled and N. Magen-Nagar [6]; Y. Nissim, M. Barak and D. Ben-Zvi [28] pointed out the characteristics 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.

According to reports of the Ministry of Information Technology and Communications [29], The Moldavian Ministry of Education, Culture and Science [30], and UNESCO-IBE [31] Moldova achieved meaningful progress in implementation of information technology in society. The national strategy of development of the information society "Digital Moldova 2020" aims to create conditions for the development of the information society on three essential dimensions: infrastructure and access; digital content and electronic services; capabilities and use [32]. The action plan for an open government 2012-2013 included sub-actions for the integration of ICT in education, which evolved into detailed objectives of strategic direction 6 "Effective integration of ICT in education" of the Education 2020 Strategy. Due to this Strategy the educational system in the Republic of Moldova aims to become a quality one through school programs adapted to the needs of the information economic society; by training teachers for the effective implementation of ICT in education; by integrating information technology into the teaching process; by creating digital educational content, including through support for lifelong learning. This is why the pedagogical researches of the Moldovan scientists are focused on the intense study of these aspects of education. For example, Anatol Gremalschi treats the implementation of information and communication technologies in education as a means of modernizing pre-university education [33]. For the university professor in the didactics of computer science Valeriu Cabac, digital technologies contribute to the formation of professional competences [34] and have had an impact on the emergence and becoming of the university didactics [35]. The methodology of using information and communication technologies in higher education was researched by Andrei Braicov and Sergiu Corlat [36]. Also, various contributions to the study of the impact of ICT on the study of school and university disciplines was made by researchers: L: Chiriac, A. Globa [37], L. Mihălache [38], N. Deinego, C. Negara [39], M. Pavel [40], A. Gasnaș [41] etc.

Studies on the use of ICT in teaching biology, internationally, have been conducted by G. Ezekoka [42], M. Al-Rsa'i [43], Y. Garraway-Lashley [44], A.C. Kafyulilo, P. Fisser, J. Pieters and J. Voogt [45], R. Trumper [46] and A. Šorgo, T. Verčkovnik and S. Kocijančič [47] who also examined progress in scientific literacy through the use of ICT in teaching science in general. A retrospective of online tools and educational software specialized in teaching biology was made by Christophe Merinat, who emphasized that the use of such digital resources is possible, only that the teacher must be aware of the different constraints and inherent limitations [48]. In Israel, M. Darsler, R. Ehrenberg and L. Sela [49], D. Steiner, M. Mendelovitch [50] studied the subject of ICT integration in science teaching and mainly addressed the education and development of thinking in science and technology learning and integrating computer simulations into their teaching. Also, researchers R. Deaney, K. Ruthven and S. Hennessy [51], Y. Rosen [52] and K. Barak, M. Shani and G. Kurtz [53] 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. For example К.В. Хайбулина [54], experiments with the teaching of biology through ICT and investigates their impact on the students' school results, but refers only to some separate topics, without elaborating a pedagogical model in this aspect. Т.И. Крылова approaches the topic of modern means of information and communication technologies in organizing homework at biology [55]. Other studies refer to the activity of practicing school teachers who share their experience of using ICT in biology lessons, but without referring to scientific pedagogical research. We can mention here: Ю. А. Косторных [56], А. Коробченко [57], Т.М. Демина [58] etc.

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 such as: D. Coşcodan, L. Moşanu-Şupac [59], D. Placinta, E. Coropceanu [60, 61], L. Ivancov [62], I. Cristea [63] et al.

The aforementioned highlights **the research problem** which consists in *determining the theoretical and methodological foundations of the efficiency improvement of the teaching-learning process of the biology in the gymnasium through the information and communication technologies*.

The goal of the research is summarized in *the theoretical foundation and elaboration of a pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology*. In order to solve the research problem and reach its goal, the following **objectives** have been advanced:

- *Analysis of the advantages offered by the information and communication technologies and the argumentation of their implementation in the middle school education in biology;*
- *Elaboration of the pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology;*
- *Arguing the methodological benchmarks for implementing the elaborated pedagogical model;*
- *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.*

The following **research hypothesis** was advanced: the implementation of the pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology will lead to the efficiency of teaching-learning process of biology in the gymnasium through information and communication technologies, which will materialize through increasing student achievement in biology.

The methodology of scientific research included the following components:

- theoretical methods: the analysis of the specialized literature, the analysis of the curricular documents, the scientific documentation, the comparison, the synthesis, the description, the pedagogical modelling, the systematization, the generalization;
- practical methods: observation, investigation, test method, data collection, analysis, data processing and systematization, evaluation, experimental data processing by statistical methods [64];

- experimental methods: the pedagogical experiment of finding and the pedagogical experiment of training.

The research period is between 2015 and 2018 and contains four basic stages:

a. The first stage was carried out during the years 2015-2016 and was one of documentation which involved a series of activities such as: studying the specialized literature related to the subject of ICT integration in the teaching and learning of biology (adapting the education system in Israel to the century XXI, ICT in the learning of biology, ICT tools necessary for the teacher and the student, the integration of ICT in the learning of biology from the perspective of the constructivist approach: implications on the development of a high-order thinking, increasing the motivation to learn and significant learning), analysis of the curricular documents.

b. The second stage (2016-2017) refers to the research design: research planning, identification of the problem, purpose and objectives of the research, elaboration of the pedagogical model of ICT integration in the teaching-learning process of biology, identification of the experimental samples.

c. The third stage, the experimental one, covers the years 2017-2018 and involves determining the differences between the samples participating in the experiment, regarding the influence of the ICT integration on the students' school results and the motivation of learning biology in the gymnasium. The experiment comprised six sub-stages: in the first sub-stage (May 2017) a request was submitted to the Ministry of Education for permission to conduct the experiment; the second sub-stage (September 2017) refers to the acquaintance with the school, its management, biology teachers and students who will participate in the experiment, then providing explanations regarding the conduct of the experiment in school; in the third sub-stage (October - December 2017) the experiment testing takes place, the fourth sub-stage (January - May 2018) contains the actual conduct of the experiment; the fifth sub-stage (March - May 2018) is the control: two tests are carried out to evaluate the students' knowledge of biology after the use of ICT; sixth sub-stage (end of May 2018), questioning and data collection.

d. The fourth stage (June 2018) was intended for analysis and conclusions: the analysis and description of the research results (the experiment and the questionnaire) was done, the connection between the theoretical and empirical conclusions was investigated, the perspective directions were designed to extend the research in this domain.

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 improves the results of students in biology; increase motivation and self-efficacy in learning among students in biology lessons; determines the positive attitude of students towards the integration of ICT in the process of studying biology; optimally enhances the dimensions of meaningful learning.

The scientific solved problem lies in the *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 theoretical significance of the investigation consists of: studying the effect produced by the information and communication technologies implemented in the teaching process in biology; determining the theoretical-methodological aspects regarding the elaboration of the pedagogical model of integrating the informational and communication technologies in the process of teaching-learning of biology.

The applicative value of the paper is determined by the successful approval and implementation in the biology didactic process at the secondary school of the elaborated pedagogical model.

The main scientific results submitted for defence are:

- *the pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology, elaborated and theoretically based;*
- *the methodology of implementing the elaborated pedagogical model;*
- *the efficiency, validated experimentally, of the developed model and methodology, through pedagogical experiment in the process of teaching-learning of the 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, therefore 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 national and international scientific conferences:

- Symposium "*Innovative Methodologies in Education*", Kaye Academic College of Education, Israel, 2018;
- Republican Teachers' Conference, March 1-2, 2019. TSU, Chisinau, RM, 2019;
- Moldovan-Polish-Romanian International Scientific Congress: *Education - Politics - Society*, April 1-4, 2019. TSU, Chisinau, RM, 2019;
- National Scientific Conference with International Participation *Higher Education: Traditions, Values, Perspectives*, September 27 - 28, 2019. TSU, Chisinau, RM, 2019;
- Republican Teachers' Conference, February 28-29, 2020. TSU, Chisinau, RM, 2020.

Publications on the topic of the doctoral thesis. The results of the research on the thesis topic are reflected in 8 publications: 4 scientific articles in category B and C magazines; 4 communications at conferences and scientific symposia.

Summary of chapters 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 and identifies the research problem. 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. It also describes the models and methods of teaching through ICT and specifies the tools and technologies that the teacher can use for this purpose. The conclusions of this chapter highlight the need to elucidate the research problem and outline the objectives that will lead to its solution.

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, elaborated and theoretically based and describes the methodology of implementing this model. The chapter ends with the highlighting, within its conclusions, of the achieved objectives.

In 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, describing each stage in detail. The statistical analysis of the results of the experiment is also presented, using the tools offered by the specialized software SPSS. The statistical tests are applied to both the experimental and the control sample, determining the differences regarding the school results obtained in biology through ICT. The conclusions of this chapter highlight the efficiency of the model and the methodology developed.

The general conclusions reflect the scientific results obtained by the author and are correlated with the achieved objectives, which helped to solve the scientific problem of the current investigation.

1. THEORETICAL ASPECTS OF INFORMATION AND COMMUNICATION TECHNOLOGIES USING IN THE BIOLOGY DIDACTICAL PROCESS

1.1. General perception and policies related to the implementation of Information and Communication Technologies in education

1.1.1. General approaches related to Information and Communication Technologies

The term Information and Communications Technology (ICT) refers to the usages of technology for reception, presentation and broadcast of information electronically. The term is an equivalent to the term Information Technology (IT), though this term emphasizes the importance of the media in using technologies for information. During the past couple of decades, the IT expanded to being ICT, and became more dominant in the schools. The expression of ICT was used by researchers in the academy since the 80's. The addition of Communication to the term IT, stems from the increasing importance of the various media, especially the Internet, in handling information [51, 65].

The goal of information technologies in education is to positively influence the learning process, by providing the necessary tools to create learning environments adapted to the learner. There are two ways to use ICT in education: 1. providing tools and training ICT skills; 2. the use of ICT as a means of progressive training of students as part of the formal school curriculum. In practice, however, these methods of use are not fully utilized in schools (Israel): teachers report that they don't use ICT tools in their lessons, some say they use ICT inefficiently, and others believe that information technologies have a minor contribution to improving learning. Since most ICT implementation programs are planned for three or five years, so time-limited, often school teachers perceive the use of information technologies in their lesson as a fad, as a teaching method that can only be used for a few years. Organizations that promote ICT in education are perceived as followers of technology and not implicitly as facilitators of it optimal use. The approach that guides the use of ICT for the strengthening of the instructional-educational process is that education in general and the education system in particular should provide the necessary conditions for updating and improving learning, for strengthening and promoting knowledge-building and the acquisition of ICT skills that will support this process in a considerable extent [66].

Numerous arguments have been made regarding the potential contribution of ICT to the learning process of students. Technology is perceived as an immediate provider of tools for teachers and students alike, and its main uses are for developing technical skills. However, some researchers believe that the most important and successful role of the computer in education is that of complex involvement in the connection of the activity of teachers and students, between the available machines and software. Although the quality and level of ICT resources continue to improve in many schools, supply only with equipment is of limited value, according to other researchers, unless the use of technology in the work has been rational, has led to the improvement of pedagogical strategies for the learning of students who it can be usefully developed through them [67].

In recent decades, there has been intense development, as well as extensive assimilation of information technology all over the world. The knowledge, understanding and use of information technologies become the fundamental skills of life in modern society. The education system shares these changes and also acts in a dynamic world that is changing rapidly. That is why, the Israeli Ministry of Education has launched an innovative program called "Adapting the education system to the 21st century", which is based on the assimilation of innovative, resource-rich technologies in schools. At the same time, the adaptation of the educational programs and the training of the teaching staff take place in order to develop to the students the learning skills necessary for the citizens of the current technological age [68]. The "information age" is characterized by overloading, abundance of information and numerous technological developments, including the ICT revolution. Nowadays students are exposed to a world driven by mega speeds in the digital and online domain, in the media and even in interpersonal relationships. They are subjected to multiple challenges simultaneously. These challenges are very exciting, which leads to difficulty focusing on a particular thing for a long time. The digital and online world bring a dramatic change in the hierarchical structure of the source of knowledge and accessibility to information, affecting the student, the teacher, the curriculum, the teaching-learning processes and the educational environment. All of these, forces the education to adapt to the needs of the learner and society, to highlight the significant learning that involves the student, increases the interest, motivation and creates a responsible and enjoyable process for both the student and the teacher [69], [70], [71].

The claim that living with technology affected the way of thinking and the preferable methods of learning of students today, aroused a concern for a cultural detachment between the education institutions in their traditional form and the students. Some researchers even found anger and frustration among the students for a small and unsubstantial combination of technology in the school. From this portrayal it is possible to foresee that students will be pleased and cooperate with technology-integrated pedagogic initiatives [72]. On the other hand, others like N. Selwyn [73] found that students, despite their passion for and use of the internet, are not eager to let it in to the school learning and alter the traditional learning.

It is not possible today to have a modern education system that will not integrate technology in the learning and teaching, rather this integration obligates the operation of an extensive system of in-depth considerations, which without them the assimilation might fail. Most studies indicate that even though the efforts invested in the integration of diverse and innovative technologies, in many schools across Israel and around the world, the teaching and learning culture has hardly changed. Parallelly, most studies that weigh the impact of technologies on the culture of the education system, emphasize the disappointment over the change that technology has made - especially when you consider the high costs associated with it. So, is the assimilation of innovative technologies into educational systems unnecessary? Certainly not! Clearly, it is not possible to maintain a modern education system that will not integrate intensely technology in learning and teaching it holds [68].

1.1.2. The Israel national program for adapting the education system to the 21st century

In view of the rapid infiltration and expansion of the information and communication technologies, the state of Israel faces with adapting the education system to the 21st century by allocating resources as a part of the ICT Reform [74]. Since 2010 a multiyear national ICT program called "Adapting the Education System to the 21st Century" is implemented, that promotes ICT implementation in the school in the purpose of turning them into ICT organizations (hereinafter, *national ICT program*). An emphasis in the program is on assimilating innovative pedagogy and developing digital literacy in the various online fields in order to better teaching, learning and evaluation processes as well as promoting social-cooperative processes.

The main goal of the national ICT program is integrating the Information and Communication Technology within the teaching-learning-evaluating processes. In order to do so, the Ministry of Education embraced the conception of the international IEA project (International Association for the Evaluation of Educational Achievement), according to which, the students should be taught Computer and Information Literacy - CIL. This literacy is the individual's ability to use computers for effective research, creation and communication at the school, at home and in the community [69].

The program aims to promote the assimilation of information and communication technologies in the organizational, pedagogical and social fields of the school, to lead to the existence of an innovative pedagogy in the school and to provide opportunities for training and development of the 21st century skills, concurrently with the integration of ICT. The 21st century skills are focused on three important areas to which innovative pedagogy should provide an answer: 1. High-order thinking skills that include creative thinking and ingenuity, critical thinking and problem solving skills. 2. Collaborative working skills, independent learning and ethics. 3.

Digital and communicative information management skills including information literacy, media literacy and ICT literacy [70].

The new ICT national program "Adapting the Education System to the 21st Century" is a practical program for practicing at schools which is aimed at changing the behavior of teachers in the classroom. The program is based on a computerized model of innovative pedagogy, which purpose is assimilating optimal pedagogy in the school on a systemic level, while imparting 21st century skills to students, combined with ICT technology. Such an innovative model empowers the role of the teacher in his relation to his students and to his school and it also continuously changes his role in the classroom. The aspiration is that all school teachers will practice technology-based optimal pedagogy in the school lifestyle, will use information management systems and will have regular communication with parents and the community. The plan is planned to be gradually practiced in all schools in the country over five years, while in the first couple of years elementary schools from the Northern, Southern and Jerusalem districts join to the program in order to narrow down the digital gap in these districts [3]. The national ICT program provides a technological and pedagogical infrastructure for imparting 21st century skills and enabling the preparing graduates of the Israeli education system to face with the global labor market and the academy in the purpose of preparing the state of Israel to face with its future local and global economic, cultural, and security challenges. The emphasis in the program is on the teachers, with the understanding that the investments in this resource will produce the best return. The holistic conception of the program involves guaranteeing success and achieving its objectives by combining its complementary elements: adapting the curriculum; digital content; professional development of teaching staff; infrastructure and maintenance; control and evaluation [74].

According to the 12th version of the Master Document of the national ICT program, elaborated by the Ministry of Education [75], the 21st century skills include:

1. *Use of ICT tools* - involves the use of different types of computerized tools for teaching and learning, the selection and use of different ICT tools according to the needs and the combination to increase their value. This competence also includes organizing and managing information in personal files, storing them on the web, working with multiple windows of different applications, developing a database in spreadsheet programs, creating graphs and analysing its results, working with several peers in a collaborative document using Google tools, etc.

2. *ICT literacy* - a derivative of the abundance of information in the virtual space. This competence includes particular importance for the intelligent management of information, knowing its different representations, locating relevant information in different ways (in relation to the required type of information), indexing references and merging information, evaluating

information and representing it, for example creating a digital text that includes context-related references (links), searching through different strategies for information: operators use, keywords, database search and various search engines.

3. *Critical thinking and problem solving* - in a dynamic world that requires innovation, high-order thinking and analytical skills, students should be trained to be creative and original inventors who think differently; to have the ability to identify new connections between concepts, to identify different strategies in a process or mission. Students must be trained in taking positions and formulating opinions, forecasts, developing intuition, skepticism, critical, metacognitive thinking, guided to exploration and choice.

4. *Collaborative communication and teamwork*. The need for this competence is explained by the fact that in the modern world of work it is important for a person to have the ability to work in a team, while at the same time being aware of his / her advantages regarding some of the skills that they possess, as well as to train their skills where he is weaker using the experience of the other team members. Also, the members of a team must allow the flow of information and knowledge, the sharing of tasks, etc.

5. *Student independence*. An independent student constantly updates his knowledge, studies, has initiative, is motivated and active on the internet, and acquires information intelligently. The independent student must identify his / her optimal learning style and act upon it.

6. *Ethical competences and network protection* - the digital space presents new challenges regarding the protection of intellectual property, confidentiality and ethics on the Internet. Therefore, students should develop the ability to raise awareness and personal and social responsibility; be trained for ethical conduct and protection on the Internet; for knowledge of copyright laws and especially ethical behaviour [75].

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 and strengthening of the connection between home and school; administration that relies on the information technology. The program encompasses hundreds of primary schools and junior high schools that constitute about 40% of all the educational institutions in Israel. The primary evaluation of program's efficiency rises from the recent national Meitzav report, showing that the use of ICT for learning is on the rise and significantly improved compared to previous years [76].

The ICT is a necessary condition for actualizing the innovative pedagogy. An intelligent use of ICT, that bases on knowing its relative advantages and disadvantages, can greatly assist in the implementation of the innovative pedagogy. Using ICT, among others, can assist in promoting dialogue interaction and cooperation between the teacher and the students, in which the students have a part in constructing the lesson and its content, in order to cause a deeper understanding and assimilation of concepts and processes. These interactions are characterized by lively discussions and reflective reactions on the part of the teacher. At the expense of using authoritative interaction, in which the teacher sets the structure and content of the lesson, and the students do not response actively [77]. A use of ICT can turn the innovative pedagogy to more relevant to the learners, the more it would intelligently base on the profitable usages in their everyday life (social networks, blogs, computer games and more). The teacher is the decisive factor determining what use will be made of the ICT tool.

1.1.3. Factors involved in the implementing of national ICT program

Assimilating the change in the education systems is different from change processes occurring in other fields of society. Differently from changes in the field of business and industry that regulated by the free market processes, educational organization are usually supported by governments, and thus, they cannot change without a planning “from above”. This kind of planning is a necessary, though not sufficient condition. Usually, this kind of forced planning included vision formation, setting standards, making changes in the curriculums, setting procedures regarding contingent acceptance of grants from the government and the appointment of institutional and systemic leadership [78]. Educational processes are dynamic and complex processes that entail changing the patterns of action of the teaching staff, changing the school’s identity, improvement of student performances, and environmental change adaptation. Numerous researchers engage in researching the factors that help or inhibit the success of educational changes in general and the ICT combination in particular. Some emphasize the organizational aspect and the way in which the organization is preparing to assimilate the change in its structure and actions, and others highlight the teachers and the way they cope with the demand to change. A part of researchers stress the importance of the principal and his support in the process of assimilating innovativeness and others examine the contribution of factors external to the school to the ICT integration:

1. The Organizational-Administrative Dimension: this dimension refers to the school management and the supervision, as it is expressed in their support of teachers training processes, in directing the assimilation process, in cooperation with external bodies and motivating the staff toward cooperation with the process. The common thinking regarding ICT integration as a part of the school vision is critical to the assimilation process, and it should include a statement of role holders to lead the implementation and will be an educational leadership in the field [26]. The school principal is an especially important factor in implementing a change in the system, researches pointed out that projects that received the principal's support, were with higher chances for success, since his involvement increases the gravity of the project, provides psychological support and recruits the required resources. Additionally, the principal or the leader of the project provides the vision that clarifies to the teachers what are the common purposes, and causes the movement of resource toward the agreed directions [79].

2. The Teaching Staff and the Level of Pedagogical Knowledge: the support of the teachers is another significant factor in implementing a change in the school. Their objection can derive of reasons such as failures of previous attempts, Lack of adequate compensation, fear of the unfamiliar, and interests of different power groups [80]. Hence, teachers training is a prerequisite when it is about implementing innovations and improvements in the school. The study of O. Avidov-Ungar and A. Cohen [21] found that the higher level of technological pedagogical knowledge is, the higher level of ICT assimilation will be. Therefore, the teacher's pedagogical knowledge is of significant importance for the assimilation of information technologies. Thus, a teacher who has no technological knowledge, manages to implement ICT due to his pedagogical abilities.

3. Structure and processes within the school: many researchers claim that without essential changes in the school's structure (division to classes, study units) and in the learning processes (methods of teaching and evaluating) essential changes in the education process would be impossible. Significant factors in this group are time, space, role division, patterns of communication among the teachers, and school policy.

4. Factors surrounding the school: perceiving the school as on open organizational system that interacts with its surrounding, gives great importance to external bodies in the influence on procedures of change, although not always in the desired efficiency. Among the most prominent factors in the school surrounding we can include the Ministry of Education, supervisory bodies, local authorities, and other intervening entities [26].

5. Infrastructures: an additional factor, contributing to promoting innovation in education is the availability of suitable infrastructure resources: hardware, measured by the amount of the computers available in the schools to students and teachers for teaching and learning purposes, the quality and function of the equipment (processor speed, operating systems, peripherals, and Internet access). Software, including open-source software and subject-focused learning.

However, the equipment itself is not enough, and it should be accompanied by another valuable factor: technical and pedagogical support [79].

Furthermore, institutional and systematic factors affect the embracement of technological ingenuity, in order for the assimilation of information technology will create an organizational change, numerous conditions should take place. A review of trends in educational change shows, that the future changes become more comprehensive and complex, so that their application would require governmental involvement. An involvement that carries with it a promise and a commitment of leaders, a power of new ideas and great resources. However, they come with unrealistic time schedules, incompatible demands, simplistic solutions, resources directed to incorrect destinations, and inconsistent performance. D. Surry, D. Ensminger and M. Jones [23] explored the factors that influence the ICT integration in teaching in institutions for high-education. They created a model called RIPPLES (Resources, Infrastructure, Policy, People, Learning, Evaluation, Support) which identifies seven major factors: a) resources and budget allocation; b) developing hardware, software, networking infrastructures and so on; c) Policy - vision, a declared plan and supportive leadership of the institution's management; d) the faculty’s motivation, beliefs, attitudes and values; e) seeing the change as a means to achieving educational targets; f) forming an evaluation that examines the impact of the change on teaching and developing a program to locate the factors that progress or inhibit the process, examining the relation between the investment and the outputs; g) support and encouragement - training the faculty, providing technical, pedagogical and administrative support (grades, promotion, rewards). The ability of the institutions’ leaders to lead the change constitutes a substantial factor in the success of its assimilation.

1.1.4. Variables that support or inhibit ICT integrated pedagogic innovation

The requirement of the Ministry of Education to adapt the schools to the 21st century positions new challenges to those practicing teaching. Consequentially, the need and the necessity to examine the factors that promote and inhibit ICT integration in the schools arise, as well as observing the process of change at different points of time [22]. Today students live in a world going through rapid changes in the areas of occupation, study and personal life, including extensive use of technologies. In accordance, the education system puts an emphasis on developing and implementing appropriate pedagogies of preparing students to the challenges of the future [72].

The ICT creates changes that obligate the education system to response, cope and change. The most relevant information and communication technologies for processes of learning and teaching constitute a huge challenge for the education system. The ICT is perceived today as a potential catalyst of changes in the education system and as a means that will enable to equip the citizens of tomorrow with the necessary tools for life in the society of information. Identification and definition of the factors involved in ICT integrated educational innovation, measuring the power of their involvement and locating the connections between the levels of innovations and the causers of innovation – all of these may contribute to the conceptual frame of ICT integration in the education system in general and in the school in particular [79].

The results of the researches of D. Mioduser, R. Nachmias, A. Porcush and D. Tobin [79] present the involvement and contribution of the groups of factors in the innovative initiatives integrating ICT. These factors are attested at several levels:

1. *System level*. At this level there is a significant increase of educational initiatives related to ICT integration, most of them being in the transition phase, so that innovation can be combined in different ways;

2. *School level*. ICT brings institutional changes, especially in pedagogical implementations. The chances of success of the innovation depend on the human, organizational and technical infrastructure, such as the head of the institution or a supportive manager. External intervention is often just a tool in implementing the innovative initiative;

3. *Pedagogical level*. Pedagogy is the one that has identified ICT integration as the main factor in innovation. Innovative initiatives allowed a learning through authentic tasks, and the change gradually expands and targeted both the field of knowledge and the functions in the school, both at the technology and curriculum levels. Moreover, digital applications have expanded to the level of development and implementation according to learning needs and alternative assessment;

4. *Teachers level*. Many teachers still need support in the ICT field, and their training process requires differentiation according to the areas of integration of ICT and the needs of the teacher. However, the process of innovation and training of teaching staff should not be large-scale and should not necessarily include the entire staff of the school;

5. The *level of students*, they are the main beneficiaries of ICT integration, both academically and in terms of their roles as learners: They experience significant authentic tasks, and changes in their roles as learners can be identified.

Innovative initiatives can be implemented among different categories of population capable of learning to meet unique needs. According to Nira Hativa [2], 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: the positive attitude increases the motivation to integrate and overcome obstacles. 2. *Successful experience* from the background in the field of technology integration in teaching. It has been found that teachers who have already successfully used certain technologies in their teaching have positive attitudes towards the integration of the same technology, as well as others, while teachers who do not have such experience tend to have less positive attitudes. This is explained by the fact that the cumulative experience of integrating a certain technology in the teaching, gives the teachers a greater self-confidence and a feeling of comfort in this use. Therefore, previous experience and the satisfaction of the results of such integration in the past are essential for the continued use of specific technology and even other teaching technologies. 3. The *high personal motivation* to teach well, to develop as a teacher and a personal commitment to promote student learning are expressed through devotion and dedication of considerable time but also through the effort to prepare lessons. 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 [2].

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 [22].

According to the results of the research of O. Avidov-Ungar and A. Forkosh-Baruch [22], the integration of ICT in the teaching is related to external and internal factors that can be encouraging or inhibiting. Teachers' perceptions and beliefs about ICT and its integration into teaching, as well as support for knowledge and pedagogical technological skills, are common internal and external factors of encouragement or inhibitors. In addition to these, there are external factors advocating for ICT integration in teaching. In order to successfully integrate technology for learning progress, it is important to consider all the factors that may affect it - both the factors that disrupt the application of technology in classroom teaching, and those that promote this process.

1.1.5. Expectations of ICT integration in the education system and science studies

During the last century, there was one attempt after another to combine newly developed technologies in the teaching (such as film, radio, instructive machines, television, computer, online teaching). There were big expectations from each technology to bring to a revolution in the teaching and that it would dramatically progress the learning efficiency. The history and the reality comes to show that after the first years of enthusiasm, very few of these technologies were combined to a large scale in classroom teaching. In the two recent decades an amazing revolution began in the consumption and production of global knowledge, especially due to the massive expansion of mobile technology usage (tablets and smartphones), of communication networks and their applications in the social media (such as Facebook and Twitter) and of the Cloud technologies. This revolution influenced and still is on every aspect in modern life and of course it did not pass over the teaching and learning in the academy and schools [2].

The contribution of the knowledge technology to the rapid economic growth in the 90's raised the question regarding its possible contribution to education improvement, especially in light of the fact that some of the information technology's characteristics are compatible with learning principles and are suitable for improving learning. On the base of economic considerations and the ICT potential to improve education, numerous countries began developing a policy that encourages the computerization of education. For instance, around the world, from Chile to Finland and from Singapore to the USA as well Israel, all countries set national policies that gave ICT a central position in the curricular and educational reforms [79].

Researches and reports in the field show that ICT may contribute to teaching and learning processes, as well as enabling platforms for courses and curriculums as part of distance learning processes. Additionally, the information technology can be used as a bridge head for innovative pedagogy in education. The technologies allow opportunities for "open" learning, which bases on dealing with storages of knowledge, filtering them and adding them in a process of a true solution. This atmosphere cultivates a learner with self-orientation, by encouraging free thinking, taking responsibility, and working as a part of a team. That is to say, ICT integration enables the student's interaction with the studies material in volume and quality that are different from any other technology. The ICT allows progressing in personal pace, active learning, choice, and immediate feedback, a possibility of training and improvement, interest, challenge and self-image improvement. A learning environment in which the computer is intelligently integrated into the teaching and learning process, allows the teacher to versify his ways of working, to change patterns of interaction between him and his students and pay further attention to their variance. Such an environment makes it possible to perform challenging tasks that were difficult to perform in the absence of the computer, and invites team work situations. For these reasons, there is an expectation that learning in ICT environment will improve the students' attitudes toward the various subjects of study, will increase their motivation, will progress their learning skills. According to Israeli researchers ICT will bring to a situation in which many students will be able to maximize their abilities and improve their scholastic achievements [79].

A study of ICT integration in the teaching of mathematics and science [81, p. 7], determined that the Science teachers in Israel who use ICT in teaching believe that the use of ICT intensifies their personal abilities, enriches and optimizes the instruction they are responsible for. They also believe that their students benefit from integrating ICT in the teaching. More than 70% of the teachers who used ICT to teach reported that ICT intensified their personal capabilities, enriched them with innovative teaching methods, contributed to access to high quality teaching resources and to cooperation with peers. More than half of the teachers reported that in addition, the classroom teaching processes were improved and optimized. About three quarters of the Science teachers in Israel who used ICT believe that this use increased their students' motivation to learn, to acquire knowledge and developing skills in information-processing, self-learning and communication. The ICT is considered, both by principals and Science teachers as a contributor to learning and empowering capabilities and performances of teachers as well as students, especially in the Arab sector.

Educational innovation may be expresses in all levels, starting with innovations in the educational paradigm, through the design of time, space, the educational practice, and ending with learning and thinking processes and the field of the curriculum [79].

Information and Communication Technologies are not a necessary condition for the achievement of innovative pedagogy, but the intelligent use of ICT, based on the recognition of their relative advantages and disadvantages, has a great contribution in the implementation of this pedagogy. The transformation of the given process into concrete actions will determine their degree of usefulness in teaching-learning. The main question does not refer to the need of ICT in education, but rather: under what conditions is ICT useful? For whom? What are the unwanted side effects? And how can they be prevented?

1.1.6 Implementation of the ICT Programs in countries around the world and in Moldova

Many education systems around the world, including the education system from Israel, invested not insignificant resources in the integration of computer technologies. Comprehensive surveys conducted in the United States and in developed countries that are members of the OECD indicate an increase in the percentage of teachers and students who enjoy access to computers, more opportunities for teachers to acquire computer skills and a greater number of teachers reporting on computer integration in classroom. It seems that finally the conditions for the successful integration of this technology into the education system have matured [82], [83], [84].

The connection between economic growth and investment in education has not been overlooked by governments and ministries of education around the world. Despite the economic crisis took place in the world in recent years, the subject of ICT in education has not dropped out from the agenda, and in many other countries this issue is given priority. Moreover, it has been decided in some OECD countries that are still in the recent economic crisis to increase public investment in education in general and in computerized education in particular. Thus, for example, in Britain and the United States, the volume of education budgets for education increased in 2010 [85].

In the US state of Maine, the national ICT program, which has been operating for more than 10 years, is based on laptops in middle schools. All of Maine's 225 middle schools were equipped with laptops ten years ago, and every year or two computer equipment is updated. Based on this program, the following conclusions were made: 1. Laptops are primarily learning tools and not necessarily pedagogical entities, and once teachers have learned to use laptops as technological devices for collecting and processing information, including using Excel tools, they tend to integrate them into their lessons. 2. By implementing innovative teaching methods by teachers, it was shown that the laptop itself did not lead to more flexible learning methods, unless the teacher was convinced of this need. Therefore, schools in the world that submit projects for laptops in classrooms should first offer advanced pedagogical courses to teachers and then only initiation courses for laptop applications. 3. It is necessary to continue guidance, even after 10 years, to support teachers in schools. Apparently, teachers need continuous technological and pedagogical guidance. The schools that required teachers to follow a regular training over the years were more successful than those schools that stopped the teacher training after 6 years [86].

Multiple countries in the world that have succeeded in their educational ICT programs have operated between the years 1997 and 2008, such as: Norway, Hong Kong, Denmark, Singapore, France, Finland and Japan. Most of the programs are designed to create learning opportunities for teachers with the aim of: improving their computer skills; allowing them to use the computer in teaching their subject; promoting the use of computerized means in schools by teachers; computerizing as well as modifying teachers' teaching methods and adapting them to the ICT era. In the first stage, all countries reached the level of computers equipment over 75% in almost all schools and in the second stage new ICT curricula were developed focusing on information skills for students in an Internet environment. In addition, all teachers were required to undergo systematic training in computer applications in order to teach in class via computers and Internet communications. These programs were successful, for instance: recent data from France indicate that 76% of French teachers make innovative pedagogic use of the ICT systems established for them. In addition, as of 2009, 90% of schools in Singapore have a computerized system online for learning management (LMS), including a computerized classroom learning space. The teachers in

Norway are considered to be the most advanced teachers in Europe in the use of ICT-supported teaching methods. In addition, 86% of teachers in Hong Kong use computers to actively activate students in class. Furthermore, the Danes succeeded in transferring their evaluation system to a set of computerized exams, including assessment of students' information skills. This achievement is considered one of the greatest success generators in the world's ICT programs. This stage of action was also reflected in the creation of ICT learning materials that encompass 60% of the curricula in Denmark [87], [88].

Building a country's future is inconceivable without a digital strategy that will create opportunities to renew and develop on the base of ICT technologies. The EU has adopted and implements the "European Digital Agenda", countries that rank first in international rankings also approved digital strategies aiming to assure accelerated development (USA, UK, Estonia and Qatar) [30], [89]. The Republic of Moldova achieved significant progress in application of Information Technologies in society. Every citizen can use the internet, more than a half of the householders have at least one computer, most householders have access to the Internet, and this country is among the 20 leading countries in the world by internet access speed, biometric passport, electronic signature ID card.

Moldova embraced the national strategy for developing of the information society “Digital Moldova 2020” (“Digital Strategy”) that is aimed to create conditions through minimal intervention of the state, but with a maximal influence on the social development, focusing on three important dimensions: *infrastructure and access* - improving connectivity and network access; *digital contents and electronic services* - promotion of productive digital contents and services; *capabilities and use* - strengthening literacy and digital skills to enable innovation and encourage use. These three dimensions have a great positive impact on the following three components of the society: 1. *communities / populations* that enjoy a more comfortable and better life; 2. *businesses*, which will increase the level of competitiveness; 3. *governance*, which will improve their performance and will provide services to citizens at anytime, anywhere on any terminal equipment. The state implements the strategic program of the technological modernization, action plan for an open government 2012-2013 that includes, among others, education field, integration of ICT in education to improve the process of education and management at the level of the system, the school and the classroom; e-Education will initiate the preparation of the strategic plan [29]. This plan evolved into detailed objectives of strategic direction 6 "Effective integration of ICT in education" of the Education 2020 Strategy. Due to this Strategy the educational system in the Republic of Moldova aims to become a quality one through school programs adapted to the needs of the information economic society; by training teachers for the effective implementation of ICT in education; by integrating information technology into the teaching process; by creating digital educational content, including through support for lifelong learning.

According to the global IT 2012 report, Moldova is ranked 69th out of 142 in mathematics and science education. Only 14% of the population aged 35-44 and 10% of the population aged 45-54 are internet users, and it's a disturbing fact. Additionally, the level of ICT use is low as well – merely 2-3 points out of 7 (instead 90 out of 142) [90]. Though in earlier years the government made efforts to implement the ICT in general education (800 computer classes in 1997, and the "SALT" program, financial resources for opening at least one computer classroom in each school with access to the Internet and the purchase of Didactic software), these are not fully integrated into the didactic process [30].

Despite the increase in the level of equipment of the general education institutions, there is a lack of management, maintenance and budgeting for computer labs, and most licensed software are not allowed, at the same time the open programs are poorly used. Some of the ICT program's sections are outdated and there is no institutionalized process for periodic update. Graduates of educational institutions do not have sufficient practical skills to work in informational society. There is a shortage of qualified staff: half of computer science teachers have education in exact science and only 3 out of 10 of them are graduates of computer sciences. Most of the didactic staff teaching computer science and other fields have never participated in training courses nor acquired teaching degrees. Many teachers do not have general computer skills (e-mail, Internet, etc.), and even fewer are able to use ICT in the teaching. Teachers in the school of the main fields of study (apart from 140 schools equipped with educational programs) are not equipped with educational software and have not been trained to handle such programs. Although there is an increase in applications using ICT in the school and university learning materials, most of the school's learning materials do not have specific educational software [29].

Republic of Moldova, as well as all of Europe, faces an increase in the ICT skills gap and a low level of digital literacy. Even though citizens have computers and are Internet users, a large part of the population of the Republic of Moldova does not obtain digital knowledge or skills. This fact reduces opportunities to participate in the global digital economy. Raising the level of digital literacy of the population begins with the education system, then by a quality education system that mainly includes: the curriculum is adapted to economic needs based on knowledge; training the teaching staff to effectively implement of ICT in educational processes; the integration of Information Technology in the didactic process; creating digital educational content, including support for lifelong education [31].

This is why the pedagogical researches of the Moldovan scientists are focused on the intense study of these aspects of education. For example, Anatol Gremalschi treats the implementation of information and communication technologies in education as a means of modernizing pre-university education [33]. For the university professor in the didactics of computer science Valeriu Cabac, digital technologies contribute to the formation of professional competences [34] and have had an impact on the emergence and becoming of the university didactics [35]. The methodology of using information and communication technologies in higher education was researched by Andrei Braicov and Sergiu Corlat [36]. Also, various contributions to the study of the impact of ICT on the study of school and university disciplines was made by researchers: L: Chiriac, A. Globa [37], L. Mihălache [38], N. Deinego, C. Negara [39], M. Pavel [40], A. Gasnaș [41] etc.

1.2. ICT integration of learning Biology in the constructivist approach: implications for the development of high-order thinking and increasing motivation to study

The innovative pedagogy has been developed in the last decades due to a combination of theories and studies in various fields, such as: constructivism, self-regulated learning, motivation, learning styles, exploration and identity formation [91]. Numerous curriculums recommend the use of advance technologies, among them, the new curriculum in Science and Technology from Israel. In the new curriculum, it is recommended to make use computer as well as the current teaching and combine means to illustrate abstract phenomena [92]. The national ICT curriculum sees the students as leaders – "online leaders" and as such they are full partners in leading pedagogical processes in the school.

1.2.1. Review of studies that examined the ICT effect on the motivation to study Biology

Many researches show that motivation has a major effect on learning and achievements. Challenging instructive materials allow students to progress independently and influence, positively, on their motivation. The youth, today, are affected by a wide range of digital medias, computers, smartphones, and other devices, that enable dynamic reading and creation. Digital games and social media have great weight in the social life and the academic life of the youth [93]. 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.

The study of Y. Rosen [52] examined the influence of the ICT learning environment based on animation videos on high-order thinking and motivation to study science among students from elementary and middle schools. It has shown that the experimentation in learning environment that combines *Brainpop* animation videos significantly increased the motivation to study science and technology. On the other side, the students of the control group examined in this study experienced a decline in the motivation to study science and technology at the same period. The motivational elements mentioned by the students and the teachers in the experimental classes in relation to the new environment, match the concept of "Optimal Experience": feelings of concentration and pleasure, inner motivation and a tendency to repeat the activity that caused this feeling "I feel like another kid that understood and built the video". All of the teachers noted that the concentration level of all the students, in lessons in which there was a use of videos, was above the concentration level achieved in "regular" lessons and "subjects that they didn't even think the students will be interested in became suddenly interesting because of the animation" [52].

The role of the teacher is to develop the motivation of the students to study science, including biology. The act of *motivating* is defined as a move that begins the process of learning and preserves it. As long as the learner has no motivation, he cannot learn, and since students differ from one another in terms of learning ability and style as well as in personal intellectual tendencies, the teacher must adopt diverse teaching methods, that will encourage the inner motivation of the learner stems from the actual interest and pleasure from the studied subject [94]. Teaching that uses visual illustration, such as models, animations, graphs, in order to make abstract tangible, and clarify ideas or concepts, increases the motivation and the inner drive of the student.

Y. Rosen's [52] study shows that ICT integrated science lessons, begins to produce a conceptual change among students regarding the study of science and technology. The students perceived themselves as more central to the classroom interactions, felt interested in the learning, and put more emphasize on the combination of ICT and experiments during the lessons. A change that occurred among the learners following the experimentation in the new environment does not narrow down merely to the motivational dimension, but rather spread to a conceptual change regarding essence of learning. The findings brought by M. Barak's research [92] show an improvement of the motivation to study science among both study groups: experimental and control, but the improvement among the students of the experimental group was distinctively higher statistically in comparison to the improvement among the students of the control group. Therefore, the combination of ICT via Brainpop animation videos increases distinctively the students' motivation to study science.

In K. Randall's research [95], regarding the issue of students' involvement in "Problem-based learning", 11 environmental elements were found as evoking motivation: authenticity, challenge, cognitive involvement, capability, choice, fantasy, identity, interactivity, novelty, sensory involvement and social relationships. The research mainly examines the change made in learning science and the connection between motivation and learning after using the problem-based learning called *Alien Rescue*: the goal of learning in the *Alien Rescue ICT environment*, is to draw students to solve complex problem that require use of tools, procedures, knowledge about space, sciences of the planets and the solar system. The main mission presented in the *Alien Rescue* program: six kinds of aliens, with unique qualities, arrived to planet Earth since their planet was destroyed. Students take upon themselves the role of scientists and they need to find a home for the aliens and thus assure their survival. In order to do so, the students need to study a range of problem solutions, collecting information, and activities that include investigating all of the aliens' requirements and factor analysis, such as life-bearing temperature ranges and basic atmospheric composition for survival. The research's conclusion regarding the use of *Aliens Rescue* as a problem-based learning is: a substantial increase in the scientific knowledge among students; students have acquired sufficient understanding of scientific concepts by self-directed learning, intensification of discussions in class or discussion with peers while using the app; the students saw this mission as a different scientific project and eventually they had a really good time; students are driven to solve problems when they are challenged and have control over the learning processes, as a result, a learning took place on the base of solving the suggested problems; students dealt with planning and making decisions as well as determining how to use the available resources efficiently.

The use of ICT educational technologies can cause a better learning due to the fact that there is a better access to information. This access allows teachers and students to use the opportunity for a joint learning with experts, for sharing information and conduct self-investigation more effectively. In addition, technologies that support content based teaching which focuses more on the student, and is mostly based on asking questions and enables receiving a better picture of the complex processes, has a higher potential to make a positive change in studying scientific subjects. Integration and assimilation of ICT will affect the learning quality, will open the students' thinking and improve their academic achievements. Learning in this way will evoke interest in them and increase their motivation to study. The extent of the student's belief in the mission's success may grow due to ICT learning and thus his self-esteem will strengthen which will affect his motivation to study. The key to the success of ICT learning is related to teacher's ability to create high motivation in the student.

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 such as: D. Coşcodan, L. Moşanu-Şupac [59], D. Placinta, E. Coropceanu [60, 61], L. Ivancov [62], I. Cristea [63] et al.

Russian researchers are also involved in studying the aspects of implementing information technologies in biology classes. For example К.В. Хайбулина [54], experiments with the teaching of biology through ICT and investigates their impact on the students' school results, but refers only to some separate topics, without elaborating a pedagogical model in this aspect. Т.И. Крылова approaches the topic of modern means of information and communication technologies in organizing homework at biology [55]. Other studies refer to the activity of practicing school teachers who share their experience of using ICT in biology lessons, but without referring to scientific pedagogical research. We can mention here: Ю. А. Косторных [56], А. Коробченко [57], Т.М. Демина [58] etc.

A retrospective of online tools and educational software specialized in teaching biology was made by Christophe Merinat, who emphasized that the use of such digital resources is possible, only that the teacher must be aware of the different constraints and inherent limitations [48].

In Israel, M. Dersler, R. Ehrenberg and L. Sela [49], D. Steiner and M. Mendelovitch [50] studied the subject of ICT integration in science teaching and mainly addressed the education and development of thinking in science and technology learning and integrating computer simulations into their teaching. Also, researchers R. Deaney, K. Ruthven and S. Hennessy [51], Y. Rosen [52] and K. Barak, M. Shani and G. Kurtz [53] 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.

1.2.2. The constructivist approach and its influence on high-order thinking in ICT usage

The core of the innovative pedagogy is based on the constructivist approach, according to, the experience of the learner determines the reality which is relative, and the knowledge is constructed or made by student, thus, the emphasis is placed on the ICT environment in developing skills of the 21st century. The interest of this teaching conception is to better the teachers' skills and provide the essential necessities for effective learning, so that the future adult will be able to function efficiently and independently in a competitive, global, dynamic and high-tech reality [75]. In order to fit in the public space and the changing reality, knowledge and new skills are required, hence, the early requirements from the students are of a cognitive, meta-cognitive and motivational nature, and they are dependent on his ability to organize his studies and regulate them [96]. The ICT program underlies the technological and pedagogical infrastructure for the imparting of these skills, the skills of the 21st century, for the design of the education system graduate who is prepared for the challenges of the age of information, who knows how to use his acquired skills, both to his personal needs and in order to serve the society and the country when coping with future, local, global, economic, cultural and security challenges they face with.

The constructivist theory is a conceptual frame that aids to deal with the search after a profound understanding. Many people of education today embraced this world view in relation to educational activity. According to this theory, the learner is perceived as an active agent who creates meanings and forms incites regarding educational situations. The constructivist point of view cancels the conception that the learner absorbs information passively from the book or the teacher. Even when the chore that the student has to preform obligates memorization alone, the learner fills an extremely active role. He struggles to understand, form experimental perceptions and then examines and changes them. A teacher cannot simply install conceptual understanding to his student. This kind of understanding has to be constructed while making an effort [97].

The curriculums in science teaching emphasize that the science teachers must use strategies that develop thorough scientific understanding while combining research skills, problem solving and providing answers to complex questions. According to the standards, the science teachers' roles are to guide the learner, encourage construction of new knowledge based on prior knowledge, as well as assisting the learners to take responsibility for their learning. The science teachers are required to encourage learning by having discussions between the scholars and encourage collaboration and the creation of learning communities [98]. Numerous studies show that the technological revolution brought to pedagogical and organizational extensive modifications in the schools, therefore, the national ICT program was meant to produce a change and turn the school to a learning ICT organization which optimally integrates the ICT technologies. The technological abilities of gathering, managing, creation and sharing information allow to fulfil multiple opportunities for constructivist innovative learning in which the students are involved in the learning process and are active partners in it. In the learning process the learner is at the centre, and the interactions with the environment are necessary. In the teaching process, the emphasis is on nurturing skills of thinking, searching, information management and processing it whilst increasing the learner's meta-cognitive awareness [91]. In the study of Y. Nissim, M. Barak and D. Ben-Zvi [98], was examined whether there is compatibility between the science teachers' perception of their role and the teaching strategies in which they use ICT. The findings focused on four aspects that characterize the role of the teacher who combines ICT: a guide, a motivator, a partner and an innovator. Additionally, four teaching strategies, that encourage learning in the constructivist approach, were tested: illustration, problem solution, research learning and reflective learning. The research findings indicate that in lessons that combined ICT, the teachers mostly functioned as guiders and motivators of the learning processes, while using teaching strategies that included: illustration, problem solution and research. That is to say, there is a high compatibility between the roles: a guide and a motivator and the aforementioned teaching strategies.

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 [99]. Curriculums that base on the students' performances and abilities, rather than merely on their achievements, can benefit greatly from a correct combination of ICT. The ICT allows a diverse and broad access to sources of information, research study of students, problem-based learning, authentic and relevant learning, and turning the teacher into a mentor and a trainer and less an expert in the field of knowledge. Informative skills and new literacy are of great importance constructed, among the students, by the ICT learning. This approach towards the knowledge consists with the constructivist theories that see the student's social and cognitive development at the centre, and the learning environment as supporting and enabling active experiential learning [100].

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 [101].

According to R. Oliver [102], the power of ICT as a generator of change and pedagogical innovation in the 21st century, affects four elementary questions in the educational pedagogy: (a) what do we learn? (b) how do we learn? (c) where and when the learning occurs? (d) who is the learner and who is the teacher?

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 high-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: *high-order thinking*: creativity, ingenuity, critical thinking and skill in solving complex problems; *collaborative learning skills*, personal learning, and maintaining ethics; *digital information processing skills* [103].

Under the general umbrella of "constructivism", there are diverse views regarding learning that their common key word in the learner's definition is "constructive". In the demonstration of the way that the constructivist views can be implemented in biology teaching, two general principals common to these views are being addressed: 1) *the learning* is a process of an active construction of knowledge; 2) *the teaching* is more a process of supporting a construction of knowledge than a process of delivering it to the students. It seems that according to constructivist conceptions, biology "teaching" is not the issue, but rather the student's coping, guided by the teacher, with learning biology [99]. A learning environment that combines ICT means may provide a structured opportunity for integrative learning, in which the students are active, receive feedback (from the teacher and/or from ICT tools), while improving their understanding and constructing new knowledge. Utilizing the potential of computerized tools to improve teaching-learning processes may lead to an interaction in which the student is at the centre of the learning, that is done by the teacher [104]. Realization of the constructive approach in education, according to which the learner is at the centre of the teaching process and actively constructs knowledge, is possible, to a great extent, by ICT and the possibilities it embodies. The technologies of the computer are a toll for cognitive design and structure of the student – an actual interaction takes place between him and the learning material, materials that their volume and quality differ from those learned in any other technology and their assistance in understanding broad learning [105].

1.3. Aspects in assimilation of ICT in schools – models and teaching methods

In the recent decade we are witnessing an extensive assimilation of educational technologies as an integral part of teaching, learning and guidance processes, this assimilation is pronounced by the development of unique strategies for transforming multimedia and communication technologies for educational purposes as well as by projects for assimilation of innovative technologies, such as: 'Interactive Boards', 'Smart Classrooms', 'Computer to every teacher' or 'Computer to every child'. Assimilation of new technologies in the schools has become a means for other ends such as improving the level of teaching, creating interest in classes, imparting literacy skills, and more [75].

1.3.1. Models and teaching methods in the integration of ICT in the classroom

In the current research literature two main models are describes regarding assimilation of new technologies in the education system:

- Islands of Innovation Model: Innovation encompasses only a small part of the organization and is usually focused on a specific content or task. This model usually leads to first-rate changes in the organization, that is, quantitative changes rather than essential, supposedly 'more of the same'. These are changes that mostly include differences in organizational characteristics and behaviour, without any significant change in the organizational culture - meaning, in its norms and hypotheses.

- The Comprehensive Innovation Model: the innovation encompasses all levels of the organization creating organizational culture and leads to a second-rate organizational change, affecting the values and hypotheses of the organization at the highest level. This innovation may even turn into a broad paradigmatic change in the organization [24].

Integration of digital teaching-learning in the schools involves a change in a teaching-learning paradigm in several stages, expressing the depth of the change:

- **A first stage** is "domestication" of the technology to available teaching-learning habits. In this stage, the change is of the first order and is expressed by a diverse illustration beyond the "chalk and board", painted and written posters, pictures and screening video clips regarding the subjects in the class. Further, with the assimilation of technology into teachers' habits of use, we will also find a use in presentations for displaying information in various media, using the Internet as additional information on available textbooks and the like.
- **A second stage** in which a change of the second order occurs, is expresses by adapting pedagogy to the digital age. The Digital learning in this stage implements activation of Knowledge Structuring Community - "The Third Model" which entails the intelligent use of digital communication among the learners and between them and the teacher, in constructing collaborative knowledge through online sharing tools, and the routine use of digital information accessible to any learner at any time and place. The expectation is that the application of digital teaching-learning will lead teachers to adopt student-centred methods, to experiment with authentic research processes and to construct knowledge independently and to encourage cooperative activities among students [27].

K. Burden’s [106] proposes the following steps that a teacher takes to assimilate the use of technology in the teaching:

1. *Infusion*: technology is being used to strengthen teaching in the existing format, mainly as an aid. The learners are mostly passive.
2. *Integration*: the technology is embedded within the school and curriculum and supports the teaching goals of the subjects. Learners in this case are more active.
3. *Transformation*: the technology integrates where it provides an added value to the learning process. Teachers use and create a variety of online learning resources that, among other things, increase research-based learning. The learners are active.

The online environment is an answer to various learners, at different levels of literacy in general and digital literacy in particular, with different learning styles, unique needs and different interests. ICT resources are accessible and available at all times, allowing students to function independently in the environment [91]. In schools, teachers have many possibilities for integrating online computers and technologies according to five models of integrating ICT into the classroom [107, 108]: 1) one computer in the classroom; 2) one computer in the classroom, connected to the video projector or interactive board; 3) 2-5 computers in the classroom: 4) computer lab; 5) class without computers. These models refers to technological aspects but not represents pedagogical models of ICT implementing in biology classes.

1.3.2. The technological tools and services used by the teacher for the implementation of digital teaching-learning

In the process of teaching-learning must be considered the following three dimensions: pedagogical, organizational-administrative and technological dimension [109]. A study of N. Magen-Nagar, T. Shamir-Inbal [27], shows that the technological tools and services used by teachers to implement digital teaching-learning are diverse and abundant (table 1.1).

Table 1.1. The technological tools and services used by the teacher to implement digital learning instruction

Category	Way of use
Visual illustrations tools	Watching photo albums, videos on YouTube and others, Google Earth and editing information about them, simulations, concepts organizers (like Popplet), a demo by visual illustrations
Digital content	Viewing, using and displaying in class written online learning materials such as content companies, with diverse means, including a digital book
Production tools	Word processor, presentation, electronic spreadsheet, video production and editing etc. ("office" tools)
Tools for sharing	Sharing in students learning by blog, forum, sharable documents on Google Docs, social network, survey etc.
Pedagogical management tools	Management of education (presence, grades, behaviour) in a designated pedagogical management tool online
Communication tools	Email, forum, chat, text messaging, Skype, video conferencing, email
Information retrieval tools	Data retrieval online, the use of designated databases about the learned subjects and general databases such as encyclopaedias, Wikipedia, wiki dictionary, lexicon, Google search etc.
Tools for organizing information in the cloud	SkyDrive, Google Drive, Dropbox, Microsoft Office
Play tools	Various games and comics such as Toon Doo

In the mentioned study, it was found the moderate prevalence of using production and sharing tools, after the more frequently using of visualization tools and digital content, considered by teachers as most meaningful in the context of technology integration. Teachers use collaborative tools as a tool that encourages cooperative information creation and representing it to study groups or individuals. Sometimes the teacher and the student collaborate, but in most cases, the work is shared by all the students in the class. Such tasks also enable efficient and convenient sharing among students from other schools. Another thing that can be learned from the reports is that production tools and sharing tools allow for an open and creative work rather than solely using visualization tools and digital content. These open tools for sharing enable teachers to create their own teaching activities according to their pedagogical needs and to enrich and diversify their work and the student is given the opportunity to be an active learner, to create information and to share it with his colleagues and teachers [110]. In addition, the research findings show that following the entry of the ICT program into the school, there has been a significant change in teachers' perceptions of understanding the added value of integrating technology into teaching. Most teachers say that ICT helps them illustrate and stimulates motivation for learning among students. Some refer to the professional empowerment they experience as teachers following the acquisition of the skills that enable them to open the world of teaching and learning beyond to what they were familiar with to this day. But the ICT resources and tools identified by the researchers as being useful in the biology and science lessons were not integrated into a pedagogical model and their connections with the other components of the instructional-educational process based on information technologies were not identified.

1.3.3. Evaluation of ICT activities

ICT technology gives an added value to socio-constructivist teaching approaches. It allows the teacher to design activities supporting active and cooperative learning, and to the student it allows to experiment with building rich productions and acquire high-order thinking skills. T. Shamir-Inbal and K. Yael [26] have developed an indicator that assess the educational quality of the ICT activities. The Indicator (table 1.2) includes six dimensions, that each one received three levels of performance: low, medium and high. It should be noted that the indicator, additionally to its function as a tool for evaluating and characterizing ICT activities, it also serves as a tool for directing teachers in the development of their ICT activities.

Table 1.2. Indicator for evaluating and characterizing ICT activities with a socio-constructivist emphasis

Dimension	Low Level (1)	Intermediate Level (2)	High Level (3)
Use of the Technology's Added Value	Use of technology is technical and does not affect the essence of learning. Students download traditional worksheets, fill them out and return them to the	The technological component might create interest and innovation, but with no fundamental change in the essence of the learning.	Technology is essential for the activity. Students are referred to a variety of rich, current websites. They interact with the content by using web2

	forum or directly to the teacher.		tools as active participant in online dialogue.
Required Level of Thinking	Memorization of knowledge. Focus on standard questions and answers. Oriented towards simple information-gathering assignments. (Level 1 - Bloom, 1956)	The activity requires the learner to give examples, descriptions, summaries or general explanations of information gathered from the internet. (Level 2 - Bloom, 1956)	The activity encourages high-order thinking: (posing questions, taking a stand, making conclusions) and encourages creativity, responsibility and knowledge integration. (Levels 3-6 - Bloom, 1956)
Peer Learning	There is no reference to collaborative learning. Learners are sometimes prevented from cooperating with one another. Projects are occasionally uploaded to the forum, but only for review by the teacher.	Scaffolds explicitly require students to work in pairs or groups, but there is no technological support for interaction between fellow students or between the groups.	Online components are used to support collaborative learning as an essential part of the activity. Learners serve as information sources for their peers.
Making Contents Accessible	There is no attempt to relate and make the contents accessible. Emphasis is on content that the learner must know or remember.	An attempt is made to relate the activity to the learner's world, but the connection is artificial or not meaningful.	The activity is connected to the learner's cultural world and previous knowledge and experience, by choice of contents, nature of problems, social context.
Scaffolding for Rich Artifacts	Scaffolds guide towards a uniform, closed artefact defined by the teacher. No creativity is required to produce the artefact. Such activities include: standard questions and answers, sorting of data in a table, etc.	Scaffolds enable a product with a certain degree of openness and personal expression, but are too general to support a complex task. For instance, “Write a story about…", "What I would do if…", "My opinion on…"	Structured and scaffolded assignments, that help learners construct an artefact, and enable the teacher to serve as a facilitator. Artefact is diverse, creative and promotes personal capabilities and self-expression.
Embedded Assessment	There is no reference to the way in which the learner is assessed. Assessment is summative. Products are sent to the teacher to be checked and graded.	There is reference to unclear criteria of artefacts assessment. Artefacts are sometimes presented on the website or in class, but without prompts for further learning from these artefacts.	Assessment is performed by the teacher or by fellow students according to clear and known criteria. Formative assessment is embedded in the learning process and enhances it.

Usage of technology while integrating a socio-constructivist pedagogic rational enables to expose the learners to rich and diverse information, allowing them to practice in complex and relevant contents, to experiment in building rich productions, and conduct an educational dialogue with teachers and colleagues. Despite the increasing use of computers in schools, the use of technology in a way that implements educational principles as described, is not assimilated, most of the use of technology in schools is technical without a cohesive pedagogic rational basing on surfing the web, gathering information, and processing it in a simple level. A significant assimilation, may be created when the school-culture encourages ICT usage, open for introduction of innovative pedagogies and team-work, and when there is a suitable support for the teaching staff and the management. ICT culture is expressed by an everyday use of ICT in relation to school subjects, at the extent in which the teacher conducting an online communication of the teacher-student type, and at the extent in which such communication takes place among the students as well, a communication allowing collaborations and mutual support [111].

1.4. The ICT innovative pedagogy and its implication over the significant learning ability in science education

Relevant skills to optimal functioning in the 21st century, students could acquire through innovative pedagogy, in which the instruction is adapted to the students' language, breaking barriers between the school and the outside world through optimal, yet intelligent use of technology, in order to advance the teaching processes at the pedagogic and management levels [77]. According to A. Tal, R. Mints and M. Dressler [112], the pedagogic challenges forwarded by innovative pedagogy, raise the need to train teachers to know how to integrate pedagogic innovation in ICT environment, requiring a qualification for a new kind of teaching: development of research tasks and missions suitable to the age of information, imparting informatics skills along with research skills, a full use of visual media, teaching with real-time data, research with illustration software and computerized tools, management of discussion groups, electronic communication between teachers and students, evaluation of students' ICT products. The learning environment, relating to innovative theories of learning is characterized by: *personal dimension*, *social context*, *exceeding the limits of time and space*, *potential to lead students to comprehension performance*s [113]. The advantages of technology as an educational tool are caused of its assimilation in the schools for various educational purposes that support teaching and learning. This assimilation triggers and examines different themes related to it. One of the important themes of this assimilation is its influence on the teacher’s teaching method [114]. Use of ICT can make the innovative pedagogy more relevant to the learners, intelligently based on the prevalent usages in their daily lives (social networks, blogs, video games and more).

One of the main activities of the educational process, towards which the innovative pedagogy is oriented, in the sense of developing and implementing new teaching strategies and methods, is learning. There are a number of approaches of innovative learning, but most give the learner a primary role, with the task of restructuring and organizing knowledge so that it is connected to those previously accumulated. This approach refers to the concept of meaningful learning (significant learning), which is promoted within the education systems and gained in recent years an increasing interest [115]. The Ministry of Education launched the national program "Israel Moves Up a Grade" in the school year of 2014, national program for significant learning, that encourage active experiential learning, teamwork, thought and research, equipping the learner to face with the challenges of the 21^{st} century [116]. The research literature indicates the variety of definitions and models of significant learning, but all of them base on the same premises regarding Significant Learning: according to D.P. Ausubel [117], significant learning is both a process and an outcome. In order to occur the significant learning, the learner will show a tendency to produce the inherent meaning of the reviewed material that will possess a significant power for the learner. Significant learning is a learning in which the student raises questions, locates sources of information, processes information and creates new information relevant for his or her personal life and to living in the technological age of the 21^{st} century, reorganize what has been learned and will be learned [118, 119]. It bases on three coexisting elements: *valuable to the learner and the society, involvement of the learner and the teacher, relevance to the learner* [4]. This elements are described from Biology and Science studies point of view by S. Cohen [120]. A. Avni and A. Rotem emphasis that learning becomes significant when it has importance, value and meaning to the learner in harmony with their world of concepts, cognition and emotion, and its actual manifestation designs the reality of the learner's life, personality, skills, development and future [121]. According to A. Perneps [122], in significant learning the student is driven by curiosity, that why he inquires, locates sources of information through technological tools and conversing with peers, processing information creates new information and shares it with the learners' community. M. Vidislavsky mention the various spaces in which significant learning takes place: in the school and outside of it, in the class, in the schoolyard, in the community, in different sites and in the digital space [123]. There are nine pedagogical principles, identified by S. Azoulay in significant learning [124]: *representation, purpose, responsiveness, performance, feedback, public character, tempting, bar* and *routine*. After L. Cohen, people of education should consider intelligent consumption of interactive web environments to promote Significant Learning [25], that would be possible while changing the teacher's role and emphasizing active learning [125], which in an innovative technological environment leads to a joyous learning experience [53]. The significant learning is characterized by J.L Howland, D. Jonassen, R.M. Marra [126], as: *active, constructive, intentional, authentic and cooperative* learning [127]. Therefore, these aspects should be examined in order to think how the learning can become more significant with the ICT combination.

In conclusion, the ICT opened new opportunities to increase the effectivity of teaching-learning processes [128]. In order to promote Significant Learning as a deep and enriching learning experience that is relevant and valuable for the learners, and summons their involvement and participation, there are profound alternative teaching-learning-evaluation methods such as: learning through inquiry, project-based learning, collection, etc.

1.5. Conclusions to Chapter 1

1. Information and communication technologies have revolutionized all areas of human activity, and, inevitably, the education. Researchers in the field of education have intensely exploited the topic of ICT integration in the teaching-learning-evaluation process of different school disciplines, including biology. The implementation of ICT in the education process is also supported by international educational policies, the policies of the State of Israel and of the Republic of Moldova. The analysis of the advantages offered by the information and communication technologies 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.

2. The research of the specialized literature did not allow the identification of some pedagogical models for integrating the information and communication technologies in the process of teaching-learning the biology, but only the identification of some technical models for the use of computers in the classroom. 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* is a priority objective of this research.

3. The methodology of using ICT in biology lessons, proposed by researchers in the field, is a modern one, based on interactivity, but it does not have the purpose of implementing any pedagogical model or is not adapted to the middle school education from Israel.

4. The scientific results and the recommendations of the researchers in the field of biology didactics are based on the isolated implementation of ICT in the process of studying some topics or modules, or they are only theoretically based and are not confirmed by the extensive pedagogical experiment conducted in the Israeli gymnasium or by statistical tests.

5. The above findings allowed to advance the research problem that consists in *determining the theoretical and methodological foundations of the efficiency improvement of the teaching-learning process of the biology in the gymnasium through the information and communication technologies*, to the solution of which will contribute the achievement of the proposed objectives.

2. THEORETICAL-METHODOLOGICAL BENCHMARKS FOR INFORMATION AND COMMUNICATION TECHNOLOGIES IMPLEMENTATION IN THE BIOLOGY TEACHING-LEARNING PROCESS

2.1. Conceptual premises for the pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology

2.1.1. The science and technology curriculum in middle school in Israel

The new science and technology curriculum in middle school in Israel constitutes update of the curriculum "Science and Technology Studies" written in 1996 bases on the *Science*, *Technology*, *Society* (STS) approach. According to the new curriculum, there is an explicit reference to the central disciplines at the base of the profession. The subjects were gathered from four content areas (Physical sciences: Physics, Chemistry; Life Sciences: Biology; and Technology sciences), ensuring that subjects from all four disciplines to be represented in each classroom [46].

The structure of Science studies in Israel went through many modifications throughout the years, especially in the three recent decades. Beginning with the focusing on "Knowledge Structure" method, passing through "Science, Technology and Society" approach [46], [129], [130], according to which there were two curriculums in junior high school, one in biology and other in physics-chemistry, it finished with a new program for the combined profession in middle school, *Science and Technology*. This program based primarily on the programs in biology and physics-chemistry but other subjects were added to it as well as chapters in technology. This program is interdisciplinary, that is, it allows the teacher the freedom to create continuity between scientific school subjects.

In junior high school, the curriculum in biology is a part of the general curriculum in science and technology, according to which the biology is a science that bases on knowledge achieved via theoretical and experimental research, in the purpose of developing scientific literacy in biology. This literacy is a part of human culture, and it is a necessary load for an educated citizen and an important means of knowledge and understanding the world [131]. The findings collected by the researchers are explained and interpreted in accordance to popular theories at that time. Biological theories, being scientific theories, are constantly undergoing a process examination and development occurring due to new revelations, bringing the formation of new theories. These theories also affected by other sciences, from new technologies and social conceptions, while influencing them simultaneously [132].

The goal of the curriculum is to train its' graduates to a successful cope with the future challenges in a dynamic and high-tech society by nurturing 21st century skills. The biology curriculum, which is, accommodated to meaningful learning on all its elements, bases on three main axes that intertwined in teaching:

Axe of content: the curriculum includes subjects relating to everyday lives, relevant to the student, as well as fascinating subjects that some of them are at the front page of science. Central ideas used as organizing elements of the curriculum have been highlighted in the program. These ideas are expressed in each of every organization level and can assist in organizing teaching and learning.

Axe of thinking and learning strategies: in all of the curriculum's components, general principals of thinking and learning strategies development are used which are also unique for the biology content areas. The combination of the teaching and learning in the method of research, in lab experiments, in research work, in reading and analysing studies, allow to deepen the understanding of contents while constructing knowledge by the students.

Axe of values: an emphasis on moral aspects runs through all levels of the organization of the curriculum. Engaging these aspects, combined with acquiring relevant knowledge, may contribute to the education of a graduate who is involved, knowledgeable in issues on the agenda regarding the individual's life and the society [131].

The laboratorial activity is a corner stone in the teaching of science including the teaching of biology, and thus, it is consistently integrated in the teaching and inseparable of it. The activity in the laboratory has a central place in the biology curriculum. In these lessons, the activities base on observations, tests, and experiments carried out by the students, and rely on the knowledge infrastructure. The lab allows to the student a unique method of learning - "the practical learning". Every student learning biology has to experiment in a laboratory during his or her studies. The biology teachers are familiar with the importance of learning in a lab as an integral and main part in biology studies. A great part of the biology teaching goals can be achieved with laboratory lessons [131].

Understanding of biological processes is a complex and complicated matter since it includes many abstract things that are not always perceptible by the students. As a result, in their daily activity, biology teachers face students who have difficulty with understanding and internalizing biological processes. There are numerous factors that can affect the students' level of understanding, such as: the student's way of thinking, the level of attention and concentration of the student in the class, the skills and tools given to them, as well as the teacher professional competences used in class [133]. A solution of this problems is the implementation of demonstrative experiences methods in teaching biology. It has more advantages: 1) experiments can demonstrate and reify learned phenomena; 2) making conclusions from an experiment encourages a process of constructing students new knowledge; 3) performing experiments enable to improve the student's understanding of the knowledge creation process in science; 4) experiments allow to develop research skills, such as: examining hypotheses, selection of research methods, having observations and measurements, organizing findings and reporting them, performing experiments and making conclusions, evoke critical thinking; 5) performing experiments increase curiosity, motivation and interest in scientific subjects; 6) via experiments it is possible to diversify the teaching methods [131].

The researchers, engaged in learning of high-school biology course with use of ICT, have found that the students perceive the use of technology as obligating practice, allowing progress at personal pace and encouraging independent learning, contributing the biological understanding by the information sources multiplicity, visualization means, and Excel skills. The students perceived the possibility to see the phenomenon through the chart and graphs and to have a visual interpretation of theoretical information [72].

In this order of ideas, the national biology curriculum is a foundation for *pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology*.

2.1.2. ICT use in the teaching of Biology and Science in middle school of Israel in comparison to the developed countries in the OECD

The main role of the education system is to impart every one of its' graduates the necessary tools for optimal integration in technological, cultural and social advanced society. Thus, throughout the years, the Israeli education system attributed a unique importance to the learning of science that will prepare the student to a life in a scientific-technological society and will give him or her scientific ways of thinking. The common conception is that a student with scientific literacy will contribute in the future to a scientific-technological creation, which constitutes a base for the development and growth of the state of Israel. The common curriculum in Israel regarding science and technology studies bases on the recommendation of "Tomorrow 98" report and addresses to studies from kindergarten to high school. The curriculum gives an expression to various principals, such as: knowledge of concepts, phenomena, processes and scientific principles; understanding the meaning of scientific and technological knowledge both for the individual and for the society; as well as nurturing thinking skills while experimenting, explorative learning and problem solving. All these are necessary for a successful graduate in tomorrow's society [134].

The student's choice to learn a scientific subject for the matriculation is made by the end of his or her experiment in science studies in middle school. Therefore, it is important to understand and know the nature of this education in middle school. The Israeli educational researches and reports recommend six hours weekly of science study, with an integrative learning content rather than learning each subject separately. Practically, and despite the recommendations, a maximum of four weekly study hours are currently taught. From data about the rate of science studies from 2002, it seems that in middle schools in Israel, relatively to the studies rate in the OECD countries (12-14 ages) less students learn science: 10% of all mandatory hours as opposed to 12% in the OECD countries. Additionally, it rises that while in OECD countries (in 2007) the science studies focus on areas of **Biology (28%), Physics (27%),** and **chemistry (24%)**, in Israel-53% of science studies dedicated to contents of Biology. This focus on biology is on the expanse of physics studies, that merely constitute 15% of the contents, and on the expanse of earth sciences learned at a rate lower than the international average as well. From a report examining the "Tomorrow 98" reform regarding the way in which the integration of science studies in middle school is implemented rise that science studies in middle schools are not taught as science and technology studies, but rather the teaching is disciplinary (by the teacher's qualification) and the knowledge source is scientific. The majority of the middle schools teachers are of a biology background and qualification, which hardens the actualization of integrative science studies [135].

In the year 2006, a SITES study was conducted (Second International Technology in Education Study) in 22 states and planned by the international organization the IEA (International Association for the Evaluation of Educational Achievement) in order to examine the integration of ICT in school teaching processes. The SITES 2006 research, the third in a series of SITES studies, was held as a survey among schools principals, ICT coordinators and teachers of mathematics and science, and based on the findings of the previous two SITES studies held in 1998 and 2003. The research purposes: A) mapping the use of ICT in schools; B) Providing insights regarding the way in which school and systematic factors affect the pedagogic embrace of ICT by teachers; C) Examining the way in which mathematics and science 8^{th} grades teachers use ICT for teaching purposes. In order to determine the situation in the field of ICT implementation in the process of studying biology and sciences, the results of this report were analysed.

ICT were perceived, especially in the Arab sector in Israel, by both principals and teachers of mathematics and science as contributing to the learning as well as empowering abilities and performances of teachers and students as well. However, in terms of the actual use of ICT, the findings indicate insufficient level of infrastructures and a little use of ICT for teaching and learning support. Moreover, ICT is used for preservation of traditional teaching and learning methods, and hardly as a leverage for promoting innovative paradigms in teaching [81].

Focusing on the teachers of science in middle school, the research showed that approximately 53% of the science teachers teaching 8th grade used ICT for teaching purposes; a slightly lower rate from the global average. Only in four states (out of 22) there was a lower rate of use among science teachers than in Israel. The average of ICT use among science teachers in most countries is higher than that of mathematics teachers.

Regarding to the way of use, the science teachers who integrate ICT in their teaching mainly do it according to the traditional teaching paradigm. Nonetheless, though in a relative small degree, the use of ICT also promoted the innovative paradigm for learning. Among the more common usages we can find two activities classifies as belonged to the traditional school of teaching: presenting information, demonstrations and giving instructions for class work (29,4%), and evaluation of the learning via tests (25,5%). However, there were attested a use of ICT for activities relating to a more innovative school of lifelong learning: counselling for students in research activities (30,6%), organization, observation and supervision of classroom discussions, demonstrations and presentations in the management of students (25,4%). The common ICT uses among teachers that do integrate ICT in the students' learning are: searching ideas and information (about 46%), projects combined with short assignments (about 40%), and data processing and analysis (about 36%). These reflect innovative teaching paradigms, and thus one may conclude that when there was a use of ICT, it was consistent to the advantages of the computer enables to the learning. Activities in which ICT use is lowest are laboratory experiments (15,4%) and field exploration activities (16,4%).

The use of ICT among teachers is mostly in software for practice and training (about 20%) and office, such as word processor, data arrangers, spreadsheets, and presentation software (about 20%). According to reports, there is a relatively little use of software for simulation, design of digital learning models and games (about 8%), as well as multimedia production tools (9%). The use of technology among science teachers in Israel is low in absolute criteria as well, given that the parameter refers to at least one experience throughout the year. This use is also low in comparison to findings in the other countries. About 45% of the science and mathematics teachers integrate ICT for assessment purposes in the traditional approach (for instance, writing tests, chores and exercises), about a third - for assessment of learning products, and only about a fifth - for cooperative assessment methods, for example, peer assessment. In all things regarding the ICT integration in assessing innovative approaches, the rate of use among science teachers in Israel is substantially higher than the use among mathematics teachers. These findings pose Israel in the upper half of the rating of countries in science and in the lower part in mathematics [81], [136].

The education system in Israel in comparison to European countries regarding ICT use, is influenced by the technological myth about ”laptop computers to each student” (originally from the USA), since in European countries in general oppositely to this myth, the emphasis is not on computers but rather in accessibility to information online, learners communities, in networks connecting between the students and their peers, between teachers and their colleagues, between teachers and students and students’ parents in the same school. In most OECD states national ICT programs were developed, and every goal and targets of these programs focused on the common aim, which is to bring the students to an ethical and responsible use of ICT in order to support critical and creative thinking regarding information and media, as part of them being citizens of the global society. This aim is specified in three objectives: cognitive objective - develop critical thinking in the student; effective objective – educate to ethical and responsible behaviour; instrumental objective – impart ICT skills. The conception are positive in the Israeli education system regarding the integration of ICT in the learning and management systems in schools, along with possible and complex influences of the national program. It seems that the importance in basing a technological infrastructure for leading pedagogy adapted to the 21st century has been internalized among the teachers and students. Despite the difficulties accompanying the whole process – difficulties obligating renovated thinking, both on the implementation level and on the level of the program's objectives, positive trends rise from the teachers and students both toward the technological-pedagogical revolution taking place in schools in recent years [132], [136], [137].

The new national American curriculum in 2010 emphasizes information based learning and development of information and research learner. The main goal in France and Germany of the ICT curriculum is changing the teaching methods of the teachers and adapting them to the age of ICT, operating curriculums that their principle is developing information literacy among students and teachers in the internet age, as well as in Finland the curriculum referred also to the teachers in Finland as an opinion-seeking population that should deepen its professional development in ICT. That is to say, the directions of the operation were to deepen knowledge through guidance, training, self-learning and ICT tools. In Britain, the main goals of the curriculum were to improve the teachers’ teaching in ICT environment, deepen the learning and increase the efficiency of the ICT support services in schools and among teachers [136].

Slovenian researchers A. Šorgo, T. Verčkovnik and S. Kocijančič [47] examined the degree of the use and the integration of ICT among biology teachers in schools that received computers equipped with sensors and data processors to be used in teaching physics, chemistry and biology. The research discovered that a relatively small part of the teachers use the equipment donated to the classes and laboratories, and most of the use is in applications (word processing, e-mail and internet use). The teachers can make materials at home and then use the materials in class, and applications such as: presentations, use of data bloggers, computer programs and virtual lab. Teachers should have positive views toward the use and importance of these applications, but they do not use it because of the packed curriculums, as well as due to the lack of equipment and inappropriate training. Regarding the applications (computer games and programs), that the teachers showed negative views toward them, don’t use them, and the integration of these applications in the teaching is far from being realistic at the moment. An important moment for broader use of computers is the teacher's perception of the importance of the application, as well as the teachers’ skill. A skilled use is the optimal combination of the application and a sense of its importance. G. K. Ezekoka [42] recommends, among other things, that workshops, seminars and symposia should be held for social science teachers about the awareness to the innovative teaching strategies. Since each one of the strategies has specific areas of efficiency, there is a need to organize a training for teachers regarding the ways in which they can implement the teaching innovative strategies efficiently. Teacher qualification institutes should include the strategies into the curriculum, make intentional efforts in order to train biology teachers with the qualification to use each innovative strategy effectively and actively, while integrating the ICT tools. This fortifies the results of the Tanzania study examining the use of information technologies in science and mathematics in the training of teachers. Via developing a pedagogic technological knowledge, the researchers came to the conclusion that opportunities to student teachers in participating in professional development programs, that include class planning, instruction, evaluation and reformation, can be useful for the development of the knowledge and skills of technology integration in the teaching of science and mathematics [45].

2.1.3. Improvement of Biology and Science teaching through ICT

Scientifically, the educated man or woman is a person armed with skills such as: understanding basic scientific facts and their meaning; exploration, searching for and answering questions deriving from curiosity on daily experience; description, explanation, and forecast natural phenomena; conscious reading of newspaper articles engaging social discussions and make conclusions; evaluation of scientific information quality on the base of its resources and production methods, creation and assessment of arguments basing on testimonies and implementation of the conclusions correctly [43].

The conventional standards in science teaching field emphasize that science teachers should use strategies that develop profound scientific understanding while combining research of students, problem solution, and providing answers to complex questions. The standards state that the roles of science teachers is to guide the learners, encourage new information construction which bases on prior knowledge, and to assist the learners take responsibility for learning. Science teachers should encourage learning via conducting discussions between the learner's collaboration and creation of learners' communities. Teachers are recommended to teach with the help of their peers both from science and from other fields of knowledge, in order to link between the sciences and others fields of knowledge such as technology, languages and social sciences [28].

An efficient means for raising the level of understanding in scientific subjects is the development of learning materials and research based-teaching strategies aimed to impart skills and thinking methods characterizing the scientific research to students. Instruction that bases on learning as research in an authentic connection by visitations of students in research laboratories improves the students' understanding of the various aspects of the essence of science and positively affects the students' approaches toward science.

There are two approaches to study research: "Learning in the research way" and "Learning as research". In "Learning in the research way" students perform research tasks by themselves in a lab or at the field. Biology students in Israel receive the opportunity to engage in science in the way of research via research assignments limited in scope as a part of studying in class (laboratory experiments, research work), or in rare cases through extensive projects guided by researchers of different universities. On the other hand, in "Learning as research" students are exposed to different elements of the research process by representing the research process through reading and analysing research articles, the historical degree of science and other relevant materials. Students specializing in biology (biology majors) in Israel are exposed to learning as a research via reading sections from scientific articles on various subjects as part of their studies [138]. In both approaches the use of ICT is an advantage that may greatly contribute to the quality and effectiveness of the research process in biology.

The study of M. Al- Rsa'i1 [43], which aimed to identify the way in which ICT can be used in the teaching of science for developing a scientific literacy level, argues that there is a strong connection between the use of information and media technologies by students and their scientific literacy level, this connection relies on the way in which the students use ICT and how skilled they are to use it, as well as the nature of the learning tasks of the students. Developing scientific literacy and constructing scientific consciousness obligates a new connection between the learner and the knowledge sources in order to identify the most useful things to the learning and acquiring the best sources, the modern technology is the optimal way that can assist in this matter. ICT considered as a key role for the continuation of the learning, since it insures fast access to every new knowledge worldwide regardless spatial and time limitations and provides an increasing range of tools for handling digital data and access to a wide variety of information-supporting content. However, in order to receive the best advantages of this technology in the purpose of developing the student culture and better their ability to create scientific knowledge, education institutions should obey the correct methodology of information and media technology use through constructive learning processes and strategies. ICT provides numerous tools and patterns that can be used by learning strategies in constructivist teaching in which the student can perform several activities and be in charge of his or her own learning process.

In the ICT science teaching that bases on the use of PEA technology (Pedagogy, Environment, Attitude), M. Al-Rsa'i1 [43] planned and developed a model according to the following three requirements: use of information and media technologies in a way that coincides with the students' courses and approaches; constructing educative content basing on the constructive learning theory; providing social learning environment.

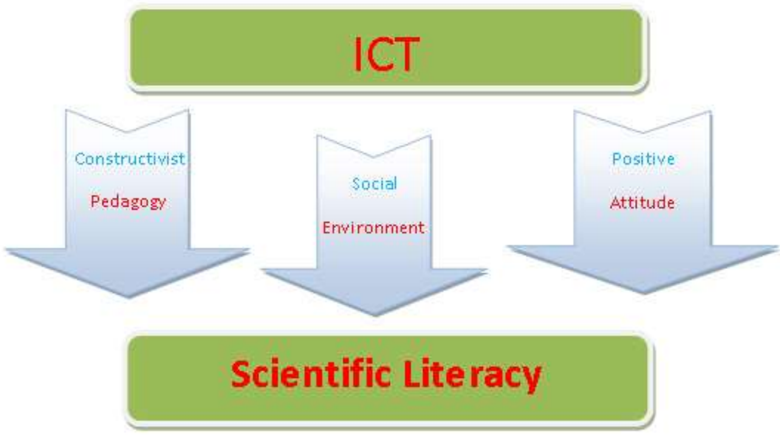


Fig. 2.1. The PEA model

The implementation of the scientific literacy model necessitates a planning of different curriculums and especially scientific curriculums in accordance to the strategy of information and media technology use of the teaching of science basing on the constructivist teaching, as well as planning the suitable learning environment, via providing the networks and classrooms equipped with new technologies enabling communication with the world easily and quickly.

2.2. The pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology

The analysis of the specialized literature on the topic of the research, emphasized the need to integrate the Information and Communication Technologies (ICT) in the biology educational process in the Israel secondary schools and allowed to highlight the research problem: *determining the theoretical and methodological foundations of the efficiency improvement of the teaching-learning process of the biology in the gymnasium through the information and communication technologies*. In order to solve the research problem, the goal of the research was advanced, which is summarized in *the theoretical foundation and elaboration of a pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology*. Therefore, in order to achieve one of the objectives that will contribute to reaching the goal and solving the research problem was *elaborated the pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology*. The necessity of this model also resides in the fact that, researches in this area does not attest the pedagogical models theoretically and practically based, that would approach the process of integrating ICT in the study of biology, or the existing ones focus on some separate topics from this curricular area, or they are not adapted to the specific of educational policies and the high school curriculum in Israel.

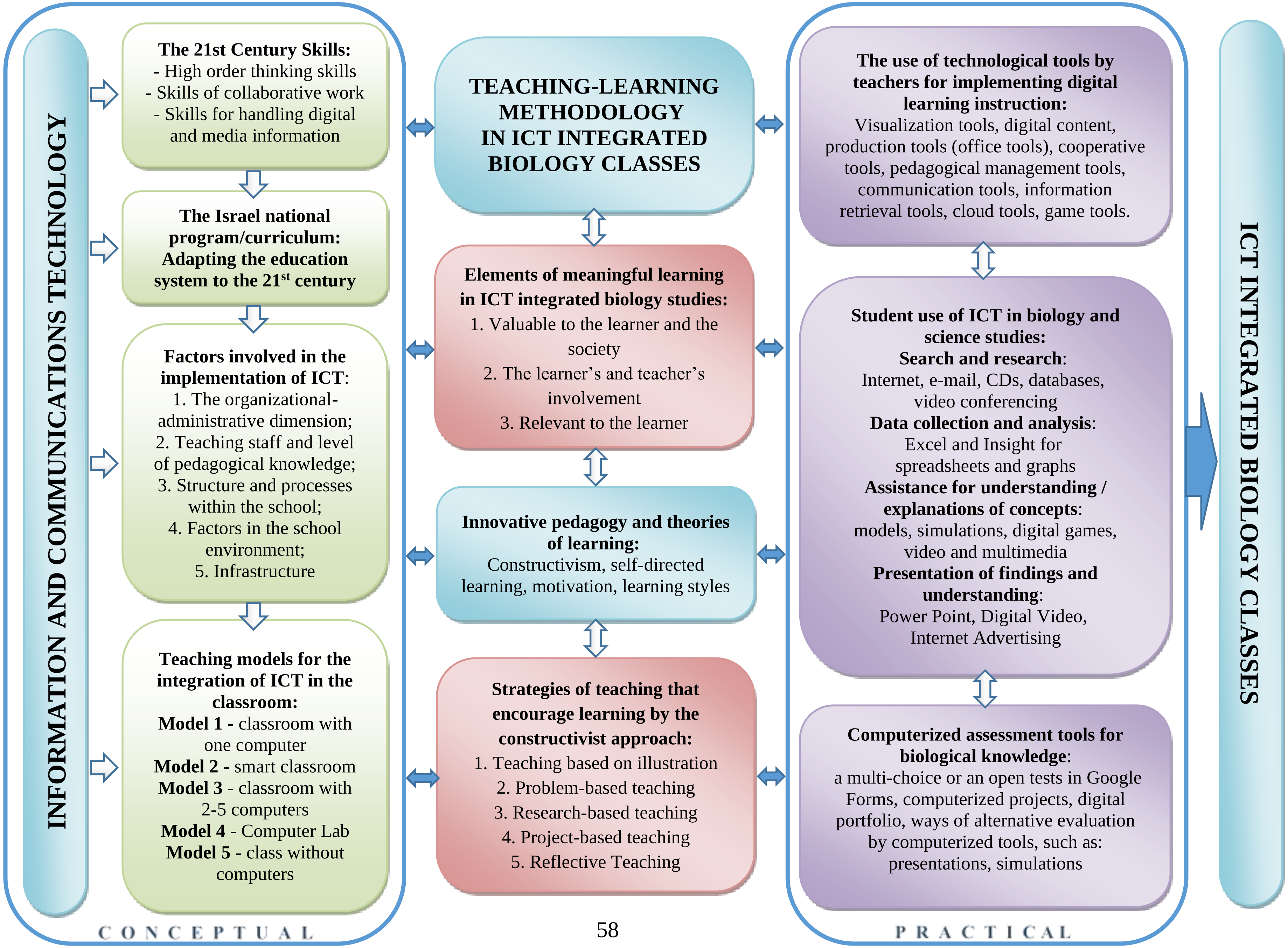
The input cell in model (Fig. 2.2) represents the information and communication technologies that have revolutionized all spheres of modern life, including education. ICT, representing the technologies used for the reception, presentation and electronic distribution of information, requires from the members of the 21st century society, the information age, specific competences such as:

- high-order thinking, which includes creative thinking, critical thinking, ingenuity and problem solving skills;

- collaborative work skills, involving teamwork, independent learning and ethics;

- skills for handling digital and media information, which refers to information literacy, media and ICT literacy [70].

Fig. 2.2. Pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology



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 [139]. That why, it represents another input cell of model.

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 [91], 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, whose details and description of optimal pedagogical application follow:

1. *Basic position of the teacher* (*Teaching Model 1*) - in the classroom there is only one computer connected to the Internet, projector, screen and ICT content, the cheapest and most used (basic) model. In this model, the computer environment is focused on the teacher, which actively uses ICT and integrates it into his teaching act. The teacher has access to information on the Internet whose content is expertized, uses digital materials online, elaborates digital content himself using specific devices (camera, video camera), uses digital tools for manipulation and processing in the content of the lesson and manages learning in the own digital space: the teacher's website, the class's website.

2. *Teacher computer connected to the internet, projector, smart tablet and computerized content* (*Teaching Model 2*) - in this model the computerized environment focuses on the teacher as well, but in addition to model 1, the teacher acts interactively with the computerized surrounding and integrates in his or her teaching. He uses pre-made tablet pages and creates own tablet pages while teaching and saving them, visualizes and demonstrates materials on the tablet, while sharing with the students during the lesson, uses custom templates for content, predefined and saved in the tablet software, records the lesson on the tablet, according to its documentation.

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)* - the computerized environment focuses both on the teacher and on student, the teacher operates an active and interactive learning, manage the lesson in accordance with the number of computers (2-5 computers) both physically and technically. The computers stand in one side of the classroom, when the lesson is a frontal lesson, or a lesson integrated with computer-teacher. The teacher directs students who need assistive technologies to the computers during the lesson in order that they will make use of them. The groups use the computers as an informational tool and as an auxiliary tool for the learning of students with difficulties [91].

4. *The position of the teacher and additionally computers to all the learners during the lesson (Teaching Model 4)* - the teacher and the student manage their work in the computerized environment spaces. Similarly, to model 3, the computerized environment focuses both on the student and on the teacher, while the learning is active and interactive. In the Computer Lab, the teacher takes the lesson in a model of mediation and guidance for personal learning. The learning is active with the preparation of personal work as an integral part of the lesson. The teacher divides learners into groups in the computer lab. The knowledge construction is by collaborative work and representing it to a discussion to all learners gradually. Students with difficulties are assisted by their teammates and assistive technologies available to all participants. The teacher should prepare the lesson materials in an environment of learning with computers or loading it to a computerized learning environment, to which he will send the students during the lesson. He also has to master the use of assistive technologies in the computers, in their operation and in understanding the abilities they provide to different students. During the lesson, the teacher will walk among the students, assist students with difficulties, open assistive technologies to the use of the learners, briefly explain their added value in accordance to the difficulties arising from the surface and will advance the learners as a class and the classmates as individuals.

Teaching Model 5. In a class without computers, for a laptop learner, the lesson is conducted as a frontal lesson. The learner uses the assistive technologies found in his computer, according to his needs [108].

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 learners 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).

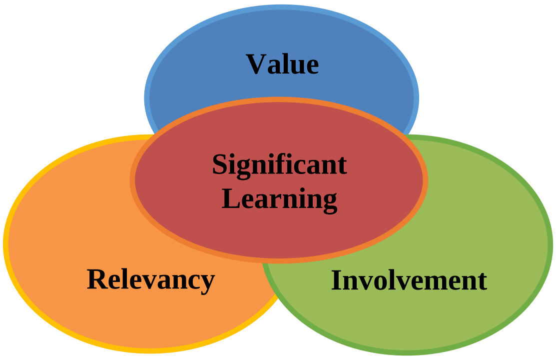


Fig. 2.3. Main elements of Significant Learning

From the point of view of Biology and Science studies in the school, the valuable significant learning takes place when, for example, development of scientific and technological thinking can equip the learner with high thinking skills that will be able to aid them in solving problems and making decisions in their civilian lives. The involvement is realized when the students actively practice through experiment and practical observation the scientific research at the biology lessons.

E. A. Ashburn and R. E. Floden [140] stress that the technology is used by the learners as an intellectual partner that assist them in progressing thinking, learning, and understanding of the world we live in. Learning with technology will advance significant learning if it will be based on the learners' involvement in constructing knowledge about, in conversation, in self-expression of the acquired knowledge and reflective thinking. This take place via learning processes such as: exploring, designing, communication, writing, building models and visualization.

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 [140].

Characteristics of the learning environment, relating to innovative theories of learning, are:

- *Personal dimension* - the needs, fields of interests, the learning styles and additional factors are essentially reflected in the learning process, which occurs through the learners themselves. Knowledge construction is a process in which learners actively assimilate new with old knowledge, process, interpret, expand and structure the world of knowledge [132].
- *Social context* - the learners are developed cognitively in a social-cultural context while executing actions with skilled people in their daily lives. Learning in ICT environment mostly occurring as an interpersonal process as well. Discussion groups, conference calls, network exploration tasks, dialogue with experts and other actions on the Internet offer a broad platform for creating interactions that promote learning processes and the construction of meaning for the knowledge and concepts that have been understood.
- *Exceeding the limits of time and space* - through digital communication, students and teachers create a report of educational discourse in the network space.
- *Potential to lead students to comprehension performance*s - these performances can be expressed, for instance, in research or product design that can be presented on a personal website, in a presentation, in a digital file and in additional ICT ways.

Within the innovative pedagogy, several theories such as: constructivism, self-directed learning, motivation and learning styles intersect. 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 [70]. The intelligent use of ICT contributes greatly to the updating of innovative pedagogy and makes it more relevant for students.

The skills of researching and the complete process of a scientific research constitute a central part in the teaching-learning-evaluation processes in learning Biology and Science at schools. The explicit occupation with research skills in instruction starting with knowledge construction, understanding and mastering the scientific contents as well as cultivating high-order thinking and 21st century skills such as collaboration, creativity and criticism, take place the empowering of motivation and the joy to learn Science and Biology. The teaching-learning-evaluation processes that combine scientific research skills, spherically, in all age groups, are meant to cultivate adults with technological scientific literacy, who are involved and responsible for the learning process and self-directed [141].

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.

Additionally, Projects-Based Learning (PBL), is a way to apply Significant Learning, that hypothesizes that there are a subject or a question required to be inquired and learned, a process that is actualized and presented in the product, which should be meaningful to man and to the world. The project is a process driven by a deadline to submit the product and presenting it, it expresses the learning that took place in its duration, as well as the skills and the learning habits acquired during the work on the project. As been said, during the project, the students deal with a systematic and planned process of exploration that focuses on an authentic and complex question or problem. They promote the project with the teacher’s guidance and present voices and opinions regarding the process of creation. During the project, the students acquire a profound understanding of academic knowledge and in mastering learning skills, they acquire competences such as team working, brainstorming, locating information and presentation to an audience [142]. In the teaching-learning-evaluation processes are intertwined and nourish one another on the way to a significant learning.

The innovative pedagogy and its implication on Biology and Science significant learning through ICT is represented in fig. 2.4.

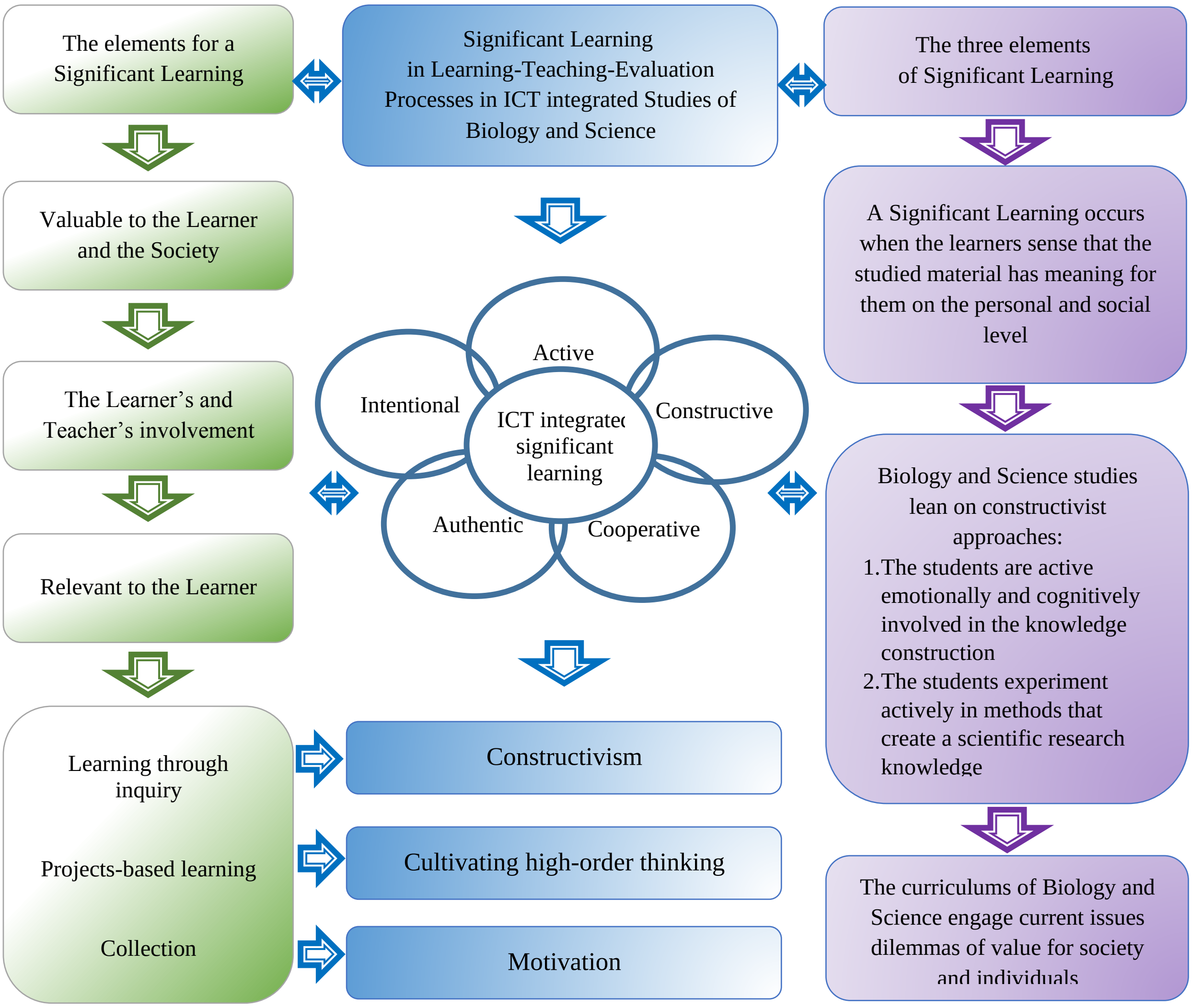


Fig. 2.4. The innovative pedagogy and its implication on Biology and Science significant learning through ICT

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.

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" [143]. 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.

Hence, student evaluation also needs to be in accordance with the information age, which requires standards and tools of alternative assessment in line with 21st century skills, 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, high-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 revolution of the Information and Communication Technologies. This fact allows the updating at the conceptual, methodological level, but the easiest at the practical level, by replacing the digital applications and tools with new ones, according to the technological evolutions.

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 [144].

2.3. Practical premises for the pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology

The information technology revolution have changed face of earth. The information online continuously multiply systematically and it increasingly becomes more and more approachable, hence, in the teaching qualification today there is no longer the need for the teacher to pass down information. The widespread response of the education systems is to move from learning "material" to skill cultivation, instead of focusing on "knowing that…" it is offered to focus on "knowing how…", the main question is not what the student knows but rather how can the student reach the knowledge and what can he or she do with it? This question brings to essential modifications in the learning-teaching processes. The educational paradigm has changed in different aspects: no longer a "knowledgeable" teacher and an "ignorant" student, no longer "imparting" teacher and "acquiring" student, no more lessons in which the teacher actualizes a predetermined script of a meticulously planned "lesson course" moving systematically and consistently from targets to evaluation. In the learning process called "deep learning" there is a special place for dialogue, a special role for collaborative learning and a special value to mental and creative flexibility and coping with occasional, relevant and challenging things [145]. The science teaching in schools is in a constant process of change, in the attempt to contribute to the formation of citizens' character, capable to deal with a world that is increasingly influenced by science and technology [146]. The main goals of teaching science in recent decades are developing scientific literacy and high-order thinking among the students. Achieving these goals is attainable via contextual learning and a learning of scientific terms and processes, which bases on analysis of everyday problems through processed scientific articles and case studies [147].

A systematic growth and availability of digital information and ICT create unique opportunities to learn and teach in high school and middle school biology curriculum. Digital technologies allow to develop significant knowledge and understanding of biological processes that were very difficult to teach and understand in the past. As it appears, a large part of life sciences can be passed efficiently via digital technology, since its representative and symbolic forms are found in digital formats [148].

In recent years a significant progress of ICT development in schools has begun, in terms of the ability and the availability of fine quality digital resources. This assists science teachers, who go through this professional development, to start significantly use of ICT to improve the learning. ICT integration in science lessons, in order to benefit students rather than for the mere use itself, should be realised when it is compatible to the improvement of the learning by providing the user, whether it is for the student or teacher, the option to focus and achieve the lesson's goals, meaning, to advance knowledge and better understanding in science. The use of ICT should allow to teacher or to student to obtain something that they could not achieve without using it, as well as allowing the teacher to teach and the student to learn or something else more effectively than without the use, it should add value to teaching [149].

2.3.1. Teacher's ICT use in the process of teaching biology

The potential of the internet use in education is great and diverse, due to its interactivity; possibility of teachers to use convenient tool for simultaneous engagement of different students in various activities; the accessibility, what mean everyone can be connected, and everyone can be available to anyone, (teachers, students, parents, study material, assessment people etc.); the policy on which the internet is based: rules and regulations known and accepted all over the world. This enables accessibility to different platforms (such as web browsers) and boundless exchange of knowledge. The great advantage of internet use is the richness of information, means of demonstration, illustration, means of operation, texts, pictures, animations and simulations, movies and virtual labs.

Tools that assist the teacher during class. ICT integration in teaching, as we know today, mainly bases on browsing in the different websites, collection information and processing it in a relatively simple level. According to the teachers, digital material for study purposes, do make the learning updated, authentic and more relevant to the learner's life. However, the way they are used does not lead to the expected pedagogical change. The implementation of the second stage of teaching - updated digital learning, bases on complex study behaviours, requiring learning in a cooperative and social context, while using the potential technology holds. This stage is performed in practice via the tools for sharing and constructing the knowledge provided by Web 2.0 technology. These tools allow a wide range of possibilities for cooperative work, as well as personal, by following the learning objectives with which the teacher faces the class. Tools of knowledge construction, connectivity and modern digital communications, such as Wiki, Google Docs, Moodle, and Office 365, enable the learners to share with peers details of information in various textual, visual and audio media. It allows learning peers to add, edit, comment and response to details of information brought by the learners cooperatively or personally. These technology capabilities enable to actualize numerous opportunities for innovative-socio-constructivist learning in which the students are involved and active participants in the learning process. ICT integrated innovative learning allows a redesign of processes, tasks and definitions of learning products, as well as enables modifications in the teaching methods, in the roles of both students and teachers, in the way in which the teacher uses as an instructor and learning advancer and not necessarily as the exclusive source of information in the class (see Table 2.1) [27].

Table 2.1. Technological tools applied by teacher during the biology and science lesson

Tools	Presentation tools	Way of applying
Word	Pictures, tables, texts	During the lesson and homework: submission paper
Excel	Graphs, formulas, math calculations, tables	In biology lesson or any other science lesson in which the will is to present information by graph charts
Power Point	Image, video, animations, graphs, text	For the teacher: presentation of a topic - introduction and summary of the lesson.
Learning software	All presentations	During the lesson
Internet - databases, content sites	All presentations	During the lesson
Tools for sharing - blog, wiki	All presentations	During and outside the lesson
School website	All presentations	During and outside the lesson
Education game's	Content-related	During the lesson
Video clips	All presentations	A short clip opens to display the subject. Part of the lesson or all of it, in summary. Learning beyond the lesson.
Projector + computer	All presentations	Throughout the lesson

Smart board	All presentations	It is used at the beginning and at the end of the lesson, and of course throughout the lesson instead of the usual board.
Computer stands	All presentations	Students: during the lesson
Digital Indicators	Choice questions	Subject summary

In view of the findings of the international study about ICT in education conducted by the researchers D. Miodoser, R. Nachmias and A. Forcush-Baruch [81], rises the notion that the way in which ICT is used in science and biology teaching in the school by teachers is mostly according to a traditional teaching paradigm. Nonetheless, though in a relatively small degree, the use of ICT advanced the innovative learning paradigm: among the most commonly used ICT application one can find two activities classified as belonging to the traditional teaching approach: 1) presentation of information, demonstrations and instructions for classroom work (29.4%); and 2) evaluation of learning with tests (25.5%). However, a use of ICT can be seen also in activities of the more innovative learning approach of learning throughout life: counselling for students in research activity (30.6%), and organization, observation and supervision of classroom discussions, demonstrations and presentations in the management of students (25.4%). The prevalent usages of ICT among teachers that do integrate ICT in their students' learning are: search for ideas and information (about 46%), projects with short tasks (about 40%), and data processing and analysis (approximately 36%). These reflect the innovative teaching paradigms, and thus it may be concluded that ICT is used – it coincides with the advantages the computer brings to the learning. The activities in which ICT use is the lowest are: laboratory experiments (15.4%), and field exploration activities (16.4%). This fact is surprising, because the undeniable advantages of ICT for these activities are known. The use of ICT among teachers is mainly in training and practice software (about 20%), and office software, such as word processor, databases, spreadsheets and presentation software (about 20%). A relatively little use of software for simulations, for models design and educational digital games (about 8%) and multimedia production tools (9%) was reported [81, p.7].

ICT may lead to a revolution in education and promote empowerment of the learning, as long as there will be a paradigmatic change in the teaching's character, educated integration in the learning and use of assimilation strategies fitted to the school's character and its cultures. An additional elementary condition is to pose the teacher as a leader of the educational change [66]. Project, called 3D LAB in cooperation with Greece, Australia, Slovenia, supports the system of teaching and learning biology, and it focused on developing Electronic Learning courses (e-learning) regarding the subjects, such as: human body, especially on the brain and the eye, for all ages, elementary middle school and high school. The project was mainly destined for biology teachers in order to be familiar with the ICT's advantages and integrate them in their teaching as well as for pupils and students to use ICT-based methods in biology classes. The main goal for this project is developing a new model for a successful application of e-learning, implementation of 3D and 2D computer simulations in teaching/learning biology in all levels of education and developing cutting edge and quality 3D simulations for teaching/learning biology as well as for the ICT exams. Additionally, project's purpose was the evaluation of their impact on the learning achievements of students and pupils. The general evaluation for the project was very positive in terms of efficiency and improvement on the part of teachers and students [150].

Collaborative learning is a central part of the 21st century skills. The computers open the opportunity to create online communication between the learners that work together. The technological system supports organization of information, in an interactive process of learning enabling a higher level of coordination and collaboration among peers. The merit of these kind of systems is by giving the possibility to develop interactive activities and update them at all times, even by teachers who do not have technological expertise. In light of the awareness to the educational potential that ICT integration in teaching possess, the technology will be at the pedagogy's disposal and aid in its actualization [109]. Alongside the obvious merits in the teaching-learning quality, and sharing with the students the abilities and limitations of every one, this kind of teaching-learning does not become the school routine yet, and one of the main goals of the ICT curriculum is assimilation of collaborative learning in the routine school life. Collaborative learning is in fellowship, study in a learning group when observing the other. Giving, teamwork with full trust and reliance on the other are the cornerstone of this learning, as a part of it or all of it is online. The collaborative learning characterizes with self-initiated interaction of the learners as an active part of the learning process and the construction of knowledge. The learning takes place during the construction of knowledge that is built upon, among others, the interaction between the partners in the learning process, as well as between them and the teacher, between the human sources of information, that is, experts in the field in question. In practice, the collaborative learning is a key element of the constructivist educational approach [151].

In research about collaborative learning by building a model as a tool for knowledge construction in biology [133], S. Orly chose creating an understanding for student model of blood groups by collaborative learning. The conclusion was that the knowledge construction of the students was improved significantly as a result of the collaborative learning, in which student is active and does things, remembers better and most importantly understands better. Meaningful learning occurs during a dialogue and exchanging opinions among colleagues, that is, when there is a collaborative learning. The reciprocal relationship between the student and the social environment has a crucial effect on the knowledge construction. Exploiting the potential for development depends on full social interaction within the learning group.

In the study of A. Herschkowitz and Y. Dory [152], regarding the integration of collaborative learning in the laboratory, which constitutes an essential and unique element in the science teaching, the research results indicate that it is important to implement collaborative learning methods in laboratory activity. The level of interest and enjoyment, emphasized in all groups (mostly among the students), consist with the targets of the collaborative learning, which highlight, along with the cognitive aspect, the social element that is involved in collaborative learning. The successful experimentation among students in laboratory activity indicates that it is possible to integrate cooperative activities in various levels. The positive approach toward the activity in the level of interest, cooperation and knowledge by all students, attests the great significance of integrating cooperative methods in the learning. This integration is important not merely as a means for diversifying the teaching, but mostly for the improvement of teaching/learning processes in heterogenic classrooms as well, in addition to encourage and develop social values and skills required for successful fusion of students into the society of adults.

A Nigerian study exploring the ICT influences on collaborative learning in the Imo State University in Nigeria, discovered that the integration of ICT tools and means empowers and improves the collaborative learning via increasing the students' participation level. The research determined the possibility of using the following ICT tools for collaborative learning: social networking services (such as Facebook, Twitter), virtual worlds, e-mail, online games, newsgroups / blogs / micro blogs, wiki, Web Chat or any other chat medium, video conferencing, GSM phones and World Wide Web. Furthermore, the study revealed the ways in which the ICT tools empower the collaborative learning and increase the student participation level in collaborative learning, encourage online discussion among students outside of the school; give the students the freedom and flexibility to learn in their own time and pace; encouraging students to broaden their learning with further inquiry, which allowing students to receive ideas from field experts around the world; and collaborative learning is not limited in time or distance when ICT is used. The collaboration technologies dismiss the time, distance and resources blocks. As been said, the use of ICT tools in collaborative learning aids to increase the students' involvement and participation. Moreover, the fact that these tools can be available at all times and at any place encourages students and pupils to broaden their learning, their subjects of interest. When the students are involved in finding information or solving problems, they tend to retain knowledge acquired for a longer period [153].

2.3.2. ICT specific tools used by pupils for learning Biology

One of primary goals of biology teaching is that the pupils will learn the subject in a meaningful way, which is possible when the learner associates a new knowledge he or she learns to their prior knowledge [117]. One way to accomplish meaningful learning is teaching by various means of illustration. Animation is considered as a tool via which it is possible to improve and progress the meaningful learning skills. Teaching that encourages illustration-based learning is aided by visual illustration (models, animation, simulations) in order to clarify ideas or abstract concepts. The human ability to easily remember visual means describing information could aid in the learning process. With illustrations, the teachers and the pupils can represent thoughts, discuss ideas and share the knowledge with others. In order to aid the learning process by visual tools integration, there are recommended the forms of activities that will be part of the scientific curriculum obligating high level thinking, such as solving problems or conducting laboratory experiments [28]. Nowadays teachers are required to allow the pupils not only knowledge construction, but acquiring tools for handling information as well. For example: nurture their ability to ask questions and find suitable solutions, look for information, deeply understand new information, knowing how to criticize the degree of its relevance and credibility, integrating different resources, making conclusions, arguing well-reasoned claims, and more require complex learning abilities. Thus, in order for the school to be relevant to the 21st century society, paying considerable attention to the pupils' development of thinking is essential [154].

Animation enables to visualize the biological principles without pupils having to memorize concepts. For example, in a lesson about the hereditary information, the teacher was assisted by animation. She presented the pupils with an experiment held by biology researchers, a test that examined the function of the cell nucleus. The pupils were asked to follow the animation and fill an assignment sheet [28].

Fig. 2.5. Example of animation tool about the hereditary information

An additional research about biology teaching examined the understanding of biotechnological processes by using animation versus understanding it with images. It was found that there is a significant advantage to animations in progressing understanding process: pupils who learned via images showed difficulties in understanding the process stages, these difficulties were not shown among the pupils who learned by animations [155]. The researchers claim that pupils activate critical thinking in the process of looking for the proper animation for a subject, for example, cell nucleus and protein production, as well as in the learning process from the animation, that means the teaching is performed not merely by watching the animation but also by evaluation it. The results show a significant improvement in the level of understanding and knowledge construction progression among the pupils, so that the pupils will be able to associate prior knowledge from a superficial learning of the subject from 9th grade to a more deepening learning in 11th grade. The teaching method through animation illustrates the abstract subject and turns it to a more feasible subject. In addition to the fact that according to the constructive theory, involving the pupils themselves in the learning process triggers them to be more interested in the studied material and contributes to knowledge construction progression and their meaningful learning.

According to H. Abdullahi [156], the student use of ICT in the school's science laboratory is greatly significant, one of the major things is progressing student cognitive qualities by high-order thinking, problem solution, improvement of communication skill, and a deeper understanding of the educational tools and their relations to the learning.

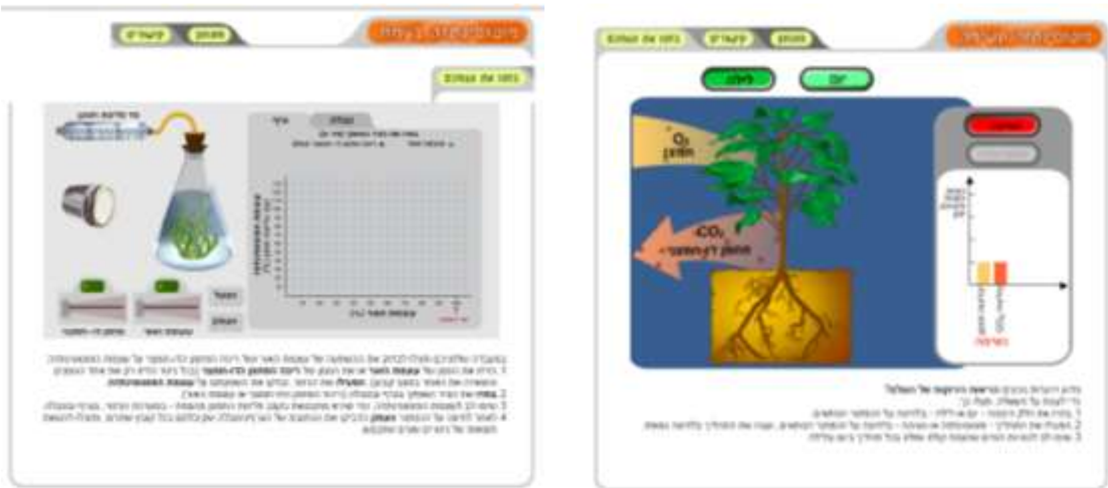


Fig. 2.6. Example of animation tools about photosynthesis and the respiratory process

The national science curriculum includes many ways and methods for the student use of ICT in science studies, such as: using a software for handling data in order to analyse the fieldwork data; using in a simulation software for sampling changes in populations of bacteria under different conditions; using sensors to record factors affecting photosynthesis; searching database for information on material characteristics; using the internet in order to find updated information about environmental subjects; using video or cd to learn the solar system; using spreadsheets for recording, analyse and evaluate information about diet; using a temperature sensor when checking how the temperature changes when two liquids cool down; asking students to find the air's boiling point (liquid air) in a book or database etc. The multimedia means accessibility increases the various dynamic situations in front of students. A classic example for using multimedia in teaching science, is the presentation of a static ECG chart, displaying a dynamic monitoring of the heart rate and the timed heart sounds. V. Oldham [149], divides the aforementioned uses of ICT into four major categories:

- **Research and exploration**: for instance, a research about science and scientists (internet, e-mail, CD's database, video conferences).
- **Collecting data,** handling and interpreting / data analysis (data logging, use of software such as Excel and Insight for spreadsheets and graphs).
- **Assistance for understanding / explanations of concepts**, especially simulation of abstract concepts and processes (using models, simulations, games, digital video and multimedia).
- **Presentation** of the findings and the understanding, that is to say, passing on ideas (using presentation software such as: Power Point, Digital Video, Desktop Advertisement, Internet Advertisement).

The basic requirement of the curriculum is to place the student in a variety of situations of dealing with problems, that is enabled by high speed of receiving data, graphical or other representations, for a student with basic skills of dialogue with the software, and who knows what to ask [157]. The Internet is associated with the use of a wide range of multimedia devices, using of which enables the development of cognitive skills directly relevant to the goals of the biology curriculum such as: observation, data organization, analysis and interpretation and problem solving skills.

2.3.3. ICT evaluation of biology knowledge

The teaching and learning processes in the classroom must be updated, grown, and made them more interesting and relevant for the pupils. Among the proper methods for this purpose are project-based learning, game-based learning, mobile learning, flipped classroom and more. The common goal of these methods is the desire to connect the students to the studied content through a variety of means that encourage the motivation and enjoyment from learning, and the combining group learning that imparts relevant skills and life competencies. This type of learning is authentic and relevant to the student and related to daily life. Along with the integration of these teaching skills, it is essential to update the way to evaluate and integrate alternative assessment methods in learning management. An alternative assessment is a process shared by the teacher and the students. The evaluation program is accompanying the studied project, or the teaching unit built with full transparency to the students and sometimes in dialogue with them. The result is a full understanding of what is required of the student and his or her increased responsibility for meeting the goals set. This method of assessment refers to the heterogeneity of the classroom and enables the teacher and the students to decide on appropriate assessment tools for the content and strengths of each student [158].

According to the traditional approach of teaching, learning and evaluation planted in perception, by which there is one objective truth, there is knowledge out there that needs to be discovered. The knowledge is not in relation to the learner himself or to his or her experience. The teaching, in view of this approach, was perceived as passing knowledge to the student, and hence the learning is related to memorizing the studied material. The assessment was an evaluation of memorizing skills and the memory ability of the student, and its goal is to diagnose the students regarding their ability to memorize and remember [159]. The modern researches noted that it is necessary to reinvent the examination methods, or else they will become irrelevant, both regarding the learning contents and the modern ways to learn. Therefore, the education system, the school, the community, parents and student should be opened minded as well as critical, for an intelligent embracement of an alternative evaluation. The characteristics of the alternative evaluation coincides with those of the post-modern age: it is comprehensive, multidimensional, valid, generalizable, egalitarian and sensitive to individual differences among learners. With its help, it is possible to provide relevant and quality information about the student achievements. Alternative evaluations has a positive influence on the students, hence, the teachers will have a much greater inclination to recognize their value and embrace them as a worthy addition for their teaching repertoire [160].

According to A. Herschkowitz [159], there are two main approaches today combining the different conception regarding evaluation:

1. *Quantitative approach*, according to which the evaluation is perceived as an “*evaluation of the learning*”. The targets according to this approach are a conclusion or a report concerning the level of achievement of the learners, usually a numerical assessment. This evaluation is made in order to make sorting decisions, and dictates the use of objective tests with one correct answer.

2. *Qualitative approach*, according to which the evaluation is perceived as "*evaluation for learning*". The targets of the evaluation by the alternative approach are giving a detailed feedback to the learner in the purpose of the learning and teaching progression and prevention of constant mistakes. This approach that refers importance to the context in which the learning was conducted, perceives the evaluation as an ongoing process. It also assesses the process (as well as the product) and it is exclusive in the hands of teachers or outside specialists. The evaluation is an inseparable part from the learning and teaching, and thus the learner is obliged to this evaluation no less than the teacher is.

The purpose of this evaluation is the awareness of the learners and teachers to the learning process, locating points of strength and points for strengthening. The culture of this evaluation directs the learners and teachers to collect evidences for their doing and understanding, while interactively judging the accumulating evidences. The attention in this approach is on the nurturing of meta-cognitive capabilities and internal motivation of the students and passes the responsibility for the learning to the student.

The approach that integrates "*evaluation of the learning*" with "*evaluation for the learning*" is the popular approach today and it is discussed in literature as educational evaluation. Because there is no learning without evaluation, for the goal of effective learning, the evaluation must be made throughout the learning process and only when it ends. This evaluation can be done in various stages throughout the teaching and learning process [159].

An alternative evaluation is aimed to determine the learners' function by focusing on their thinking and learning processes. When these processes are performed at a high level, it enables every learner the possibility to reorganize, understand the information and function openly and flexibly, which encourages creative functioning in learning [161].

The types of knowledge that can be evaluate in science studies are:

1. *Declarative knowledge* is a factual knowledge in a certain field on which the learner can overtly declare. This is a knowledge existing in the individual in the same field. Democracy, bacterium, punctuation rules, game rules are examples of declarative knowledge. Declarative knowledge is detailed in the curriculum with central ideas of the main study subjects and in the milestones (specification of content for each year of age);
2. *Procedural knowledge* is knowledge of procedures uses for problems solution in a certain field. These procedures (a series of specific rules and regulations) guide us to attach the elements of the task in the same field in order to achieve the optimal solution to the problem (reading a map, making long division, conducting an experiment, designing a product,

editing an article and building a graph are examples of process knowledge). The procedural knowledge is detailed in the skills chapter of the curriculum;

3. *Contextual knowledge* refers to a situation and the circumstances under which a declarative and procedural knowledge is used. For Instance, this knowledge addresses to social and cultural contexts as well as to the interrelationship between science, technology and society, and it is detailed in the tables of contexts of the main subjects of the curriculum [49].

We live in a changing world, in which the volume of information is growing rapidly and the power of the technology is consistently increasing. Hence, it is indispensable the scientific studies in school prepare the learner to live in this world. This obligates a use of various teaching and evaluation strategies that should reflect the essential changes in the adaptation of the curricula, and they are:

1. Relevancy of science studies to the learner's life should be reflected throughout the entire learning process as well as in the evaluation process. It should provide answers to the questions such as: Can the student use the scientific knowledge for explaining everyday phenomena? Can the student provide specific examples from the everyday life to a certain scientific idea?

2. The learning process should be focused on the understanding of central ideas rather than specific details of knowledge or techniques of solving exercises. The central ideas to be included in the science teaching constitute the core of the scientific knowledge of the curriculum. For example, the principle understanding in biology that the process of photosynthesis is responsible for building a mass of trees and plants, is more important than the ability to formulate the stages of light and the stages of darkness in the process.

3. The developing of the skills cannot be made by passive learning. The student needs to practically experiment in searching for information, reading an article or working on a project. Additionally to the evaluation of understanding the main ideas, an evaluation of the student's skills should be included as well. The evaluation of the entire learning process and not only of its products and the use of protective evaluation tools, will provide a more complete picture of the student's thinking skills [146].

The use of ICT for evaluating information is possible in the following ways:

Multi-choice test or an open test with Goggle Docs: the studies in this field noted the effectiveness of this tool regarding the following achievements: developing research skills; perceiving biology as a quantitative empirical science; raising the cognitive ability of the student; the teachers' and students' content with the diversity and interest added to the lessons; developing skills relating to "the computer culture" of the student; handling information and a more meaningful use of the computer for the learning in general and for science in particular; development of an independent learner; discussions among students. The ICT test is an example of utilizing modern technological means to improve the assessment of examinees' achievements. The measured accomplishment level meets the biology teachers' aspirations of our time.

Project-Based Learning (PBL): The pedagogical approach of PBL supports the development of the skills required in the scientific era. This obligates students to use ICT for research purposes and for developing a shared product, which requires from the teachers to deal with embracing technological-pedagogical innovation, as well as coping with project-based teaching and alternative ways of evaluation [162]. Through it, the learners acquire skills relevant to the 21st century, including ability to work in a team, abilities to handle information and acquiring knowledge, apply research processes, producing products in a high level, and finally – acquiring profound understanding in the academic knowledge and dominating the learning skills, acquiring skills such as teamwork, brainstorming, locating and processing information and the ability to present their ideas to the audience - in the presentation (a public presentation in front of an audience), in which they explain the product, protect it and perform a replication, which means mirroring the learning process [163].

During the project-based learning activities in science the students use the computer technology as a tool for gathering information, organizing it and presenting it to their peers. The students who conducted a research (via guided research processes), interact with peers, teachers and community via personal interviews and visitations and represent their understanding by presenting webpages [164]. The main product to which the learning is aiming is predefined (for example: an exhibition, building a device or a structure, writing a play, going to a demonstration, teaching a lesson, editing a film). The project, versus the question and the theme, requires imagination and thinking about the final product even at the early stages of learning (for example: how will the final product would look like?).

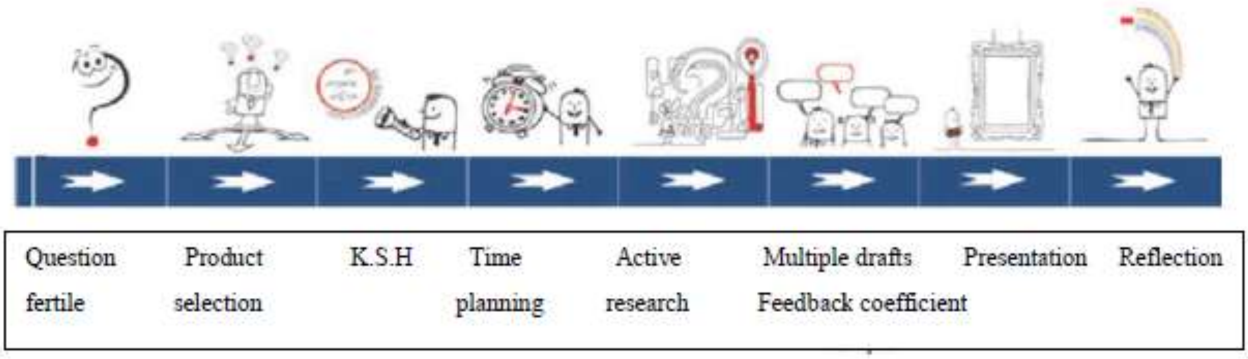


Fig. 2.7. Milestones in Project-Based Learning [166]

In the high-tech school chain from San Diego (USA) the learning is project-based. Thus, for instance, as part of the science lessons, the students learn about the circulatory system and apply their knowledge in formulating a public poster to donate to the blood bank [165].

Evaluation in the PBL way does not only addresses to the products of the learning process but to learning process as well. In this process there are chronological stages and transverse processes that occur along all the way and are accompanied by submitting numerous drafts, reflection processes and advancing feedback. All of these should be expressed in the general evaluation of the project. In every stage of the process there will be reference to three evaluation elements: Knowledge, Skills and Habits (K.S.H). Regarding the ICT integration in the project, the evaluation will be in relation to the skills related to the learning process: written communication skills (in various kinds), spoken communication (facing an audience), online communication, unspoken communication; skills of using various technological tools to represent information: advanced use of software such as Word, Excel, presentations, movies, blogs and various personal sites; skills of collecting and processing data: retrieval, organization, analysis, assessment of information sources, digital processing of information (film processing, graphic processing, numerical processing) [116], [165].

Digital Portfolio: The portfolio movement in education has developed against the background of the growth of alternative evaluation methods. Generally, the portfolio is defined as "an intentional collection of papers (in process or finished papers) of the student, in which he or she presents their efforts, progress and achievements in several fields [166].

An alternative evaluation with a portfolio is common in the level of school evaluation (and mostly elementary) and only a few in the external evaluation on Matriculation Exams [116]. Most of the evaluation through the portfolio is a formative evaluation of the learning process using the tools included in it. When this process is complete, a summarizing evaluation is performed with the complete tool. In every portfolio there are student papers and through them it is possible to identify domination in the learned skills and in the knowledge of the content of the curriculums chosen to be taught and the scientific ideas intertwined in them [167].

The use of digital portfolio ICT tools is thanks to the influence of the Web 2.0 technology that increased the students' involvement in the evaluation process and in gathering information [168]. That tool can be used for collecting and sharing works. Students learn to gather information and construct knowledge and organise it into their portfolio with ICT tools such as EverNote. Among the ICT tools for creating a digital portfolio for the school students, Goggle Sites and Workspaces can assist in the management of students' projects and their documentation on the Internet, create a website for sharing papers and projects. Potential users must be at least 13 years old to sign up. Students can use the “clothing file” option to upload files and the Project Foundry tools. This tool organizes, follows and shares learning in a class trough project-based learning [169]. A new and efficient ICT tool for managing digital portfolio for students or student teachers is called Dropr.com – a platform for creating portfolio. It enable to create a portfolio consisting of a large number of pages, when each page gets a link of its own. The advantage of it is that every page from the portfolio can be published in a different time, with finishing work on it. The product can be shared in online networks or assimilate in a website / a blog [170]. Goggle tools and Moodle based work enable using of additional digital tools: Smore, Onenote, Thinglink, Spiderscrub, Blubbr [171]. The main goals for using portfolio in science teaching are: development of understanding and appreciation of the science character and the ability to critically assess news regarding science on media and to scientifically communicate with subjects that will develop their scientific literacy [172]. The digital portfolio advances an optimal discourse in a digital environment between the teacher and the student along with optimal accessibility to the studied materials and using digital cooperative tools for the mission [171].

In Science and Technology studies in Society (STS), the portfolio is an integral part of the teaching-learning-evaluation process for matriculation. The STS portfolio integrates within it: a) two tasks that are based on popular scientific articles: each one of the tasks includes an expression for scientific ideas and/or scientific contents, an expression for understanding and use of skills, assessment of reliability of information source and expression for understanding and use of at least one additional thinking skill (26%); b) a personal task that combines various ways of expression, such as: chart, drawing, presentation preparation, personal writing, concept mapping, dramatization, model construction, camera trip, etc. (14%); c) a group task such as: poster, educational game, wall newspaper, model, presentation, show. The task will present: expression of scientific ideas and / or scientific contents, expression of skills and expression of the group's progress in developing the product (30%), personal page (25%), a general assessment that relates to the student's overall functioning (5%) [116]. The final product, the digital portfolio futures to stand along with the physical portfolio to every STS student and use the benefits and the added value of the digital and physical surrounding (pages portfolio). In these tasks the student is evaluated by both his or her domination in the scientific concepts and contents and by their ability to use high-order thinking skills and application of the portfolio principles in the digital environment while using Moodle and Google tools [171].

The thinking skills required in the portfolio: deciphering information from graphs, comparison, differentiation between fact and interpretation, asking questions, argument construction that includes claim presentation and basing it on proofs, identifying relevant evidence for constructing the argument, addressing arguments based on incomplete, incorrect or erroneous information. One can say that the school combines both inquiry-based and project-based learning [116].

Other ways of ICT alternative evaluation can be trough *presentations*: a group of students addresses a given subject by preparing presentations, brought in a deadline to the classroom forum. The technological ability of the students will affect the level of the presentations' complexity, and their academic level – the quality of the presented subjects. After presenting the presentations, the students will perform a reflection regarding the presentation's quality and point out things to improve in the future. An example of alternative evaluation by presentation is presented in appendix 6.

Additionally, *the simulations*, can be used as an alternative way of evaluation: the students build factional scripts mimicking the reality of various fields. There is an example for that in literature from the history books: students enter the minds of historical figures and make decisions based on constraints dictated by the teacher in real time [173].

2.4. Implementation methodology of the elaborated pedagogical model

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 and evaluation processes, 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. This integration necessitates the operation of an extensive system of deep thought considerations, that without them the assimilation might fail. The assimilation process of any change in schools will be substantial, hence, it should include the planning of specific implementation activities on how to implement the change in the classrooms. This kind of planning should include both control processes and evaluation of assimilation, while addressing to all subjects of change: the managers, the teachers and the guides of change. A school culture that encourages pedagogic changes and innovations, and teamwork may constitutes a fertile ground for the process of implementing changes.

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 [26].

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: methods and ways to integrate ICT in learning biology and ICT tasks.

2.4.1. Intervention program on the level of the teachers

Throughout the whole process it was organised meetings with teachers and most of them included: introduction, exposure, direction and guidance to integrate ICT tools in biology teaching (table 2.2). *There is a gap between the educational potential the ICT integration in teaching possess, and its practical implementation in schools*. The main use of ICT in schools bases on surfing websites, collection information and processing it abstractly. When the ICT technology is implemented while combining a pedagogic socio-constructivist rational, it allows the teacher to design activities that support independent learning and provide the student with the opportunity to experiment in building rich products as well as acquiring high-order thinking skills. In order for teachers to benefit from integrating ICT in their teaching, they should integrate the technology on the class and school agenda, in relation to curriculum and according to school policy. Therefore, at first it was highly important to expose the teachers to the benefits and the usefulness of ICT integration in order to gain maximal cooperation in our process.

A part of the application of the model and the ICT integrated intervention program has been made according to the intervention model for training ICT assimilating teachers of Tamar Shamir-Inbal [26], which combine pedagogic, technologic and organizational-administrative dimensions.

Table 2.2. The topics of the intervention program on the level of the teachers

No.	Topic	Details of the topics, which included pedagogical and technological dimension
1.	**Introduction**	- Recruiting the principal's support; - Introduction with the teachers and classes participating in the research;

		- Revealing the research subject, goal and destination, and manners of cooperation between the teachers and the author of this research (Appendix 2); - Listening to teachers' requests and the present constraints of the school, the teachers' opinion on the subject and their background regarding informational technologies and ICT integration; - Signing teachers on consent forms for participating in the research in the behalf of the Chief Scientist (Appendix 3); - Check the readiness and availability of computers in the school.
2.	**Demonstration**	- Guidance in acquiring the technological work skill. Experiencing active and collaborative ICT work in a supportive environment. - Exposure to an evaluation of existing ICT activities. - Receiving permission to work with the digital content providers' ICT content environments and issue a user name and password for teachers. - Demonstration through online work using websites and purchased content units: CET: Centre for Educational Technology – *Brainpop* http://sites.education.gov.il/cloud/home/Digital_Content/Pages/knisa_meuvtachat.aspx -Guidelines for opening a class on Google in cooperation with the IT coordinator: each teacher will open a class on Google Classroom, copies the class code to the site, opens a document in Google Docs and assigns the assignment to the students. After the meeting, the teachers instruct the students to register for the class and perform the activity. Put the following guidance video on the site. List of instructional videos by stages of opening a class on Google: Tutorial Video - Opening a classroom in Google Tutorial Video - Copy a class code to the class site. Tutorial video - assigning a task to students. Tutorial video - Entering students into a class and performing a task.
3.	**Teaching methods for teachers**	-Teachers' initial experience in building activities and tasks for students via Google Forms. - Experimenting in the delivery of ICT biology tasks through the digital school bag to students from junior high school, 9^{th} grades http://ar.ebag.cet.ac.il/ -Exposure - the teachers' experiment in building educational games and knowledge tests via the new online teacher's toolbox, which includes educational games and online activities. http://urilon.wixsite.com/new-argaz/fun-trivia
4.	**Students learning methods**	- Presentation of the collection of activities organized on the website of the Information Technology Division of the Ministry of Education, which encompasses all computer and information skills required by Computer and Information Literacy for primary and junior high schools. http://online.lms.education.gov.il/course/index.php?categoryid=54 - Instructing the teachers to refer the students to a topic from the curriculum and to building a presentation; Data files are provided by the students to the topic studied and a presentation in pairs or trios in front of the entire class. Examples such as: Familiarize yourself with the food ingredients, you've built a file and insert the data into it, but what does all this mean? What is each ingredient? Explore the subject online.
5.	**Evaluation methods**	- Alternative assessment: the investigation of relevant knowledge, the students document their progress and report to the teacher through various means, such as: collection, a work diary, reflection reports.

		- Students present the learning outcomes and discuss the process they have undergone. - Two ICT tests and tasks (Appendix 4).
6.	**Feedback, conclusion and reflection**	- A final meeting with the teachers in order to hear a reflection and feedback of the process that was underwent during the year and its influence on the teaching, learning and evaluation in biology lessons. - Listening to the encountered difficulties during the year (technical, delivery of the study material). - Comments and suggestions from teachers to improve the process.

The intervention model refers to assimilation dimensions within the school and includes reference to two dimensions: a) *pedagogic dimension*: thinking on ways in which one can use technology so it will encourage the use of high-order thinking skills, aid in conducting research, allow the use of different presentations, constitute a platform to represent products, and promote feedbacks and cooperation among the learners; b) technological dimension: giving a technological instruction to improve dominating technology use skills in order to enable teachers and students to feel comfortable with the tool [110]. The support for the intervention was in full administrative cooperation assisted by the ICT coordinator and the computer teacher at the school.

The ICT tools assimilation process (animation videos, online games, presentations, online tasks) with teachers, included the following stages:

Introduction (the first meeting). At the first meeting there was an open introduction conversation with the teachers participating in the experiment. At first, the teachers expresses many concerns and fears regarding the implementation of the ICT program for several reasons: their lack of education in computers, ICT tools and technological knowledge; their relatively low level in familiarity with the technological pedagogical content; delay in delivering the required material in biology, which may cause a drop in student achievements in biology; the possibility that the technology will not work, or might lead to a waste of time; they also question its effectivity as a substitute for the traditional practices. The teachers are concerned that the students will not be familiar with the technology, and worry that the students might do or say something inappropriate on the web. The technology represents a more extensive fear of change and to a certain extent, a threat. After listening to the teachers' opinions, there was conducted the encouraging discourse and was presented the topic and its importance to biology lessons, and explained that when teachers are progressed in this program, they gain an increased access to an aggregate collection of lessons, strategies, tips, and resources. These resources may decrease some of their anxieties surrounding technology use. When the teachers acknowledge that they can ask for help of researcher or of the ICT coordinator, and if necessary, they can also consult with an external professional, it can help them. When the teachers feel that they receive support when using technology, they are more expected to try new approaches and feel more secure if something goes wrong. Finally, the principal also presented willingness to implement the experiment and supported the participating teachers, and clarified that such successful teachers will become ambassadors – encourage their colleagues to take the plunge, try new techniques or tools – and share their successes and failures.

At the end of the meeting, were signed three forms of the teachers who participate in the study on behalf of the Scientist Chief, and there was toured the school to check the state of readiness and availability of computers in the school.

Demonstration (the second meeting). There was made the introduction with *Brainpop* website, animation videos and the pedagogic tool; experimenting and using them under the instruction of the ICT coordinator at the school; a guidance that focuses on matching the videos to the studied subjects according to the standards of the Ministry of Education, (table 2.3). Additionally, the meeting focused on selecting videos to match the topics taught in biology during the experiment, and will be efficiently and intelligently combined, for instance: In the cell structure and function topic, the choice was regarding the video, the tasks, the accompanying examiner and the activities from the Israeli *Brainpop* site (Appendix 7. A).

Table 2.3. Selected topics from biology curriculum

Main topic	Number of hours	Sequence of instruction in biology
Systems and processes in living cell organisms	6 hours	Needs for existence of living beings, characteristics of life; Cell: Structure and functions
Feeding	4 hours	Plant feeding: photosynthesis process; Auto-cosmetic feeding, Mineral fertilizer
	5 hours	Feeding in humans and animals: hetero tropical feeding; The importance of digestion; Components of the human digestive system; Adjustment of the digestive system to its functioning in humans.
Genetics	20 hours	Genetic material: organizational levels; Structure and organization of genetic material - DNA; DNA function as hereditary; Changes in hereditary material (mutations) and their effects on the individual and on biodiversity; Avoiding DNA damage; The principles of heredity; Genetic diversity; Heredity and environment; Human intervention in the process of inheritance.

Teaching methods for teachers (the third meeting). At this stage has been written tasks for students, such as: a question that its answer is received during watching a video, a request to conclude the taught video subject, giving text segments in which missing words must be completed while watching a video, exploring events, solving problems, crosswords, riddles and more. In addition, at this meeting, teachers were guided how to send biology online tasks to students via the digital school bag of OFEK website, the tasks focused on:

1. Feeding in plants and photosynthesis; digestion process and components of the digestive system in humans, adjustment of the digestive system to its functioning in humans. During the meeting, the teachers were presented with planned activities and games such as “Who wants to be a millionaire?”, which will be used to summarize the subject of nutrition and digestion.

2. A simulation film was presented - The Journey after DNA, the students will be familiar with the different levels of organization within our bodies: they are asked to enter level after level into the body, into the cell and the nucleus, until they reach the chromosomes and the DNA. Then they solve the answers that accompany the simulation.

Students learning methods (the fourth meeting). At this meeting, teachers were presented with a collection of activities organized on the website of the Information Technology Division of the Ministry of Education. The collection of the activities organized in this website was developed by a team of guides of the Information Technology Division. It is meant for all teaching workers and it surrounds all the information and computer skills required by the Computer and Information Literacy (CIL) documents for elementary and middle schools. The developed activities’ subjects match the material studied at the schools and are relevant to the learner’s world. An emphasis was placed on imparting 21st century skills and promoting meaningful learning. Each activity has a file of instruction how to operate the activity for the teacher and another file for the student. Every teacher can adjust and change the activity in accordance to the class’s needs and the learners’ level. The chosen activities engage the diet subject. In the chosen task “The big research on food” students will conduct a “Kolbotek” style investigation of different types of food. The class will be divided in teams. Each team will get a different type of a common Israeli food and will be asked to compare the nutritional composition of the same food produced in the various food companies. The students will collect data about the nutritional composition of food. Each group will study the food ingredients that appear in its food tables, will process and sort the data with an electronic sheet, grade the products and present the findings and the recommendations to the class.

Evaluation methods (the fifth meeting). In this meeting there was a common thought between the author of the research and the teachers regarding the alternative evaluation methods while integrating ICT in biology lessons. The discussion was focused on alternative evaluation methods through which the students can be assessed, such as: tasks on selected topics in biology that will include activity, exercise or a task requiring the student or group of students to solve a specific problem or demonstrate knowledge on certain subjects using prior knowledge and relevant skills, and presenting the outcomes to all students in the class with a multimedia presentation. For example, was presented the large food investigation (Appendix 5 Task 1) that the students will be divided into teams and each group will have a research on a certain type of food. At the end of the process, each team will present its outcomes and recommendations to the class. The research will base on the tables of the food groups that appear on each product according to the rule. The students will work according to five stages: data collection, data writing, familiarity with the food components, processing of the data, composing a presentation to represent to the class. Preparing and presenting a PPT presentation to the class develops skills for intelligent information search, organization of information in a given framework of content and time, differentiating between the primary and the minor, ability to present information clearly, in concise, and in different forms (verbal, visual) and ability to present orally. The students will receive instructions for preparing a presentation and the assessment will be based on an indicator detailing the stages of the activity at all stages of the process (Appendix 6). Students are also required to solve computerized tasks and send answers to the teacher via the digital school bag. In addition to the assignments, students undergo tests that test their knowledge and level of thinking.

Feedback, conclusion and reflection (the sixth meeting). In this meeting, was presented the whole process and activity throughout the experiment during that year. The teachers expressed content with the program, they addressed the importance of integrating ICT in the teaching in general and in biology lessons in particular, after they had concerns and fears relating to the idea of ICT integration, the possibility that it might delay the learning process and slow down the delivering of scholastic material, which may harm student achievements.

The teachers noted that the ICT integration advances teaching and learning, the ICT integrated teaching is more visual and the lessons are more experiential and interesting, and there are many online activities that diversify the lessons and make the teaching active and challenging. ICT integration empowers the meaningful learning of the student while self-experiencing in activities, the computer aids in the students' self-learning and mostly those who experience difficulties are more exposed to learn and investigate. In addition, the computer and the ICT tools are from the student's world and thus, in order to get close to the students we must know their world which strengthens the bond even with the shy students.

The teachers believe that the biology teacher must be computer literate and that their role as biology teachers has changed due to ICT integration in the computer. The teachers stated that they prefer to teach in the constructivist approach, and the ICT integration betters their teaching and aids their professional progress and they also notice the positive effect the ICT integrated teaching on the students. The teachers observed that the use in ICT increases the level of interest of the students, the student is more active and the cooperation of learning between the teacher and the student is higher versus non-ICT learning. Furthermore, the teachers agree that the use of ICT enriches the explorative learning and the meaningful learning in biology. However, this does not say that active learning and explorative learning does not occur without ICT.

The participating teachers reported on computer applications that they used during the experiment divided to:

- *basic applications*: using word processor, searching for information on the Internet, using closed lessons for practice in class and integration of multimedia presentation (power point and so on);
- As well as *progressed applications*, such as: participation in the class-forum via the school site, activation of the class site, in addition to computerized simulations and labs in the lesson, preparing and using digital games through the online teacher toolbox site.

Moreover, the teachers reported difficulties they encountered, such as: technical problems, slow Internet surfing, lack of training, and so on.

In conclusion, following the process the teachers undergo throughout the year they claim that the use of ICT caused change in their role, in their teaching approach, such as: methods of teaching and methods of evaluation; and changes in teaching organization, such as: changes in the organization of time and the learning environment. All teachers believe that the more active person and partner in the action, the more he feels significant and belong; the more provided spaces of creativity and activity to the students, the more they will feel belong and more active tutors and learners.

2.4.2. Intervention program on the level of the students: methods and ways to integrate ICT in learning Biology and ICT tasks

Implementing the experiment inside the classes with the students was through the teachers who received guidance by the researcher and the ICT coordinator on the ways to integrate ICT in the classroom, in addition to the personal knowledge every teacher had in the matter.

In the experimental group, the participating students used ICT applications during the school day as well as after the school day, they used basic applications, such as: search the web for articles and watch movies that helped them solve their tasks, closed lessons for practice. In addition, they also used progressed applications, such as: researching a topic in biology and preparing presentations that include tables and graphs and presenting data to all students; preparing a concluding learning game through templates for online activities; in addition to an online connection with the teachers after school hours (sending emails, login to ICT tasks, forum and digital school bag etc.). The ICT tools were accommodated according to the biology topics, according to the curriculum, throughout the experiment period from September 2017 to May 2018.

The teachers gave the students tasks for searching sources online, correspondence in e-mail, submission of printed reports, submission and presentation of tasks by digital means (Table 2.4).

Table 2.4. Designed program to integrate ICT for the students

No.	Topics in biology	ICT methods
1.	*Needs for existence of living beings, characteristics of life; The cell as the basic unit of structure and function*	1. Viewing the video *Introduction to the characteristics of life*: Students are asked to summarize from the film the characteristics of living things. https://www.youtube.com/watch?v=juxLuosH6M&feature=youtu.be 2. The students are divided into groups and each group prepares a presentation on the subject: *Needs for the existence of living beings and the characteristics of life* and show to the class after the lesson. 3. An ICT task on the concentration of blood glucose: the task will open in a new window, this activity will last about a minute: https://tdigital.lms.education.gov.il/mod/scorm/player.php?a=230&currentorg=Lnet&scoid=437&sesskey=tZ7dUSQJfe&display=popup&mode=normal Activate the animation - click the *Start* button and answer the eight questions. At the end of the task, click the *Submit* button, close the task window, and log off.
2.	*Cell: structure and function ;Level of organization*	1. A film - *Journey into the Cell*: presenting the most basic parts of the body: the cells, will be presented to the students. They will learn what cells are, how small they are, and how and where do they live. Know the parts and structure of a typical cell, such as: Cell wall, nucleus, and mitochondria. Discover the different functions a cell can perform and the diverse forms of cells. In addition, see how the cells divides and multiplies to help the growth. Cells are absolutely tiny handworkers! https://www.youtube.com/watch?v=WZdaVrsh7WQ After viewing the video, the students answer to the video questions accompanying the film. 2. Interactive activity from the digital school bag from *Ofek Elementary* site: *Go on a journey through the components of the biological hierarchy*. Choose one of the ecosystems and navigate among the different levels of organization it includes. http://lo.cet.ac.il/player/?document=20247bc1-e2fd-433f-a1fd-4c2092da9e38&language=ar&sitekey=ar.ebag# Students should read a piece of information on what is the biological hierarchy, and answer the questions related to the subject with self-examination for each question. 3. Activity through a microscope: using the digital microscope, students will acquire the skill of using a microscope and watch types of cells and different processes in the cell: from an egg to cell accumulation, from bacteria to colony, and more. http://apps.assets.cet.ac.il/library/science/microscope/he/index.-77575834666333.htm

3.	*Plant feeding: photosynthesis process*	Teachers send the following tasks to students: 1. Interactive activity for all students: imaging and checking through experiment of the effect of light intensity and the concentration of carbon dioxide on the rate of photosynthesis. http://lo.cet.ac.il/player/?document=772266ae-8a0c-402e-a299- The students are asked to write a detailed report for the process. 2. The activity deals with the breathing process and the process of photosynthesis: activate the simulation, observe the exchange of gases in breathing and photosynthesis in the plant at day and at night, and see how these processes complement one another. http://lo.cet.ac.il/player/?document=3806e95d-1887-448e-b41f- Students are asked to view the simulation and then answer the accompanying questions that examine the understanding of the subject. 3. A task for students on photosynthesis and respiration (Appendix 5, Task 3): a) Students are asked to enter the CET site for photosynthesis and breathing and to solve the exercises and task questions. http://science.cet.ac.il/science/energy/energy3.asp b) Enter to the subject of photosynthesis and light, and to solve the questions of the second part of the task. http://science.cet.ac.il/science/energy/energy1.asp
4.	*Human nutrition: the importance of digestion; Components of the human digestive system; Adjustment of the digestive system to its functioning in humans.*	1. Activity for the students: in this unit the student will be introduced with the function of the digestive system on all its parts. With the simulation, check what occurs at any stage of the digestion. http://lo.cet.ac.il/player/?document=4ee9a9c7-3ccc-486f-8e1c-c7b8161dae0d&language=ar&sitekey=ar.ebag# Students are asked to answer the questions following the simulation: **a.** How does the digestive system work?; **b.** What happens to the food that passes through it? **c.** (Table order) What parts of the digestive system do the food groups break down? and present the answers to the class. 2. Interactive activity and questions about materials and energy in body cells: in this simulation, students can examine how the digestive, respiratory and blood systems work together, enabling the supply of oxygen and glucose to the cells of the body, and can convince themself about the existence of the process of cellular respiration, which provides energy for cell activity. http://lo.cet.ac.il/player/?document=6b4fd43b-64ee-4b2b-af5c-d7db0531a6be&language=ar&sitekey=ar.ebag# Students are asked to activate the simulation and go through each stage and answer the questions. 3. Task *Large Food Research* (Appendix 5, Task 1): familiarization with the food ingredients. Students has built a file and inserted the data, but what does all this mean? What is each component? Explore the subject on the internet. The class will be divided into teams. Each team will receive a different type of common Israeli food and will be asked to compare the nutritional composition of the same food produced in the various food companies. The students will collect data about the nutritional composition of food. Each group will study the food ingredients that appear in its food tables, will process and sort the data with an electronic sheet, grade the products and present the findings and the recommendations to the class. 4. Chore, vegetarian nutrition (Appendix 5, Task 2): students are asked to get into the article "Is vegetarian diet healthier than eating meat?" or, a free search online, answer the task's questions, and send it to the teacher's email.

5.	*Genetic material (genome): organizational levels; Structure and organization of genetic material - DNA; DNA function as hereditary material*	1. In this simulation the students reveal the different levels of organization in our bodies: they virtually enter into the body, into the cell and into the nucleus, step after step, until they reach the chromosomes and DNA. http://lo.cet.ac.il/player/?document=7edafcdc-ef8c-46a8-af74-42d04e606cf8&language=ar&sitekey=ar.ebag# a) The students are asked to go through all of the different organization stages, each organization level that includes the level that is next, from the human body to the chromosomes in the cell and DNA and summarize all the stages of the organization levels in a Word file. b) Answer the questions accompanying each simulation. 2. An interactive activity in the subject: a) Meiosis - reduction division: one cell is divided into 4 breeding cells. What happens to the number of chromosomes in this process? Start the animation and find the answer. http://lo.cet.ac.il/player/?document=9185a2b6-c387-4df2-9ebb-b570dd888b25&language=ar&sitekey=ar.ebag# b) Mitosis: run the simulation step by step, and examine how one cell is divided into two cells, and at the end of the division each of them contains the same number of chromosomes as the original cell. http://lo.cet.ac.il/player/?document=d86426cf-f961-4a90-8011-356c8006366e&language=ar&sitekey=ar.ebag# The students are then asked to watch the film and to compare the distribution of the reduction (meiosis) with the mitosis. https://www.youtube.com/watch?v=JzrxCkc-CBw
6.	*The principles of inheritance and the Mendelian laws*	1. Task Mendelian laws (Appendix 5, Task 4): students will watch both videos on the Mendel Experiment and answer the task questions. https://www.youtube.com/watch?v=sTEixbYJ6Ss https://www.youtube.com/watch?v=Q18uV2-xC-Q 2. Online tasks on inheritance of one attribute - numerical relationships: in this simulation, students can improve various plants and reach desired traits by hybridizing individuals with appropriate properties. http://lo.cet.ac.il/player/?document=4da00bf0-9e8a-4585-993a-3964b5ba9587&language=ar&sitekey=ar.ebag# 3. Online task: students are asked to prepare a final assignment for the topic of inheritance and Mendelian laws through the online teacher's toolbox. a. Each couple of students chooses a template from the templates on the site for an online learning game and prepares a final question game on the subject and presents the questions to the entire class. The work is done with pairs. b. Each pair chooses the questions freely. http://urilon.wixsite.com/new-argaz/fun-trivia 4. An online assessment task on heritance and genetics: students must enter the link on Google Forms, answer the questions and press "*Send*". https://docs.google.com/forms/d/1DZydIsztU3wjg-NLn4qmq93BVNOBEV3boEf0CZ0M75Q/edit
7.	*Changes in hereditary material (mutations) and their effects on the individual and on biodiversity; human intervention in the process of heredity.*	1. Interactive activity *From a gene to the biological trait - Skin colour*: the animation shows the relationship between a gene and a biological trait, how a certain gene is coded to a protein that is manifested in the human skin colour. The simulation presents the phenomenon of albinism which occurs when there is a mutation in this gene. http://lo.cet.ac.il/player/?document=0dbf1d8b-7112-4a54-950a-71f45f8ad75e&language=ar&sitekey=ar.ebag#

		Students are asked to watch the simulation's stages and describe the relationship between the gene and the trait and compare between healthy skin colour and the phenomenon of albinism. 2. Task on *Down Syndrome* (Appendix 5, Task 6): students are asked to read an article and watch the film and answer five questions in the assignment and submit to the teacher through the class site. http://mawdoo3.com/%D9%85%D8%A7_%D8%A3%D8%B3%D8%A8 3. A task on the use of cell cloning techniques: students should watch the film and describe the importance of cloning to a breakthrough to find a cure and a solution to diseases such as diabetes, Alzheimer's, and Parkinson's blindness. https://www.youtube.com/watch?v=7o2VL1Ajfi8 4. Evaluation task *Choose the gender of the new-born*: the students should watch the film *In vitro fertilization to choose the gender of the new-born* "A boy or a girl? The technology that enables to discover the sex of the fetus" and read the information section and solve the questions.

The students participating in the research express positive positions regarding the subject of ICT integration in biology lessons. They are aware to the power and ability of technology to contribute significantly to the learning environment, all the participating students in the experiment stated that ICT integration affected them significantly and the progress of their learning, as well as raising their motivation to study biology: "Interesting, intriguing, fun and enjoying to work with ICT integration", "Learning style is interesting and intriguing", "Using computers is part of knowing biology and contributes to an authentic and meaningful learning. Part of the biology studies is using computers, graphs, the ability to analyse data", which caused a change in their learning approach. The students expressed content from using media such as: videos, animations, simulations that greatly helped to explain the learned concepts: "an ICT task includes animations and information evoking thinking rather than only memorizing, which makes it possible to check the knowledge by the ability to analyse an experiment or a scientific research". They felt satisfaction and enthusiasm about the digital games they prepared, which dealt with conclusions to biology topics and the links to the websites are useful for real-time updated information, moreover, the ICT tasks from the digital school bag from the CET site through which one may check the answers immediately and independently. Additionally, cooperative learning with classmates affects positively on passing information and mutual help among the students empowered the responsibility for the learning, the students feel that they are active partners in building the learning process, asking interesting and fruitful questions and looking for answers by themselves.

The students labelled as weak in achievements, found themselves improving and able to manifest their ability. The use of ICT made them to improve their learning experience, their motivation and to a great extent their thinking skills as well. Learning in an ICT environment means empowerment of the learner and giving expression to the learning processes. Students discovered research skills and scientific skills that they developed while learning in an ICT environment online. Information technology was meant to empower the learner by supporting the interaction processes of his learning, whether it is in increasing his curiosity or encouraging cooperation with his learning companions via ICT. Advanced skills that the student acquires are reflected in a different way. They are expressed in nonconventional evaluation methods capable to reflect ability to cope with a project, ability to distinguish between primary and secondary [174]. ICT affects the student, from a passive student, who receives materials from the teacher, who have not the choice and does not realizes his potential, to an independent learner who receives a learning appropriate to his needs, which enables him to realize his personal potential.

2.5. Conclusions to Chapter 2

1. The Information and Communication Technology has greatly influenced the world educational policies, including that of the State of Israel, which has led to the modernisation of the national curriculum that has integrated contents from Science, Technology and Society. Curriculum in biology, as an integral part of the general science and technology curriculum, aims to implementing innovative pedagogy and developing for students the specific skills of the 21st century: high-order thinking, collaborative working, and handling of digital and media information. This goal is in accordance with the national program of adapting the education system to the 21st century, program that involves the implementation of ICT in this field.

2. The implementation of ICT depends on the involved factors such as: administrative and teaching staff; structure and school processes; infrastructure and school environment. This occurs in accordance with existing five teaching model of technology using.

3. The afore mentioned aspects constitutes the *conceptual* component of elaborated pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology, that influenced the afferent *teaching-learning methodology*. 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.

4. The central cells of pedagogical model determined bidirectionaly the *practical* component of it – the output cells, that details the ICT tools implemented in teaching, learning and

evaluation processes. The practical component is diversified and includes traditional digital tools (text processing, spreadsheets, presentation, information internet searching etc.) and progressive tools (video, simulation software, digital assessment tools etc.).

5. 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.

3. EXPERIMENTAL ARGUMENTATION OF THE EFFICIENCY OF THE PEDAGOGICAL MODEL OF INTEGRATING THE ICT IN THE PROCESS OF TEACHING-LEARNING OF THE BIOLOGY AND OF THE ELABORATED METHODOLOGY

3.1. Research methodology

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: the implementation of the pedagogical model of integrating information and communication technologies in the process of teaching-learning of biology will lead to the efficiency of teaching-learning process of biology in the gymnasium through information and communication technologies, which will materialize through increasing student's achievements in biology.

The review of speciality scientific literature led to set the following destinations of research:

- Examination of the effect of biology ICT use on student achievements in 9th grade;
- Identification of the students' attitudes regarding the use online learning technologies in the biology classes, toward the way in which they use and perceive them as assisting the learning process;
- Testing and examination, additionally, of the motivation and self-efficacy, among students, to learn through ICT;
- Identification and valuation of the implications of using ICT tools in biology on meaningful learning.

Therefore, **the main research established question** is: what are the patterns of ICT use within the biology classes? From this, the research questions were deriving:

- Does and to what extent ICT integrated learning affects learners' achievements as expressed in biology students' diploma grades?
- To what extent does ICT integrated learning affect motivation and self-efficacy to learn biology among the learners?
- What is the students' approach toward integrating ICT in biology lessons?
- Is ICT integration in biology lessons improves the dimensions of meaningful learning of students?

The field of the research. The research was conducted in a junior high school in the northern district, which belongs to the Arab sector, with 577 learners (306 boys, 271 girls). Most of the students come from a mediocre socioeconomic background. Number of classes is 21, average number of students per class is nearly 27.5. In terms of the learning environment and technological accessibility, the school has one computer lab, the students learn in classes without computers stations. Only the teacher has a computer station equipped with online connection and a projector that the teacher uses to project digital contents and books on the board. Students have a casual approach to a computer lab, without the use of personal computers; they use the teacher's station to display the products of their work. The number of teachers is 52, among them there are 7 biology teachers. In the ninth grades, in which the study has been held, there are 3 biology teachers.

The research population. The research was focused on five out of seven 9th grades at the school, two of them are control group and three are the experimental group (table 3.1). Choosing this school was intentional due to several reasons: adapting the biology curriculum throughout the year, not only to a certain period of time as it is costumed in most schools; accessibility of ICT tools relevant to the research; collaboration with school management and readiness of biology teachers with background in ICT skills to contribute to the completion of the study. Choosing the 9th grades is because the materials they learn in biology are suitable for acquiring thinking skills combined with ICT.

All classes at the school are heterogenic, the national educational policy of the state of Israel bases on the principle of heterogeneous learning and education. This policy has been set in order to nurture processes of social integration. The population can be defined in a heterogeneous class according to two dimensions. One dimension relates to identification by social category and the second dimension, the division of students to the strong and the weak bases on the average of their scholastic achievements. In junior high schools, students from different elementary schools, from different levels and from different backgrounds, study together [175].

Table 3.1. 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							

All students, participating in the research, study 3 hours of biology during the week from 8 hours of science to the entire class according to a disciplinary division: 3 biology, 3 chemistry, 2 physiques. Each participating class is taught by three teachers of a compatible disciplinary training. Regarding the biology experiment groups - each group is taught by a different teacher and all teachers have the identical training.

The experimental group focused on ICT integrated biology lessons that implemented animations, simulation videos, preparation of online lessons and computerized tasks adjusted to the same subjects of Ofek CET website. The activities of Ofek's digital pack is a learning environment that advances digital pedagogy of CET - Centre of Educational Technology http://ar.ebag.cet.ac.il/ in Arabic. As well, ICT integrated biology lessons used the Israeli videos website - Brainpop https://il.brainpop.com/, which includes videos, animations and lessons arrays in the learned subject, as well as digital games. During the time in which the biology relevant study units program was taught, the control group students did not experiment in ICT learning.

The schooling context. 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.

Research Variables and Hypotheses.

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).

*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 were 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 are 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.

Experimental methods and tools. Due to the formulated research hypothesis and goals, a process of collecting data has begun, which includes two experimental methods: (a) methods and statistical tests that included: averages, standard deviations and significance, t test for independent samples, variance tests ANOVA and ANCOVA, alpha Cronbach method; (b) empirical methods of data collection in order to perform the processes and tests. As well, there were used the following tools: tests (before and after the experiment), questionnaire, and conversations with teachers.

The research was conducted by the correlative quantitative method and bases on the experimental design theory of F. N. Kerlinger [176, pp. 479–555]. Therefore, preliminary and final tests was given to the representatives of two research groups: experimental and control samples.

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 (appendix 4, A 1, 2). The first test was a mapping test, held in October, in order to examine and identify the preliminary level of 9^{th} graders in biology. The test results directed to choose the research groups (the control group with the high average score and experimental group with the low average score; difference of almost 15 points on average). The second test was conducted in mid-December and examined the experience and the achievements of students in both groups before using ICT means.

✓ Two tests occurred after using ICT, by the end of studying the relevant school units in biology for 9^{th} grade (appendix 4, B 1, 2). The first test was held in March, which examined the students' scores during the experiment while integrating ICT in the experimental group only. The second test was conducted on mid-May after studying all relevant units in biology and ending the experiment.

B. Online closed questionnaire. The questionnaire is a tool to collect data on a certain phenomenon. The closed questionnaire is cohesive and composed of questions the subjects are required to grade according to a predetermined scale (the answers numbered in numerical or moral order). The data collected for this research refer to the 2017-2018 school year, as the questionnaires were given to the students by the end of learning the relevant study units in biology in order to allow the students to express their opinion after finishing the ICT integrated study units. The students' reports were made by Google Forms platform, the link was given to the students via the class's forum and they answered the questions from home without any influence from the teachers. The students were told that the findings of the questionnaire will be used for research purposes and conclusions aiding to upgrade the learning processes and their optimal integration in the system. In order to increase the reaction pace and prevent bias, it was made clear explanation to the respondents that the findings would be confidential and anonymous.

The questionnaire's components. The questionnaire (appendix 1) 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, as shown in Table 3.2 below:

Table 3.2. Items of the questionnaire and reliability of Alpha Cronbach Coefficient

	Category	Component items	Alpha Cronbach
First part	Personal character questions		
Second part	Examines students' opinions regarding improvement of motivation and self-capability via ICT integration in biology classes	1, 2, 3, 4, 7, 8, 9, 12, 22	0.849
	Examines students' general attitudes towards the integration of ICT in biology classes	10, 16, 14, 20, 23, 24, 25, 26, 27	0.721
	Examines the students' opinions regarding ICT integration in the study of biology and meaningful learning	5, 6, 11, 13, 15, 17, 18, 19, 21	0.858

The data of table 3.2 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 sufficient for the ends of the current study.

Respondents noted for each item the degree of consent, according to the Likert scale, ranging from 1 to 4, (1. Definitely disagree, 4. Definitely agree). There were chose to pass the neutral midpoint because many subjects have a tendency to escape to the safe place that is the midpoint. In addition, in order to enrich the understanding regarding students' perception of biology study and motivation with ICT integration, the students were asked to write in a text box next to every closed questions: “explain your answer or present examples”. The items in Likert scale were declarative sentences, that their range of answers was a degree of agreement. These were used mainly to measure opinions, beliefs and attitudes. A good Likert scale expresses an opinion or a concept in clear terms [177].

The items were developed on the base of several questionnaires conducted in the subject, such as: 1) a questionnaire that examines students' attitudes to meaningful learning in the integration of ICT by S. Dori and G. Kurtz [178]; 2) a questionnaire that examines motivation by M. Barak Miriam [92] and Science Motivation Questionnaire (SMQ) by S. M. Glynn and T. R. Koballa [179]; 3) a questionnaire of A. Chwat and Y. Ben-David Kolikant [72], to study learning in a "pedagogical island" from the students’ perspective, based on the case of the ICT instructional unit in biology. In order to test the validity of the questionnaire, it was send to an expert in the integration of ICT in teaching as well as to a group of junior high school teachers, and in light of their comments, some of the items were revised and redrafted in accordance with the students level. Moreover, the final questionnaire was transferred to a sample of 20 students outside the study population.

The research process. The process was conducted between the years 2016-2018 and included 4 basic periods:

a. First period (2016) – *orientation*, consist in studying the relevant literature in the subject of ICT integration in the teaching and learning of biology (adapting the education system to the 21st century in Israel, ICT in studying biology, ICT tools aiding the teacher and the student, ICT integration in learning biology in the constructivist approach: implications on the development of a high-order thinking and increasing motivation to learn and for meaningful learning).
b. Second period (2016-2017) – *design*, included elaboration of the pedagogic model of ICT integration in biology lessons.
c. Third period (May 2017 – May 2018) – *experimental*, consist in development of the pedagogical experiment regarding ICT integration in biology lessons and collecting of experimental data in middle school. The experiment included six stages:
    1. The first stage (May 2017): submitting a request to the chief scientist of the Ministry of Education and receiving an approval to perform the study in the subject of ICT integration in teaching biology in middle school in Israel. The middle school, which belongs to the Ministry of Education, is situated in the Northern District, and the permit was received in July 2017.

2. Second stage (September 2017): introduction with the school, the management, the biology teachers and students as well as an explanation regarding the experiment preformed at the school, and passing requests for the biology teachers' consent to participate in the research.
3. Third stage (October-December 2017): conducting of the initial tests that were held before the experiment and the groups selection for the research, the experimental and control group, according to the tests' results.
4. Fourth stage (January – May 2018): implementing the experiment - teaching the experimental groups the relevant study units in biology with ICT tools.
5. Fifth stage (March – May 2018): conducting two tests for examining the students' achievements in biology after using ICT.
6. Sixth stage (end of May 2018): conducting of the questionnaire and collecting data - a questionnaire that examines: motivation, capability and internal orientation, students' attitudes toward meaningful learning integrated with ICT in biology lessons for the research groups (control and experimental).

d. The fourth period (June 2018) – *conclusion,* included the analysis of the research findings and the description of the findings of the research (the experiment and the questionnaire), the study of the connection between the theoretical conclusions and the empirical conclusions, expanding perspective directions for further scientific research in this field.

Table 3.3. Stages of the pedagogical experiment

Primarily stage	**Experiment examination**	
	Experimental group (86 students, 9th grades number: 3, 4, 5)	**Control group** (59 students, 9th grades number: 1, 2)
October - December 2017	Two mapping tests to examine students' level of knowledge in biology	Two mapping tests to examine students' level of knowledge in biology
Second stage	**Experiment implementation**	
January-May 2018	Teaching biology units **with** ICT integration	Teaching biology units **without** ICT integration
Third stage	**Experiment control**	
	Two tests to examine students' knowledge of biology after using ICT	Two tests to examine students' knowledge of biology

Processing the data. The statistical tests used in the context of the current research were:

- t-test for independent samples to examine the differences between the experimental and control groups means before intervention and t-test for paired samples to examine the significance of the increase in the achievements of students in the experimental groups after the intervention through ICT.

- ANOVA variance test to examine differences in the levels of motivation and self-capability in the learning, attitudes toward ICT and meaningful learning, when comparing the control groups to the experimental groups.
- ANCOVA variance test in order to examine the ICT influence on student achievements in biology, this after using two quarantines which are the two tests before the intervention.
- alpha Cronbach coefficient for estimating the reliability of the data.
- Average and standard deviation for the purpose of examining achievements and ranking of phrases.
- Descriptive statistical tests for the examination of parameters of centring and distribution of data.

Research limitations. There are several potential limitations of the research mostly regarding the possibility of generalizing research results on the research environments and similar populations, and they are:

a. Israel is a multicultural society, all study participants are from the Arab sector and this can influence the inclusion of the findings onto populations from different cultures, such as: the Jewish sector. Since the participants in the study were Muslims and Christians belonging to the Arab sector, the author recommends examining the various issues raised in the various sectors.

b. The study was conducted only for ninth graders in middle school and did not include the rest of the strata, nor did it examine the integration of ICT in other age groups, such as elementary and high school.

c. The attitudes of the school principals towards ICT were not examined, as well as the ways in which managers intent to promote the assimilation of the ICT culture in the teaching and learning processes. Giza Shaviv-Schneider, Gad Yair and Zachi Milgrom [180] attest that the school principal's attitude and his own use of ICT technology can lead to significant changes in the organizational culture of the school, which relates to the field of computerization.

3.2. Description of the finding experiment

The goal of the experiment was to examine and test the students' level of understanding and knowledge of biology before to the experiment and the ICT integration in biology classes. Therefore, two tests were performed at the finding stage, which contributed to the selection of the research samples.

The biology tests that were conducted before the experiment. Two assessment tests in life sciences for 9th grades were composed with the rest of the teaching staff before the experiment.

Test subjects were selected according with the obligatory junior high school curriculum of science and technology from 2017. The tests are part of the assessment tools used to examine the level of knowledge and understanding for ninth graders in biology. The test time is an hour and a half.

Test targets*:* evaluate the knowledge, understanding and skill in biology the students have acquired; enable the teaching staff and the researcher, to make conclusions for bettering the teaching; create cohesiveness in evaluation among all schools.

1. *The first mapping test* was held in mid-October, an analysis of 15 items of evaluation taken from the T.L.E (teaching, learning, evaluating) system. The test evaluate the knowledge and understanding of concepts, principles, processes and phenomenon in: the chemical connection and the energy in a chemical process; the carbon element and its compounds; requirements for the existence of living things, characteristics of life; the cell: built and function. The test is divided to two parts: the first part is of 10 closed items, about 40% of the grade and the second part is of 5 open items, about 60% of the grade, the open questions require higher levels of thinking. The thinking levels of the items are divided to approximately a third to each level: knowledge/understanding, implementation, high-order thinking.

2. *The second test* was held in mid-December, and consist of 17 evaluation items taken from the T.L.E. (teaching, learning, evaluating) system. The test evaluate knowledge and understanding of concepts, principles, processes and phenomena in: organic materials and types of carbs, cell organelles and cell types, types of solutions, cellular respiration and cell membrane. The test is divided to three parts: the first part is of 5 closed items, about 20% of the grade. The second part is of 6 open items regarding the explanation of phenomena and facts, about 35% of the grade. The third part is of 6 open items, about 45% of the grade. Both parts of the open questions and explanation of phenomena require higher levels of thinking. The high levels of thinking of the items are divided to approximately a third to each level: knowledge/understanding, implementation, high-order thinking.

Both tests examined and mapped the level of knowledge and understanding of the students in biology and their control in thinking skills of: handling information, scientific thinking- research and problem solving and the planning process. In addition, the tests examined photographic and visual thinking skill, which is the ability to decipher and intuitively understand instructions and messages presented in visual-graphic interfaces [116], such as: decode a graph showing the blood glucose level after a rich meal.

The teachers checked the students' tests along with giving feedback to the students, as well as collecting mapping files for the achievements of those classes. The mapping files were united to perform a quantitative analysis of the students' achievements according to the various test subjects and according to questions. Based on the quantitative analysis, difficulties were found and the students' achievements were low in the open questions.

Table 3.4. The students' achievements in biology before the experiment

	Class	First test mean, October	Second test mean, December	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	

Basing on the table 3.4, 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. In light of the preliminary grade's differences of the control and the experimental groups, the grades of the control groups were higher than that of the experimental group. These significant differences were attested with t-test for independent samples, the result of which, are showed in the table 3.5.

Table 3.5. T-test for independent samples: control and experimental

Group Statistics					
	group	N	Mean	Std. Deviation	Std. Error Mean
Mean before the experiment	control group	59	76,2034	16,58679	2,15942
	experimental group	86	64,4651	20,42415	2,20239

Independent Samples Test										
		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Differen-ce	95% Confidence Interval of the Difference	
									Lo-wer	Up-per
Mean before the experi-ment	Equal variances assumed	7,77	,006	3,66	143	,00	11,74	3,21	5,40	18,07
	Equal variances not assumed			3,81	138,89	,00	11,74	3,1	5,64	17,84

The Levene's test for equality of variances attests homogeneity of variances ($p=0.006<0.05$), and the results of t-test were read from first line. Therefore, $t(143)=3.66$ and $p=0.0<0.05$, that means there are significant differences between control and experimental groups. The mean difference is 11.74, and is contained in the 95% Confidence Interval of the Difference.

In both groups, the students complained on the structure of the tests and also showed a difficulty in solving the questions, because some of the questions require thinking skill that the students cannot acquire in the traditional frontal teaching method.

Analysis of the tests' findings. In view of the mapping of the tests and the conversation with the students and teachers, several factors that can be pointed out show that the level of achievements of students in the experimental group is dependent on these factors. Several main variables should be addressed: **a)** factors relating to the difficulty of the test level and types of questions; **b)** factors associated with the frontal method in teaching science, which does not suffice enough thinking skill acquirement; **c)** the lack of use of simulation means, animation, video-clips that visualize the learned subject [181].

From the analysis of the mistakes in students' answers to the questions, one can see in both tests a difference between the percentages of the successful in both question sections: the closed (60%), versus the open (40%). This difference indicates a difficulty in phrasing a reasoned answer supported by correct scientific evidences. One can presume that this difficulty derived from a lingual problems or lack of dominancy in the contents which making it difficult to select a relevant evidence to formulate a correct answer as well as a difficulty in understanding the question, which probably deriving from the formulation of the question or from difficulties in reading and deciphering what the question requires, a lack of knowledge or a lacking understanding of the required contents. In addition, the frontal teaching method the teachers practice in the classes with no aids reduces the ability to apply skills.

Many teachers adhere to the method of "knowledge transfer" and mainly use methods of routine knowledge transference. The teachers act in an aged environment that is not compatible to the age we live in, in which nearly every house has at least one online computer allowing every citizen to acquire information easily and being a member in the global community. The education system in Israel has not yet educated to change the teaching and learning environment to be technological, and thus does not enable the use of updated and relevant teaching and learning methods, that create continuity between school and home, as has been done in numerous progressed countries.

Biology teachers should use strategies that develop deepening scientific understanding while integrating research skills of the students, problem solution and answering complex questions. Students think that the roles of biology teachers are to guide the learners, encourage new knowledge built which will base on prior knowledge and aid students to be responsible for their learning. Biology teachers should encourage learning by having discussion among the learners, collaboration and integration of ICT means in teaching biology. It is important to teach and demonstrate throughout the teaching of all subjects, the structure required to explain phenomena, how to phrase an explanation to a phenomenon. It is recommended to give the students the opportunity to be introduced with the phenomenon via direct experience through experimentation, observation. It is important to keep an accurate description of the parts of the system and the processes that occur in the order in which they occurred.

3.3. Validation of the pedagogical model of ICT integration within the biology classes

3.3.1. Biology ICT integration effects on the students' level of knowledge

The experiment aims to check the level of knowledge of biology students after ICT integration in biology lessons. In the following they will be examined firstly the hypotheses, research questions and the findings of this study.

The first research question: whether and to what extent does the ICT integrated learning affects learners' achievements as it is expressed in the biology students' diploma grades?

First hypothesis: the achievements in biology among students who learned through the ICT based method were significantly higher than those of the students who learned by the traditional manner.

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 3.6 below:

Table 3.6. Student achievement before and after the experiment

	Achievements *before* the experiment				**Achievements *after* the experiment**			
Class No	First test October	Second test December	Average	Average for all	Third test March	Fourth test May	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). Graphical illustration for this finding is showed in fig. 3.1. For purpose to confirm it, t-test for paired samples was done in SPSS, for the control group and the experimental group.

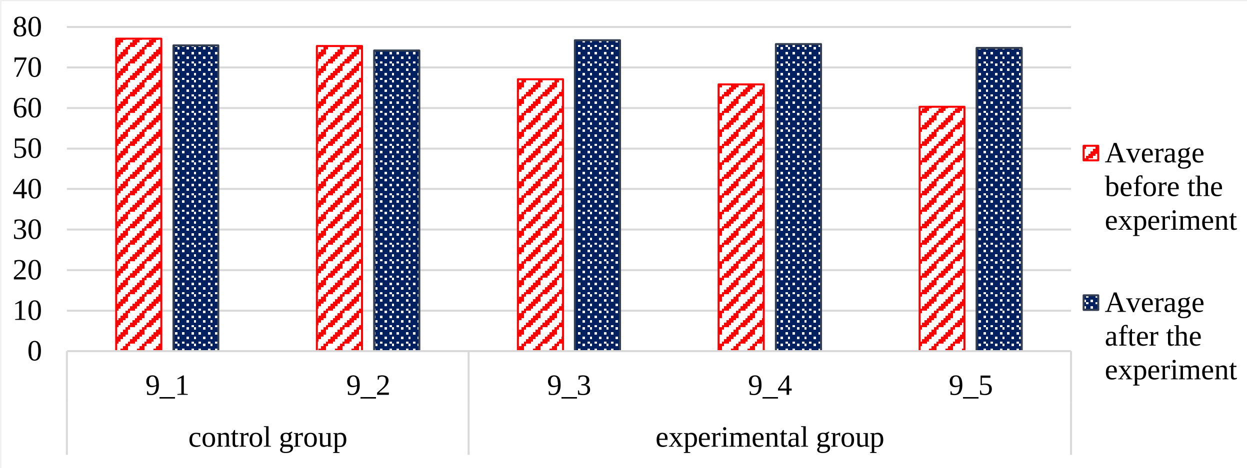


Fig. 3.1. Differences in the achievements of students before and after the intervention in the experimental and control groups

The output of t-test for paired samples in SPSS for control group is represented in table 3.7, in which paired variables was the averages before and after the experiment. In the table *Paired Samples Test* is showed 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.

Table 3.7. T-test for paired samples for control group

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Control group	Average before the experiment	76,2034	59	16,58679	2,15942
	Average after the experiment	74,8390	59	16,09922	2,09594

Paired Samples Correlations				
		N	Correlation	Sig.
control group	Average before the experiment & Average after the experiment	59	,885	,000

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
control group	Mean before the experiment - mean after the experiment	1,36	7,85	1,02	-,68	3,41	1,336	58	,187

For experimental group, the output of t-test for paired samples in SPSS is represented in table 3.8. In this case t(85)=12.276, with an p-value p=0.000<0.05, that mean there is attested significant difference between students' achievements before and after intervention for experimental group.

Table 3.8. T-test for paired samples for experimental group

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
experimental group	Mean before the experiment	64,4651	86	20,42415	2,20239
	mean after the experiment	75,8081	86	16,54498	1,78409

Paired Samples Correlations				
		N	Correlation	Sig.
experimental group	Mean before the experiment & mean after the experiment	86	,914	,000

Paired Samples Test									
		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Experi-mental group	Mean before the experiment - mean after the experiment	-11,34	8,57	,92	-13,18	-9,51	-12,276	85	,000

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 [181].

To examine the impact of ICT on achievements in biology, a multi-factor variance test of the ANCOVA type was conducted. The data from table 3.9 and figure 3.2 show that ICT improved significantly and distinctively ($F_{(4, 133)} = 9.11$, $p < 0.001$) the students' achievements in the first test after the intervention; in addition, it was found that ICT significantly and distinctively improved ($F_{(4, 133)} = 25.21$, $p < 0.001$) students' achievements in the second test after the intervention, for experimental group.

Table 3.9. ANCOVA variance test to examine the impact of ICT on achievements in biology for experimental group

Tests	$F_{(4, 133)}$	Wilks' Lambda
Achievements in the first exam after the intervention	9.11***	11.02***
Achievements in the second exam after the intervention	25.21***	

****p<0.001*

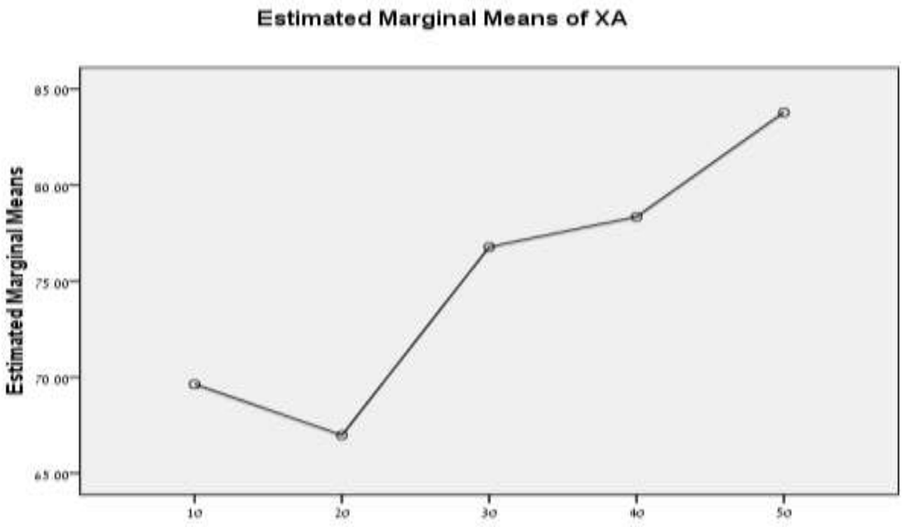


Fig. 3.2. Students' achievements in the tests after the intervention by grade distribution

The effect of ICT on student achievement in the second test was significantly higher than the first test, which shows that the first research hypothesis that *the achievements in biology among students who learned through the ICT based method were significantly higher than those of the students who learned by the traditional manner*, has been verified. Meaning, these findings also answer to the first research question, ICT has improved student achievement in the subject of biology.

3.3.2. ICT integrated learning effects on motivation and self-efficacy to learn biology among the learners

In this paragraph will be examined the additional hypothesis (2-4), beginning with the second research question that will be answered: *to what extent does ICT integrated learning affects motivation and self-efficacy to learn biology among the learners?* and will be verified the second research hypothesis*: the motivation and self-efficacy in learning among students who studied biology by the ICT method are significantly higher in comparison to the dimensions of motivation and self-efficacy in learning among students who studied by the traditional method*. The research in this context will be based on the analysis of the questioner described in paragraph 3.1 and presented in appendix 1. For this purpose, a variance ANOVA test was conducted, as it is shown in table 3.10 below.

Table 3.10. ANOVA test to examine differences in levels of motivation and self-efficacy in learning between the control and the experimental groups

Group	Class	Mean (scale 1-4)	Standard deviation	$F_{(4, 139)}$
control	**9th grade 1**	3.37	0.55	2.10
	9th grade 2	3.41	0.41	
experimental	**9th grade 3**	3.57	0.39	
	9th grade 4	3.22	0.51	
	9th grade 5	3.28	0.54	

The data in Table 3.10 show that there is no significant difference (F (4, 139) = 2.10, p=0.083>0.05, appendix 8) between motivation and self-efficacy in comparison between the control groups (classes 1,2) and the experimental groups (classes 3, 4, 5). That is to say, the second hypothesis was refuted.

To examine the question: to what extent does ICT integrated learning affects motivation and self-efficacy in learning biology among the learners, the average and standard deviation were calculated for motivation and self-efficacy dimensions among the study population. In the questionnaire, nine statements were presented to the subjects who identified the positions on motivation and self-efficacy. The subjects were asked to scale their level of consent regarding the statement on a scale that increases from 1 to 4, (4 - Definitely agree, 1 - Definitely disagree).

Table 3.11. Mean and standard deviation of the motivation and self-efficacy scale among the study population

No.	Statement (N=145)	Average	Standard deviation
1	I am happy that I learn biology with ICT	3.61	0.66
2	I think I'll receive a high score in biology with ICT	3.43	0.74
3	The integration of ICT will help me to understand the material	3.59	0.68
4	I will be more concentrated in the biology class when it is integrated with ICT	3.39	0.77
5	With ICT, I can succeed in biology even without the help of the teacher	2.85	0.89
6	I'm sure I can do a really good job in papers and tests in ICT integrated biology	3.39	0.75
7	ICT integration makes biology more interesting	3.62	0.61
8	Learning ICT integrated biology is hard for me	3.26	0.87
9	Learning in an ICT environment cause difficulties and stress during the lesson	3.26	0.92
Weighted Score		**3.77**	**0.24**

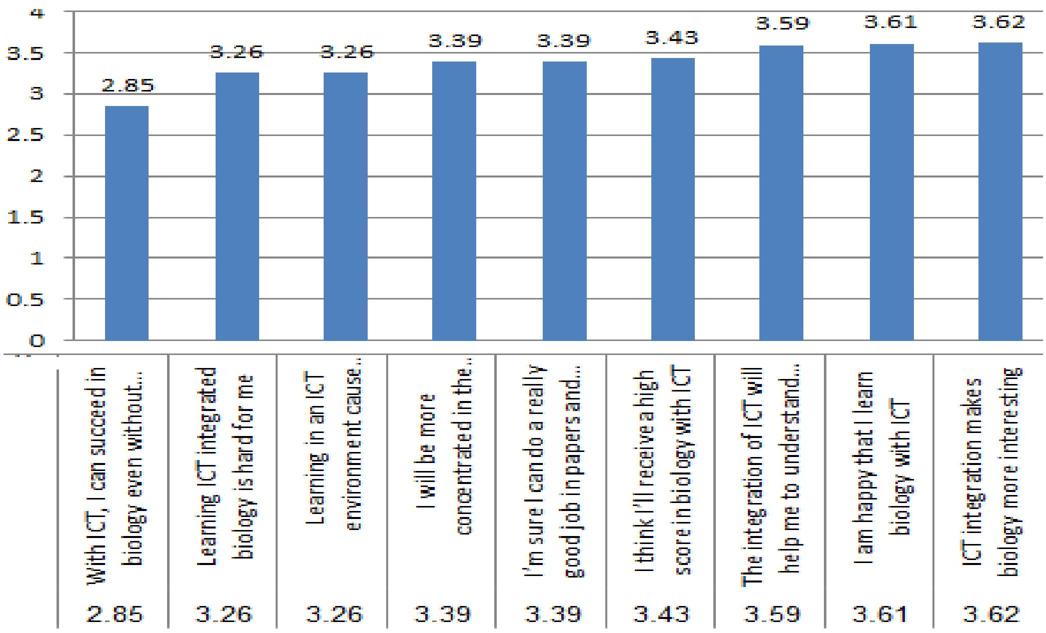


Fig. 3.3. Mean of motivation and self-efficacy scale

Table 3.11 and figure 3.3 present averages and deviations of the statements. The findings indicate that the students expressed positive attitudes at a high level toward ICT in terms of its abilities to raise their motivation and self-efficacy in learning biology. The range of answers ranges from "I can succeed in biology without the help of the teacher" (M = 2.85, SD = 0.89); to "The integration of ICT makes the biology subject more interesting "(M = 3.62, SD = 0.61). The weighted grade of the students' positions in the 9 items about motivation is 3.77 (scale 1-4) (SD = 0.24). The Cronbach alpha coefficient, which indicates the internal consistency (reliability) between the items, is α = 0.849, indicating high reliability. In addition, the rates of motivation and self-efficacy were examined for the ICT lessons reported by the students from all five classes (figure 3.4):

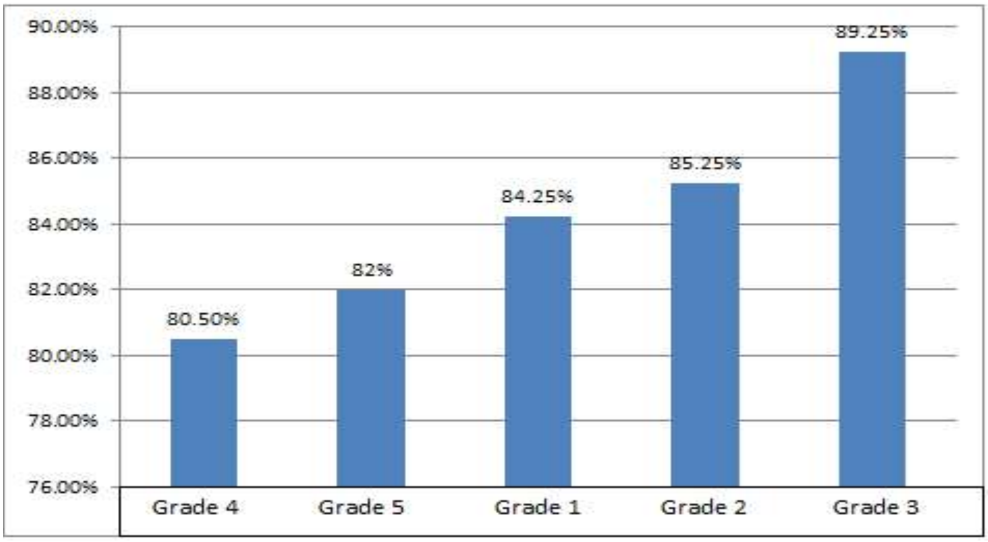


Fig. 3.4. Students' motivation and self-efficacy rates in ICT biology lessons

Figure 3.4 shows that 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 finally 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*.

In the following, the third research question: *what is the attitude of students towards integrating ICT in biology lessons*? and the third hypothesis*: students who studied biology by the ICT method will show more positive attitudes toward ICT in comparison to students who studied by the traditional method*, will be examined. For this purpose, a variance ANOVA test was conducted, results of which are shown in table 3.12 below.

Table 3.12. ANOVA variance test to examine differences in attitudes toward ICT in comparison between control groups and experimental groups

Group	Class	Mean (scale 1-4)	Standard deviation	$F_{(4, 139)}$
control	**9th grade 1**	3.26	0.42	1.69
	9th grade 2	3.19	0.40	
experimental	**9th grade 3**	3.41	0.36	
	9th grade 4	3.19	0.49	
	9th grade 5	3.11	0.58	

The data in table 3.12 indicate that there is no significant difference (F (4, 139) = 1.69, p=0.154> 0.05) in attitudes towards ICT in comparison between the control groups (classes 1, 2) and the experimental groups (classes 3, 4, 5). In other words, the second hypothesis is that students who have studied biology by the ICT method will show more positive attitudes toward ICT compared to students who studied by the traditional method, was refuted.

In order to examine the third research question: *what is the students' attitude toward the integration of ICT in biology classes?*, the average and standard deviation were calculated for the components of the variable, student attitudes. In the research questionnaire, the respondents were presented with nine statements that represent students' attitudes toward the integration of ICT in biology classes, the subjects were asked to rate their agreement on a scale from 1 to 4 (4 - definitely, 1 - strongly disagree). Table 3.13 presents averages and standard deviations of the statements.

Table 3.13. Averages and standard deviation of the scale of student attitudes toward the integration of ICT in biology classes

No.	Statement (N=145)	Average	Standard deviation
1	I would want every lessons at school will be ICT integrated	3.4	0.84
2	Studying ICT integrated biology bore me	3.35	0.85
3	I think learning biology with ICT is more interesting than the regular method	3.5	0.71
4	I believe than learning in an ICT environment will help me in the future as well	3.48	0.7
5	In your opinion, the learning with ICT was/will be different from learning as you've learned this far?	3.23	0.71
6	I am pleased that I studied / will study biology this year in with ICT.	3.36	0.78
7	Do you prefer to study and test in ICT integrated biology rather than the usual frontal method?	3.34	0.8
8	If you could choose, would you choose to study online units in other subjects as well?	3.44	0.79
9	The theoretical exam is more appropriate to check that the student is good in biology than the ICT exam	2.14	1.03
Weighted Score		**3.24**	**0.42**

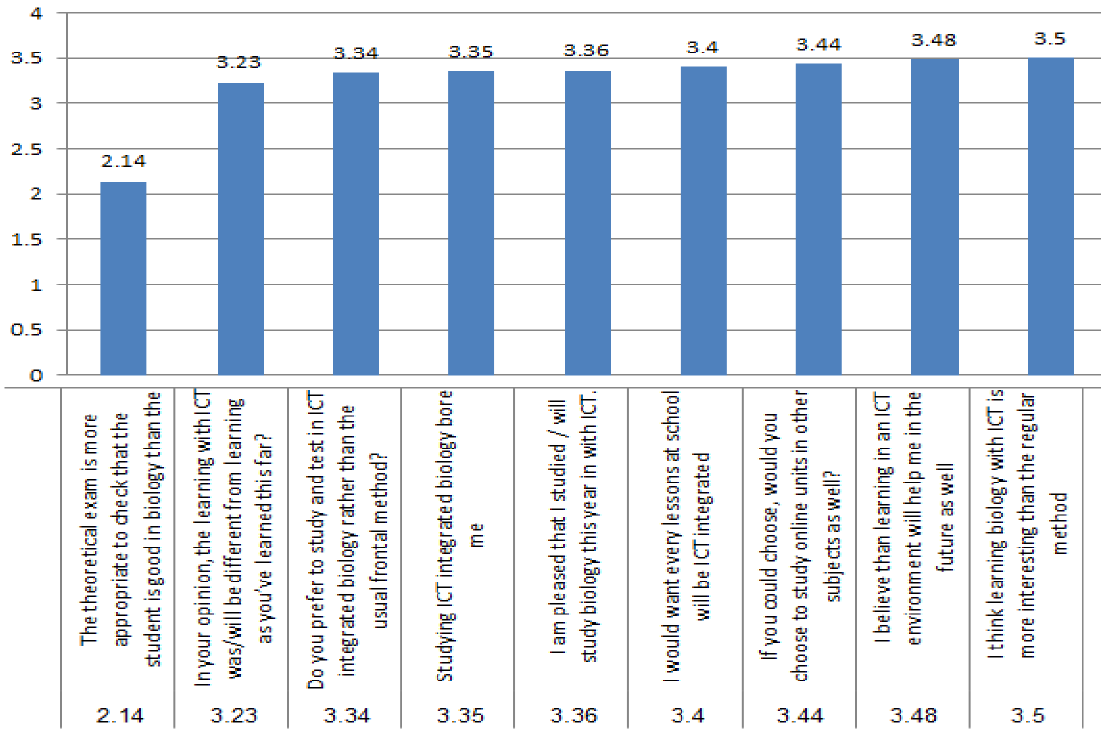


Fig. 3.5. Average of students' attitudes toward the assimilation of ICT in the biology class

Table 3.13 and figure 3.5, which display the statements in ascending order according to the average value, show that the students expressed very positive attitudes towards the assimilation of ICT in biology classes. The average positions ranged from "the theoretical exam more appropriate to check that the student is good in biology from the ICT aspect?" (M = 2.14, SD = 1.03) to "I think it is more interesting to study biology using ICT than the usual method" (M = 3.5, SD = 0.71). The weighted score of the students' positions in the 9 items regarding attitudes toward ICT integration is 3.24 (scale 1-4) (SD = 0.42). The Cronbach alpha coefficient, which indicates the internal consistency (reliability) between the items, is α = 0.721, which indicates high reliability.

Additionally, the rates of attitudes of all students, experimental and control groups, were examined with regard to the ICT lessons. These rates appear in ascending order, broken down by grade, in figure 3.6 below.

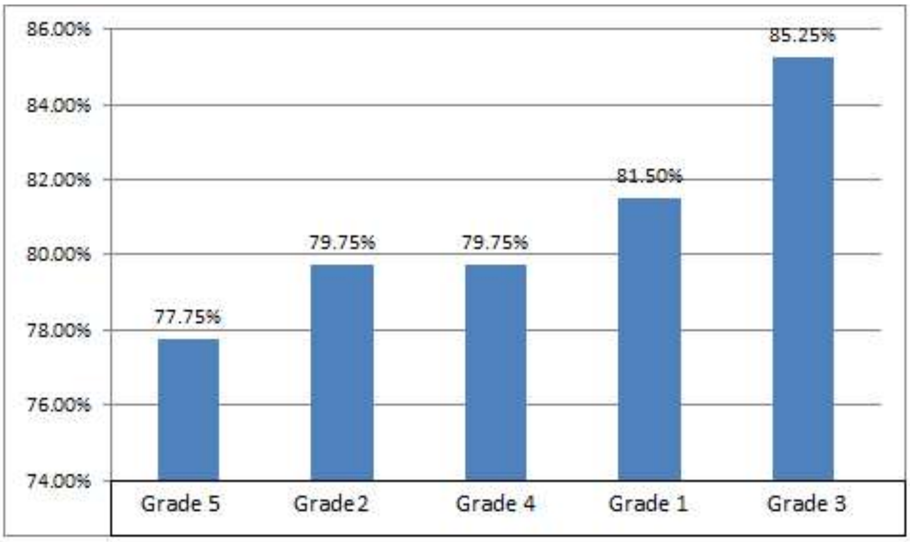


Fig. 3.6. Attitudes of all students, experimental and control groups toward the rates of ICT biology lessons

Figure 3.6 shows that 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 who experienced the biology subject during regular school sessions, not necessarily in the current research, answer the third research question, and express that *the students have shown positive and significant attitudes towards ICT learning of the biology subject*.

The fourth research question examines if *the integration of ICT in biology lessons improve students' meaningful learning* and in order to answer to it, the fourth hypothesis: *students who studied biology by the ICT method will report that learning is more meaningful for them than for students who studied by the traditional way*, was tested through the ANOVA results of which are shown in table 3.14 below.

Table 3.14. ANOVA test of variances that examine differences in meaningful learning concepts by comparison between control groups and experimental groups

Group	Class	Mean (scale 1-4)	Standard deviation	$F_{(4, 139)}$
control	**9th grade 1**	3.37	0.44	1.54
	9th grade 2	3.40	0.42	
experimental	**9th grade 3**	3.52	0.42	
	9th grade 4	3.28	0.50	
	9th grade 5	3.23	0.59	

The data in table 3.14 indicate that there is no significant difference ($F (4, 139) = 1.54$, $p > 0.05$) in the meaningful learning concepts compared to the control groups (classes 1, 2) and the experimental groups (classes 3, 4, 5). In other words, the fourth hypothesis that students who studied biology by the ICT method will report that learning is more significant for them than for students who studied by the traditional method was disproved.

In order to examine the fourth research question: *does the integration of ICT in biology lessons improve the dimensions of meaningful learning among students*?, the average and standard deviation were calculated for attitudes towards significant learning in ICT integration among the study population. In the questionnaire, the respondents were presented with nine statements that presented attitudes toward meaningful learning. The interviewees were asked to rate their agreement to a scale of 1 to 4 (4 – definitely agree, 1 - strongly disagree).

Table 3.15. Averages and standard deviation of the ICT integration scale in the study of biology and significant learning

No.	Statement (N=145)	Average	Standard deviation
1	In the integrated biology class, I am more active than in a regular lesson	3.36	0.75
2	In ICT integrated biology lesson I also learn from classmates (not just from the teacher)	3.26	0.74
3	In ICT integrated biology lessons, we waste time in class	3.41	0.88
4	I can help others in ICT integrated biology lessons	3.26	0.75
5	In e-biology classes I can express my own ideas	3.16	0.76
6	The ICT biology lessons have caused me pleasure and a learning experience	3.51	0.68
7	Learning biology in a leading ICT environment can lead to a sense of involvement in learning	3.42	0.76
8	Learning biology in ICT environment contributes to the development of knowledge	3.53	0.62
9	Teaching biology in an ICT environment encourages learning related to everyday life	3.34	0.76
Weighted Score		**3.36**	**0.12**

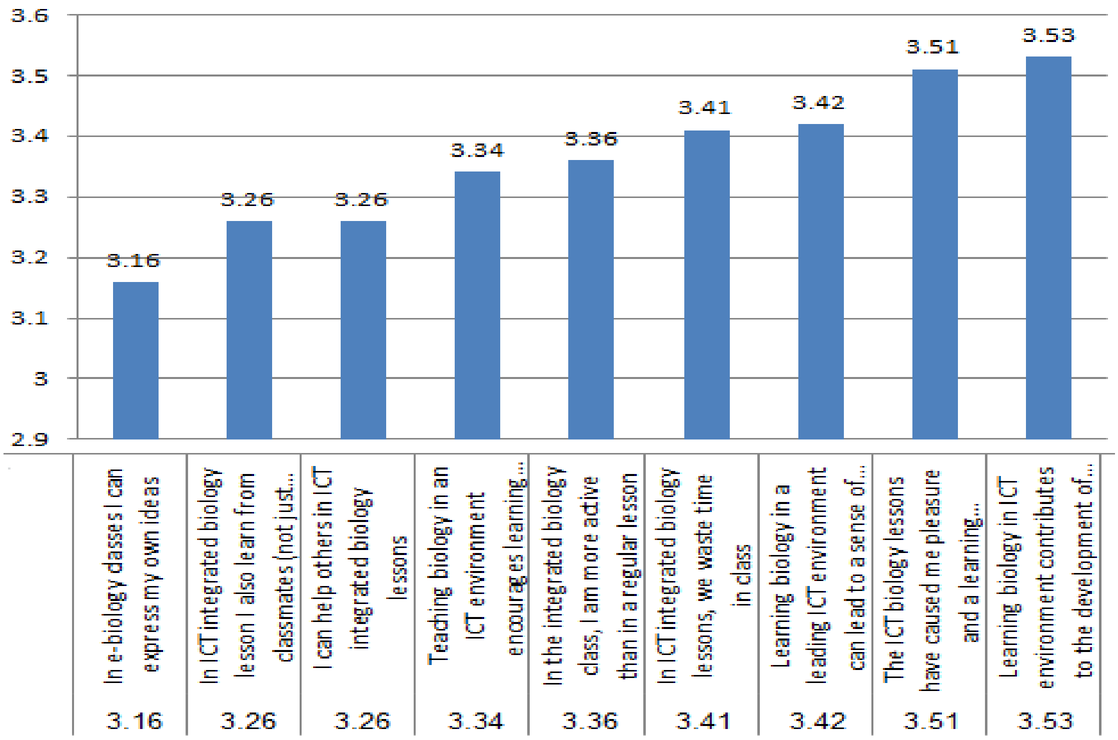


Fig. 3.7. Mean of the significant learning scale in ascending order

Table 3.15 and figure 3.7 show that the students reported a very high level of meaningful learning because of learning through the assimilation of ICT in the teaching of biology (grades 3 + 4). The average range of student responses was between "I can express my own ideas" (M = 3.16, SD = 0.76) to "Learning biology in the ICT environment contributes to the development of knowledge" (M = 3.53, SD = 0.62). The weighted score of the students' attitudes in the 9 items about the significant learning is (M= 3.36, SD= 0.12) All of this on the Likert scale of (1-4), the Cronbach alpha coefficient, which indicates the internal consistency (reliability) between the items, is α = 0.858, which indicates high reliability. In addition, the meaningful learning rates of all students, control and experimental, in ICT lessons were examined. These rates appear in ascending order, broken down by class, in figure 3.8.

According to figure 3.8, all students in the experimental and control groups reported very high rates of significant biology learning in ICT lessons. 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, the significance of these findings is that all students, whether they are students of the experimental group who have experimented with the ICT learning in biology, as part of the intervention in the present study, or whether they are students of the control groups who have experimented with ICT learning in biology lessons in the course of regular school-based learning rather than in the intervention of the current study, who responded to the fourth research question, reported that *ICT biology classes are best for improving their meaningful learning.*

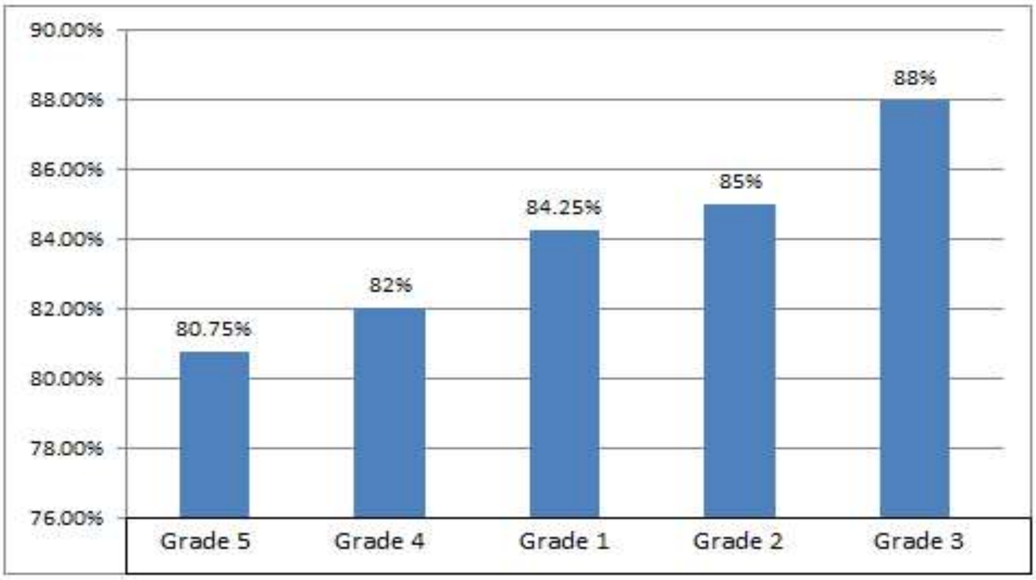


Fig. 3.8. Perceptions of all students, experimental and control groups, on the significant learning rates of the biology subject, using the ICT integrated lessons

In summary, table data (3.11, 3.13, 3.15) and figures (3.3, 3.5, 3.7) indicate that the responses of the participants ranged on the average between "ICT integration makes biology subject more interesting" (M = 3.62, SD = 0.61) and "the theoretical examination is more appropriate to check that the student is good in biology from the online aspect" (M = 2.14, SD = 1.03). Meaning, the participants found positive attitudes at a very high level towards the assimilation of ICT in biology classes, in all ways and aspects [182].

3.3.3. Discussing the Findings

The findings of the control experiment and the intervention program show significant differences in student achievements in biology tests among the experimental group versus the control group. From the research results one can observe that achievements in biology among students who learned by the ICT method were substantially higher in comparison to the students learning by the traditional method, their grades were clearly improved, that is, ICT led to an improvement in the students' achievements in biology. This finding supports the claim that with the ICT tools, students are exposed to a wide variety of subjects presented in a form of asking questions and exploring information. The presented topics and their unformal presentation constitute completion and expansion of the material studied in the classroom, as well as improving the development of students' thinking skills. The interesting and challenging learning process leads to achieving relatively high grades in the end of year certificates as well. Perhaps learning with ICT tools, such as: animation videos in a higher frequency and in a wider variety of subjects will lead to a significant improvement in student achievement. Moreover, in classes which held ICT integrated teaching\learning, there has been an inclination to close gaps between weak students and outstanding students in biology scores, this is compared with the control classes [92]. On the other hand, R. Reynard [174] presents and describes in her article the problem of measuring standard school achievements in an ICT learning environment. In her view, each standing point for examining school achievements in an ICT environment bases on false conceptions and hypotheses. Those same factors who try to assess in present and normative tools the educational change in an ICT environment, are actually lacking insight and unaware of the complex reality of learning in an ICT environment. The ICT environment was not necessarily built to improve school achievements of students but rather to improve the learner's learning experience, his or her motivation and their thinking skills to a great extent.

The current research findings indicate that the students showed a high level of positive approaches toward ICT in terms of its ability to increase their motivation and self-efficacy in learning biology. Furthermore, the control group students expressed these approaches as well, only if we enable them to learn biology with ICT. This coincides with Y. Rosen’s [52] findings, that experimenting in an ICT integrated learning environment, such as BrainPop animation videos, have significantly increased motivation to learn science and technology. The motivational elements mentioned by the students and the teachers regarding the new environment match with the concept of “optimal experience”, feelings of concentration and enjoyment, internal motivation and tendency to repeat the activity that caused this feeling. This also coincides with the findings of M. Barak’s [92] research, according to which the animation videos are a factor that promotes interest, enjoyment and drive (motivation and self-efficacy) among the students.

In addition, this coincides with the research findings of D. Mioduser, R. Nachmias and A. Forcosh-Baruch [81], which show that about three quarters of the science teachers in Israel, who used ICT believe that this use increased their students’ motivation to learn, to acquire knowledge and develop skills for handling information, autodidactic and communication skills. In this way, they are similar to their counterparts in the world, who gave very high scores to the influence of ICT on their students. The statistical findings emphasize that improvement and increasing of motivation and self-efficacy within students as a result of ICT integration, which confirms the words and results of S. Dori and G. Kurtz's [178] research, who found that the main contribution of digital tools usage is by them enabling possibilities to choose various subjects, contributing to understand the learned material, developing knowledge, organizing information, obtain a sense of ability and capability to perform tasks that the friendly environment makes useful and allows to learn anywhere. Moreover, they enable to produce products that cause a sense of success, enjoyment and contribute to a more creative and quality learning production. And this is consistent with Ministry of Education policies, who noted that it is possible to increase motivation through the diversification and innovation of the material. Integration of visualization and multimedia mean can also aid to students' experiences of success, and thus to increase their motivation and self-efficacy.

Research findings show that all students, whether in the experimental group who experienced ICT learning of biology as part of the intervention of current research or it is the control group students who experienced ICT learning of biology lessons during their routine regular school day, rather than due to the intervention of this study, have reported that ICT biology lessons are the best for the improvement of their meaningful learning dimensions, learning that enables emotional, social and cognitive learning experience, which bases on three components that exist simultaneously: a value to the learner and to society, involvement of the learner and the tutor, relevance to the learner.

This finding supported the claim that learning in an ICT environment means empowering the learner and giving expression to the learning processes. Information technologies were not meant to replace the teacher, but rather to empower the learner by supporting the interaction processes of his learning, whether it is by increasing his curiosity or encouraging him to collaborate with fellow students via ICT. It could be that the normative evaluation procedure of a student learning in an ICT environment will discover that his dominancy in the content is no better than a student in the traditional classroom. However, will he discover the research and scientific skills he developed while learning in an online ICT environment? The student acquires advanced skills; ability to deal with a project, ability to differentiate between main and minor. These advanced skills in a student are not immediately expressed, they are expressed in the long term and sometimes even years after, when the students arrives to the university and needs to deal with writing a research paper or a seminarian [174].

Researches, T. Shamir-Imbal and Y. Kelly [109] and S. Dori and G. Kurtz [178] show that an educated use of ICT in the teaching may support the meaningful learning, increase the interactivity of the learner, improve his thinking abilities, and his social roles as well as causing enjoyment and a learning experience. In their article, A. Avni and A. Rotem [121] give evidence that the meaningful learning uses the opportunities available by the learning means designed by technology for the teaching and the learning in order to empower the student's learning experience. It also aims to enable initiation and courage in taking responsibility for the learning, increasing the consciousness and reflectivity, to provide an experience of success and strengthen the sense of self-worth. The essence of meaningful learning is to outline a meaningful learner's life, mediated by a meaningful educator and in the significant contexts of the learner's personal, social and cultural life in the 21st century.

The presented research findings indicate that the students, whether in the experimental groups or in the control group, who have experimented in learning biology and other subjects during the regular school lessons, and not necessarily in the context of this research, showed significantly and distinctively positive attitudes toward ICT learning of biology. This finding is in line with the findings of A. Chwat and Y. Ben-David Kolikant [72] who show that the use of technology is perceived by the students as obligating action, allowing progress at a personal pace and encourages independent learning. The multiplicity of sources of information and means of illustration is credited to the technology and Excel skills were seen as contributing to the understanding of biology. On the other hand, according to Y. Ben-David Kolikant [183], the students were ambivalent regarding the use of ICT, they saw the internet as easy to use, decreasing the workload and “fun”, however, the internet was at the same time perceived as “unreliable”, not “serious” enough, and “does not include what they need to know”. Students used the Internet mainly for "unimportant" tasks such as routine homework. The explanation for this is that the students saw the teachers as the only (almost) exclusive authority for the information needed. On the other hand, the evaluation findings for the Smart School project which examined the contribution of ICT to the implementation of the school pedagogic vision, shown by E. Manny-Ikan, T. Berger-Tikochinski and Z. Bashan [104], that throughout the years students’ attitudes became more positive toward learning with technology and its influence, especially regarding the frequency of using technology in a variety of ways, the learning interaction between teacher and students, and the acquisition of 21st century skill.

3.4. Conclusions to Chapter 3

The pedagogic experiment focused on the use patterns of ICT tools in biology in middle school (9th grade), and on the effect of it on the students level of knowledge and understanding of biology before and after the use. Additionally, the experiment examined the efficiency of the pedagogic model on the improvement of the teaching, learning and evaluation methodology of the learned subjects in accordance to the regular biology curriculum. Moreover, the experiment examined the effect of ICT usage on student achievements in biology studies, and examined the motivation and self-efficacy to learn among the students with ICT integration, as well as the implications of using ICT tools on the improvement of meaningful learning dimensions in biology lessons, by a comparison between the experimental group and the control group. Therefore, the following conclusions can be made:

1. *The significant differences* in biology achievements between tests results before and after experiment among students who learned through the ICT based method (experimental groups) *was identified*, and no significant difference between students' achievements before and after intervention for control groups, those of the students who learned by the traditional manner, means that ICT has improved student achievement in the subject of biology, and the first research hypothesis was confirmed.

2. The analysis of student's answers to questionnaire's questions relating on motivation and self-efficacy identified that all students, without significant differences between control and experimental groups, think that the ICT lessons in biology significantly improve their learning motivation and self-efficacy. Therefore, the second research hypothesis, which supposed that the motivation and self-efficacy in learning among students who studied biology in the ICT method are significantly higher in comparison to the dimensions of motivation and self-efficacy in learning among students who studied in the traditional method, was rejected.

3. The use of ICT increases the level of interest of the students. 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.

4. The analysis of student's answers to questionnaire's questions relating on meaningful learning identified that all students consider the use of ICT enriches the meaningful learning in biology, despite the rejected fourth research hypothesis: 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.

5. ICT affects the 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, the use of ICT among students is not a substitute for the presence of the teacher in the classroom, but rather complement one another.

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

We live in a continuous changing world, in which the volume of scientific information increases rapidly and the power of technology increases as well. This obligates a use of various teaching and evaluation strategies required to reflect the essential changes in adapting the biology curriculum, which is a part of the inclusive science and technology curriculum in middle schools aimed to qualify its graduates to cope successfully with the future's challenges in a dynamic and knowledge-intensive society by nurturing 21st century skills. Integrating ICT in the teaching depends on external and internal factors that constitute encouraging and inhibiting factors such as: the organizational aspect and the way in which the organization is prepared to assimilate the change in its built and actions; the teachers and their handling with the demand to change; the principal and his or her support in the assimilation process of the innovation. The integration of ICT tools in the teaching/learning of biology connects directly with the constructivist learning approach, biology teachers must use strategies developing deepening scientific understanding, while combining the students' research skills, solving problems and answering complex questions. The teachers' role is to encourage construction of new knowledge based on prior knowledge and assist the learners to be responsible for their learning. The high-tech learning environment may support and advance meaningful learning as a deepening and enriching learning experience that is relevant and valuable to the learners and requires their involvement and cooperation. Digital technologies enable to develop significant knowledge and understanding of biological processes that were very difficult to explain and teach in the past. The students use information and communication technology in biology studies for: research and exploration, collecting data, handling and interpreting / data analysis, aids for understanding / explanations of concepts, mostly illustration of abstract concepts and processes, the use of simulations, presentation of findings and understanding, delivering ideas. The above mentioned allowed to advance the research problem that consists in *determining the theoretical and methodological foundations of the efficiency improvement of the teaching-learning process of the biology in the gymnasium through the information and communication technologies.* Therefore, the following conclusions can be made:

1. The analysis of the advantages offered by the information and communication technologies 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.

2. The research of the specialized literature did not allow the identification of some pedagogical models for integrating the information and communication technologies in the process of teaching-learning the biology, but only the identification of some technical models for the use of computers in the classroom. 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.

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.

4. 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.

5. The pedagogical experiment allowed to identify significant differences 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 between students' achievements before and after intervention for control groups, those of the students who learned by the traditional manner, means that ICT has improved student achievement in the subject of biology.

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.

7. ICT affects the 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, the use of ICT among students is not a substitute for the presence of the teacher in the classroom, but rather complement one another.

In conclusion, the findings of the current research coincide with the importance of ICT assimilation in the teaching/learning of biology in middle schools, 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 terms and aspects. It allowed to solve the **scientific problem**: *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. Improve the logistic conditions within the school, such as: the number of computers available for students and teachers for teaching and learning at the school, equipment quality and functioning (processor speed, operating systems, peripherals, and Internet access).

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. An educated use of ICT in the teaching and the online activities that encourage meaningful learning, hence the teachers should be trained not only to operate the devices but also

to improve their teaching methodology, as an integral part of the curriculum to match the integration of ICT into the classroom.

2. Encourage a change in the teachers' role, their ways of teaching and evaluating due to the assimilation of ICT; developing and forming the teaching approach to an efficient use of the online learning environment in biology studies, while making use of its advantages; as well as application of this approach in other subjects of study.

3. Valorisation of the methodology of implementing the proposed pedagogical model.

For the students:

1. Developing introduction and awareness of students with the various patterns of ICT learning.

2. Leading ICT processes at the school by the students, developing a program to train a group of students in the fields of computers. This training will make the students to leaders of ICT, these students will be used as help for the teachers in integrating ICT in the teaching and the learning, and will participate in schools' ICT processes.

More suggestions for further research

A research that will focus on the quantitative and qualitative approach, examine teachers' conceptions and attitudes in relation to ICT integration and teachers' personal interpretations to their attitudes which may help in creating a deeper understanding of teachers' perceptions. This type of understanding will progress the handling with the need for change in perceptions, spur the assimilation of ICT technologies in the education system.

This research examined the issue of ICT assimilation only in middle-school, it is possible to examine these issues for all age groups, elementary, middle and high school. In addition, the research questions examination was conducted in an Arab school in the northern area, it will be interesting to examine whether there are differences between the various areas in Israel as well as between the Arab and Jewish sectors.

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APPENDICES

Appendix 1. Questionnaire for the student

Details of questionnaire definitions by categories

Number of definition	Categories
22 ,12 ,9 ,8 ,7 ,4 ,3 ,2 ,1	**Motivation and self-capability**
27 ,26 ,25 ,24 ,23 ,20 ,16, 14 ,10	**Student approaches**
21 ,11 ,19 ,17 ,18 ,15 ,13 , 6, 5	**Meaningful learning**

A questionnaire about use of ICT in biology and science classes

Gender: girl/boy grade:_______

Dear student,

We will thank you for answering the question after a considerable thought.

1. I am happy with studying biology integrated with ICT (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

____

2. I believe I will get a high grade in biology integrated with ICT (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

____

3. ICT integration will help to understand the material better (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

____

4. I will be more focused in biology class when it is ICT integrated (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

____

5. I am more active in a biology class integrated with ICT than in a regular class (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

____

6. In ICT integrated biology class I study from my classmates as well (not only from the teacher) (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

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7. With ICT I can succeed in biology even without the help of the teacher (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

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8. I am sure that I could do the work and tests in biology integrated with ICT very well (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

---

9. The integration of ICT makes the biology subject more interesting (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

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10. I would like all classes in the school to be integrated with ICT (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

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11. In ICT integrated biology classes the time in the classroom goes to waste (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

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12. Learning ICT integrated biology is difficult for me (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

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13. I can help others in ICT integrated biology classes (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

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14. ICT integrated biology classes bore me (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

____

15. In the ICT biology classes I can express ideas of my own (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

____

16. I think it is more interesting to learn biology with ICT than in the regular method (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

____

17. The ICT biology classes made me / will make me enjoy and have a learning experience (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

____

18. Learning biology in ICT environment leads / could lead to a sense of involvement in the learning (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

____

19. Learning biology in ICT environment contributes to knowledge development (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

____

20. I believe that the learning in ICT environment will assist me in the future as well (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

____

21. The teaching of biology in ICT environment encourages learning related to everyday life (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

____

22. Learning in ICT environment creates difficulties and causes stress in class (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

---

23. To what extent, in your opinion, the ICT integrated learning will be / was different from learning biology until then? (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

---

24. To what extent are you happy with learning ICT integrated biology? (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

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25. To what extent do you prefer learn and be examined in ICT integrated biology or in the traditional frontal biology? (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

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26. If you could choose, would you pick learning ICT units in other subjects as well? (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

---

27. In your opinion, what exam will be better to that the student is good in biology, the computerized or the theoretical? (Definitely agree \ Agree \ Disagree \ Strongly disagree). Put into detail/Give an example

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Appendix 2. Letter of request addressed to teachers for consent to participate in the research

The school year: 2017/2018
Date: ___________________

Dear Teacher,

Re: <u>Your participation in a research on ICT Integration in the Process of Teaching Biology in Middle-School in Israel</u>

I wish to request your consent to participate in the research in question, which is planned to take place in the school where you are employed. The research focuses on the examination of the effect of teaching and learning that base on the integration of ICT in biology studies in 9^{th} grade on students' achievements in the studied topics. For the purpose of the study, I would like your participation in these activities:

1. During the teaching of the topics; The Cell and Systems and Processes in Living Things, Feeding and The Digestive System, I ask you to participate in the meetings that will be guided by me in order to design the methods for implementation in the classrooms of teaching the above subjects in a way that is based on integrating ICT tasks during the teaching and the learning.
2. The meetings will be held, with the consent of the school's management, in coordination with the teachers agreeing to participate in the study, once every three weeks for three months (about 4-5 in total) and each one will take about 45-60 minutes. They will engage in application of advanced learning and teaching approaches via technology and technologies in education, how to innovatively use them in the teaching and the learning.
3. During the period mentioned above, I will ask to observe in several lessons in which the teachers will implement the principles of teaching that were discussed at the meetings I have guided. The documentation of the observations will be in writing. After one of the lessons, in which an observation would be held, I will ask to interview every subjected teacher individually. The main target of the interview is to examine the teachers' conceptions regarding the significant maneuvers in class from their point of view in relation to ICT integration in biology studies and its effect on the motivation to learn and the understanding of the material due to the courses of learning and the evaluation tasks that have been conducted. The interview will be documented in writing as well. In order to cross-reference the information collected during the observations with the information collected in the interview I will write the name of the subjected teacher on the documentation sheets of the observations and interviews (no particulars identifying details of any other person shall be recorded except for the subjected teacher's himself).
4. I will ask to receive from the subjected teachers copies in writing of tests and evaluation tasks their students performed during the research period. As well as a report via "mapping forms",

that I will give them for the results of the tests and assessment tasks to be included in the teaching in the research’s framework. It should be emphasized that every identifying detail in the copies of the tests and the assessment tasks to be submitted must be deleted (before they are delivered) every detail that identifies the students. The "mapping forms" will also not record any detail identifying any student.

In addition to collecting the above information from the teachers, the collection of unrecognized information from the students is planned for the research, including the following:

1. A questionnaire for students who will examine professional and personal characteristics, **Motivation: internal competence and orientation, students’ attitudes toward meaningful learning with the integration of ICT in biology classes**, and will demonstrate the students' use of ICT in the lesson.
2. At the end of completing the above questionnaire, I will ask to conduct an individual interview with the students, in which I will ask them to relate to the learning processes in the subjects studied with the ICT integration. The interview will last for 15 minutes at most. In order to participate in it, each student would leave the class in coordination with the teacher. The students' interviews will also be documented in writing without specifying any detail identifying the interviewee or any other person.

All information from the students will be edited in a way that does not identify the subjected students, (the cross-referencing of the data collected from students from the various sources will be edited at a group level only). It is also important to clarify that:

1. I will ensure that the identification data collected about the teachers is kept confidential by storing them in a password-protected file known only to me and to the instructors of my work. I also undertake to permanently omit any identifying detail from the data that I collect immediately upon the completion of the processing of the findings or until December 31, 2018, whichever is earlier.
2. The research findings will be published in a way that will not allow the subjects to be identified.
3. The right of the teachers to decide not to participate in the research, as well as the right of those who have begun to participate, to cease their participation at any moment.
4. If you would like to receive more information about the research program, please contact me, my phone number- 0544636451.
5. If you agree to your participation in the study described, you are requested to fill in the enclosed letter of consent and submit it as soon as possible to the school secretariat.

Best regards, Ghalib Badarne, PhD student at the Tiraspol State University from Moldova

Appendix 3. Letter of consent from the teachers participating in the study to collect identified information

Dear Mr. Ghalib Badarne,

Re: My participation in the research on "**Integration of ICT in the process of teaching biology in junior high schools in Israel"**

Since you are doing research on "**Integrating ICT into the process of teaching biology in junior high schools in Israel"** and since you requested my consent to participate in instructional sessions under your guidance at school as well as my participation in information gathering activities that include identifying data about me.

I hereby declare:

1. That you have explained to me the research objectives and the topics and issues to be examined within it;
2. That you have explained to me all the actions and their content in which I will participate in this research;
3. That you specify the time at which the identification will be permanently deleted from the data collected about me;
4. That you have described to me the measure you will take to ensure the confidentiality of the identified data until identification is removed permanently;
5. Because you undertook that the findings of the study should be published in a manner that would not allow the participants to be identified after I understood all of the above, I hereby give my consent to participate in all of the aforementioned activities. The collection of the data, with my obligation to comply with the curriculum set in the Science and Technology (Biology) course in middle-school.

In witness whereof I have Signed

___________________	_________________________	__________________
Signature	Name of the teacher	Date

Appendix 4. Tests in biology for testing students' achievements before and after the experiment

A. Two mapping tests to test the level of knowledge for students in biology before and after the experiment (use of ICT).

1. First Test October 2017:

Al Ain Preparatory School - Kafreasif

A monthly biology exam 1 for the ninth grade

Student Name: ___________ class: _________

Circle in the correct answer, and detail your answer (40 Marks)

1) Observations in liver cells showed that the number of mitochondria in a cell is larger compared to skin cells. What can be deduced from this result?

1. Liver cells produce more energy than skin cells.

2. Liver cells within the body, which reach less oxygen than skin cells.

3. Skin cells also breathe without oxygen.

4. Cells in the outer skin layer are eroded and replaced faster than liver cells.

2) Plants are called products because they are:

1. Able to produce inorganic materials from organic materials

2. Dissolution of organic matter

3. Organic substances are produced from inorganic materials

4. Because they are not self-feeding

3) The tissue in the living body is:

1. A group of cells with a common function and a similar structure.

2. Sew a wound in the skin to stimulate wound healing.

3. Each group of cells connected to each other.

4. A group of cells of different types present in the same organ.

4) **Which group of the following material groups are organic materials?**

1. Complex sugars, albumin, vitamins and fat

2. Complex sugars, albumin, water and carbon dioxide Calcium salts, iron salts, water and oxygen

4. Enzymes, nitrogen salts, water and iron salts

5) The seeds get energy that needs to germinate straight from:

1. Mineral salts in soil.

3. Saving materials in which.

2. The oxygen in the soil. 4. Sunlight

6) The process that occurs in the mitochondria in the cells of the creature's body can affect its environment because:

1. This process releases oxygen into the environment.
2. This process reduces the amount of carbon dioxide in the environment.
3. This process reduces the temperature of the environment.
4. This process releases heat into the environment.

7) Which of the following materials can operate a source of energy in humans? Explain your answer using the equation of interaction of the process of cellular respiration and explain the base where this process occurs

1. Proteins
2. Sugars
3. Water
4. Iron and phosphate

8) common between starch and glycogen and fats:

1. They are savings materials and do not change the pressure in the cells
2. They are savings materials and change the pressure of the Osmozi in the cells
3. Regulates the osmotic pressure and insoluble in cytoplasm
4. Saving material and moving from one cell to another across the membrane

9) What is the source of cholesterol in the human body?

1. Part of it is built in the body and the other source of animal food.
2. Part of it is built in the body and the other is derived from vegetarian food.
3. Cholesterol is not built in the body and its source of vegetarian food only
4. Cholesterol is not built in the body and its source is animal food only

10) What can be said about water in the human body?

1. General and good solvent therefore constitutes a suitable medium for chemical reactions in the body
2. Inorganic materials, which is the main compound in the body in terms of quantity
3. There are many interactions in it but it is never shared
4. All answers are correct

<u>Section II: (60 marks)</u>

1. The process of oxidation of organic materials to produce energy in all living organisms.

A. Write the equation of the chemical reaction of the process, and in which cell occurs the cell?

B. The human body of 40 kg produces chemical energy (ATP) per day, but when examining the amount of energy in the cell we find it very low! Explain.

----

2. A herd of cattle is permanently grazed in a particular field. A carbon atom in the food eaten by a certain cow eventually reached the body of another cow. Describe a possible path of the carbon atom from the first cow's food until it reaches the body of the second cow.

----

3. In many patients, the patient is fed a glucose solution by injection into the vein, but sugar can not be injected with sucrose, for example. Because: He explained your answer using the advantages of glucose?

----

4. Sugars:

A)What is the importance and function of sugars in the body?

B) What is the basic building unit for sugars? ---

C) Indicate the difference between monoclonal, bilateral and complex sugars? Address the features ---

----

D) Can the cell membrane be made of sugars only? Explain your answer?

----

5. An alternative medicine company has published a drug that eliminates all cholesterol and fat in the body and leads to a reduction in blood levels to 0 mg / ml. Do you recommend using this medicine? Explain your answer?

With great success

Staff of biology teachers

2. Test Two December 2017:

Al Ain Preparatory School – Kafr easif

Biological examination 2 of the ninth class

Student Name: ___________ class: _________

Section 1: **<u>Circle the correct answer (20 marks).</u>**

1. The basic compound that gives the plant cell its shape is:

A – starch b – glycogen c – cellulose d – sucrose

2. When the human temperature approaches 42 ° C, there is a need to reduce the temperature, why is it important to reduce the temperature? (Answer your answer)

1. High temperature may cause high acidity of the body cells.
2. High temperature may damage the enzymes, thereby disrupting the basic processes that occur in the cell.
3. A high temperature may increase glucose analysis and thus lower blood glucose level.
4. Elevated temperature may increase the glycogen analysis of the liver, lowering the level of sugar in the blood.

3. Which group of the following materials are organic?

1. Complex sugars, albumin, vitamins and fat
2. Complex sugars, albumin, water and carbon dioxide
3. Calcium salts, iron salts, water and oxygen
4. Enzymes, nitrogen salts, water and iron salts.

4. Biologists discovered a kind of drug hinders the process of producing proteins in the cell, so it can be assumed that this poison affects: the answer to your answer

1. Mitochondria 2. Membrane cell 3. Ribosome 4. Cell wall

5. A multicellular organism whose cells are nuclei and without walls?

1. bacteria 2. fungus 3. animal 4. Plant

Section 2: **<u>Explain the following facts using an illustration (35 marks).</u>**

1. **Red blood cells entering a 0.9% solution Nacl (physiological solution) do not swell or contract.**

   ----

2. **Keep fruit jam in a concentrated sugar solution for a long time without rot.**

----

3. **Red blood cells inserted into the salt concentration in it is known and shrunk immediately.**

----

4. **How to cancel the plasmolysis of plant cells passed through the process of plasmolysis.**

----

5. **Eating a large amount of carbohydrates leads to high weight.**

----

6. **Eat a person with a meal rich in gluten, in his intestines sucking the amino acids into the blood until the concentration becomes zero in the intestines (address your answer to the ways of crossing the material).**

Section 3: **<u>Answer the following questions (45 marks).</u>**

1. **Slim complained of fatigue and tiredness, after testing that he suffered from anemia. The doctor advised him to eat meat, liver, grains, legumes and green vegetables. What are the salts in these foods that help to treat a healthy disease? (Answer your answer to hemoglobin and red blood cells).**

----

2. **Sami drink without knowing anything about him and as a result felt tired and tired and found after tests that the poison inhibits the work of mitochondria. Explain what is the relationship of mitochondria to fatigue and exhaustion? (Address your answer to the process of cellular respiration and chemical reaction equation).**

----

3. **Cell membrane** (10 marks):

   A. **Describe the relationship between the cell membrane structure and the functions it performs? Discuss your answer to the characteristics and qualities of the membrane (use a drawing).**

   B. **Why when they slowly copy a red beetroot into the water at a temperature of 60°C, the water becomes red? Explain**

----

4. **Explain what happens if we put animal cells and plant cells in distilled water? Use drawing (6 marks)**

----

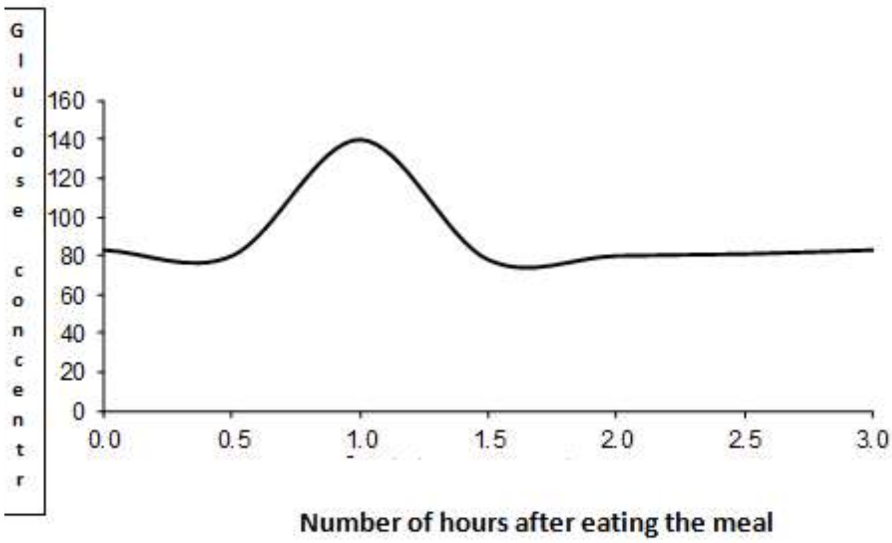
5. **Explain how (in any way) this situation is saved:** (6 marks)

   The concentration of K potassium ions within a moss cell is 500 molar (Mm) and its concentration in seawater is 10 molar? Use a drawing.

----

6. **The following diagram shows the results of a blood glucose concentration test following a meal (time 0 = meal time) (10 marks).**

   A. Depending on the drawing, what is: related variable ------- Independent factor ----------



B. What is the reason for the high concentration of glucose in blood after an hour of eating the meal? Explain your answer.

C. What is the cause of low blood glucose concentration after an hour and a half of eating the meal? Explain your answer.

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Staff of biology teachers

B. Two tests for testing students' knowledge of biology after the experiment (use of ICT).

1. Third test in March 2018:

Al Ain Preparatory School – Kafr easif

Biological examination 3 of the ninth class

Student Name: ___________ class: _________

Section 1: Circle the correct answer (27 marks).

1. What is the difference between photosynthesis and cellular respiration? Write the two interaction equations for the two processes.

A. The process of photosynthesis occurs in the plant while the breathing process does not occur in the plant

B. In photosynthesis, oxygen is released as a result of burning sugar while in the breathing process carbon dioxide is released as a product of sugar building.

C. In photosynthesis, oxygen is released as a result of sugar formation. In the breathing process, carbon dioxide is released as a result of sugar burning.

D. Breathing occurs only at night while photosynthesis in the day.

2. What is the function of proteins in the body?

A. As a primary energy source for cells in the organism's body.

B. To prevent loss of body temperature and to protect organs from injuries.

C. To build cells, tissues and chemical processes that occur within them.

D. As storage materials in plants and animals.

3. What could be a possible measure of the frequency of photosynthesis?

A. The amount of oxygen absorbed in the unit of time.

B. The quantity of heat discharged in a time unit.

C. The amount of light absorbed in a time unit.

D. The amount of carbon dioxide released in a time unit.

4. In a hot and dry development house is expected to find in the foundation?

A. Plants with branch roots and large leaves.

B. Plants with branch roots and small leaves.

C. Plants with roots and branches and large leaves.

D. Plants with unbroken roots and leaves.

5. What phenomenon is an example of a consumer-producer relationship?

A. Rats eat plant seeds. B. snakes eat rats.

C. a person eating fungus. D. plants that absorb salts from the soil.

6. What damage may be caused to the biosphere Increase the amount of sandy space in the forest?

A. high concentration of CO_2 in the atmosphere due to low amount of photosynthesis.

B. The high concentration of oxygen in the atmosphere due to the low amount of photosynthesis.

C. Low CO_2 concentration in the atmosphere due to low photosynthesis.

D. High concentration of oxygen in the atmosphere as a result of low breathing.

7. Any process that distinguishes all living creatures?

A. Analysis and synthesis of compounds by enzymes.

B. Release of oxygen O(2) as a result of analysis of carbon compounds.

C. the stabilization of atmospheric nitrogen in nitrogen compounds.

D. Composition of vehicles by absorbing carbon dioxide from the atmosphere.

8. The size that the cell can reach is limited by:

A. Quantity of oxygen in its surroundings.

B. The quantity of dissolved substances in their vicinity.

C. The ratio of its external surface to its size.

D. The efficiency of the organism's transport device.

9. Any process from which you consume energy? Explain your answer?

A. Entering the materials of the propagation process into the plant cells.

B. Transmission of CO_2 gas from the cells of the body to the capillaries.

C. Water transfer through the cell membrane.

D. Sodium - potassium pump.

Section 2: **<u>Read the sentences and the following issues and explain them and give an example if necessary, (answer 5 of 6) (25 mark).</u>**

1. In recent years there has been a rise in the concentration of carbon dioxide in the atmosphere. What is the likely conclusion that caused this phenomenon?

____

____

2. When the human temperature approaches - ° C40, there is a need to lower the temperature.

____

____

3. The relationship of competition also exists in plants.

____

____

4. Lower layers in aquifers are dominated by anaerobic conditions despite the ventilation of the upper layer water in aquifers.

____

____

5. When doing a physical activity, we release more carbon dioxide, compared to the amount we release during rest.

____

____

6. Mitochondrial damage can damage the activity of the cell membrane.

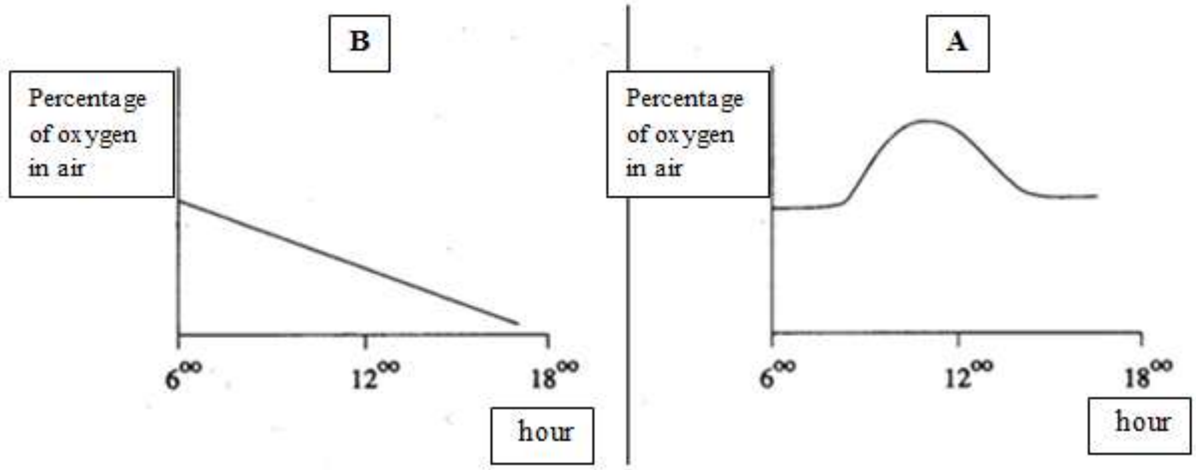
____

____

Section 3: **<u>Read the following information carefully and then answer all questions followed.</u>**

Question 1 (16 marks): Enter two similar plants with similar plants into two greenhouses, from 6 am to 6 pm. Insert one of the tubes into a light-emitting greenhouse, and insert the second pot into a non-light greenhouse. The rest of the other conditions in the two greenhouses were similar, and both were humid and the soil irrigated. Figures A and B show the percentage of oxygen measured during the experiment in the air inside the greenhouses.

A. What curve shows the plants that were in the light-emitting greenhouse, and which curve shows the plants that were in the non-light greenhouse? Explain how you have identified this.



B. Why is it important to mention that the conditions were similar in the two greenhouses?

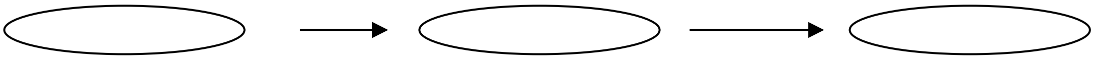
C. What is the importance and function of chlorophyll molecules in the process of photosynthesis?

D. What is the relationship between light intensity and the frequency of photosynthesis?

Question 2 (16 marks): In one of the agricultural villages farmers planted wheat, and lived in the fields of rats, which were fed on the seeds of wheat. Also lived in this area birds of prey - effective at night - which were fed on rats.

At a certain stage, the rats multiplied significantly and were affected in the wheat seed product, making the farmers spray a pesticide against the rats. Many of them have already died, but the birds that feed on the dead rats also died.

A. Describe in the following chart the food chain that is described in the piece.



B. What happened to the rats after spraying the pesticide?

____

____

C. What is the cause of the death of birds of prey?

____

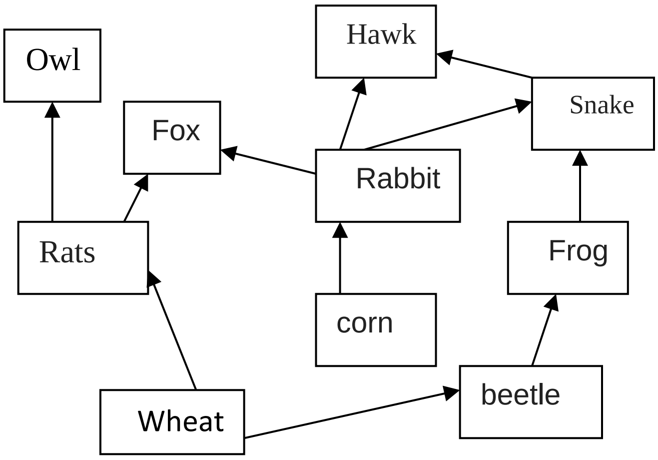
____

D. What happens to your number of rats after several months? Why?

____

____

Question 3: Consider the following chart and then answer the questions that follow (16 mark).



A. What organisms represent secondary products and consumables that appear in the scheme?

____

____

B. If the frogs are extinct, what do you expect to happen to the clan of beetles and aphids? Why?

____

____

C. What would happen if a farmer sprayed the wheat field with lethal chemicals for the rats?

D. Usually the ecological pyramid (the pyramid of the biomass) becomes more narrow with the elevation of a certain level of nutrition to the next level. Explain why?

With great success

Staff of biology teachers

2. Fourth test in May 2018:

Al Ain Preparatory School **– Kafr easif**

Biological examination of the ninth class

Student Name: ___________ class: _________

Section 1: **<u>Circle the correct answer (45 marks).</u>**

1. Choose a list of terms that describe the level of organization in the cell from the smallest to the largest.

A. chromosome, cell nucleus, cell, DNA, gene B. Gene, DNA, chromosome, cell nucleus, cell

C. DNA, gene, cell nucleus, chromosome, cell D. cell nucleus, gene, DNA, chromosome, cell.

2. Girls get X chromosomes?

A. Father B. From mother C. Of parents Monday D. Do not get at all.

3. What do we mean by genetic status?

A. common denominator for all members of the family.

B. The character of the worker being transferred from one generation to another.

C. an attribute whose factor is affected only by the environment;

D. Appears in every generation and generation.

4. How to keep the number of chromosomes constant in the same type over generations?

A. Because the reproductive cells contain half the number of chromosomes contained by the somatic cells.

B. In the fertilized egg, half of the chromosomes are dissolved.

C. Because the first division of the fertilized egg is a meiosis.

D. because after the fertilized egg unite the chromosomes are identical.

5. The function of large intestine:

A. Absorption of organic matter

B. Digest proteins and convert them into amino acids

C. Absorption of water and salts

D. Digestion of fats and converted to fatty acids and glycerol

6. The membrane of the cell has a dynamic structure, what can be said about this membrane?

A. A two-layer compound composed of phospholipids and amino acids

B. Maintains stable internal environment different from external environment

C. Can accommodate signals from the external environment to the internal environment

D. All answers are correct

7. Anaerobic breathing is appropriate for an environment:

A. Low carbon dioxide B. Low oxygen C. Low water D. Their temperatures are low

8. Which of the following operations is most likely to be affected if one person's large intestine is shortened?

A. Absorption of amino acids into blood B. Absorbing water into the blood.

C. Absorbing sugars into the blood. D. Absorbing lipids into the blood.

9. Amylase, found in saliva, analyses starch into simple sugars. If we add the enzyme amylase to the proteins, it will not decompose because:

A. Proteins are very important for cell survival.

B. Proteins are large molecules.

C. Enzyme activity - Specialized in a specific substance

D. The amount of enzyme decreases with time.

10. In the small intestine in humans:

A. There are bacteria that produce insulin

B. Produce urea excreted with urine

C. Final analysis of the food and its absorption into the blood

D. Produces white blood cells

11. Fat can be used in the body as:

A. Savings materials B. Insulation materials against heat loss

C. Basic Materials in Energy Extraction Processes D. All answers are correct

12. The basic chewing of food accelerates digestion, because the smaller the particles of food?

A. Particles seep more easily into blood.

B. The surface of food contact increases with enzymes.

C. The particles fall easier in the gastrointestinal tract.

D. The particles are excreted easier than the body.

13. Which of the following substances cannot be digested by humans? Why?

A. Glycogen B. Starch C. Cellulose D. Vegetable protein

14. In the digestive system there is a mechanical treatment of food mainly:

A. In the mouth and in the esophagus. B. In the esophagus and in the stomach.

C. In the small intestines and in the stomach. D. In the mouth and in the stomach.

15. Arranging the stages in which the starch passes until its compounds are used to produce energy in muscle cells:

A. Absorption, entry into the cell, digestion. B. Enter into the cell, digestion, absorption.

C. absorption, digestion, enter into the cell. D. digestion, absorption, entry into the cell

16. A significant rise in the number of white blood cells can be due to:

A. Feeding is not balanced B. High blood pressure

C. Bacteria entered into the body D. Lack of sleep and fatigue

Section 2: <u>Check and then answer the following questions (55 mark).</u>

Question 1: You have a list showing concentrations of different substances in the blood entering the kidney and in the urine (12 marks).

	Concentrate (g / 100 ml) in	
Material	**Blood**	**Urine**
Glucose	0.10	0.00
Salts	0.32	0.35
Water	95	80
Urea	0.03	2.00

A. Explain on the basis of the list the important role played by kidney?

B. Explain why the amount of water coming out with the urine is low and concentrated, when the worker working in the field on a summer day?

C. According to the list of concentrations of different substances mentioned above, do you think this person is diabetic? Explain

----

Question 2: Explain the following processes (10 marks)

A. Insulin injections into the blood of a fasting and healthy person can pose a threat to his life. Explain the mechanism of his work?

B. What can damage the eradication of the yellow sac (gallbladder bag)?

Question 3: Starch is a multi-sugar, Saliva contains an enzyme that analyzes starch into monosaccharides. Students conducted an experiment examining the effect of saliva on starch. For each of the tubes 1 and 2 added an equal amount of starch, the tube 1 added saliva while the tube 2 added saliva which boiled before the experiment. Watch the drawing that describes the course of the experiment. (7 marks)

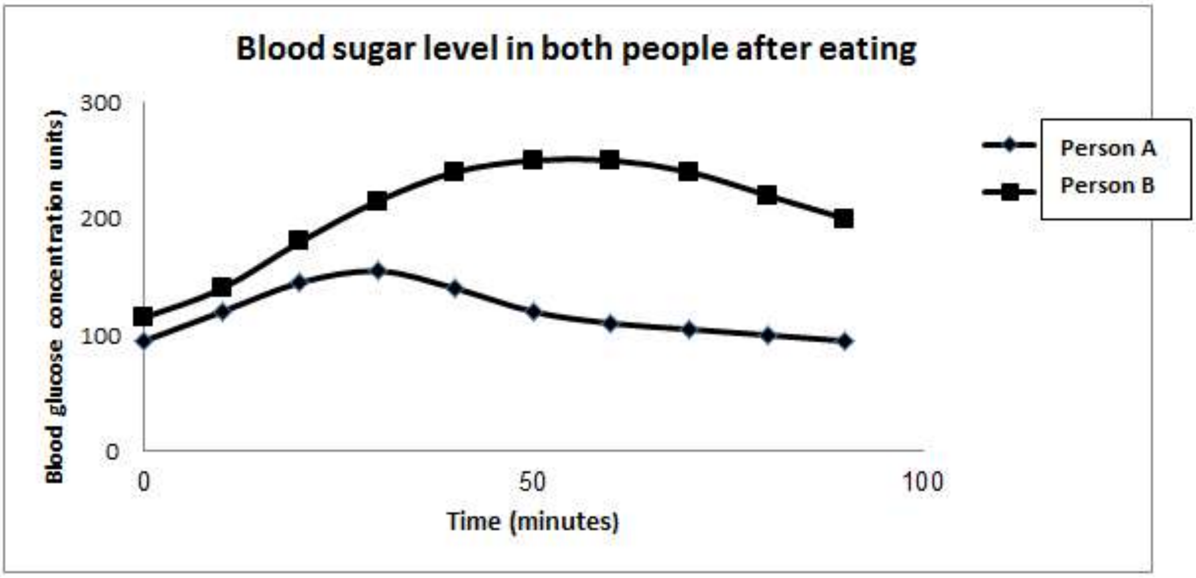
Tube No. 1 Tube No.2

10 minutes after the start of the experiment, each of the tubes added material (detector). Which changed colour to yellow with monoclonal sugars (eg, glucose). The students saw only a yellow colour <u>in one of the tubes.</u>

A. Write in any yellow coloured tube. --

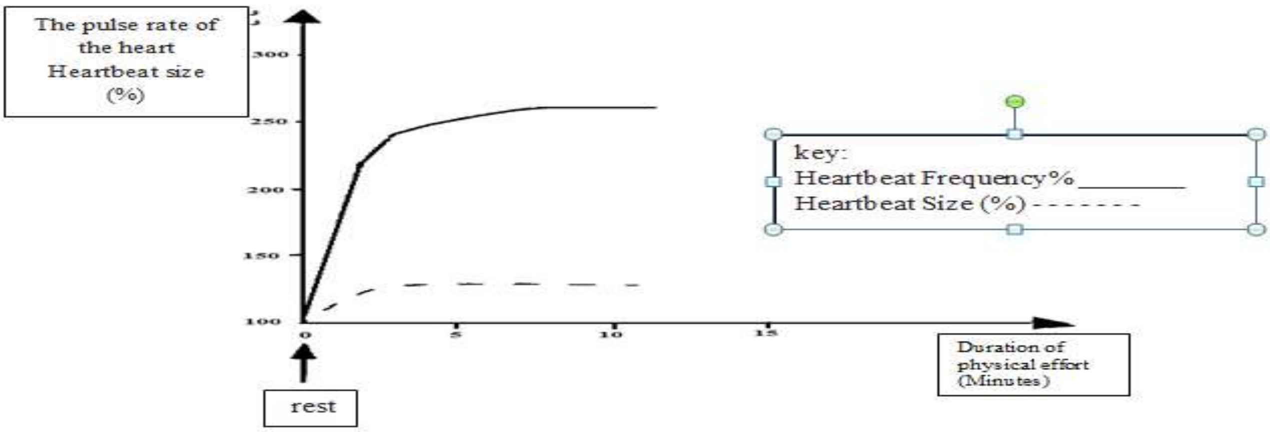
B. Suggested an explanation for the difference in the results that appeared in the tubes**.**

Question 4: Two people (A and B), one diabetic and the other healthy, ate an equal amount of sugar (glucose). Then, within an hour and a half, they examined the concentration of sugar in people's blood. (6 marks)



Which person is diabetic? Explain your answer.

Question 5: The graph before you describes the relationship between the duration of the physical effort and the frequency of the heartbeat and the size of the heartbeat of a particular person. (Value 100% refers to the two values during rest) (12 marks).



A. Explain how to increase the pulse size the increased heart rate, described in the graph, can perform physical exertion?

B. Explain why the frequency of inhalation and exhalation increases during the physical effort?

C**.** Explain how to get rid of excess heat resulting from the performance of physical effort?

Question 6: Explain the following phenomena (8 marks)

A. The enzyme Pepsin, which is released from the wall of the stomach, is active only in the stomach and when it reaches the Duodenum stops its activity, explain why?

B. How to fit the installation Small intestine function?

With great success

Staff of biology teachers

Appendix 5. Online assignments given to students during the experiment

Task 1: The Great Food Research

There are a number of foods on most families in Israel: cereals, cheese, dairy delicacies, hummus, ready schnitzel and more. Each such dish is produced by different companies trying to compete. There are many types of cereals, a large and varied amount of dairy delicacies, humus of various kinds. Common to all these food companies is that each company claims its product is the healthiest product. In this activity, you will examine the food ingredients in the products of the various companies, compare them and check whether there is really a difference between the companies. If there are differences, what? Which company provides a healthier product? Or in the case of snacks and soft drinks Which company provides the least harmful product?

Types of food are possible for testing:

- cereal
- Dairy delicacies
- Cheese
- Snacks
- Soft drinks
- Hummus
- Industrial Schnitzel

The class will be divided into teams, and each team will conduct research on a particular type of food. At the end of the process, each team will present its results and recommendations to the class. The research will be based on the tables of the food groups that appear on each product according to the law.

Stage A - Data Collection

Collect tables of food ingredients of products that belong to your food type. The food tables are on the product cover. The best way to collect the tables is to photograph them. You can photograph tables of products in your home or go to the supermarket or the nearest store and take a picture there.

Two images must be taken for each product:

1. The product itself - so you know which product each table belongs to.
2. Table of product components - Take a picture of zoom because the tables are small.

It is important that you find a method for how to associate each table of food ingredients with its own. Save all the photos you've collected on your computer and upload them to the presentation. In each slide, the product image and the picture of the food ingredient table will appear clearly.

Stage B - Writing the data

Open the presentation you created. Create a spreadsheet file and insert the data about each company's food ingredients as they appear in the food ingredients table. It does not matter if you still do not understand exactly what each ingredient means.

Enter your data very carefully for your investigation to be accurate.

Note the units of measure:

1. Most of the tables refer to the amount of ingredient in 100 grams. Since this is a comparison, it is important that we always enter data about the same quantity.

2. There are components measured in grams and there are those measured in milligrams. Be sure to insert identical units into the table.

Product name	**Company**	**Ingredient 1**	**Ingredient 2**	**Ingredient 3**	**Ingredient 4**	**Ingredient 5**

You can work in a collaborative file and share your work.

Stage C - Know the ingredients of the food

You've built a file and put the data into it, but what does it all mean? What is each ingredient? Explore the subject online.

Find out:

What is each ingredient?

Is it healthy food? Harmful? Does not affect?

Write a brief summary of each component. This summary will help you present the subject to the class.

Stage D - Data Processing

Once you have understood each component, you can start the product rating work.

Open the spreadsheet you built in step B and look at the data.

Think:

According to what should you rate the products?

Checking which component will help you understand which product is healthier?

What do all the products have in common?

Is there a significant difference between the products?

Write a few questions to help you rank your products.

The spreadsheet allows us to sort the data each time according to another question.

Sort the data in the sheet according to the questions you have entered.

Video, Sorting in a spreadsheet

Stage E - Creating a presentation for the presentation to the class

Gate	The type of food you have checked
The products you have tested	The products you have reviewed are accompanied by photos
The ingredients	The common ingredients in all products and an explanation of each component
The questions	The questions you have written and examined
The results	View each question and the numbered sheet that answers it
Conclusions	The conclusions can be drawn directly from the data
Recommendations	Which products do you recommend using?

Once you have reviewed all the product data, you must present the process and results to the class. Build a presentation that includes the following slides:

Task 2: Vegetarian Nutrition

Plant nutrition

Read the next piece, and enter the link, [Is vegetarian food healthier than eating meat?](#)

A duty to the questions that follow.

Many scientific studies suggest that vegetarian food (plant-only) may lead to vitamin B12 deficiency, because plants do not produce vitamin B12. The deficiency of vitamin B12 mainly leads to a defect in the process of producing red blood cells as well as affects the cells of the digestive system and nervous system.

The most difficult phenomena that can result from vitamin B12 deficiency are anemia (a low concentration of hemoglobin in the blood, and probably a decrease in the number of red blood cells) and injury to the nervous system.

Dutch scientists studied the development of 72 boys aged between 15 and 9 years.

A group of 48 children ate only vegetarian food during the first six years of their lives. Without dairy products and without eggs.

Scientists have found that some children are deficient in vitamin B12. Group B consisted of 24 children, who ate vegetarian and animal food.

Scientists found that vitamin B12 in their body was normal. Scientists examined the mental abilities of boys in both groups.

They worked for the two groups some exams that measured their mental abilities. The results of the tests indicated that the children in group (A) had less success than the children in group (B). In addition, there were many symptoms of botanical children indicating the deficiency of vitamin B12, although the vegetable boys ate in the seventh year of their food As well as vegetarian food.

Question 1: Refer to foods containing vitamin B12.

Beef, wheat bread, Milk yogurt, eggs, Orange, chicken breast

Question 2: What is the "independent" variable in the above study?

A. The mental abilities of children who fed animal food during the first six years of their lives.

B. The mental abilities of children who fed vegetarian food during the first six years of their lives.

C. Source of food fed by the two groups during their first six years.

D. Effect of vegetarian food on the mental abilities of children.

Question 3: Why did Dutch scientists study the development of children who fed animal food during their childhood?

____

____

____

Question 4: Vegetarian food omaima also feed on eggs and milk, She have read Dutch research, and decided to continue feeding her young children a vegetarian food that is similar to their diet. Refer to the appropriate explanations for the Omayma decision in your opinion (may be more than one answer):

A. Search results are not valid in the State of Israel.

B. Feeding the boys who were examined in the research is different from the nutrition of the mother and her children.

C. We can not conclude general conclusions because of the small number of children Who participated in the research.

D. Vegetables in Israel contain vitamin B12 and in the Netherlands do not.

E. The children of Omaima have high mental abilities.

Question 5: A group of scientists want to examine whether vegetarian food in the first six years of a child's life will affect their mental abilities in the future. They suggested to scientists how it could be checked?

___

___

___

Question 6: Give two advice to a vegetarian girl who is deficient in vitamin B12.

___

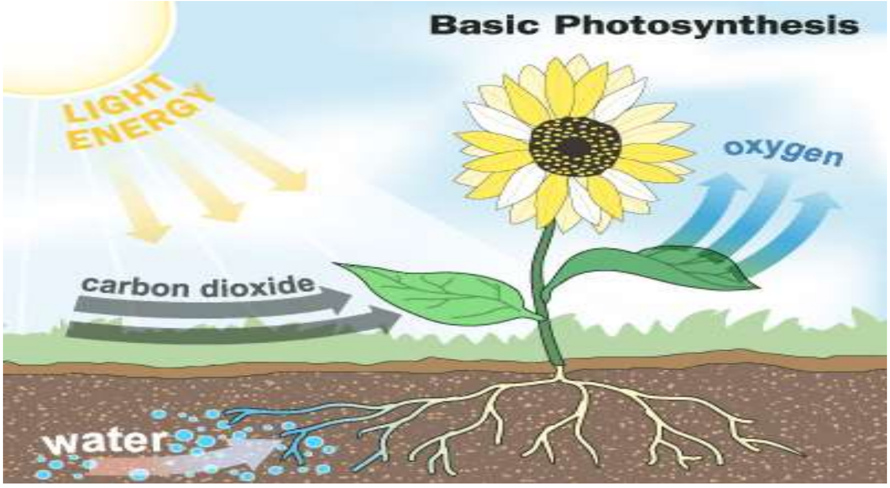
___

___

Fun work ☺

Task 3: Photosynthesis and the respiratory process

Photosynthesis and the respiratory process



Dear students please login to the site and follow the tasks as required: photosynthesis

On your books summarize the information so that you can learn and progress in the rest of the tasks.

1. They crossed through a stock chart for:

   Breathing process in plants: ____

   Process of photosynthesis: ____

2. What is the process of breathing in plants?

   ____

3. What is photosynthesis in plants?

   ____

4. Build a "banner" that reflects the two processes (you can use the balls and the colors attached)

   Let's go forward and learn more ....

5. Factors involved in the process of photosynthesis:

   ____

Please log in and answer questions in your books ...

Light**....**

<u>Are all spectrum required for photosynthesis?</u>

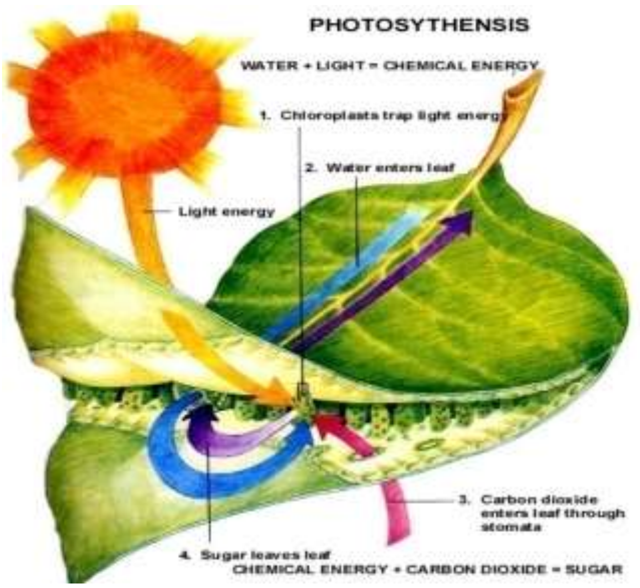
Please answer questions in your books

What is the appropriate search query for this experiment: ______________________________?

What is the purpose of this experiment:____

In this experiment, the influencing factor is ____________, the affected factor is ____________

Complete the following table:



The relationship between wavelength (nanometer) and the intensity of photosynthesis	
Wave length (nanometers)	Intensity of photosynthesis (%)
40	
50	
60	
70	

At what wavelengths of light was the intensity of photosynthesis higher in the experiment?

____

At what wavelengths of light did light fixtures occur, or was the intensity of photosynthesis particularly low? ____

How can photosensitivity be determined? ______________________________________

____

What is your conclusion from the results you have obtained? _______________________

____

A delightful and interesting work ☺

Task 4: Genetics - Mendel's Laws

Mendel's Laws

<u>Watch the movie that describes Mendel's experiments on the pea plant and then answer the following questions:</u>

Link to the movie: https://www.youtube.com/watch?v=sTEixbYJ6Ss

https://www.youtube.com/watch?v=Q18uV2-xC-Q

1. What qualities did Mendel look at in his experiments on the plant of the peas according to the film?____

____

2. What genetic terms are mentioned in the film. Know these terms.

____

3. Why did Mendel choose a pea plant for his experiments?

____

4. Define the phenotype (the model). ____

5. Explain how Mendel prevented self-vaccination in the flower of the peas.

____

____

6. How did Mendel prevent access to pollen granules from an unknown source of pea plant?

____

7. When Mendel gathered the results of his experiments he observed certain phenomena. What are these phenomena? ____

____

8. What analyzes and interpretations did Mendel propose to explain its results?

____

____

9. How did Mendel get the second generation? ________________________________

____

10. What laws did Mendel derive from the results of his experiments? _________________

____

11. Did Mendel search all the qualities in one experiment (in one plant)? _______________

A delightful and interesting work ☺

Task 5: Genetics - Choose your baby's sex

Choose your baby's sex

Read the next section, and enter the link to the film for the following questions.

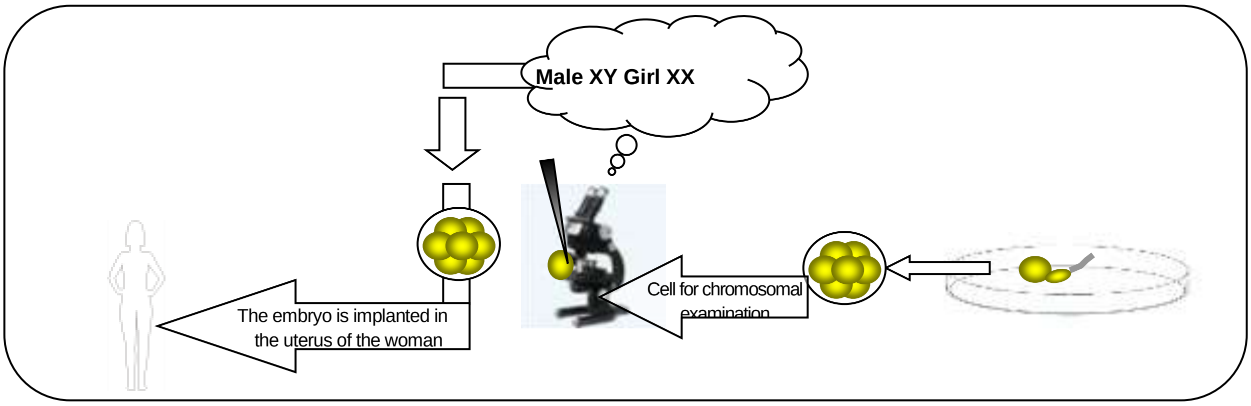
https://www.youtube.com/watch?v=WAA7ZIhnwTU

It was published in the newspapers on 02/10/18 that for the first time in Israel, the Ministry of Health agreed that parents should choose in advance the sex of the fetus, which will grow in fertilization outside the body.

This approval is unusual and is given only in special cases such as families with genetic diseases that affect only males.

How do they choose the sex of the fetus in fertilization outside the body? They take out eggs from the woman's ovaries and fertilize them outside the body. Embryos grow after fertilization. The embryo is then divided into 8 cells, and they take only one cell for examination. This process does not affect the development and growth of the fetus in the future.

The cell, which is separated by special material to examine the type of chromosomes in the nucleus, and we can by the results of the examination to know the sex of the baby, If the chromosomes are XX, the embryo will be female, but if the chromosomes are XY The fetus will develop into a male. The following diagram describes: the process of fertilization outside the body, selection of the fetus and implantation in the mother's womb.



Question 1: Doctors explain to parents that half of the embryos resulting from fertilization outside the body are female embryos. Draw a diagram showing how the expected ratio will be between males and females, and then refer to the genotype and model.

Question 2: Say next to each of the following sentences <u>true or false.</u>

A. The sex of the fetus is determined by the chromosomes of the egg. True / False

B. The sex of the fetus is determined by the existing chromosomes In sperm cells. True / False.

C. The identical twins are made up of one egg fertilized with two medium cells. True / False

D. Each of the first eight cells in the embryo, contain On genetic information. True / False

E. Each of the first eight cells in the embryo, contains On the same number of chromosomes. True / False

Question 3: The character of colour blindness, a recessive attribute called "sex-related attribute", is found in males more colourless than females. The gene responsible for colour blindness exists in the chromosome. A man with a colour vision married a woman with a healthy vision. The woman gave birth to a boy with a healthy vision, and a girl suffering from colour blindness. What is the genotype of the mother?

A. Homozygote is recessive B. Homozygote is dominant

C. Heterozygote D. We can not determine.

Question 4: A man and his wife came to the genetic counselling clinic. They wanted to have children, and they had read in the paper about a genetic disease called Tai-Zex. They asked to know if there was a possibility that they would have children with the disease.

Write two questions to the genetic counsellor to ask them about the man and his wife about their condition, so that they can answer their question.

____

____

Question 5: Treatment of reproductive problems and prenatal examination of the fetus costs the state very high sums. Indicate in the right place how much you agree with the following terms:

	OK	Not OK	No Opinion
A. Embryo screening is performed only if there are people in the parents' family who are suffering from genetic diseases.			
B. Every man and his wife must determine the sex of the baby by examining the fetus before birth.			
C. Pre-selection of the sex of the baby is undesirable interference, and disrupts the balance in nature between males and females.			
D. Every embryo is given the right to survive even if it has a genetic defect.			

A delightful and interesting work ☺

Task 6: Genetics - Down Syndrome

Down Syndrome

Read the next section and then click on the link and watch the movie and read the article and answer the questions.

The link of the film and the article entitled: What causes the birth of a child Mongolian?

http://mawdoo3.com/%D9%85%D8%A7_%D8%A3%D8%B3%D8%A8

Tamer was born to a 51-year-old boy. He was observed to be different from the rest of the children in the hospital. His face was wide and his eyes were oblong to the sides. These qualities remind us of a great similarity between him and the Mongolian people.

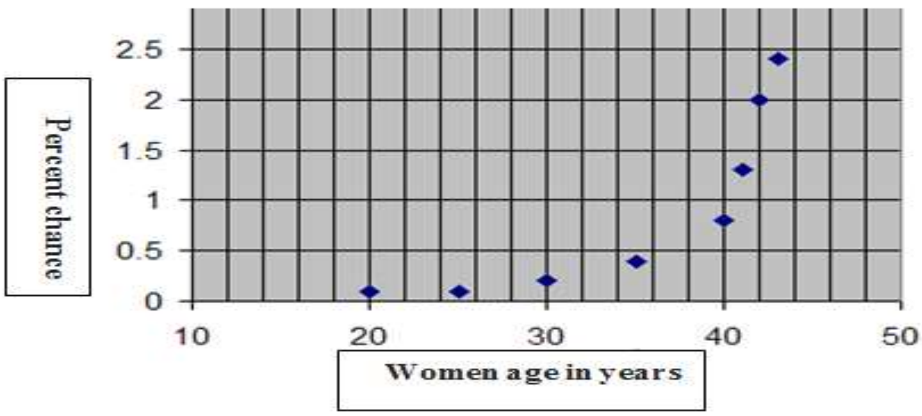
The doctor explained to the parents that their son was suffering from symptoms of Down (Mongolian).

The name of the disease is named after Doctor Down, whom he described for the first time. The doctor added that people suffering from the disease suffer from a weakness in the mind. This vulnerability can be of varying degrees.

In the cells of the body with Down's symptoms there are three chromosomes of chromosome 21 instead of two.

Various studies have shown that a 35-year-old baby with Down's Lam is more likely to have a mother than a younger mother.

The following diagram describes this relationship: the relationship between the mother's generation and the probability of having a child with Down's syndrome (Mongolian).



Question 1: Today, we can examine the possibility of three chromosomes of chromosome 21 in fetal cells, by means of a liquid fluid test. This test is performed at week 16 of pregnancy. The costs of this screening are prohibitive, so the patient funds fund this screening only for pregnant women aged 35 and over. **Explain why do patients' funds fund this screening only for women aged 35 or over?**

____

____

Question 2:

A. According to the data, calculate how many children will experience Down's symptoms, from 100 births to women aged 42____

B. A woman gave birth to a child with Down's syndrome when she was 40, and two years after she was born, she wanted to have another child. What is the probability of having a child with Down syndrome?

A. 0 % B. 2 % C. 0.8 % D. We do not know

Question 3: Say next to all of the following sentences, True or False:

A The total number of chromosomes in the body cells of people Suffering from Down syndrome is 47 chromosome. True / False

B. The fertilized egg with Down syndrome will develop into Embryo, containing three chromosomes of chromosome 21. True / False

C. In the body cells a woman gave birth to a child suffering from Down syndrome, there are 21 chromosomes. True / False

D. The number of chromosomes in the body cells increases in women Aged 35 and over. True / False

Question 4: Pregnant women who have been tested for amniotic fluid, and found that each of them carries a fetus with Down's symptoms, the doctor advises after consultation, to consider the possibility of artificial abortion. **Write one explanation that supports the idea of artificial abortion, and one does not support the idea.**

____

____

Question 5: Point in the right place to the extent of your consent to the following words:

	OK	Not OK	No Opinion
A. It is strictly forbidden to advise a pregnant woman to undergo an artificial abortion.			
B. Only parents decide to perform artificial abortion for a fetus with Down syndrome.			
C. Artificial abortion is recommended for a fetus with Down syndrome.			
D. We recommend a woman who is 40 years of age and older but not pregnant.			

A delightful and interesting work ☺

Appendix 6. Indicator for alternative assessment in biology by presentation

Target Audience: 9th graders studying biology in science classes.

Justification: The preparation and presentation of PPT presentation to the class develops skills for intelligent search of information, organization of information in a given framework of content and time, a distinction between primary and secondary, the ability to present information in concise, clear and different forms (verbal and visual).

Instructions for students to prepare a presentation.

The student will present a topic chosen in coordination with the teacher. The presentation should include:
1. Four slides + slide with the presentation theme and the presenter's name
2. Make sure the slides contain a few words and lots of visual information: pictures, illustrations, animations, etc.
3. One of the slides will contain quantitative information. Ie, information expressed in numbers in a table or graph. (Optional) Do not forget to give a title to a table / graph, headers for columns / axes and units if needed.
4. The play time in the class is between 5 and 7 minutes. Absolutely no more than 7 minutes. It is important to practice at home with a watch. You do not want to talk fast - it's better to focus on fewer things that are clear than many details.
5. The presentation should contain at least two concepts from the biology curriculum.
6. Consider every detail you put into the presentation: Can you explain it? Is it really important to understanding the subject? If the answer to one of the questions is "no" - and give up!

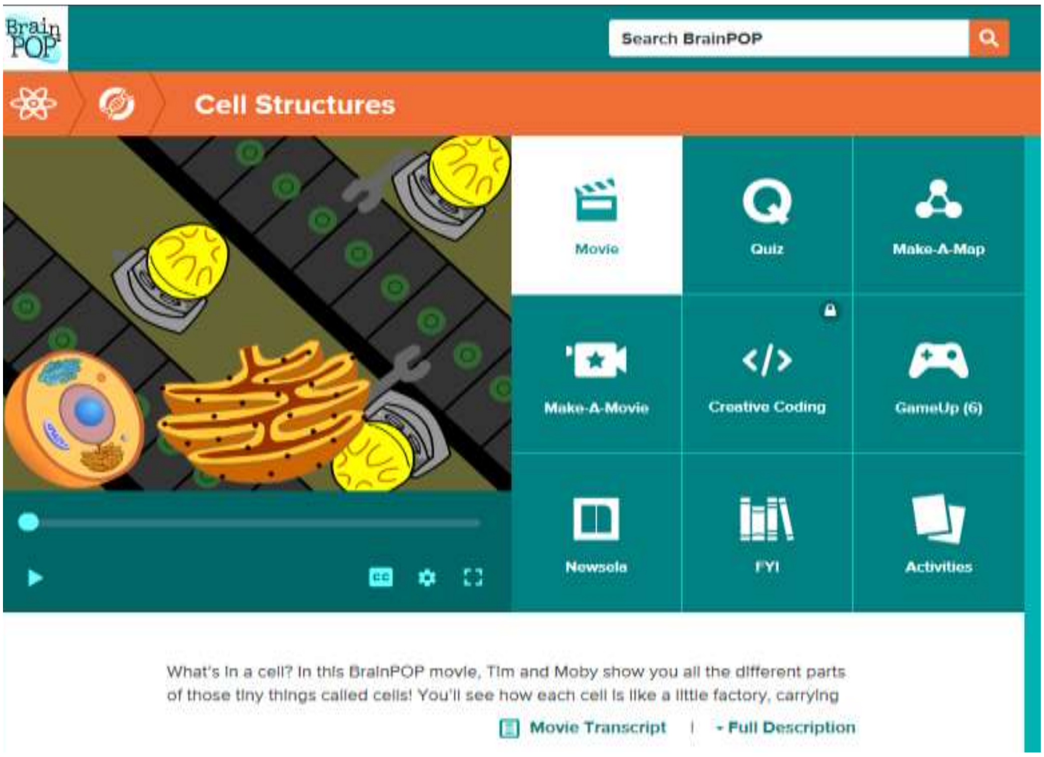
Evaluation

The index can also be used for peer assessment, and to weigh the grade received from students with the teacher's score.

	Indicator for evaluation of subject display
Contents	Presentation of biological principles and processes (scientific level) [20%]
	Clarification of explanations [20%]
	A link to concepts (at least two) or principles (at least one) that we learned [20%]
	Quantitative presentation - Is the information important, has it been explained clearly [10%]
A visual aspect	to what extent the illustrations contributed to the understanding of the content [20%]
	Organization Presentation: The ratio of text to images, size and clarity of images [10%]
Bonus	creativity and originality [up to 10%]

Appendix 7. Websites in Biology

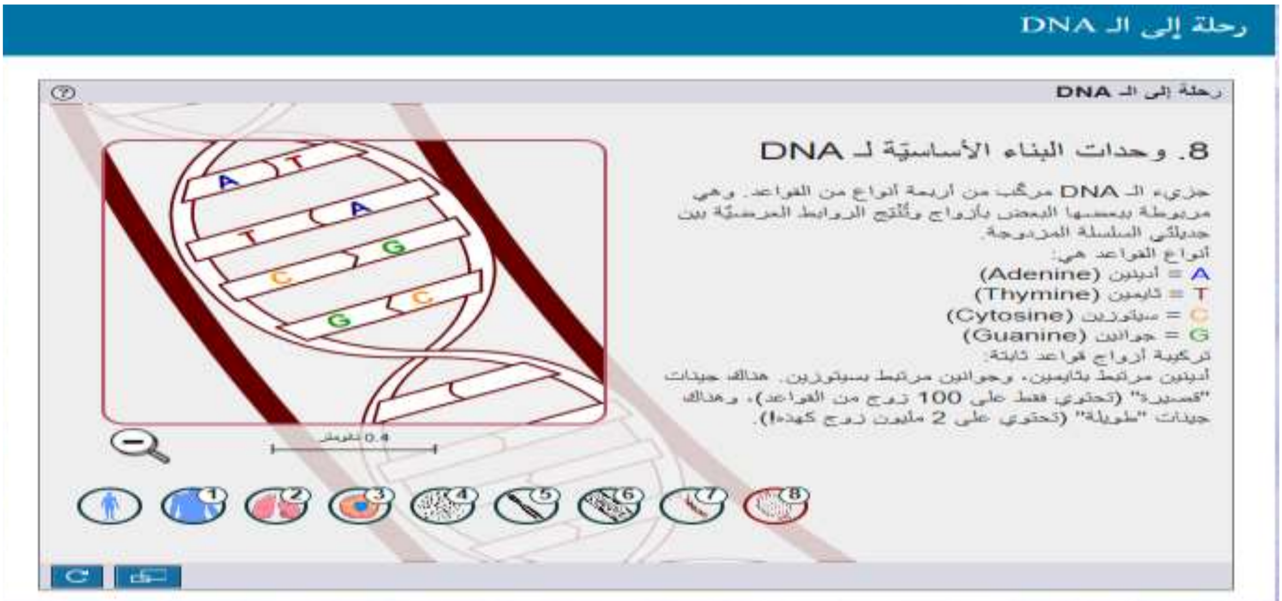
A. Brain pop: https://il.brainpop.com/category_8 /



B. The digital school bag - Center for Educational Technology

http://ebaghigh.cet.ac.il/%D7%9E%D7%90%D7%92%D7%A8/%D7%97%D7%98%D7

The journey to DNA



C. A game who wants to be a millionaire

D. Secondary school site - Al Ain, https://sites.google.com/a/ein.tzafonet.org.il/ein/

Appendix 8. Lycart Results - Statistical Tables Outputs SPSS

```
ONEWAY motivation Attitudes Meaningful BY class
  /STATISTICS DESCRIPTIVES
  /MISSING ANALYSIS
  /POSTHOC=TUKEY ALPHA(0.05).
```

Oneway

Notes

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ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
motivation	Between Groups	2.007	4	.502	2.109	.083
	Within Groups	32.130	135	.238		
	Total	34.137	139			
Attitudes	Between Groups	1.451	4	.363	1.697	.154
	Within Groups	28.864	135	.214		
	Total	30.315	139			
Meaningful Learning	Between Groups	1.428	4	.357	1.544	.193
	Within Groups	31.229	135	.231		
	Total	32.657	139			

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Class	(J) Class	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
motivation	Ninth 1	Ninth 2	-.04643	.13038	.997	-.4069	.3141
		Ninth 3	-.20357	.13038	.525	-.5641	.1569
		Ninth 4	.14643	.13038	.794	-.2141	.5069
		Ninth 5	.08214	.13038	.970	-.2784	.4427
	Ninth2	Ninth 1	.04643	.13038	.997	-.3141	.4069
		Ninth3	-.15714	.13038	.748	-.5177	.2034
		Ninth 4	.19286	.13038	.578	-.1677	.5534
		Ninth 5	.12857	.13038	.861	-.2319	.4891
	Ninth 3	Ninth 1	.20357	.13038	.525	-.1569	.5641
		Ninth 2	.15714	.13038	.748	-.2034	.5177
		Ninth 4	.35000	.13038	.062	-.0105	.7105
		Ninth 5	.28571	.13038	.189	-.0748	.6462
	Ninth 4	Ninth 1	-.14643	.13038	.794	-.5069	.2141
		Ninth 2	-.19286	.13038	.578	-.5534	.1677
		Ninth 3	-.35000	.13038	.062	-.7105	.0105
		Ninth 5	-.06429	.13038	.988	-.4248	.2962
	Ninth 5	Ninth 1	-.08214	.13038	.970	-.4427	.2784
		Ninth 2	-.12857	.13038	.861	-.4891	.2319
		Ninth 3	-.28571	.13038	.189	-.6462	.0748
		Ninth 4	.06429	.13038	.988	-.2962	.4248
Attitudes	Ninth 1	Ninth 2	.07143	.12358	.978	-.2703	.4131
		Ninth 3	-.15179	.12358	.735	-.4935	.1899
		Ninth 4	.06696	.12358	.983	-.2747	.4087
		Ninth 5	.15179	.12358	.735	-.1899	.4935
	Ninth2	Ninth 1	-.07143	.12358	.978	-.4131	.2703
		Ninth3	-.22321	.12358	.374	-.5649	.1185
		Ninth 4	-.00446	.12358	1.000	-.3462	.3372
		Ninth 5	.08036	.12358	.966	-.2613	.4221
	Ninth 3	Ninth 1	.15179	.12358	.735	-.1899	.4935
		Ninth 2	.22321	.12358	.374	-.1185	.5649
		Ninth 4	.21875	.12358	.395	-.1229	.5604
		Ninth 5	.30357	.12358	.107	-.0381	.6453
	Ninth 4	Ninth 1	-.06696	.12358	.983	-.4087	.2747
		Ninth 2	.00446	.12358	1.000	-.3372	.3462
		Ninth 3	-.21875	.12358	.395	-.5604	.1229
		Ninth 5	.08482	.12358	.959	-.2569	.4265

	Ninth 5	Ninth 1	-.15179	.12358	.735	-.4935	.1899
		Ninth 2	-.08036	.12358	.966	-.4221	.2613
		Ninth 3	-.30357	.12358	.107	-.6453	.0381
		Ninth 4	-.08482	.12358	.959	-.4265	.2569
Meaningful Learning	Ninth 1	Ninth 2	-.02778	.12854	1.000	-.3832	.3276
		Ninth 3	-.15079	.12854	.767	-.5062	.2046
		Ninth 4	.08730	.12854	.961	-.2681	.4427
		Ninth 5	.14286	.12854	.800	-.2126	.4983
	Ninth2	Ninth 1	.02778	.12854	1.000	-.3276	.3832
		Ninth3	-.12302	.12854	.874	-.4784	.2324
		Ninth 4	.11508	.12854	.898	-.2403	.4705
		Ninth 5	.17063	.12854	.675	-.1848	.5261
	Ninth 3	Ninth 1	.15079	.12854	.767	-.2046	.5062
		Ninth 2	.12302	.12854	.874	-.2324	.4784
		Ninth 4	.23810	.12854	.348	-.1173	.5935
		Ninth 5	.29365	.12854	.156	-.0618	.6491
	Ninth 4	Ninth 1	-.08730	.12854	.961	-.4427	.2681
		Ninth 2	-.11508	.12854	.898	-.4705	.2403
		Ninth 3	-.23810	.12854	.348	-.5935	.1173
		Ninth 5	.05556	.12854	.993	-.2999	.4110
	Ninth 5	Ninth 1	-.14286	.12854	.800	-.4983	.2126
		Ninth 2	-.17063	.12854	.675	-.5261	.1848
		Ninth 3	-.29365	.12854	.156	-.6491	.0618
		Ninth 4	-.05556	.12854	.993	-.4110	.2999

Homogeneous Subsets

motivation

Tukey HSD

class	N	Subset for alpha = 0.05
		1
Ninth 4	28	3.2250
Ninth 5	28	3.2893
Ninth 1	28	3.3714
Ninth 2	28	3.4179
Ninth 3	28	3.5750
Sig.		.062

Means for groups in homogeneous subsets are displayed.

Attitudes

Tukey HSD

class	N	Subset for alpha = 0.05
		1
Ninth 5	28	3.1116
Ninth 2	28	3.1920
Ninth 4	28	3.1964
Ninth 1	28	3.2634
Ninth 3	28	3.4152
Sig.		.107

Means for groups in homogeneous subsets are displayed.

Meaningful Learning

Tukey HSD

class	N	Subset for alpha = 0.05
		1
Ninth 5	28	3.2302
Ninth 4	28	3.2857
Ninth 1	28	3.3730
Ninth 2	28	3.4008
Ninth 3	28	3.5238
Sig.		.156

Means for groups in homogeneous subsets are displayed.

General Linear Model

Notes

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	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM X1A X2A BY כיתה WITH X1B X2B /METHOD=SSTYPE(3) /INTERCEPT=INCLUDE /CRITERIA=ALPHA(.05) /DESIGN=X1B X2B כיתה.
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Between-Subjects Factors

		Value Label	N
class	1	Ninth 1	28
	2	Ninth 2	28
	3	Ninth 3	28
	4	Ninth 4	28
	5	Ninth 5	28

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.287	26.507[a]	2.000	132.000	.000
	Wilks' Lambda	.713	26.507[a]	2.000	132.000	.000
	Hotelling's Trace	.402	26.507[a]	2.000	132.000	.000
	Roy's Largest Root	.402	26.507[a]	2.000	132.000	.000
X1B	Pillai's Trace	.311	29.781[a]	2.000	132.000	.000
	Wilks' Lambda	.689	29.781[a]	2.000	132.000	.000
	Hotelling's Trace	.451	29.781[a]	2.000	132.000	.000
	Roy's Largest Root	.451	29.781[a]	2.000	132.000	.000
X2B	Pillai's Trace	.019	1.257[a]	2.000	132.000	.288
	Wilks' Lambda	.981	1.257[a]	2.000	132.000	.288
	Hotelling's Trace	.019	1.257[a]	2.000	132.000	.288
	Roy's Largest Root	.019	1.257[a]	2.000	132.000	.288
class	Pillai's Trace	.442	9.445	8.000	266.000	.000
	Wilks' Lambda	.562	11.026[a]	8.000	264.000	.000
	Hotelling's Trace	.772	12.645	8.000	262.000	.000
	Roy's Largest Root	.762	25.344[b]	4.000	133.000	.000

a. Exact statistic

b. The statistic is an upper bound on F that yields a lower bound on the significance level.

c. Design: Intercept + X1B + X2B + class

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Test 1 after intervention	32964.932[a]	6	5494.155	96.325	.000
	Test 2 after intervention	30525.890[b]	6	5087.648	77.327	.000
Intercept	Test 1 after intervention	1983.010	1	1983.010	34.767	.000
	Test 2 after intervention	3037.648	1	3037.648	46.169	.000
X1B	Test 1 after intervention	3277.818	1	3277.818	57.468	.000
	Test 2 after intervention	1909.284	1	1909.284	29.019	.000
X2B	Test 1 after intervention	45.916	1	45.916	.805	.371
	Test 2 after intervention	26.550	1	26.550	.404	.526
class	Test 1 after intervention	2079.640	4	519.910	9.115	.000
	Test 2 after intervention	6635.131	4	1658.783	25.212	.000
Error	Test 1 after intervention	7586.004	133	57.038		
	Test 2 after intervention	8750.646	133	65.794		
Total	Test 1 after intervention	828501.000	140			
	Test 2 after intervention	830531.000	140			
Corrected Total	Test 1 after intervention	40550.936	139			
	Test 2 after intervention	39276.536	139			

a. R Squared = .813 (Adjusted R Squared = .804)

b. R Squared = .777 (Adjusted R Squared = .767)

```
GLM X1A X2A BY כיתה WITH X1B X2B
  /METHOD=SSTYPE(3)
  /INTERCEPT=INCLUDE
  /PLOT=PROFILE(כיתה)
  /CRITERIA=ALPHA(.05)
  /DESIGN=X1B X2B class.
```

General Linear Model

Notes

Output Created		21:35:20 IDT 04-2018-יול
Comments		
Input	Data	C:\Users\win10\Desktop\data.sav
	Active Dataset	DataSet1
	Filter	<none>
	Weight	<none>
	Split File	<none>
	N of Rows in Working Data File	140
Missing Value Handling	Definition of Missing	User-defined missing values are treated as missing.
	Cases Used	Statistics are based on all cases with valid data for all variables in the model.
Syntax		GLM X1A X2A BY כיתה WITH X1B X2B /METHOD=SSTYPE(3) /INTERCEPT=INCLUDE /PLOT=PROFILE(כיתה) /CRITERIA=ALPHA(.05) /DESIGN=X1B X2B כיתה.
Resources	Processor Time	00:00:00.640
	Elapsed Time	00:00:00.500

```
[DataSet1] C:\Users\win10\Desktop\data.sav
```

Between-Subjects Factors

		Value Label	N
class	1	Ninth 1	28
	2	Ninth 2	28
	3	Ninth 3	28
	4	Ninth 4	28
	5	Ninth 5	28

Multivariate Tests[c]

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.287	26.507[a]	2.000	132.000	.000
	Wilks' Lambda	.713	26.507[a]	2.000	132.000	.000
	Hotelling's Trace	.402	26.507[a]	2.000	132.000	.000
	Roy's Largest Root	.402	26.507[a]	2.000	132.000	.000
X1B	Pillai's Trace	.311	29.781[a]	2.000	132.000	.000
	Wilks' Lambda	.689	29.781[a]	2.000	132.000	.000
	Hotelling's Trace	.451	29.781[a]	2.000	132.000	.000
	Roy's Largest Root	.451	29.781[a]	2.000	132.000	.000
X2B	Pillai's Trace	.019	1.257[a]	2.000	132.000	.288
	Wilks' Lambda	.981	1.257[a]	2.000	132.000	.288
	Hotelling's Trace	.019	1.257[a]	2.000	132.000	.288
	Roy's Largest Root	.019	1.257[a]	2.000	132.000	.288
class	Pillai's Trace	.442	9.445	8.000	266.000	.000
	Wilks' Lambda	.562	11.026[a]	8.000	264.000	.000
	Hotelling's Trace	.772	12.645	8.000	262.000	.000
	Roy's Largest Root	.762	25.344[b]	4.000	133.000	.000

a. Exact statistic

b. The statistic is an upper bound on F that yields a lower bound on the significance level.

c. Design: Intercept + X1B + X2B + כיתה

Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Test 1 after intervention	32964.932[a]	6	5494.155	96.325	.000
	Test 2 after intervention	30525.890[b]	6	5087.648	77.327	.000
Intercept	Test 1 after intervention	1983.010	1	1983.010	34.767	.000
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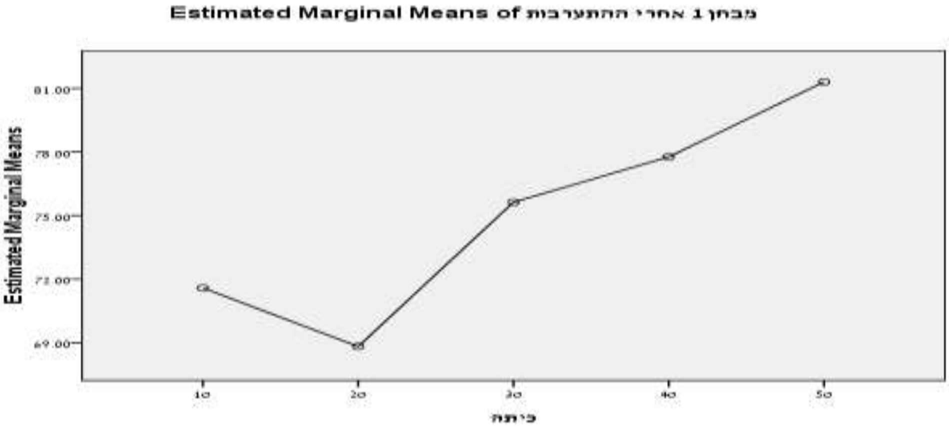
Total	Test 1 after intervention	828501.000	140			
	Test 2 after intervention	830531.000	140			
Corrected Total	Test 1 after intervention	40550.936	139			
	Test 2 after intervention	39276.536	139			

a. R Squared = .813 (Adjusted R Squared = .804)

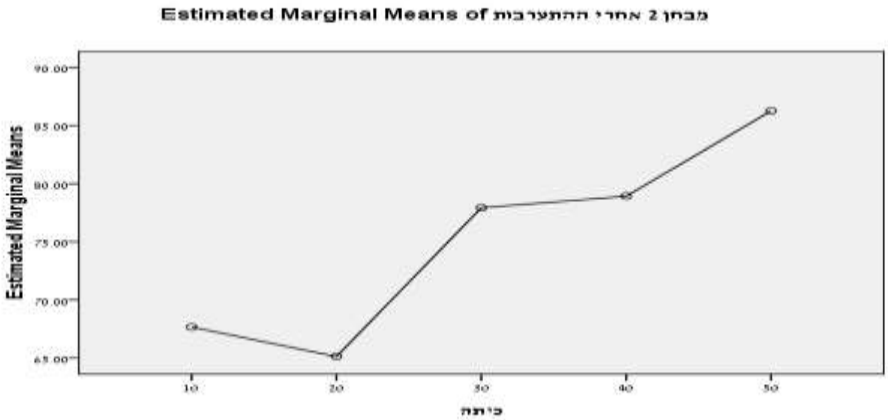
b. R Squared = .777 (Adjusted R Squared = .767)

Profile Plots

Test 1 after intervention



Test 2 after intervention



DECLARATION CONCERNING THE ASSUMPTION OF LIABILITY

I, the undersigned, declare on my own responsibility that the materials presented in the present doctoral thesis are the result of my own researches and scientific achievements. I confirm this fact; otherwise, I will bear the consequences in accordance with the law in force.

Sincerely,

Badarne Ghalib Signature

20.03.2021

CURRICULUM VITAE

A. Personal details

Name: Ghalib Baderne **I.D**: 032983744 **Date of birth**: 26.12.1978

Born in: Israel **Citizenship:** Israel

B. Education

1996: Graduated from Araba high school with biology and chemistry major

1998-2002: BA and B.Ed. in David Yellin College, Jerusalem, Biology, Chemistry and Physics specialization (**86.6 average**).

2003: License to engage in teaching in science subjects.

2008-2010: MA with honours in Science and Technology Teaching, Ben-Gurion University of the Negev (**average 91.2**).

2014-2018: Doctoral studies at the Tiraspol State University, Chisinau, Republic of Moldova. Specialty: 532.02. School didactics (Biology)

C. Course of Teaching and Roles

2000-2001: Teaching trainee in Rene Cassin middle-school in Jerusalem.

2001-2002: Instructor in Ein Rappa middle-school, Jerusalem District, 7, 8, 9 grades.

2002-2006: Instructor and environmental coordinator at Abu Obeida School in Rahat 618363, 5, 6, 7, 8 grades.

2007 to this day: Instructor and science and laboratory coordinator at Abu Obeida School in Rahat 618363, 4, 5 and 6 grades. A qualifying and mentoring teacher for interns and teaching students at Kay and Achva College.

2010 to this day: The coordinator of the Axiom Program and the distribution of school hours at the school.

2016 to this day: pedagogical instructor for second year biology-chemistry of secondary education, at Kay College.

2016-2017: Member of the Research and Evaluation Authority at Kaye College.

Professional activity: Ministry of Education and Kaye College.

D. Areas of scientific interest

1. Initiator, promoter and instructor of school projects: Recent initiatives; program of educational activity in education for a healthy lifestyle in a sustainable environment and Seeing Green project for improving school landscape and climate.

2. Adjusting the education system to the 21st century, teaching science and technology in ICT environment, planning schooling and pedagogical innovation, research processes and basic problems solution, self-management in school, educational leadership in school, teachers as mentors, methods of alternative assessment, robotics.

3. ICT: Highly ICT savvy after qualifying in professional development in the subject and as part of my MA studies, and from my role as the coordinator of sciences subject and axioma, and the need to manage and use the ICT system, MNBSNT, smartboard, planning and giving ICT lessons, processing and presenting data.

E. Participation in scientific events (national and international)

- Symposium "Innovative Methodologies in Education, Kaye Academic College of Education, Israel, 2018;
- Republican Teachers' Conference, March 1-2, 2019. TSU, Chisinau, RM, 2019;
- Moldovan-Polish-Romanian International Scientific Congress: Education - Politics - Society, April 1-4, 2019. TSU, Chisinau, RM, 2019;
- National Scientific Conference with International Participation *Higher Education: Traditions, Values, Perspectives*, September 27 - 28, 2019. TSU, Chisinau, RM, 2019;
- Republican Teachers' Conference, February 28-29, 2019. TSU, Chisinau, RM, 2020.

F. Publications. 8 publications: 4 scientific articles in category B and C magazines; 4 communications at conferences and scientific symposia.

G. Languages: Mother tongue (Arabic), Hebrew at mother tongue level, English at a good level (reading, writing and speech).

H. Additional skills. Public speaking ability, writing and controlling during a tutorial or a lesson.

I. Contacts.

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