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Computerized Simulation as a Meaningful Learning Factor in Biology Teaching

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Abstract Today's education system operates in a dynamic, rapidly changing world. Our information era is characterized by an overload of information and countless technological developments. The digital online world has triggered a dramatic change in the hierarchical structure of information sources and access to information, which affect the learner, the teacher, the curriculum, the teaching-learning processes, and the learning environment. This paper suggests a teaching method that integrates computers to operate a lab called "The Immune System – Models and Simulation" as a complementary method to teaching the immune system subject as part of biology lessons in high school. The results indicate significant improvement of students' content achievements and analysis abilities. Intelligent integration of computers in teaching, and its extension from a system that transfers information to a higher level of knowledge building and analysis could significantly improve students' achievements in science studies.

Keywords: *meaningful learning, digital learning, science education, constructive approach, computerized models, computerized simulation, immune system*

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1. Presenting the Problem: The Need for Scientific-technological Education

Designing an innovative learning environment, which serves both the teacher and the students (in the classroom and at home), has known many ups and downs over the years. Alongside psychological child development theories and adjustment of teaching and learning methods, massive technological developments have inspired insights and theories that allow access to updated information and application of personal and collective online learning. However, although the development rate of technology since the beginning of the 21st century has increased dramatically, educational-organizational perceptions develop at a much slower rate [1].

The education system is overall proud of the 'half-full glass'. In Israel, Central Bureau of Statistics (CBS) data indicate that in 2011, 29% of all high-school students took matriculation exams in one of the science subjects (chemistry, biology, physics, or computers). The 'half-empty glass' indicates that most students do not matriculate in any scientific subject.Findings of the PISA survey place Israeli children's achievements quite low in comparison to other OECD countries. The results of the PISA surveys during the last decade presentedthe architects of scientific education in Israel with a tough challenge – the need to improve scientific literacy achievements in a significant way.

Particularlyat a time when Western society is donning a typically technological mantle and the cultural perception that attributes intrinsic value to knowledge is being replaced by a utilitarian view that sees education as a means to acquire functional skills to ensure the students' future employability – scientific subjects lack good public relations. Is it because of the education system or because of fashionable trends throughout the Western world?

The education system is responsible for the distribution and dissemination of human knowledge. Alvin Toffler, in 'Future Shock' [2], claimed that due to the swift aging of human knowledge and ever-increasing life expectancy, one's chances to use the knowledge acquired in youth decrease as one ages. Schools and higher education institutions would thus be wrong to base teaching on the implied assumption that tomorrow's world would be familiar. A major part of education should be a process by which we enlarge, enrich, and improve the individual's image of the future. Toffler's conclusion was that future illiterates would not be those who cannot read, but those who did not learn how to learn. Hence, future schools should teach how to learn, and must redefine the concept of learning.

Today's field of education includes the relevant concept of "meaningful learning", which, for all aspects of learning, requires a different attitude than the traditional educational thought patterns. Technology has become an integral feature of issues such as updating the curriculum, organizing the learners, organizing study time, the learning environment, accessibility of learning resources, the human factor – teaching and training staff, and all the technological means necessary to employ "meaningful learning" in the service of every teacher and student. Technological means enable significant divergence from the physical confines of the classroom to social and global learning circles. The essence of meaningful learning is to design a meaningful learner's experience, mediated by a meaningful educator, and in contexts that are meaningful to the personal, social, and cultural reality of the learner in the 21st century [3].

Through meaningful learning, the education system faces not only a challenge and an opportunity, but possesses the practical means to realize its commitment to the appropriate growth and empowerment of future generations.

Today's education system operates in a dynamic, rapidly changing world. Our "information era" is characterized by a flood of information and many technological developments, including the teleprocessing revolution. Students are exposed to a world that operates at mega-speed in the digital and online arena, communications, and even interpersonal relationships. The digital online world has caused a dramatic change in the hierarchical structure of the knowledge source and information access, which affects the teacher, the learner, the curriculum, teaching-learning processes, and the learning environment. All these require education that is relevant to the needs of the learner and society; meaningful learning that involves the learner, increases interest and motivation, and creates an empowering and enjoyable process for both students and teachers. The education system is required to portray a desired learner profile, and promote its development through describing the teachers, learning processes, curriculum, learning environment, and the ways to achieve meaningful learning [4].

The study curriculum in general, and in sciences in particular, should offer the student a wide and balanced view of the progress of science, its importance to society, and its effect on the individual's daily life. The rapid developments of modernization processes, and the political, economic, and social changes in modern countries, require reevaluation and improvement of every education system.

Modern society is deeply embedded in a technological environment, and is dependent on it for most aspects of life. In the widest sense, a technological environment includes man-made infrastructures, devices, and technologies that serve even the simplest routine activities and functions. We live in an era in which science and technology, interwoven, have infiltrated every nook and cranny. However, no technology can be understood without understanding the science that led to it, and nothing scientific can be developed without immediate technological implications. The ordinary citizen has to have a general scientific and technological education to deal with the everyday problems that modern life presents. The solution to this could only be appropriate scientific education that combines technological tools with the instruction of any scientific discipline. It has been said [5] that we should find effective ways to establish cooperation between people and computers, which would allow people to use computers' specific features to enhance their own intelligence.

If scientific and technological knowledge is the most important economic resource, then scientific and technological education is the best investment one could make to cultivate this resource. New trends and directions of scientific development need a long time to seep into the curriculums of elementary and high schools. Therefore, scientific-technological training, basic comprehension, and basic thought patterns can help us make correct use of our scientific and technological strengths, and translate them into economic strength.

This paper suggests a teaching method that integrates computers to operate a lab called "The Immune System – Models and Simulation" as a complementary method to teaching the immune system subject as part of biology lessons in high school.

2. Justification of the Topic

Our era is characterized by accelerated development of science and technology. The study of diseases and how to deal with them is important not only to doctors or researchers, but has become vital to all of us, for who has not been sick or bothered by the constant struggle with the various diseases that plague us or our environment?

Modern communication means are a lifeline for most people, and the more communication means there are, the more people feel the enormous scope of the information that flows their way. On one hand, communication reaches every home and exposes the public to many issues that are at the forefront of science and research, and on the other hand, the principles of modern science and technology are not properly understood by most. Consequently, there is an ever-increasing gap between scientists in their ivory towers and the general public.

Therefore, one of the central goals of scientific education is to promote the connection between science and the community, with the objective of increasing the interest, activity and accessibility of the general public (especially children and youths) to science topics; namely to increase exposure, to demonstrate science's effect on everyday life, its contribution to the economy, nurturing human capital, and decreasing social gaps. Hence, modern man requires current information sources that supply a perfect as possible picture of the human body and functions, the body's various reactions to negative effects, and how to avoid diseases. Furthermore, there are the intellectual aspect and natural human curiosity in scientific phenomena and innovations. An educated person, with a liberal humanistic education, whose profession is not in the realm of exact science, cannot differentiate between significant statements and nonsense uttered in the name of science, and does not possess the tools that allow critique of scientific or technological 'truths', because everyday experience and common sense are not sufficient to deal with scientific terminology or theories and their implications.

2.1. Changes in Science Education

Change is a natural condition of education, which now represents, more than in the past, a transition between old and new. The need for fundamental change is rooted in the establishment of the technological-scientific era, which is affected by information and accessible tools to transfer it by means of the numerous channels of modern communication.

Schools are expected to function in a society undergoing accelerated changes in all areas of life. The actual change in education should be perceived as restructuring the school framework. Restructuring is a systemic approach to change, which should apply to goals, regulations, roles and contexts within the school including people, knowledge, technology, time and methods that are used to improve teaching and education effectiveness in ways that serve the changing needs of society [6].

The future citizen is one who needs an infrastructure of knowledge and thought required for:

Awareness of the personal and social significance of science and technology applications;

Consciousness of one's centrality, and of the entirety of interactions with one's natural, technological and social environment;

Taking responsibility for one's behavior, commitment to improving one's quality of life, and in consideration of future implications of said behavior to oneself and the environment;

Taking a stand, initiating, and influencing policymakers on the local, national and global levels.

Over the years, the Israeli education system has held science studies, which prepare the students for life in a scientific-technological society and instill scientific thinking, in high regard. The common perception is that a science-literate student will contribute to future scientific-technological creation, which is the basis to Israel's development and growth. To this end, we are required to nurture human capital that will serve as appropriately trained manpower [7].

Moreover, scientific-technological education is perceived as essential to instilling the knowledge and skills needed by every future adult citizen of the 21st century [8], since scientific knowledge and thinking are relevant and even necessary to everyday life, to problem-solving in the real world, and to understanding and analyzing the information received from numerous sources [9].

Science teaching in schools is also changing constantly in an attempt to contribute to forming citizens that can cope with a world that increasingly affects and is affected by science and technology. It is quite common today to use the term 'instilling science literacy' as a goal of science teaching to the general public [10]. The important objective of the science curriculum is to help the student comprehend the essence of the scientific method. Two types of knowledge are included in science literacy: knowledge of science – knowledge of the natural world in various fields: physics, chemistry, biology, earth and space science, and technology-based science, and knowledge about science – knowledge of scientific means and goals, examination methods, and scientific explanations.

The conceptual framework of science literacy includes four key aspects: 1. Knowledge: To understand the world based on knowledge of and knowledge about science; 2. Skills: To identify scientific topics, explain phenomena in a scientific way, and use scientific evidence; 3. Context: To comprehend the situation and the environment in which the problem is presented; 4. Attitudes: Interest in science, support of scientific research, and motivation to act responsibly towards scientific issues (such as natural and environmental resources).

The fact that it is impossible to teach all of the accumulated knowledge, and studies that have shown that meaningful learning requires time and effort, have reinforced the need to focus on less ideas and concepts in favor of higher quality learning. The present reform calls first and foremost for commitment to meaningful teaching of scientific ideas and basic thinking skills to all students.

The 'products' of scientific education will be citizens who can experience enthusiasm from understanding the world of science, use scientific processes and principles to make personal decisions, have educated opinions about social issues that have a scientific-technological connection, and take part in the country's economic development.

Teaching learning skills is just as important as teaching science. Science teaching should focus on instilling skills that will allow the learner to search and find information when needed, to understand that information, to relate to information sources critically, and to make decisions based on facts and rational thought. The skills can be divided into learning skills (finding, choosing and evaluating information, processing information, and presenting it), thinking skills (comprehension, critical analysis, argumentation), problem solving skills (identifying the problem, finding a solution, reaching conclusions), and meta-cognitive skills. Skills cannot be learned passively. The student must actually experience finding information, reading an article on a project, or conducting an experiment. In addition to evaluating the comprehension of central ideas, learning skills must also be assessed. Evaluation of the entire learning process, not just its products, and use of varied evaluation tools will provide a fuller picture of the student's thinking skills.

Harpaz [11] believes that students learn better when they are involved in the learning process with their mind, imagination, emotions, and body. The outcome of this involvement is comprehension of meaningful ideas. Involvement in the learning process provides a positive learning experience, which is animportantpre-condition for comprehension [11].

Can learning content be made more fascinating, and how? How can schools that operate according to a strict curriculum, that lack equipment and state-of-the-art laboratories, compete with the dynamic and colorful world that the students are exposed to via their very handy digital equipment (such as TV, computer and cellphone)? How is it best to teach in order to make science lessons a challenging and creativity-provoking learning experience?

The aim of teaching in general and science lessons in particular is to teach the student how to cope with new situations, rather than situations that are familiar. This is the basic idea of integrating laboratories in the sciences curriculum, with an emphasis on teaching science as investigation rather than merely memorizing facts. The student is thus exposed to scientific thinking processes (defining the problem, formulating a hypothesis, planning an experiment, and processing data). At a later stage, the student can develop synthesis to solve scientific problems.

Science teaching is characterized by the investigation and discovery approach, and cannot be satisfied with passive transfer of information from the teacher to the learner.

Most study material in science is abstract, and therefore complex and difficult to understand. Integrating illustration methods can satisfy, on one hand, the students' natural curiosity, and on the other hand – the teacher's desire to develop creativity and problem-solving skills.

2.2 Integrating Computers in Teaching

Updated education is adjustment and implementation of past educational perceptions and learning processes to present-day methods, in preparation for training the student for the future world. Teaching 21st century skills is required in all schools so as to prepare the student for the continuously developing and changing work world [12]. Computer use in the western world has become commonplace, and the demand to incorporate computers in teaching and learning, and to prepare the learner to function in the 21st century is increasing.

Twenty-first century skills include creative thinking and intellectual curiosity; information and communication literacy (students use technology to communicate and work with others that are distant from them, with the purpose of shared learning and mutual help); interpersonal relationships and self-management (interpersonal relationships and shared work, self-learning, flexibility and adaptation, and personal and social responsibility); critical thinking, problem-solving and decision-making (information literacy or management); technological command (technological grasp and operation, software use, internet security, communications) [13].

The education system is faced with the need to deal with many educational challenges and constraints that require recalibration – a significant change of the approach to and implementation of learning. The change must be manifested in decryption, adjustment and development of an updated view that fits the changes in the environment, culture, economy and society, and is suited to the learners and their reality.

To achieve this high standard, the education system must change work methods in schools and teaching and learning methods in classrooms. When the educational surround is geared to building an empowering and motivating learning experience, when technology and its relationships to people and society are integrally built-in, computerization should be integrated as part of the meaningful learning perception. The change includes understanding the changes that occurred in the learners and learning as a result of technology integrated in the experience of living, in society, culture, economy and education, and redesigning the educational experience, vision, dreams and challenges, which would be impossible without technology [14].

The actual use of computers and technology is not the central change in teaching and learning processes. The main changes are in content, structure of learning assignments, pedagogic views, teachers' and students' conceptuality, and their diverse perceptions of technological tools [15]. Education must be adjusted to the new reality, planning educational activities that incorporate computer use, and training teachers to work in a digital learning environment [16].

2.3. Computer-related Strategies in Science Teaching

The science teacher has two hurdles to cross, one after the other. First, he or she must learn and assimilate the updated scientific paradigm in depth, and then teach the students in a way that is appropriate to their level and comprehension ability.

The constructivist approach maintains that the learner is not a passive recipient of knowledge, but an active factor in the teaching-learning process. Accordingly, students in fact build their knowledge themselves.

In recent years, computers have penetrated schools, and computer or multimedia based study programs are becoming increasingly common. One of the key reasons for increased use of computers is the expectation that the computer will considerably improve the learning process and adjust it to each student's needs.

Educational software simulations (computer imaging – 'virtual reality') are based on learning theories that emphasize building knowledge by the student himself. This approach allows the learner to define the problem he or she wants to learn, and investigate it through observation of variables presented by the software. One of the advantages of simulations is the ability to explain and illustrate abstract concepts in three-dimension, where the learner operates interactively and experientially.

We aim to design a model of a scientific idea that will serve as a form of bridge between our limited perception and the system represented by that idea. In teaching, the model's main role is to mediate between human perceptions and its constraints and a system that is unperceivable as it is because it is complex and abstract. Models and simulations enrich and strengthen the intuitive infrastructure, and thus improve the learning process.

Simulations are computer programs that imitate real activities: lab experiments, operating instruments, performing processes in stages, etc. The use of computerized imaging as a science teaching tool is a method that allows students to experience complex, dynamic systems [17].

The majority of the computer's unique teaching potential is manifested in simulations, and through advanced technological means (color, sound, movement, and high-resolution screen) a new onscreen learning environment is created– virtual reality. Computer imaging can illustrate composition, structure and processes in a clear visual way. In software based on this method, the learner reacts, and the software evaluates the reaction according to a predetermined program. The basic idea of simulations argues that it is cheaper and more economical to use a computer than to use expensive equipment and dangerous or expensive materials. Moreover, real experiments are often impossible to perform or recreate [18].

Computer imaging helps to simplify complex systems, and presents them onscreen as a 'mini-world' that imitates the real world. Imaging allows us to choose the desired variables from the real system, define the rules that govern the system, and to let students experience the system by allocating numeric values to variables, observing the swift changes that occur in the system, and understanding the system's rules through investigation and research. The learner is part of a new world, which holds previously unknown possibilities. Thus, computer imaging and simulations increase the responsibility that the student takes for the learning process.

The learner-computer interaction can help to diagnose learners' misconceptions by confronting their perception of the process with reality, and suggesting ways and information to improve comprehension, in a way that is adapted to each learner. This experience is tailored to the learner's cognitive level, learning style, and perception rate.

Technological developments and the enormous accumulation of new information require a methodical effort to prevent stagnation of the education system and its lagging behind new developments, and to ensure the penetration of new trends in science and research to schools.

Future challenges cannot be met by acquiring command of yesterday's knowledge. Society must invest in the individual's intellectual development in order to succeed to achieve future goals. It is now clear that it is impossible to teach all that is known in a certain field. Education futurists predict that technological and scientific information will increase exponentially every year. The knowledge explosion is very significant. From a futuristic viewpoint, school curriculums must find ways to intelligently incorporate the quantities of knowledge from various sources. Acknowledging the fact that knowledge in our world is multidimensional and quickly obsolete teaches us that knowledge should no longer be treated as a goal, but as an opportunity to develop thinking and comprehension. The student's development into a creative adult requires changes to the curriculum, and one of the major changes is the transition from emphasis on learning to emphasis on thinking. Use of computer technologies is active thinking. The computer holds the potential to construct a new learning environment in the spirit of teaching and learning perceptions, namely to change key emphases between a traditional and a computerized learning environment.

3. Module Development: "The immune system – models and simulations"

Knowing that pupils are primarily interested in relevant subjects that they know from everyday life, a module was written to present an innovative learning strategy for the immune system topic (Figure 1). The central axis of the module exposes a practical, relevant issue from everyday life, which deals with solving practical problems, based on general knowledge, and including multidisciplinary aspects that relate to science, technology, and society.

An objective difficulty to apply and integrate learning materials with (in vitro) lab work is inherent in the immune system topic, both because of potential danger to teachers and students and the cost of lab equipment. Needless to mention the problems involved in (in vivo) animal experiments, and the difficulty to follow changes that occur in various body systems. The module's uniqueness is that it is not conventional classroom teaching, but activates the student as a *researcher* with the computer as his/her *laboratory*.

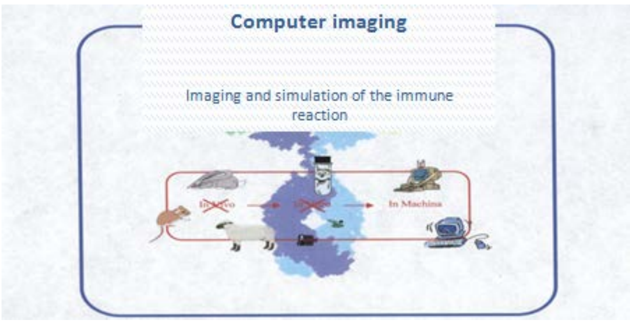

Figure 1. Imaging & simulation of the immune reaction

4. Research Methodology

4.1. Aim of Research

This research aimed to examine cognitive and affective processes among students studying the subject of the immune system by means of a computerized module developed as a model for computer-aided science teaching.

4.2. Research Questions

1. Does teaching/learning the module "Immune System – Models and Simulation" contribute to improving students' skills understanding the study material?

2. Does teaching/learning the module "Immune System – Models and Simulation" contribute to improving students' skills reading graphs and analyzing them?

4.3. Research Population

The research was performed in two stages. The first stage was conducted in 2001 – the experiment group consisted of 49 students and the control group of 71 students ('previous study'). In 2016, a mini-research was conducted that included a sample of 20 students who were examined with the same questionnaires, before and after studying the subject, and the control group learned without computers ('present study').

4.4. Research Tools

Four questionnaires were composed to answer the research questions and goals, by examining the suitability of the teaching method proposed by the module.

Questionnaire 1: Closed questions – 20 multi-choice questions that examined the students' knowledge prior to learning the immune system module, in order to neutralize initial differences between students and to allow comparison of students' achievements in various groups.

Internal reliability of Questionnaire 1:

Previous study – Cronbach's $\alpha = 0.70$

Present study – Cronbach's $\alpha = 0.86$

Questionnaire 2: Statements – 30 true/false statements, to examine students' comprehension of various aspects of the immune system.

Internal reliability of Questionnaire 2:

Previous study – Cronbach's $\alpha = 0.93$

Present study – Cronbach's $\alpha = 0.86$

Questionnaire 3: Terminology – 46 terms related to the immune system on a Likert scale of 1 (completely unfamiliar) to 4 (understandable and I can explain it to others).

The content of Questionnaire 3 was validated by four independent judges – an immunology scientist, two 12th grade biology teachers, and an educator in the field of science education who develops biology study programs. The judges examined the terms used in the test by the following criteria: content and context. The judges unanimously agreed about the test's validity.

Questionnaire 4: Data processing –The students were presented with 16 graphs which they were required to analyze, to examine if learning the module had affected their ability to analyze data presented graphically (which indicates high cognitive skills).

Internal reliability of Questionnaire 4:

Previous study – Cronbach's α = 0.80
Present study – Cronbach's α = 0.93.

5. Findings

The research examined how integrating computers as a teaching tool affects the experiment group in comparison to the control group, in reference to two major issues:

1. The degree of improvement in understanding the study material;
2. The degree of improvement in skills of reading graphs and analyzing them.

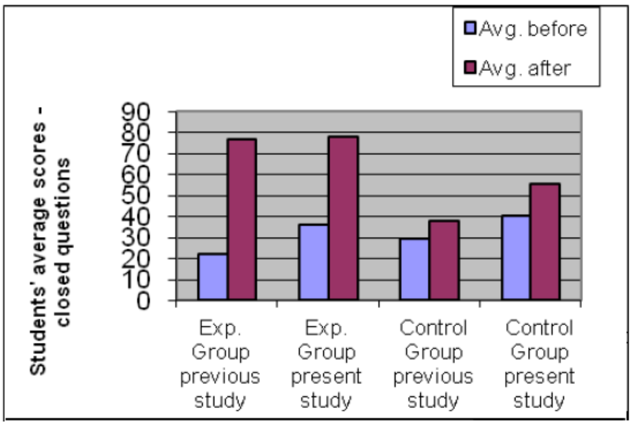

Figure 2. Effect of module on students' achievements – closed questions

Table 1. Results of F-test – closed questions

	Previous study	Present study
Time factor	P<0.000*** F(1,118)=471.56 Strength=80%	P<0.000*** F(1,36)=125.81 Strength=78%
Group factor	P<0.000*** F(1,118)=37.85 Strength=24%	P<0.1** F(1,36)=14.93 Strength=29%
Interaction	P<0.000*** F(1,118)=204.02 Strength=63%	P<0.000*** F(1,36)=21.33 Strength=37%

Figure 2 shows a significant increase in the level of achievements as indicated by the students' scores for closed questions. The previous study indicates a significant increase in the experiment group from an average of 22 to 76, whereas the increase in the control group was minor (29 to 40). This trend repeated itself in the present study – the recorded increase in the experiment group was from 36 to 78, and in the control group from 40 to only 55. Table 1 describes the results of the F-test by research groups, before and after.

The results of the first questionnaire contribute to corroborating the first research question.

Table 2. Results of F-test – statements

	Previous study	Present study
Time factor	P<0.000*** F(1,118)=373.26 Strength=76%	P<0.1** F(1,36)=100.53 Strength=73%
Group factor	P<0.000*** F(1,118)=23.66 Strength=17%	P<0.000*** F(1,36)=9.44 Strength=20%
Interaction	P<0.000*** F(1,118)=54.31 Strength=31%	P<0.000*** F(1,36)=7.13 Strength=16%

Figure 3 indicates a significant increase in the level of students' achievements test for statements on the topic of the immune system. The previous study indicates a significant increase in the experiment group from an average of 25 to 80, whereas the increase in the control group was much smaller (25 to 50). In the present study, the recorded increase in the experiment group was significant – from26 to 66, and in the control group minor – from23 to 47. Table 2 describes the results of the F-test by research groups, before and after.

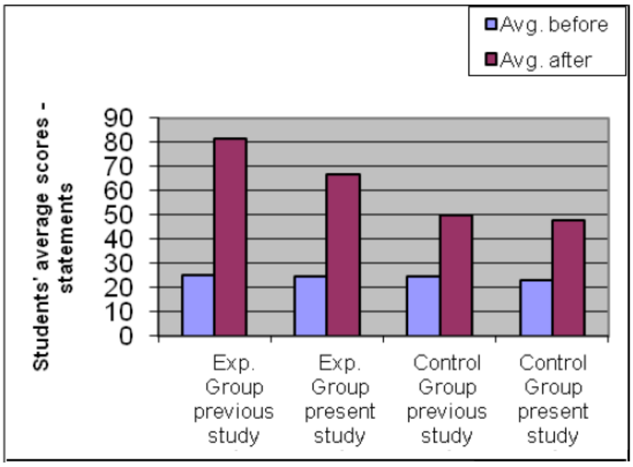

Figure 3. Effect of module on students' achievements – statements

The results of the second questionnaire contribute to corroborating the first research question.

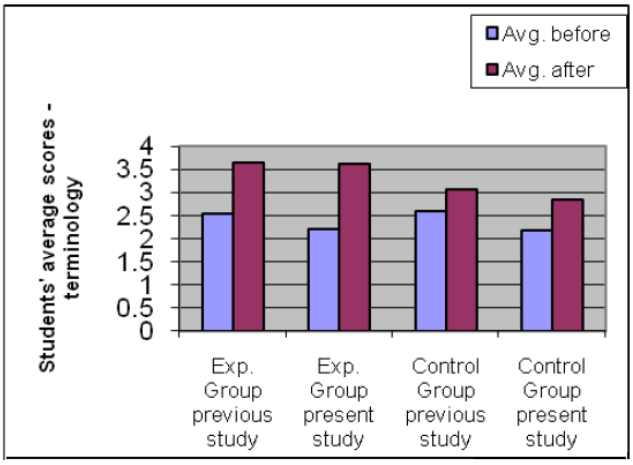

Figure 4. Effect of module on students' achievements – science terminology

Table 3. Results of F-test – science terminology

	Previous study	Present study
Time factor	P<0.000*** F(1,118)= 314.97 Strength=73%	P<0.000*** F(1,36)=149.75 Strength=80%
Group factor	P<0.000*** F(1,118)=7.2 Strength=5.8%	P<0.000*** F(1,36)=23.48 Strength=29%
Interaction	P<0.000*** F(1,118)=52.40 Strength=30%	P<0.000*** F(1,36)=20.10 Strength=35%

Figure 4 indicates a significant increase in the scores of students' achievements test for concepts and terms related to the immune system. The previous study indicates a significant increase in the experiment group from 2.54 to 3.65, whereas the increase in the control group was minor (from 2.59 to 3.05). In the present study, the experiment group showed a significant increase from 2.22 to 3.62, and the control group showed a lesser increase from 2.19 to 2.84. Table 3 describes the results of the F-test by research groups, before and after.

In summary, the results of the students that participated in the experiment group were higher than the results of the students in the control group. These findings indicate that the achievements of students who studied the immune system topic with the aid of computer imaging and simulations were significantly higher than those of students who studied in the traditional teaching method, in both the previous study and the present study.

Thus, the answer to the first research question is affirmative, based on achievements tests that examined closed questions, statements and terminology. The module significantly improved students' achievements on all counts.

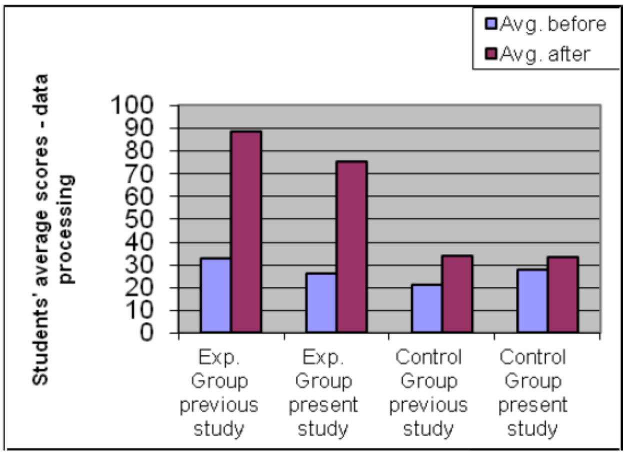

Figure 5. Effect of module on students' achievements – data processing

Table 4. Results of F-test – data processing

	Previous study	Present study
Time factor	P<0.000*** F(1,118)= 222.76 Strength=65%	P<0.01** F(1,36)=56.64 Strength=61%
Group factor	P<0.000*** F(1,118)=117.09 Strength=50%	P<0.000*** F(1,36)=30.57 Strength=46%
Interaction	P<0.000*** F(1,118)=85.93 Strength=42%	P<0.000*** F(1,36)=35.88 Strength=50%

The findings indicate a significant increase in the students achievements, manifested in their average grades in a test that examined the students' skills and ability to process data and analyze graphs in various scientific areas.

Results of the previous study show a significant increase in the experiment group from 32.52 to 88.26, whereas the change in the control group was minor from 20.86 to 33.89. Similarly, the present study's results indicate a significant increase in the experiment group from 26.11 to 75, and a minor increase in the control group from 27.77 to 33.33. Table 4 describes the results of the F-test by research groups, before and after.

Thus, the answer to the second research question is affirmative, based on achievements tests that examined graphs analysis and data processing. The module significantly improved students' skills.

6. Discussion and Conclusions

Science, technology and human society are indelibly intertwined. Understanding the interactions between these factors is a necessary condition for forming policies and making decisions in each of these fields. The development of science and technology involves many phenomena that have a crucial impact on humanity in general and on the lives of individuals.

The education system operates in a dynamic, rapidly changing world. Our time, the information era, is characterized by a huge flood of information and numerous technological developments, including the computer revolution. Present day students are exposed to a world that moves at mega-speed in the digital and online realms, communications, and even interpersonal relationships. Numerous stimuli assail them forcibly and simultaneously, and create high levels of excitation with difficulty to focus on one thing for any length of time. This situation makes it difficult to conduct a structured methodical education process, and creates a sense of stress, alienation, and even mistrust of the education system among many of its partners. The online digital world has made a dramatic change in the hierarchical structure of information and access to it, which affects learners, teachers, the curriculum, teaching-learning processes, and the learning environment.

The communications revolution and economic and organizational revolutions typical to postmodernism have changed perceptions of knowledge and learning – from passive learning of static knowledge to active learning of constantly evolving practical knowledge. The role and duty of education systems and schools today is to improve and update in congruence with the present era. Therefore, a digital-computerized learning environment must be an integral part of teaching. The major role of the education system is to provide each of its graduates with the tools necessary for optimal integration in an advanced society – technologically, culturally, and socially [19].

Science teaching in high school should create an educational space that encourages active and meaningful involvement of its students, the citizens of the future. In a time when there is great emphasis on scientific-technological developments, one of the goals of teaching science is to serve as a window through which the student is exposed to the pioneering work achieved by the enormous and accelerated technological progress.

The literature points to a number of advantages of the teaching and learning via computers model. However, most studies do not prove changes in students' achievements or increased quality of teaching and learning [20]. The majority of studies in this field focus on students' and teachers' attitudes and frequency of computer use. Few empiric studies have specifically examined students' informational abilities and their preparedness to acquire 21st century skills.

The rationale of this research was to observe the effect of a teaching and learning module as a suggestion of a computerized teaching strategy, examining it effectiveness on a student population. The goal was to examine cognitive processes that occur for students studying the topic of the immune system with computers. Students' achievements are one of the criteria of the positive contribution of the computerized strategy in the teaching and learning process.

The findings clearly indicate a significant improvement of students' comprehension achievements. In all the achievements tests, significantly better results were obtained by students whose learning method included computers. For instance, students who learned through the computerized activities developed in the learning module achieved better average scores in answering closed questions – 76.76 vs. 40.33 for the control group. The most impressive achievement was data analysis skills – an average score of 88.2 vs. 33.8 for the other students.

The visual, dynamic onscreen presentation, the students' active learning through asking questions and finding answers, which are at the core of the module, helped the students to better understand the scientific principles at the core of a complex, multi-system topic such as the immune system.

In conclusion, it can be said that teaching the module created a learning environment that contributed to promoting students' graph analysis skills. Student's achievements in the area of content and improved analysis abilities are congruent with scholars who stated that integrating computers is an advantage to constructing a supportive, thought-developing environment [3,9,11]. Computer use has been proved to improve learning skills and contribute to improving the learning potential and expanding it from a teaching system that transfers knowledge to a higher level of analysis and building knowledge.

A possible explanation for the students' high achievements is their involvement in the learned subject. Computer use enhances the students' self-value and self-efficacy, and is an empowering and enjoyable experience that builds mutual trust between the student and the adult world.

Technology has an enormous impact on all aspects of our lives [21]. It changes our environment and our way of life. It is obvious that the education system cannot afford to isolate itself from computer technology. Schools have to take part in the computerization process, because computers and the internet represent the new way of doing things, and especially since computers can facilitate learning processes. Therefore, schools are faced with a big challenge – the ability to adapt to the era they operate in and which they serve. The education system must train its students to enter the information technology age. Organizing a computerized learning environment, and the quality of its affinity to the traditional teaching environment, require changes that relate to aspects of the teaching culture. Recent technological developments can serve as a lever to develop innovative computerized teaching programs. The challenge encompasses the courage to face the unknown, breaking traditional frameworks, and implementing educational paradigms, which are not merely updated, improved versions of the existing methods, but make learning into a technology-structured personal and social existence [22].

The change process must occur simultaneously for each of the partners in the teaching process, namely teachers, students, and the teaching strategy. Implementing the change in a number of areas will enable support and completion, in order to make the most of it. This is what this study meant to demonstrate – a method to change teaching from traditional, face-to-face teaching to a teaching strategy that integrates technology, and is considered innovative and progressive.

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