An-Najah National University

Faculty of Graduate Studies

THE EFFECT OF INTEGRATION OF BIOINFORMATICS EXPERIMENTS WITHIN THE HEREDITY UNIT OF THE ELEVENTH GRADE OF THE PALESTINIAN BIOLOGY TEXT BOOK ON STUDENT ACHIEVEMENT AND MOTIVATION

By

Safa Ata Mohammad Nazzal

Supervisors

Dr. Alia Assali

Prof. Raed Alkowni

This Dissertation is submitted in Partial Fulfillment of the Requirements for the Degree of PhD in Learning and Education, Faculty of Graduate Studies, An-Najah National University, Nablus, Palestine.

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This Dissertation was Defended Successfully on 30/12/2025 and approved by

Dr. Alia Assali	
Supervisor	**Signature**
Prof. Raed Alkowni	
Co-Supervisor	**Signature**
Dr. Murad Awadallah	
External Examiner	**Signature**
Prof. Wajeeh Daher	
Internal Examiner	**Signature**
Dr. Kefah Barham	
Internal Examiner	**Signature**

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Dedication

To the soul of my father, my first driving power, who always believed in me, to his compassionate voice, and his beautiful wrinkles, and his cracked hands, in which he acquired to provide us a decent life.

To my husband, who shared each path of the journey along with me, who gave me strength when I felt weak, who gave me support whenever I felt exhausted, to whom presence is the best blessing that I ever had, to my companion.

To my mother, who always surrounded me with her prayers and blessings.

To my Kids, Malik, Ahmad, Mohammad, Mohammad, Atallah, Obadah and Amal, to the pieces of my heart.

To my family members and relatives, my brothers (Nasr, Samed, Mohammad, Mallah) and my sister (Sona), to my mother in law, and my sisters in law.

To my student colleges, and to the doctors and professors of An-Najah National University, who never hesitated to give us guidance, support and mentorship.

With deep thanks and appreciations, I dedicate this work to all of you.

Safa Ata Malalha / Nazzal

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Thank you all.

Declaration

I, the undersigned, declare that I submitted the thesis entitled:

THE EFFECT OF INTEGRATION OF BIOINFORMATICS EXPERIMENTS WITHIN THE HEREDITY UNIT OF THE ELEVENTH GRADE OF THE PALESTINIAN BIOLOGY TEXT BOOK ON STUDENT ACHIEVEMENT AND MOTIVATION

I declare that the work provided in this Dissertation, unless otherwise referenced, is the researcher's own work, and has not been submitted elsewhere for any other degree or qualification.

Student's Name: Safa Ata Mohammad Nazzal

Signature: Saf

Date: 31.12.2025

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THE EFFECT OF INTEGRATION OF BIOINFORMATICS EXPERIMENTS WITHIN THE HEREDITY UNIT OF THE ELEVENTH GRADE OF THE PALESTINIAN BIOLOGY TEXT BOOK ON STUDENT ACHIEVEMENT AND MOTIVATION

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Prof. Raed Alkowni

Abstract

This study explored the effect of integration of bioinformatics experiments within the eleventh-grade biology textbook on student's achievement and motivation in Palestine. A non -equivalent quasi-experimental approach was used to conduct the research. The research sample composed of (76) eleventh grade students within the experimental group who were subjected to bioinformatics activity based-intervention and (71) eleventh grade students within the control group. A validated biology achievement test and Biology Motivation Questionnaire (BMQ I) were used to assess student's achievement and motivation among both groups. Quade and two-way ANCOVA were used to analyze the achievement test scores while Bootstrapping ANCOVA was used to analyze BMQ scores. Results showed that the experimental samples had higher significant values of post achievement test scores compared to control sample post achievement test scores. In addition, two-way ANCOVA analysis revealed a significant difference of student's posttest scores due to the interaction of sample type along with learning environment and geographic location. However, no significant differences of student's post High Order Thinking Skills (HOTS) and post Low Order Thinking Skills (LOTS) scores were found due to the interaction of sample type with gender. In regards to students'motivation, bootstrapping ANCOVA analysis revealed that the intervention had no significant effect on students BMQ total score and BMQ subscales in regards to sample type and gender.in addition, only intrinsic motivation, extrinsic motivation and self-relevance had a significant difference in regards to learning environment and geographic location within the experimental sample in favor to Qabatya school and face-to-face learning environment. Overall, the findings indicate that the intervention of bioinformatics experiments caused a positive effect on students' cognitive capabilities but had no obvious significant effect on student's motivation. Further future studies are

recommended to apply distinct bioinformatics-based intervention protocols that might enhance student's motivation while sustaining the observed achievement gains.

Keywords: biology education, bioinformatics, achievement, motivation, biology curriculum, STEM, Palestine

Chapter One

Introduction and Theoretical Background

1.1 Introduction

“Knowledge is boring, it’s what you don’t know that’s not boring”. The previous saying was supported by Dewey’s idea for a philosophy of experience. According to him, democratizing education and scientific research practices enable students to have a variety of everyday opportunities and to participate in discoveries and real-life practices and to create new knowledge instead of passively receiving it(Bruce et al., 2003). This philosophy should be adopted in natural science curricula since a noticeable decline of student's interest and attitudes towards science learning especially at high school level was noticeable in many areas around the world including Europe and Australia. Thus, practical courses integration into science teaching is recommended to upgrade student attitude and motivation (Chan & Norlizah, 2018).

In biology teaching, integration of practical experiments is usually performed to reinforce student's theoretical knowledge, increase high order thinking skills and developing manual skills (Ologe & Shittu, 2012). However, certain subjects such as genetics and molecular biology teaching have no practical part or real-life experience due to the limited resources at schools most of the practical experiments designed were microscopy, zoology, and parasitology (Janstova, 2015). In genetics and molecular biology classes, theoretical information supplemented by technological media is mostly used to these subjects. The changing dynamic of biology education was firstly outlined in Bio 2010 which encouraged educators to make biology education more interdisciplinary, more inquiry based and emphasized on quantitative skills (Cummings & Temple, 2010) in order to cope with the rapidly evolving world of research and publicly accessible electronic data (Machluf et al., 2017). This can be done through integration of bioinformatics practical aspects in Biology teaching. This branch of biological sciences focuses on the integration of computer and statistical techniques to the management of biological data. It is the field of science in which the sciences of biology, computer and information technology integrate into a single discipline. In other simpler words, bioinformatics can be defined as of the use of computer software and information technology to collect, store, analyze, interpret data to solve biological problems (Magana et al., 2014). The field of bioinformatics has launched a revolution in

the study of biology by reframing how biological research is carried out and how that research will impact modern societies. According to the National Center for Biotechnology Information (NCBI) the field of bioinformatics promises is rapidly emerged that leading to advances in understanding basic biological processes as well as advances in the diagnosis, treatment, and prevention of many genetic diseases. As a consequence, bioinformatics theoretical and practical courses have been integrated into many Biology bachelor's and master programs throughout the world (Lownsbery, 2000). Regarding high school level, there is a need to teach Bioinformatics in high school to improve biological learning and to equip a new generation of scientists with the twenty first century skills (Nunes et al., 2015). Regarding high school biology curriculum, bioinformatics instruction and laboratory experience is highly aligned with many aspects of the Next Generation Science Standards (NGSS) that include the following indicators: Scientific Practices of Developing and Using Models; the Crosscutting Concepts of Patterns such as Cause and Effect and the Life Sciences Disciplinary Core Ideas, particularly, Structure and Function models; Inheritance of Traits; Sources of trait variation; Evidence of Common Ancestry, and Natural Selection (Cummings & Temple, 2010). Thus, Bioinformatics approaches in this educational level can improve the contents in which molecular biology, genetics, and evolutionary biology are taught(Sari et al., 2022).

In Palestine, the life sciences education curriculum has been reformed several times to provide better chances for the Palestinian students to be equipped with the 21st century skills. The reform included the redesign the activities to be student-centered and connected to life aspects. In addition, according to the strategic plan of the Palestinian Ministry of Education (2017-2022), integrating technology into science activities was suggested. The science curriculum integrated local and relevant technologies and their environmental impact whenever possible (Ministry of Education and Higher Education, 2017). In addition to governmental efforts, numerous non-governmental science initiatives have been established to encourage students to learn science by doing and playing through a set of interactive activities and procedures, including the annual International Science and Engineering Fair (ISEF) project competition and Science, Technology, Engineering and Mathematics (STEM) summer clubs (Itmazi & Khlaif, 2022). Several studies regarding the benefits of integrating basic bioinformatics at secondary level biology curricula have been conducted in many areas around the world

(Martins et al., 2020). No relevant studies are conducted at the Palestinian scale. This study will document for the first time the integration of bioinformatics experiments into the unit of Heredity in the eleventh-grade biology curriculum for the second semester in Palestine.

1.2 Theoretical background

1.2.1 Learning theories and Biology science education

Biology, the study of organisms is a scientific branch that is taught either collectively, as in general science books, or separately, as a sole subject for high school and college students. Usually, school biology courses concentrate on describing the structure and the function of organisms along with their interactions (Abimbola, 2017). Biological sciences are experimental, technical, explorative, and behavioral in nature.Studying biology will help students to gain insights into life and living organisms. It also aims to advance learners′ understanding of the mechanisms that govern the presence of life on this earth (Kumar, 2017). Knowledge in biological sciences could be used to solve contemporary challenges within the society, including human, animal, and plant health. In fact, learning biological sciences is a fundamental mandatory for the progress and the prosperity of humankind till now (Mwanda, 2017).

At the secondary stage, science teaching should help students to develop insights and practices in health and the environment. Students should be able to understand the nature of science and technology, develop problem solving and decision-making skills, inculcate the values of science and technology, and develop transfer of skills in real life scenarios (Tomar & Achary, 2016).

Advances in technology, software's and digital tools did not only contribute to the emergence of distinct and diverse biological branches such as genetics, molecular biology, bioinformatics, microbiology …etc. (Kumar, 2017). These also caused a shift in pedagogical approaches used in biology delivery to students; since the advancement of technological approaches was parallel to the development of pedagogical learning theories. Thus, technological advances played a pivotal role in the development of learning theories overtime (Huang et al., 2019).

Starting from behaviorism, which suggests that learning occurs as behaviors are adopted due to a response for a certain stimulus (Dilshad, 2017). Inside the classroom,

behaviorist biology teacher focuses mainly on behavior modification. The teacher is the only one responsible for transmitting the information to the learner in order to make the students familiar with scientific information. Classroom pedagogies include the use of repetition techniques to facilitate the remembrance of factual knowledge, and decomposition of complex tasks into simpler subsequent steps where feedback is delivered to promote or suppress behavior (Agarkar & Brock, 2017).

A few years later, cognitivism dominated the scene, where learning is viewed as an active process that involves the acquisition, processing, and storing of information. The learner is also an active participant in knowledge acquisition and integration. Compared to behaviorism, focus was concerned with the internal thinking processes of a learner and rather than solely on the observable behaviors (Dilshad, 2017). Indeed, cognitivism neglected the observable behavior by viewing learning as internal mental processes, where learners are actively involved in mental processes such as thinking, knowing, memorizing, and problem-solving (Sharma & Mahavidhyalaya, 2023). The teacher, in activist dependent approaches, is expected to foster students with rich classroom environment which is necessary for spontaneous exploration. Students are encouraged to construct their own knowledge through active experiences that reinforce assimilation and accommodation. Distinct pedagogical strategies emerged from cognitive framework including reciprocal teaching, inquiry learning, discovery learning and problem-based learning (Yilmaz, 2011). It is well documented that applications of cognitivist learning theories have a positive impact on student's achievement in teaching science subjects at secondary school level (Khan & Sultana, 2021).

A more elaborated branch of cognitivism, named as constructivism, gained more attention in recent years. Both theories conceive learning as a mental activity. Yet, constructivism theory attention is concerned with both learner and environmental factors, where knowledge is created through the specific interaction between these two variables (Ertmer & Newby, 2013).

Constructivists conceptualize students as active entities, engaged in distinct cognitive processing to build an updated construction in their learning. Constructivist frameworks supportchanging the teacher's role from authority to guidance, helping students in meaning discovery and development. This student-centered approach challenges teachers to support innovative learning environments to explore, think, and reflect their

experiences and ideas without hesitation. Learning materials are designed to focus on a wider idea rather than facts, where both student and teacher are involved in a continuous assessment protocol (Mwanda, 2017). Within biological context, Constructivist learning emphasizes the five E's elements of “Engage, Explore, Explain, Elaborate, and Evaluate”; the phenomena that surround students enabling to master skills such as critical, creative, problem-solving thinking skills and communicative skills (Abu Kassim et al., 2023). In addition, case studies, project-based studies, brainstorming and collaborative learning are all derived from a constructivist approach where students can construct their own knowledge (Dilshad, 2017).

Regarding biology education, adopting a constructivist perspective transforms teaching to become more likely to what biologists do. It converts learning into an active and social process by making sense of experiences. Using constructivism as a referent can possibly assist in obtaining a high level of student engagement and interaction with events, objects, colleuges, teachers or learning resources such as books, videotapes, and practicing scientists. Bioinformatics, through a constructivist perspective, can improve studentlearningoutcomes, help in effective concept understanding, build learningexperiences, and build social skills among students and their educators. in addition, constructivism activities help students to remember and apply biological concepts in everyday life and to use and improve critical thinking skills (Aldi et al., 2025).

Student centered classrooms were advocated by the American association for the advancement of science through the publication of " Vision and change: A call to action". The document outlined six core competencies needed for undergraduate biology education including the application of the process of science, the use of quantitative reasoning, the use of modeling and simulation, tapping into the interdisciplinary nature of science, communicating and collaborating with other disciplines and understanding the relationship between science and society (Driessen et al., 2020). The interdisciplinary in biology education, is an upcoming demand realized by different biologists, where biological questions, situations are problems are proper visualized within an integrative context rather than a sole biological perspective. A realization that transformed biology and science education into a more real, holistic, integrated, and student-centered approaches through STEM education. STEM education

is a framework where four disciplines (Science, Technology, Engineering and Mathematics) are integrated in a form of real-world problem scenarios. This student-centered interdisciplinary approach relies on several learning theories including constructivism, experiential learning, cognitive load theory, and situated learning. Constructivism aligns well with STEM scenarios through Problem solving ethos, collaborative projects and peer-peer interactions (Gavrilas & Kotsis, 2025). STEM approach also aligns well with experiential learning theoretical framework especially when incorporated to authentic daily situations (Lestari, 2021). Experiential Learning Theory (ELT) presents a holistic framework of the learning process that emphasizes the pivotal role of experience during learning process.

Compared to cognitivism, which emphasize cognition over affect and behaviorism that reject the role for subjective experience in the learning. the term "experiential" stems from the experiential works of John Dewey, Kurt Lewin, and Jean Piaget. ELT is a holistic theory that explains learning in all aspects of life, not only in formal settings. In ELT framework, Learning is best viewed as a process, not as outcomes. In addition, Learning results from synergetic interactions between the person and the environment (Kolb et al., 2014). Experiential learning is obtained when students actively participate, engage and interact with their surroundings. in experiential learning students are allowed to engage their senses in real and modern situations including hands on activities, contextualization of information in real world scenarios, and through reflection of their experiences (Prestholdt & Fletcher, 2018). In STEM protocols, the significance of ELT lies on the emphasis on Learning by doing. STEM usually deals with phenomena that can be seen, observed, traced, tested or manipulated in procedural practical settings. This can be achieved by laboratory experimentation, engineering school projects and field trips (Gavrilas & Kotsis, 2025). Another theory, named as situated learning can be used in biological educational contexts. Situated learning theory has been identified as an alternative to dominant cognitive perspectives on learning since it asserts that knowledge should be delivered in an authentic setting where learners should be involved in authentic daily practice settings. Which usually social interaction and within the "community of practice" moving learners from beginners to experts (Besar, 2018). Within STEM education, situated learning theory provide a theoretical lens that allows the experiences of students to be explored in the context of the authentic activity (Roberts et al., 2018), since this theory views the students as a part of a group of

peers or a part of a wider social and cultural context which would shape their ideas, identities, attitudes, and thoughts.Within STEM classrooms, situated learning framework might be applied by incorporating with local laboratories, industries, service-learning projects and professional engineering or research projects (Gavrilas & Kotsis, 2025).

Regarding the integration of STEM activities in Biology education; bioinformatics science represents the link in-between; where both biological data and computer science are combined to help to deliver and interpret researches in biology and medicine (Mallawaarachchi et al., 2018).

The Network for Integrating Bioinformatics into Life Sciences Education (NIBLSE) asserts the importance of the early introduction of computational practices to life science education, where students are engaged with authentic huge data sets that upon computational analysis, complex questions in evolution, molecular biology, and medical genetics will be solved and interpreted. The NIBLSE recommendations suggests the use of experiential learning along with inquiry, discovery, project-based learning that will enable students to act like scientists (Wolyniak, 2023).

However, since Bioinformatics is technology dependent approach. It is a piece of wisdom to interpret the application of bioinformatics experiments from a connectivism perspective. Connectivism, the newest learning theory that explains learning process during the digital social networking and cloud computing age (Downes, 2020). Siemens, the pioneer of connectivism, argued the limitations of previous learning theories including behaviorism, cognitivism, and constructivism in explaining learning manipulated by technology. According to him, Connectivism is proposed as an appropriate theory for a digital age (Mattar, 2018). Where “learning (defined as actionable knowledge) can reside outside of ourselves (within an organization or a database), is focused on connecting specialized information sets and the connections that enable us to learn more are more important than our current state of knowing”. Principles of connectivism include the diversity of opinions, connecting of specialized nodes of information resources, the utilization of non-human appliances.In connectivism framework, learning is a constant process that occurs through nodes and connections between people, information, and technology. Learning can be obtained by the use of Massive open online courses (MOOCs), Personal learning networks (PLNs)

including social media networks that are created by learners themselves and through Collaborative learning where learners utilize digital tools and to create and share knowledge (Alam, 2023). The connectivism approach aligns with STEM education since it is able to explain self-regulated learning in a digital world. By concentrating on "how to learn", "what to learn" and "why to learn" connectivism supports learning that is compatible to learners' needs and learning contexts that can be incorporated into STEM course environments (Guillot, 2025). In addition, Bioinformatics will offer educators to adopt Connectivism, since this learning theory provides the chances for students to gain exposure to digital media and social information, adopt and apply new tools used by others, acquire the necessary digital skills or digital resources, and express students understanding.Connectivism also might develop students' attitudes and interests towards becoming content producers, engaging in collaborative and cooperative learning scenarios(Leow & Neo, 2023).

Thus, as a consequence of emerging technologies, in addition to the versatile learning theories that supports the utilization of upcoming technologies, such as constructivism, connectivism and experiential learning theories, bioinformatics integration within high school education supports the previous theoretical frameworks within biology curriculum where students are the active core of the educational process.

1.2.2 Theoretical Concepts

1.2.2.1 Bioinformatics

The Sparkle toward bioinformatics was the discovery of the helically twisted double-stranded DNA molecule by Watson and Crick between 1951 and 1953.Followed by the sequencing of the first protein by Fredrick Sanger, bovine insulin, in 1955. Aligned with the advances being made in biology, there were also advances in computer software which led to the areas of bioinformatics. Bioinformatics, is often defined as the science that utilizes the use of computational techniques to understand, and to organize and interpret the information associated with biological macromolecules (Koury et al., 2021). Margaret Dayhoff was known as the first bioinformatician. She pioneered the application of computational methods for her research in electrochemistry. During her work at the National Biomedical Resource Foundation, along with her college Robert Ledley, a physicist who also worked on computational resources for biomedical problems. they both combined their efforts and developed COMPROTEIN, a computer

software for the IBM 7090' designed to determine protein primary structure using the data obtained from protein sequencing. Using the software, a three-letter abbreviation is used for the input and output of amino acid sequences. An Atlas of nearly 65 protein sequences was issued by Dayhoff and Ledley in 1956 (Mirsaydaliyevich, 2022). After nearly a decade, automated poly peptide sequencers emerged which participated in increasing the rate of sequence determination in a notable way. In addition, the determination of the three-dimensional structures of the first proteins including myoglobin and hemoglobin was performed.The development and spread of databases, and infrastructures was due to the recruitment of computers in systematic analysis and storage of the accumulating sequences and structures (Attwood et al., 2011).In 1964, Holley and colleagues revealed the first nucleic acid sequence ever determined, which was the ribonucleotide sequence of alanine tRNA.After couple of years, the determination of genetic code and the determination of the first gene sequence that belongs to Bacteriophage MS2 coat protein was attained.In alignment with previous scientific discoveries, recent advances in technology and next generation sequencing techniques caused huge data overload which directed the divergence of bioinformatics as a separate science. It is nearly estimated that nearly 2.5 million quintillions of Data is generated by next generation sequencing techniques on a daily basis (Amtul et al., 2024); which necessitate the need to classify bioinformatics as a single discipline. According to Pevsner(2009), the field of bioinformatics and genomics is summarized from three perspectives: the central dogma of molecular biology, the whole organism, which shows changes between the different stages of development and regions of the body, and a more global perspective that is presented through the tree of life, in which millions of species are classified into a tree of evolutionary branches.

Regarding its analytical nature, Bioinformatics has three folded objectives. The simplest form of bioinformatics objectives is to organize data in a renewable way that allows bioinformaticians to access existing information and to upload new entries once produced, including the Protein Data Bank for the three-dimensional macromolecular structures. Such data will have no value unless analyzed. Thus, the second objective is to develop tools and soft ware's that aid in the analysis process. For example, having a new sequence of particular protein must be compared to other existing ones. The third objective is to use these tools to analyze the data and interpret the results in a biologically meaningful manner at global level. Bioinformatics data is heterogeneous in

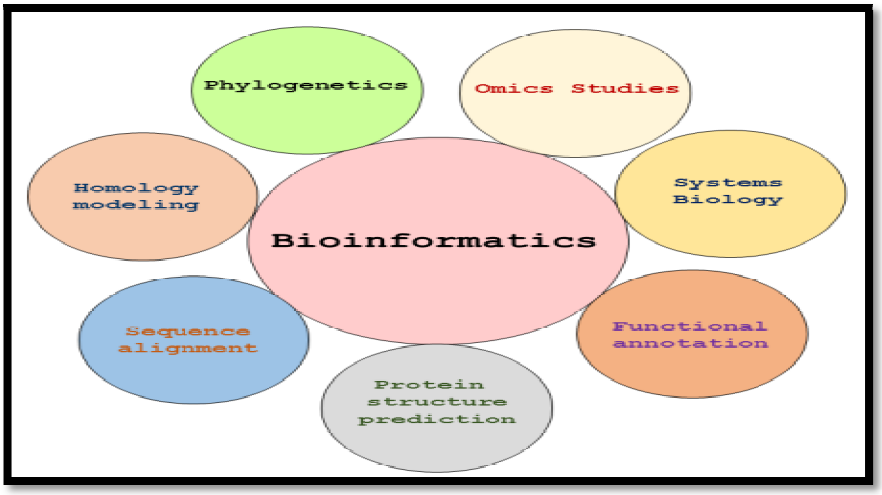
nature. It can be structured or unstructured texts, natural or synthetic images, charts and schema, raw sequences, genome sequences, protein structures, expression profiles, ontology relation diagrams, and so on. Data are usually available online from different deposits with versatile formats and algorithms (Romano et al., 2011).

Biological data is usually stored in Biological databases which are regarded as the organized sets used to store and retrieve these huge amounts of information. These databases are usually accessible for researchers to retrieve their needed information or to store their research outputs.Biological databases are considered irrefutable tool in the fields of molecular medicine, molecular biology and bioinformatics. Databases are classified in different manners, including the types of data as nucleotide databases, protein data bases, structural classification databases, 3D structures databases, ontology and biochemical pathway databases. Databases could also categorize as primary or secondary. Primary databases the raw data from experimental results such as DNA or protein sequences for example, GenBank is a primary database.Secondary databases, on the other hand, include the results of processing the information related to primary databases like Uniport database (Yekta & Arefi Oskouie, 2018).

The biological data is huge and need to be stored in certain databases. One database, named GenBank, is currently housing nearly twenty-two billion biological sequence records. The updated information in these databases are submitted by public and private scientists and is usually available to the public. Upon submitting sequences, they are usually analyzed through comparison to other sequences. One program, located on the NCBI website is BLAST. Using BLAST, many items, such as DNA nucleotide sequences or protein sequences, can be compared. In addition to comparisons, bioinformatics can perform many other tasks as well. One such task is the prediction of sequence structure and function; bioinformatics can also help in establishing evolutionary relationships among organisms. In addition, bioinformatics is used to discover single nucleotide polymorphism or SNPs (differences in genomes that define individuals as unique) and to diagnose genetic diseases (Torri et al., 2012). The jobs of bioinformatics have applications in research as shown below

Figure 1

Applications of bioinformatics



Note: Diniz & Canduri, 2017.

Bioinformatics integrated nature can be used to identify human genes, chromosomes, gene functions, genetic diseases, evolutionary relationships between organisms. bioinformatics was firstly introduced as a part of undergraduate biology courses (Campbell, 2003). The interest in merging bioinformatics within high school science activities emerged later. In an analytical study,Wefer and Sheppard (2008) have conducted an analysis of high school Biology standards where forty-nine states and the District of Columbia were screened for content related to the science of bioinformatics. Despite bioinformatics term was not used back then, nine distinct areas of bioinformatics and related aspects were found including Human Genome Project/genomics; forensics science; evolution science; biological classification; nucleotide variations; medicine; computer use; agriculture and food technology; and science/technology/society issues. However, the researchers found significant gaps in the degree to which these areas were addressed across the standards. in addition, standards statements regarding to bioinformatics content were generalized. The researchers also indicated the low representation of bioinformatics-related content that varied substantially across the different areas, with Human Genome Project, genomics and computer use being the lowest with nearly (8%), and evolution being the highest with approximate (64%) among states' science frameworks. This research recommended for reworking current standards to facilitate the goal of promoting bioinformatics literacy among high secondary school students and was one of the pioneering researches that supported bioinformatics integration within high school

biology education. Different subsequent initiatives and researches all over the world have investigated the effects and the outcomes of bioinformatics integration within biology and science curriculum either in high school or middle school education. This research will document the effect of integration of bioinformatics among high school eleventh graders on student's achievement and motivation towards learning biology.

1.2.2.2 Academic achievement

Educational assessment aims to determining, diagnosing, formalizing and identifying Student's level. Achievement has been recognized as one of the ways of student-level determination. The concept of achievement is highly related to the changes in cognitive actions and behaviors that can be changed through teaching or educational activities.Achievement is associated with concepts of Knowledge, skills, and abilities (Sahin et al., 2023).In other words, Academic achievement is defined as a set of performance outcomes that indicate the extent to which a person has accomplished desired goals regarding the activities in an instructional environment (Steinmayr et al., 2014). Measurement of achievement is an essential process that encounters crucial decisions. Regarding to student achievement, measurement is the process that encounters giving numbers that are expected to reflect and demonstrate student's ability about a subject (Susongko, 2016).

In educational systems, academic achievement is very broad term that carry a wide variety of educational outcomes, thus, the definition of academic achievement relies on the indicators used to describe and measure it. Despite the numerous criteria that indicate academic achievement, the most widely used indicators include procedural and declarative knowledge acquired. Other types of curricular-based criteria such as grades or performance on an educational achievement test are also used. In addition to cumulative indicators of academic achievement such as educational degrees and certificates. All criteria have in common that they represent intellectual capabilities and reflect the intellectual capacity of a person (Steinmayr et al., 2014).

The ubiquity of achievement indicators suggests the ubiquity of measurement tools for the achievement. According to Geisinger (2022), the ultimate indicators of academic achievement include Grade point average (GPA) and Standardized achievement tests. In GPA assessments, Grades are used to measure students' performance in the classroom

as assessed by teacher perspective while Standardized achievement tests provide more objective assessments of academic achievement than grades and can be considered as more of a "pure" indicator of academic knowledge(Anderman & Hattie, 2013).

In educational settings, tests are overemphasized since they are used to improve student outcomes, inform learners regarding their learning situation and developing learners' intellectual abilities. Usually, achievement tests are used by academics to analyze academic failure, curriculum evaluation, learning outcomes evaluation (Adeleke & Joshua, 2015). Achievement tests can either be developed by teachers, or they can be standard tests that are called standardized achievement tests. Standardized achievement tests are developed with caution to include measurement of goals and objectives that mostly common to many school systems. Achievement tests measure the knowledge of facts, concepts and principles. Such tests are used in issuing classroom-level decisions. In addition to the text book, the course syllabus and the course objectives are used as sources of question derivation (Sahin et al., 2023).

Regarding biology achievement, the utilization of digital technologies was an effective approach to enhance student's achievement in biology courses in numerous studies. For example,Eno and colleuges (2023) have reported that the use of digital devices within biology course have raised high school students achievement. The researchers elaborated the gain in achievement due to the ability of digital devices to offer multiple representations and to provide slow learners the opportunities to catch up with others. Technology is supposed to improve students cognitive, animation development and self-regulation skills that might help students in adopting healthy habits for knowledge retention which will affect student's achievement scores (Alneyadi et al., 2023). Regarding bioinformatics integration within biology curriculum, numerous studies confirmed the positive role that bioinformatics exerts on student's achievement scores. One of the earlier studies within high school context that derived the attention towards the cognitive demands needed to integrate bioinformatics at high school level is the a case study for Wefer and Anderson (2008),where ten high school students were included in an updated bioinformatics instructional program. The instructional unit of bioinformatics were conducted over ten class periods. The bioinformatics instructional unit integrated the use of computer-based programs. Students’ attainment of domain specific content and procedural skills were assessed quantitatively using a quiz and

comprehensive achievement unit test. Qualitative data were also supplemented through semi-structured interviews conducted at the end of the unit. The researchers concluded that the integration of procedural knowledge and higher order knowledge are required for effective bioinformatics instruction. The authors suggested that teachers should incorporate resources that diagnose individual student cognitive variations and organize bioinformatics instruction in a way that considers those cognitive variations. A subsequent study for Gelbart and colleagues (2009) that described the impact of a web-based simulation in bioinformatics on high school biology students' understanding of genetics research revealed that that student participation in the research simulation have elevated the generation of explanations that connect molecular mechanisms along with phenotype. in simpler words, students' participations have raised student abilities to understand and explain the relationship between structure and function. Later on, three ongoing bioinformatics training courses designed for high school teacher's development by the European molecular biology laboratory were assessed for strengths and challenges. Survey results showed that Most of teachers (62%) rated their overall learning experience as excellent, while 37% of participants showed that courses increased teachers understanding of bioinformatics and how to utilize biological data. In addition, Participants showed that the course increased their awareness of presenting new ideas for in class activities and computer-based resources during teaching (Wood & Gebhardt, 2013). In addition to that, Ghanem (2014) investigated a proposed bioinformatics curriculum with high secondary students in Cairo, Egypt, using analytical-descriptive and semi-experimental methods. Results indicated a statistically significant improvements in students' mastery of biological concepts. Similarly, Abdulaziz, Gloush, and Al-Khrainj (2023) implemented a bioinformatics-based program among 75 female secondary students in Kuwait, using an experimental design with control and experimental groups. The study found significant gains in biology achievement in the experimental group compared to the control group, supporting the integration of bioinformatics applications into biology curricula to enhance academic outcomes. The former two studies represent the only studies that investigated the effect of bioinformatics integration on student achievement in the Arabic region.until now, no Palestinian study is available regarding bioinformatics integration and its impact on student's achievement.

1.2.2.3 Motivation

"Motivation is arguably the most critical factor educators address to enhance learning outcomes. Broussard and Garrison (2004) describe it as the attribute that 'moves us to do or not to do something. Motivation is defined as the process of motivating; for a student, a motivating force is a stimulus, or influence or a drive force (a need or desire) that causes a person or student to act. According to its source, motivation can be intrinsic or extrinsic. What Students do without any type of external stimuli is called intrinsic motivation and is usually done for fun and sensation of enjoyment. From birth all individuals are spontaneously active, playful, and inquiring with no need to any kind of external stimulus to do such actions. On the other hand, the extrinsic motivation is more related to the actions that are associated with encouragement and support to get some rewards (Buzdar et al., 2017). With regard to students, learning cannot occur unless students are motivated on a continuous basis.According to Williams and Williams (2011). The recipe of the five key ingredients that affects student motivation include the student, the teacher, the content, the method/process, and the surrounding environment.

Many theories have proposed different understandings for motivation towards learning, including self-determination theory, self-efficacy theory and expectancy theory. All previous theories try to explain why students do what they do, how they do it and their confidence toward their ability to do (Martin, 2013). Self-determination theory assume that learners have fundamental psychological needs that should be satisfied in order to thrive and learn. The former psychological needs include competence, relatedness, and autonomy. In other words, the learner should feel effective in their interactions, have a sense of belonging to a community and to feel to have in control within their environment respectively. The former triangle of factors results in the presence of three types of motivation including intrinsic, extrinsic and amotivation state. Amotivation, is synonym to lack of interest, or feeling forced to perform any action (Pratt et al., 2023). In addition, self-efficacy theory, learners- specific believes about their own capacity is considered the main explicit explanation for motivation. Self-efficacy is defined as the belief that learners are capable of performing a specific task or achieving a specific goal. Self-efficacy beliefs are self-constructed since they are personally developed perceptions. Motivational gaps might occur when there is a large contradiction between

self-efficacy and ability (Seifert & Sutton, 2018). Another theory, Expectancy theory which was developed in its first version based on a work-context environment for motivating employees along their work. Expectancy theory suggest the presence of exponential relationship between the amount of effort delivered in a certain task and task performance that will lead to rewards. In educational settings, expectancy theory suggests that students should be highly motivated since they believe that the performance will be aligned with their efforts, thus, their performance will be rewarded which will offer learners a positive intrinsic attractiveness (Gopalan et al., 2017).

Motivation is considered an important factor within educational environments since it plays role in student conceptual change processes, critical thinking abilities, learning strategies and learning achievement. Due to the presence of versatile theoretical framework that describe motivation, Motivational factors are also numerous including self-perceptions of ability, effort, intrinsic goal orientation, self-regulated learning, task value, test anxiety, self-efficacy, task orientation and learning strategies (Tuan et al., 2005).

Different studies have investigated the impact of bioinformatics on different affective outcomes, including different motivational constructs. For example, in a study of Kovarik and colleges (2013) both teachers and students were investigated for the effect of bioinformatics over distinct traits including awareness, engagement, self-efficacy, and relevance. In teacher related part, twenty-four teachers were incorporated to investigate the effect of model workshop for bioinformatics curricula on teacher cognitive traits. the workshop included practices and resources to enable teachers to integrate STEM career information into their classrooms. in addition, students were incorporated into introductory and advance bioinformatics lessons. The introductory unit and the advanced units included the use of bioinformatics to teach basic concepts in genetics and molecular biology, and evolution successively. quantitative analyses of Pre–post surveys showed a significant growth among teachers regarding their preparation to teach the units. Introductory unit students showed significant gain in awareness, relevance, and self-efficacy without engagement while advanced unit students showed gains in all four areas. In addition,in a pilot study of bioinformatics, related activities from 5th to 8th science graders were performed as an after-school program. The interest of students toward bioinformatics was measured by pre and post

user surveys.Results showed that the majority of students have enjoyed the class and thought it was fun, exciting. Students were also enthusiastic about taking similar classes in the future (Cooper et al., 2017). Another relevant study explored the implementation of a bioinformatics-focused programming course for high school students. The course activities were structured into quarterly stages and included programming instruction using Scratch, alongside molecular biology projects such as DNA replication exercises. This initiative successfully motivated students and actively engaged them in learning molecular biology, effectively capturing their interest and promoting hands-on experience in the subject (Costa et al., 2024).

Other relevant studies regarding bioinformatics integration and its impact have investigated the motivation or one of its constructs along with achievement. This is a logical and a reasonable approach Since motivation and achievement are highly related and can be explained by three reasons. First, motivation is thought to be an important indicator and predictor of academic achievement. Research has shown that personality variables within students such as self-esteem and motivation, have intrinsically affected academic achievement (Amrai et al., 2011). The second reason is that motivation is considered as an academic outcome itself. Yet, till now, the identification of the motivational construct that describes and predicts academic achievement is still unresolved. There are no enough studies that investigate the relations between different motivational constructs and achievement. However, according to Steinmayr and colleagues (2014). Achievement motives, values, and ability of self-concepts are considered the most prominent motivational variables that affect academic achievement. The third reason is the presence of versatile determinants of academic achievement, including the traditional determinants which included standardized test-scores, GPA and high school rank, the demographic status determinants that include socio-economic status, gender, race. And thepsychosocial status determinantswhich include motivation to learn, academic goals, and social support which seem to be the most powerful determinants of academic achievement in learning process(Demiroz, 2021).one of the earlier studies that investigated achievement and different motivational constructs is the study of Marques and colleagues (2014) who conducted a pilot project to use bioinformatics-based scientific activities in high schools, called "Bioinformatics @ school". The project included web-based research projects for students can and a teacher training program in two high schools. Assessments were conducted by questionnaires,

structured interviews, and assessment of knowledge acquisition. Results has shown that students find bioinformatics-based approaches are enjoyable while teachers believe that bioinformatics-based projects to be useful as a teaching aid.Objective assessment of knowledge acquisition showed a clear positive effect both in knowledge and confidence of the students. In addition to that,Machluf and colleagues (2017) investigated the description of a learning environment called 'Bioinformatics in the Service of Biotechnology'. Students' attitudes and learning outcomes toward the bioinformatics learning environment were measured by questionnaires, interviews and observations. Students' knowledge acquisition and difficulties were characterized into four categories: the domain of knowledge (declarative, procedural, strategic and situational), the field of science that each question stems from (biology, bioinformatics or their combination), the level of cognitive dimension (remember, understand, apply, analyze, evaluate, create) and the type of question. Analysis of students'cognitive outcomes showed significant gain in bioinformatics field. Analysis of students' affective outcomes revealed positive attitudes toward bioinformatics and the associated learning environment, as well as students' perceptions of the teacher's role within the process. In a similar context, the Western New York-based project research explored the impact of a genomics and bioinformatics research among high school teachers and students. The project had three different stages including a teacher professional development workshop during summer, a teacher-guided student genome annotation group projects during the academic year and symposiumto showcase student work in at the end of the academic year. During the program, teachers and students performed manual gene annotations using an online annotation toolkit known as Genomics Education National Initiative-Annotation Collaboration Toolkit (GENI-ACT). Assessment of the projectshowed an increase in content knowledge regarding basic genomics and bioinformatics as well as increased confidence in using toolsand the scientific process using GENI-ACT. The findings support the fact that high school students are capable of utilizing the same bioinformatics tools as scientists in order to conduct a real-world research task(Koury et al., 2021). Bain and colleges (2022) also investigated the role of bioinformatics on students' knowledge acquisition and interests throughan open-access bioinformatics workshop for secondary school biology students. The content of the workshop is linked to the science curriculum in Scotland and addressed the learning objectives of the Scottish Qualifications Authority Higher Biology and Human Biology.

The workshop was delivered to biology students of seven schools. Assessment of student and teacher feedback was conducted quantitatively and qualitatively. Quantitative student and teacher evaluation showed that the workshop is useful and enjoyable for both male and female students, no statistically significant difference was found regarding to sex. In addition, Qualitative replies suggest that the workshop gives an increased knowledge of the field of bioinformatics and highlights its importance in everyday life. Similarly, Sucharit and Klintong (2025) investigated the use of bioinformatics tools, specifically the NCBI database and Clustal Omega, to construct phylogenetic trees for high school biology students. A team of teachers received training to design and implement the activities for 240 students, who were tasked with researching and analyzing DNA sequences from various kingdoms of living organisms. Students were able to navigate the NCBI database and use Clustal Omega to generate phylogenetic trees, thereby enhancing their practical understanding of evolutionary relationships. Post-activity surveys revealed a significant increase in students' knowledge and interest in bioinformatics, with 99% of participants demonstrating improved comprehension of bioinformatics principles and 63.2% reporting increased personal interest in the field. Based on the available literature, no local Arabic or Palestinian studies appear to have combined achievement and motivation, or achievement and any of the motivational constructs in bioinformatics integration investigations.

1.2.2.4 Palestinian biology textbook

The Palestinian Curriculum Development Center (PCDC) that belongs to the Ministry of Education and Higher Education in Palestine is responsible for curriculum matters. The year 2000 held promise to Palestinians regarding their educational system development. Since in that year Palestinian textbooks were introduced for the first time for the first, second, six and seventh grades. A step that replaced the Jordanian and the Egyptian textbooks used back then in the West Bank and Gaza during the Israeli occupation(Wahbeh, 2003). By the beginning of the 2006–2007 academic year, all textbooks were issued and a united curriculum was certified in the West Bank and the Gaza Strip. Science school textbooks have four main foundations including Intellectual Foundation Psychological foundation, Social foundations and Cognitive foundation. Science is introduced for grades 1-9 as general approach. In grades 10-12 separate

branches of chemistry, biology and physics are taught. In addition to the content knowledge, the new curriculum introduced other science-related subjects includingTechnology and applied sciences that aims to fosters students' technical practical skills that will reflect their knowledge in their lives. In addition, hygiene and environmental sciences are also incorporated. It aims to increase student's awareness of global issues worldwide. Palestinian Biology textbooks mainly focus on human and animal anatomy and physiology, cell and molecular biology, genetics and heredity, Plant Biology and organism taxonomy(Mustafa & Bisharat, 2008). According to Itmazi & Khlaif (2022)scientific activities were designed as learner centered and multidisciplinary to some extent. However, No digital or bioinformatics activities are incorporated within the textbook according to the eleventh grade biology teacher book, that was issued by the Ministry of Education and Higher education along with the student textbook (Ministry of Education and Higher Education, 2019).

Regarding the effect of technology integration within Palestinian biology textbooks, few researches have been conducted. For example, Neiroukh and Ayyoub (2025) have investigatedthe impact of virtual reality on scientific habits of mind which included critical and creative thinking skills for high school biology graders in east Jerusalem. Results indicated an enhancement of students critical and creative thinking skills. In addition, Hmoud and colleuges (2023) investigated the effect of Extended Reality (XR) onhigh school students' engagement in Biology courses. The results indicated that the XR context encouraged the students to engage in four types of engagement including cognitive engagement, emotional engagement, social engagement and behavioral engagement. However, based on the reviewed literature, there appears to be a lack of documented studies investigating bioinformatics integration in tenth, eleventh, or twelfth grade biology courses, including the use of bioinformatics databases in biology classrooms or biology high school laboratories.

1.2.3 Problem statement

This dissertation is theoretically and practically significant in many ways. The main significance originated from the need of heredity unit of the eleventh grade Palestinian Biology curriculum for the second semester for supplementary updates in bioinformatics data which will deepen Student's understanding and expand the student knowledge and experience toward real life situations. As a former teacher, the teaching

of the heredity unit in the eleventh-grade biology textbook is restricted to theoretical part with no visualization or manipulation of genes and their constituents. According to Al- Astal (2019), the Palestinian eleventh grade biology textbook was analyzed according to the NGSS standards. The content in the eleventh-grade textbook for the scientific and engineering standards was moderate. Weak use of computational and mathematical thinking, in addition to low representation of statistics and probability in the genetics unit. Regarding common concept dimension standards, certain common concepts were weakly represented, such as proportions and quantities, energy, and matter. In addition, specialized ideas standards were also moderately represented, With no representation of certain standards such as growth and evolution, ecosystems, natural selection, and genetic variation. Integrating bioinformatics into biology textbooks may lead to a higher representation to NGSS standards especially in computational and specialized standards. In addition, studies have shown that the Palestinian curricula for science and mathematics are weak in incorporating most 21st-century skills, particularly technological skills, which were included in a limited and unbalanced manner and often without being translated into practical activities or real educational contexts (Khaldi & kishek, 2020). In another study by Abualrob (2019), which aimed to describe the determinants of employing 21st-century skills in Palestinian schools, the researcher indicated that the level of students' development of 21st-century skills largely depends on teacher characteristics, such as academic experience, professional training, and the use of active learning strategies. The results also highlighted the need to design instructional and training materials aligned with the curriculum that require the integration of technological skills and 21st-century skills to support student learning.

Integration of bioinformatics science within high school level is important to producebioinformatics-literate students equipped with twenty first century skills and knowledge that will aid their careers in life aspects and to community by preparing the next generation of informed citizens (Machluf et al., 2017). In addition to that, Shuster (2016) suggested that the use of bioinformatics as scientific theme for the design of classroom activities can support important science concepts and provide engaging scenarios for students to incorporate and solve which will manifest their learning. Furthermore, according to Shim & Yoon (2024), Incorporating bioinformatics, which integrates biology content and informatics can broaden students' participation in STEM, which is currently considered a demand for the fourth-generation students.

Thus, this research aims to answer the following questions:The main question of this research is “What is the effect of bioinformatics integration in the biology heredity unit on student achievement and motivation?”.

The sub questions of this research are:

1. Is there a statistically significant difference in the mean adjusted post-test achievement scores on the heredity unit between the experimental group (integrated Bioinformatics experiments) and the control group (traditional instruction), when controlling for the pre-test scores?
2. Is there a statistically significant difference of student's mean adjusted post-test achievement scores due to the interaction between the sample type (experimental/control) and geographic location (Qabatya, Jenin, Zababdeh) after controlling the pretest scores?
3. Is there a statistically significant difference of student's mean adjusted post-test achievement scores due to the interaction between the sample type (experimental/control) and learning environment (face-face/blended) after controlling the pretest scores?
4. Is there a statistically significant difference of student's mean adjusted post-High Order Thinking Skills (HOTS) scores due to the interaction between the sample type (experimental/control) and gender (male/female) after controlling the pretest HOTS scores?
5. Is there a statistically significant difference of student's mean adjusted post-Low Order Thinking Skills (LOTS) scores due to the interaction between the sample type (experimental/control) and gender (male/female) after controlling the pretest LOTS scores?
6. Is there any statistically significant difference of students' total scores of biology motivation questionnaire and its subscales scores among experimental and control samples after controlling pre-scores?
7. Isthere any statisticallysignificant difference of students' total scores of biology motivation questionnaire and its subscales scores among female and male students within the experimental group after controlling pre-scores?
8. Is there any statisticallysignificant difference of students' total scores of biology motivation questionnaire and its subscales scores among students from different

geographical school locations within the experimental group after controlling pre-scores?

9. Is there any statistically significant difference of students' total scores of biology motivation questionnaire and its subscales scores among students of face-face and blended learning environments within the experimental group after controlling pre-scores?

The dissertation findings for the above questions will benefit decision-makers in curriculum design to upgrade the biology content in high school biology textbooks.

1.2.4 Aims of the study

1. To develop supplementary instructional materials based on bioinformatics experiments aligned with the heredity unit of the eleventh-grade biology curriculum.
2. To Provide professional training for teachers to support teachers with bioinformatics integration along the curriculum.
3. To examine the effect of integrating bioinformatics within high school biology class on student's achievement.
4. To examine the effect of integrating bioinformatics within high school biology class on student's motivation.

1.2.5 The importance of the study

1. This research is the first research that examines the effect of bioinformatics integration at high school level biology text book on student's achievement and motivation in Palestine.
2. The findings of this study may inform biology curriculum designers at the Ministry of Education and Higher Education, as well as educational supervisors and teachers, about the potential of incorporating bioinformatics into future curricula.
3. This research will offer the student the chance to perform and to apply exceptional experiences in bioinformatics for the first time and to integrate biology, computer and information technology sciences.

1.2.6 Hypothesis of the study

The null hypotheses assumed for the achievement test and motivation scale scores.

$H_0$1: There is no significant difference of the student's achievement post-test scores among experimental and control samples after controlling the pretest scores at a=0.05.

$H_0$2: There is no significant difference of student's post-test achievement scores due to the interaction between the sample type (experimental/control) and geographic location (Qabatya, Jenin, Zababdeh) at a=0.05 after controlling the pretest scores.

$H_0$3: There is no significant difference of student's post-test achievement scores due to the interaction between the sample type (experimental/control) and learning environment (face-face/blended) at a=0.05 after controlling the pretest scores.

$H_0$4: There is no significant difference of the average scores regarding student's post HOTS scores due to the interaction between the sample type (experimental/control) and gender (male/female) at a=0.05 after controlling the pretest HOTS scores.

$H_0$5: There is no significant difference of student's posttest LOTS achievement scores due to the interaction between the sample type (experimental/control) and gender (male/female) at a=0.05 after controlling the pretest LOTS scores.

$H_0$6: There is no significant differences of students' total scores of biology motivation questionnaire and its subscales scores among experimental and control samples at a=0.05 after controlling pre-scores.

$H_0$7: There is no significant difference of students' total scores of biology motivation questionnaire and its subscales scores among female and male students within the experimental group at a=0.05 after controlling pre-scores.

$H_0$8: There is no significant difference of students' total scores of biology motivation questionnaire and its subscales scores among students from different geographical school locations within the experimental group at a=0.05 after controlling pre-scores.

$H_0$9: There is no significant difference of students' total scores of biology motivation questionnaire and its subscales scores among students of face-face and blended learning environment within the experimental group at a=0.05 after controlling pre-scores.

1.2.7 Procedural definitions

Heredity: the science of transferring traits from fathers to offspring.

The Next Generation Science Standards (NGSS):a three-dimensional integrative learning approach that focuses on core ideas intertwined with science and engineering practices (SEPs), cross-cutting concepts (CCCs) and Disciplinary Core Ideas (DCIs).

Project based learning: is an active learner-centered strategy of instruction where students are characterized as autonomous learners as they practice goal setting, constructive investigations, collaboration, communication skills, and reflection measures within real-world context practices**.**

Problem based learning a student-centered pedagogical strategy that enables students to acquire knowledge by actively engaging with meaningful real-life problems.

Inquiry based learning: an educational strategy in which students mimic the methodologies and practices of professional scientists to build construct knowledge. Learners usually formulate hypotheses and test them through experimentations.

Chapter Two

Methodology

2.1 Research Design

To investigate the effect of integration of bioinformatics experiments on student's achievement and motivation, a quantitative quasi experimental approach was used. Quasi experimental designs are often called ex-post facto designs, since the experiment is applied after the groups have been formed. It is usually used when randomization is impossible, it is a type of design, that lacks random assignment, which is usually suitable when studying any intervention to a pre-prepared group, such as school classrooms (Singh, 2021).

Quasi -experimental research aims to identify cause-and-effect relationships between the variables which are highly similar to actual experiments. the independent variable's effects on the dependent variable are usually being assessed (Ghanad, 2023). One of the approaches of quasi experimental design is Pretest-posttest control group design.In this form of design, the experimental group participates in a certain type of treatment or intervention which might include single or multiple sessions of training. This form of design, both experimental and control groups; are subjected to a pretest and a posttest. The pretest is important in ensuring comparability of the two experimental and control groups before the treatment, while the posttest is important in determining the effects of the treatment or the intervention on the outcome variables (Rogers & Revesz, 2019). Intervention to the experimental groups included supplementary experiments of bioinformatics that align with the content of the heredity unit of the eleventh biology second semester textbook. Two quantitative tools were used to collect data from both experimental and control groups. The first tool is the pre-existing Biology motivation questionnaire (BMQ) I to assess student's motivation towards learning biology, the second tool was an achievement test designed specifically for the heredity unit within the biology textbook.

The researcher justifies the use of the quantitative research method since it usually yields numerical, objective, and generalizable results that can be generalized on the whole population (Khatri & Karki, 2022). This type of result is mostly needed prior to

curriculum development. Quasi experimental design was used since the students were already assigned to classes.

2.2 Research Context

To answer the research questions, a quantitative quasi experimental approach was conducted at three distinct secondary schools that belongs to Qabatya and Jenin directorate of education in Jenin Governorate -Palestine during the second semester of the academic year of 2024/2025. The application started and finished earlier in the schools that belongs to Qabatya directorate due to the occupation closure for Jenin city and its Camp within the same period. The researcher chose schools that has two sections for the eleventh class in order to be able to have both experimental and control group within each environment. six groups were involved in the quasi-experiment, three control groups and three experimental groups. The intervention was conducted in a biology course, specifically within the heredity unit for the experimental group and lasted for a whole month, the students were taught and trained by their own teachers. The researcher developed the intervention materials, which consisted of thirteen experiments designed to align closely with the textbook content. The course design adopted the use of The Analyze, Design, Develop, Implement and Evaluate (ADDIE model). Since Bioinformatics entails the use of technology within the classroom, and most teachers are not aware of using bioinformatics databases. Thus, the Technology, Pedagogy and Content Knowledge(TPACK)model was necessary to adopt as the framework to provide empirical and theoretical guidance for teachers training oftechnology integration in the classroom (Colon et al., 2023). Training sessions were held for teachers by the researcher to ensure that teachers were qualified enough to conduct the intervention experiments. At the beginning and end of the biology course, students completed pre-course and post-course achievement tests and questionnaires for motivation.

2.3 Ethical Approval

This study was conducted in compliance with ethical research guidelines. Ethical approval was obtained from An-Najah National University Institutional Review Board (IRB) before data collection. The approval was granted under reference number [IRB: Fgs/Hum. Feb. 2025/70] (Appendix A). All participants provided informed consent before participating in the study, ensuring voluntary participation, anonymity, and

confidentiality. In addition, permission to apply the intervention and to assess students' outcomes was taken from the Center of Educational Research and Development (Appendix B).

2.4 Research Population

The population of this study are all eleventh-grade students in the scientific branch of secondary schools of both Qabatya and Jenin directorates of education and higher education in Palestine

2.5 Research Sample

The present study focused on eleventh grade students at three distinct schools and were distributed in table (1). Eleventh grade student participants in experimental samples were (76) students compared to (71) students in the control samples.

Table 1

Demographic information of the student's sample

Directorate	school	School type	Student gender	# of Control sample	# of Experimental sample
Qabatya	Qabatya secondary girls' school	public	female	24	27
	University of academic education	private	male	10	10
Jenin	Jenin secondary girls' school	public	female	37	39
	Total			71	76

Teachers of the sample showed willingness to participate in the research. Participating teachers were the student's original teachers, teachers were given orientation session to familiarize them with bioinformatics science and bioinformatics-based activities. Then bioinformatics experiments were explained and applied on students either during formal biology classes, or via Zoom or Teams session in a synchronized manner. Specific bioinformatics experiments were utilized for each lesson of the heredity unit and was compatible to its content.

The sample included (147) students taught by 3 biology teachers from 3 different high schools. Schools that have two class sections for the eleventh grade were chosen in order to conduct the quasi experimental design. Within each school, the same teacher was responsible for teaching the control group which will help to eliminate the effect of teacher within each school setting.All three biology teachers were females, and qualified with a either bachelor or Master degree in Biology and all have teaching experience of more than ten years of teaching biology for high school students. Table 2 shows the demographic information of all three teachers.

Table 2

Demographic information of the teachers

Directorate	School	School type	teacher gender	Teacher qualification	Learning environment
Qabatya	Qabatya secondary girls' school	public	female	master	face-Face
	University of academic education	private	female	bachelor	blended
Jenin	Jenin secondary girls' school	public	female	master	Blended

2.6 Research Procedure

2.6.1 Intervention Design

2.6.1.1 Bioinformatics experiments design

Integration of modern technology within biology textbook for the eleventh grade of Palestinian textbook usually is a teacher effort. Since the textbook doesn't contain any link for videos, simulations or electronic games. And unlike the tenth-grade biology book, no interactive version has been issued for the eleventh grade. Thus, the researcher has redesigned the heredity unit of the eleventh-grade biology textbook for the second semester in terms of bioinformatics, where technology is utilized to examine biological data. To begin the design process, the researcher adopted ADDIE model for instructional design.ADDIE model has been used to develop curriculum in distinct fields including online continuing education.This model includes 5 phases, the analysis phase, the design phase, the development phase, the implementation phase, and the evaluation phase (Cheung, 2016).

2.6.1.1.1 Analysis phase

Both course content analysis, and learning environment analysis for the desired schools were performed. The analysis of the unit was performed first in terms of knowledge constructs (Facts, concepts, generalizations, theories and procedures) by the researcher and three qualified teachers (Appendix C figure C1). Then, the behavioral objectives of the analyzed unit were classified with the aid of eleventh biology teachers book into six levels according to the revised Bloom taxonomy pyramid starting from remembering, understanding, applying, analyzing, evaluating and creating (Appendix C figure C2) where the first two levels as termed as Low order thinking skills and the remaining four termed as high order thinking skills (Singh & Shinde, 2025). Blooms taxonomy was used since it is the most familiar taxonomy available among teachers and educators at Palestinian schools (the taxonomy should be familiar to teachers for subsequent tools design). The revised version of the taxonomy was used since it's the version used to resynthesize the digital version of the taxonomy, which will be used to classify bioinformatics specific behavioral objectives. Content analysis showed that nearly half of the course objectives were of Low Order Thinking Skills LOTS (nearly 98), and that the book unit contains no digital behavioral objectives (Appendix C Table C1). most learners at the eleventh grade can use computers and search through internet by their own.

2.6.1.1.2 Design phase

This stage involved establishing educational objectives, lesson planning, tools, and an assessment instrument. In this phase, learning outcomes such as the structure of the content, mental processes required by participants, the best tools to use are outlined. According to the previous content analysis, it turns out that the heredity unit of biology book of the eleventh grade contains two lessons, the first is composed of 6 subtitled sections, the second is composed of four subtitled sections. Where nearly half of the behavioral objectives are" Low order Thinking Skills". The design of bioinformatics experiments aims to increase the "High Order Thinking Skills" within the unit in addition to integrate technology within learning material. The researcher used the already persistence unit as a link for the designed technology dependent scientific experiments. For example, the first subtitled section of the first lesson entails the mendelian traits and genes of peas without referring to the difference between dominant

and recessive genes due to their genetic sequences. The researcher aimed to design an experiment where the student is able to classify the gene of pea stem length to dominant or recessive by annotating the DNA databases and retrieving the sequence of both dominant and recessive versions of the gene and comparing the sequences of both versions which will lead eventually to a clearer definition of gene specially upon manipulating the gene nucleotides. Additional description of designed experiment goals and objectives and how they were linked to pre-existing goals and objectives are present Appendix D.

2.6.1.1.3 Development phase

In this stage, the design process's outputs are translated from scenarios into real learning materials, resulting in the product's activity components. The researcher used the constructivist and the experiential learning approach in developing the bioinformatics experiments. Where inquiry-based learning, problem-based learning, gamification were the main pedagogical approaches of designing the learning material.

2.6.1.1.4 Implementation Phase

It is the actual course material delivery; where students participate within the experiments either through Face to face lectures or through blended learning. Each activity was firstly introduced by the teachers in order to introduce the databases and the bioinformatics tools, and a similar activity was assigned to be performed by the student through a similar procedure.

2.6.1.1.5 Evaluation Phase

This step assesses the efficacy of bioinformatics experiments in achieving the intended goals. This phase is divided into two parts: formative and summative. Formative evaluation is represented as simple tasks within each experiment designed. summative evaluation occurs at the end of the designed material delivery as a final task that assess all skills acquired from the intervention material (appendix E).

2.6.1.2 Bioinformatics teachers′ training design

Before performing the intervention, all three teachers were trained for the delivery of bioinformatics experiments. All teachers were not familiar with bioinformatics tools before training since bioinformatics undergraduate courses are usually an elective

course of biology bachelor degree courses. In addition, the researcher assisted the need to explaining bioinformatics experiments as a part of the eleventh-grade biology textbook, which represents a totally different educational level compared to bioinformatics at the undergraduate level courses in regards to pedagogical approaches involved, technological media available and the content knowledge delivered. Thus, the researcher adopted the TPACK model for teachers training.

TPACK model is composed of seven components, three basic components (pedagogy P, Technology T and knowledge K) which in turn, generate four distinct intersections between them. All 7 components are required by teachers for effective teaching within the digital era. Thismodel is considered a diagnostic framework for the digital teaching competence that teachers should have (Colon et al., 2023). Since all teachers are qualified teachers of more than 10-year experience and having diplomas of educational qualification from the ministry of education and higher education, the researcher concentrated more on the technological intersections of the model, especially, the Technological Pedagogical Knowledge (TPK) domain. The previous domain emphasizes the capability of teachers to use numerous technologies in learning contexts four basic abilities for teachers are present in this domain. The first is the ability of teachers to choose the appropriate technology that supports teaching approaches in desired learning environment: the ability to choose technology that supports student learning, the ability to adjust the use of technology for teaching activities and the ability to think carefully about how to use technology within classroom (Ardi Nugraha et al., 2022).

The researcher held numerous sessions (3-4) through Zoom and Teams media for each teacher solely, each session extended for nearly two hours, within training sessions, the experiments were explained through fully to teachers. Recordings of the training were available to teachers, in addition, supplementary training material was translated from the previous Goblet bioinformatics tutorials and was delivered to teachers. Supplementary training material is available upon request. Appendix F shows images of training sessions in addition to students' participation to the intervention required Homework’s and assessments. Teachers passed all the HomeWorks and assignments delivered from students on a continuous basis to the researcher.

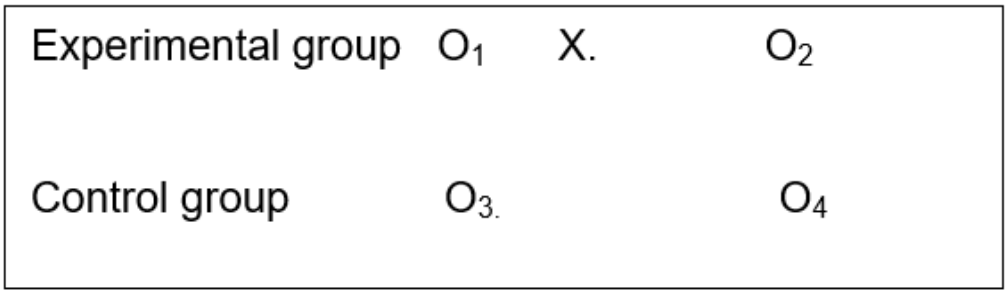
2.6.2 Quantitative Design

2.6.2.1Quasi Experimental Design

As mentioned earlier, a non-equivalent group quasi-experimental research design was used. For each school, two class sections were used as experimental and control group of the study. The intervention protocol is illustrated in Figure 2, where O1, O2 is the experimental group before and after intervention respectively, O3, O4 is the control group before and after intervention respectively. After assigning the control and experimental group for each of three schools. Pretests were applied to groups O1, O3, then the intervention was performed only to the experimental group, followed by posttests to groups O2, O4. The following BMQ and achievement test were used as pre and post- quantitative tools.

Figure 2

The Intervention designs



Note: Aryanti & Widodo, 2020.

2.6.2.2 Quantitative tool design

2.6.2.2.1 Biology Motivation questionnaire

The motivation questionnaire used in this research is an Arabic translated version of the Biology Motivation Questionnaire adopted from Science Motivation questionnaire (I) (SMQ I) developed originally by two professors at Georgia University in 2006 (Appendix G). BMQ consists of 30 items, each 5 subsequent items are gathered into a distinct subscale. The six subscales of the questionnaire are anxiety, extrinsic motivation, intrinsic motivation, self-efficacy, personal relevance and responsibility. The Questionnaire items are arranged in a 5-point Likert type. Positive items are scored as never: 1 point, rarely: 2 points, sometimes: 3 points, usually: 4 points, and always: 5 points, while negative items are evaluated in the opposite way. The science motivation

questionnaire was validated by (Glynn et al., 2009) by using construct validity measures. Different researches have documented the use of SMQ since authors gave the permission for researchers to use with acknowledging the authors. Thus, SMQ has been translated to different languages and used for specific scientific branches such as Biology, chemistry, mathematics, physic. The use of the questionnaire for specific branches is utilized by substituting the word " science" with the specific subject. The use of SMQ or its specific major versions is documented by different researchers all over the world (Lang & Sorgo, 2024). In addition, the form of SMQ specific to biology science is called (BMQ). Different studies have also re-validated the use of BMQ in motivation assessment. (Omurtak & Zeybek, 2022) validated the Turkish version of the tool using Reponses of nearly 600 students.The reliability coefficient was nearly 0.87 for the whole questionnaire. In addition, Lang & Sorgo (2024) recalculated the reliability of the Slovenian version and it was nearly 0.91 for the whole items. The researcher preferred to use the first version of the questionnaire rather than the second 25- item version since anxiety items are present. the researcher desired to explore the relationship between anxiety and motivation. The English version of the questionnaire was translated by two Arabic Language experts.

Although the above tool is previously validated in literature, the researcher followed the instructions of Gulturk (2024) to adopt a scale from different culture. After translation the BMQ, it was also validated first through content validity. The BMQ was sent to expert's reviews. All notes were taken into consideration (Table H1 in Appendix H). In addition, to assess the construct validity of the BMQ, the questionnaire was applied on a pilot sample of 138 students chosen randomly from distinct schools at the directorate, responses were used to calculate the Pearson' Correlation Coefficient to determine the correlation between each item and the overall degree of the scale to which the item belongs and with the total questionnaire. Tables H2 in Appendix H show the correlation coefficients for each dimension, and each item. According to the correlation coefficient values of each item with its corresponding scale, along with each item with the total score, and the correlations of scales with the total score, they are all positive and statistically significant at the level of significance (0.01) or less and all values are within the acceptable range, demonstrating good construct validity and suitability for measuring the target variable.

In addition, Reliability Cronbach's alpha tests were conducted for the whole questionnaire and for each scale to confirm the internal consistency of the combined tool. The total questionnaire had an internal consistency of 0.927, indicating high reliability and a good level of internal consistency (see Table H3 in Appendix H). this value is also approximate to the previously mentioned values of the questionnaire in different researches. scale reliabilities ranged from 0.701 to 0.918 which are all acceptable values of reliability. Appendix (I) contain the final Arabic translated and audited version delivered to students in addition to Arabic Language experts that translated the scales.

2.6.2.2.2 Heredity Unit Achievement Test

Achievement tests tend to assess students' level of performance regarding what the student has learned. It is usually achieved in an organized procedure of quantifying and measuring students' intended learning outcomes, Thus, an initial step of constructing an achievement test is to construct a table of specification of the intended unit. table of specification is a scheme that provides guidance to item construction through considering the relative importance to each area of the content and its cognitive level. Thus, aiding the teacher or the researcher to translate each level of subject matter content into test items(Osebhohiemen, 2019). In order to build a validated heredity unit achievement test. The researcher analyzed the unit content in terms of knowledge constructs, then the researcher, with the aid of eleventh grade teacher book issued by the Palestinian ministry of Education and Higher Education have analyzed the unit content for its procedural objectives according to Blooms revised taxonomy. The percentage of each level of taxonomy and its percentage from the total mark (50 pt.) was calculated. Test items were selected from each lesson in accordance to its percentage to the whole content and its intended level of taxonomy. The duration of the exam was estimated to be 45 min.

The test validity was maintained through constructing the table of specification, and relating the test items selected within the table. Upon items development, this version of the exam was sent to experts that included eleventh grade qualified teachers, biology supervisors and eleventh grade biology curriculum committee members in order to seek judgment and quantifying stage of content validity attainment. after receiving responses from experts, content validity ratio which is known as Lawshe's method was used to

achieve content validity which includes the calculation of the content validity ratio (CVR), where a panel of experts (n=7) are employed to rate each item within the exam (Almanasreh et al., 2019) into dichotomous scale Essential, or Not essential (41 test items).both CVR (for each item) and the content validity index (CVI) are calculated for the entire instrument where CVI is the average scores of the CVR values of the retained items. The equation used in calculations is CVR= (ne - N/2)/(N/2), ne is the number of experts or panelists indicated an item as essential, and N is the number of total panel members (Romero Jeldres et al., 2023). Twenty-six items have a value of CVR of 1.00, 15 items have a value of CVR of 0.86. all items are above 0.75 value determined specifically for 7 panelist values (Romero Jeldres et al., 2023) which is acceptable.The overall CVI is nearly 0.949 indicating excellent content validity (Table J2 Appendix J).

Test was redesigned by gathering certain items together to be close to the familiar school tests. The test contained 33 questions (50 points). The test was performed by an exploratory sample of (35) students. Responses were collected for further analysis Reliability of the test was measured by two ways, the internal consistency split half (odd-even) method. Spearman-Brown formula was used to calculate the reliability by using the correlation of the two halves. The correlation was calculated using SPSS and found to be (0.745) and the reliability was (0.85) using the formula (Table J3 appendix j). The second method for calculating the reliability was by using Cronbach a formula (Ekolu, 2016) and was found to be (0.853), the test reliability is Good (Table J4 appendix J).

In addition, item discrimination coefficient and difficulty were calculated. Most items were of suitable discrimination and difficulty levels (Table J5 Appendix J). Five items had poor discrimination (q1, q3, q10, q14 q19) either with high or low difficulty level. The researcher kept the items since deleting them would increase reliability by 0.01 value only. In addition, deleting the item will lower the content validity while rephrasing them will underestimate the taxonomic level intended to assess. furthermore, highly difficult items will help the researcher to study the effect of the intervention on the posttest and to assess HOTS.

2.7 Quantitative Data Collection

The final Arabic form of both the questionnaire and the test (Appendix K) were available either as a hard copy or soft copy. Pretests were performed to all 6 samples that included students former knowledge testing, the intervention was performed to the 3 experimental sample, and posttests were performed for the all 6 samples. Replies of the exam were corrected by the researcher and two biology teachers. All 147 participants successfully submitted the questionnaire. Data was stored into excel sheets, ensuring the anonymity of the participants and confidentiality of information. Two Missing data that were determined to be missing completely at random (MCAR) were handled by replacing the missing values with the mean of the observed responses for each respective variable.

2.8 Quantitative Data Analysis

Statistical analysis was performed by Statistical Package for the Social Sciences (SPSS) 24 version. Different types of Analyses of Covariance (ANCOVA) were used to analyze the results of achievement test and BMQ tests including two factor ANCOVA (RQ2-RQ5), Quade ANCOVA (RQ1) and Bootstrapping one-way ANCOVA (RQ6-RQ9) according to the nature of data in regards to normal distribution and homogeneity of variances among groups.

Chapter Three

Results

In this chapter, the results of the analysis of covariance (ANCOVA) with a nonequivalent control group design explored the impacts of the integration of bioinformatics experiments within the heredity unit of biology textbook for eleventh grade students on student's motivation and achievement. The research questions as well as the null hypotheses are indicated. Descriptive statistics provide the both sample measures including means and standard deviations for both post and pretests and BMQ results. The results of the one way and two-way ANCOVA analysis are illustrated to determine whether there are differences in biology achievement and motivation among students who practiced bioinformatics experiments compared to students within control groups. For achievement test analysis, several independent factors were also analyzed regarding their effect within the results such as student gender, geographic location, and learning environment.All assumption tests were performed and analyzed. Eachhypothesis was verified through Inferential statistics and presented in tables and charts. The probability of a type I error was set at $\alpha = 0.05$. The effect size is reported using partial eta squared, ηP^2.findings of achievement tests and BMQ scores are separated in the following two sections.

3.1 Results of achievement test

The null hypotheses assumed for the achievement test scores at a=0.05 are:

H01: There is no significant difference of the student's achievement posttest scores among experimental and control samples after controlling the pretest scores.

H02: There is no significant difference of student's posttest achievement scores due to the interaction between the sample type (experimental/control) and geographic location (Qabatya, Jenin, Zababdeh) after controlling the pretest scores.

H03: There is no significant difference of student's posttest achievement scores due to the interaction between the sample type (experimental/control) and learning environment (face-face/blended) after controlling the pretest scores.

H04: There is no significant difference of the average scores regarding student's post HOTS scores due to the interaction between the sample type (experimental/control) and gender (male/female) after controlling the pretest HOTS scores.

H05: There is no significant difference of student's posttest LOTS achievement scores due to the interaction between the sample type (experimental/control) and gender (male/female) after controlling the pretest LOTS scores.

Prior to each hypothesis verification, descriptive statistics were performed, and the main assumptions of the null hypothesis were verified.

3.1.1 Descriptive statistics

Both pre-test and post-test scores were analyzed through SPSS, analysis shows that the average of the post test score was (24.54), with a standard deviation of 10.438 compared to (3.90) and (3.839) points for the pretests respectively. Other statistical measures were listed in table (3). In addition, descriptive statistics specific for each independent variable tested were listed at Table L1 in Appendix L.

Table 3

Descriptive statistics of post and pre-test scores

Test			Statistic	Std. Error
posttest	Mean		24.54	.861
	95% Confidence Interval for Mean	Lower Bound	22.84	
		Upper Bound	26.25	
	5% Trimmed Mean		24.58	
	Median		24.50	
	Variance		108.948	
	Std. Deviation		10.438	
	Minimum		0	
	Maximum		49	
	Range		49	
	Interquartile Range		16	
	Skewness		-.028-	.200
	Kurtosis		-.629-	.397
pretest	Mean		3.90	.317
	95% Confidence Interval for Mean	Lower Bound	3.27	
		Upper Bound	4.52	
	5% Trimmed Mean		3.43	
	Median		3.00	
	Variance		14.740	
	Std. Deviation		3.839	
	Minimum		0	
	Maximum		23	
	Range		23	
	Interquartile Range		4	
	Skewness		2.353	.200
	Kurtosis		7.051	.397

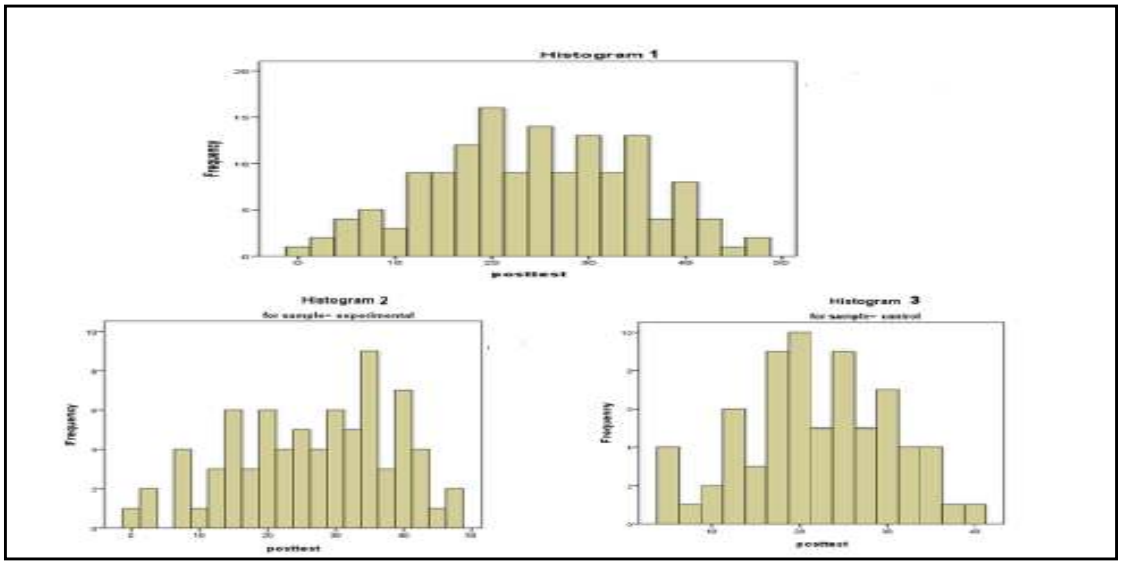
3.1.2 The main assumptions of ANCOVA analysis

Prior using ANCOVA, the research data should meet several assumptions. Main assumptions of covariance analysis in quasi experimental research is data normality, homogeneity in addition to regression and a linear relationship among the covariates

and dependent variable (Pramesti & Salsabila, 2025). The Normality tests are determined through the Shapiro-Wilk and Kolmogorov-Smirnova tests as shown in Table (4). Two assumptions of the normality test were suggested, the first assumption H0 suggests that the data of the post scores as normally distributed, while the second assumption H1 suggests that the data of the post scores as not normally distributed. Post test scores were normally distributed as shown in Figure 3.

Figure 3

Histogram of posttest scores



Results (table L2 Appendix L) show that the significance value of Kolmogorov-Smirnova analysis of the post test was (0.407) which is higher than the significance level of 0.05 suggesting the acceptance of the null assumption of normal distribution for the scores of the post test. All posttest scores and post HOTS and post LOTS scores were also normally distributed (table L2 Appendix L). All pretest scores would be covariate in ANCOVA analysis. Additional information regarding normality measurements using Kolmogorov-Smirnova and Shapiro-Wilk tests are available at table L2 in appendix L.

Other perquisite test was homogeneity of the Regression test that assumes there was no relationship between the covariate which is the pretest score and the independent variable/variables on a significance level of more than 0.05 as shown in tests of between subjects in Table L3 Appendix L, and the homogeneity test of group variances which was performed through Levene's Test for Equality of Variances for each independent

variable was also listed. Results showed that regarding to the sample (control, experimental), the F value of Levene's test was equal to (17.748) with a significance value of (0.00) which is lower than 0.05 and. thus, the two variances were not equal at significance level of 0.05, thus, the assumption of homogeneity was not achieved at 0.05 significance which directed the researchers to perform nonparametric measurements for research hypothesis concerning the sample variable.

Besides, the assumption of equal variances of all geographic locations was achieved at a significance level of (0.05) since the significance of the test is (0.184), which assumes that are the two variances are equal at α=0.05. In addition to that, there was no interaction between pretest and geographic location, the sample and the pretest, and the sample and geographic interaction with pretest since the significance is (0.411; 0.120;0.065) respectively, since all were higher than α=0.05 that asserts the homogeneity of regression assumption.

Regarding learning environment, Levene's test showed that the two learning environments (face-face, blended) were homogeneous at significance level of α=0.05 where the significance was found to be (0.081) as shown in Table L3 Appendix L. in addition, there was no interaction between pretest and the sample, the pretest and the learning environment, and the sample and learning environment with pretest since the significance was (0.733;0.320;0.147) respectively, since all were higher than α=0.05 that confirms the homogeneity of regression assumption.

Achievement test scores were also split into HOTS and LOTS scores.Gender variable was found to be homogeneous in both HOTS and LOTS scores at a significance level of α=0.05, where the values of significance were found to be (.0.661) and (0.122) for LOTS and HOTS respectively.Homogeneity of linear regression in HOTS and LOTS is also witnessed in regards to the interaction of gender with preLOTS scores, the interaction of the sample with preLOTS and the interaction of sample and gender with preLOTS and since the significance level was (0.372) (0.234) (0.865) respectively.The value of significance of all were higher than 0.05 which achieves the assumption at a significance level of α=0.05. Furthermore, Homogeneity of linear regression in HOTS was also witnessed in regards to the interaction of gender with preHOTS scores, the interaction of the sample with preHOTS and the interaction of sample and gender with

preHOTS; since the significance level was (0.591; 0.222; 0.976) respectively indicating satisfying the assumption.

3.1.3 Hypothesis Verifications

The above-mentioned research hypotheses were verified through a series of statistical examinations through parametric univariant ANCOVA tests and nonparametric tests.Results of the first hypothesis tests are listed in (Tables L6-L10 Appendix L).

Regarding to the first hypothesis, which stated that there are significant differences among the scores of experimental and control groups due to intervention at a significance level of α=0.05. The homogeneity assumption of ANCOVA was violated, thus, a parametric Robust test of equality of means was conducted (Chen & Zhu, 2001).Welch's test indicated a considerable significant difference in posttest scores with F of (8.18) at a significance level of (0.005). In addition to that, the results were confirmed by Mann-Whitney nonparametric tests. A higher mean rank for the experimental group was found of (83.51) compared to a mean rank of (63.82) of the control group at a significance value of (0.005). which suggests the positive effect of the intervention on the posttest scores of both tests. in order to covariate the pretest scores, an additional test was performed, which included the Quade ANCOVA since it is documented to be used in case of homogeneity of variances assumption violation (Santos, 2023). Results showed that experimental samples had significantly higher values of posttest scores compared to control sample posttest scores, with an F value of 8.140 and at a significance level of 0.005 and t value of 2.835 (Tables L6-L10 Appendix L).

The other remaining hypothesis's tests were stated below in table (4).During the previous measures, the posttest was the dependent variable, where the independent variable was the fixed factor either alone or with another factor, and the pretest scores were covariate.

Table 4

Results of one way and two-way ANCOVA

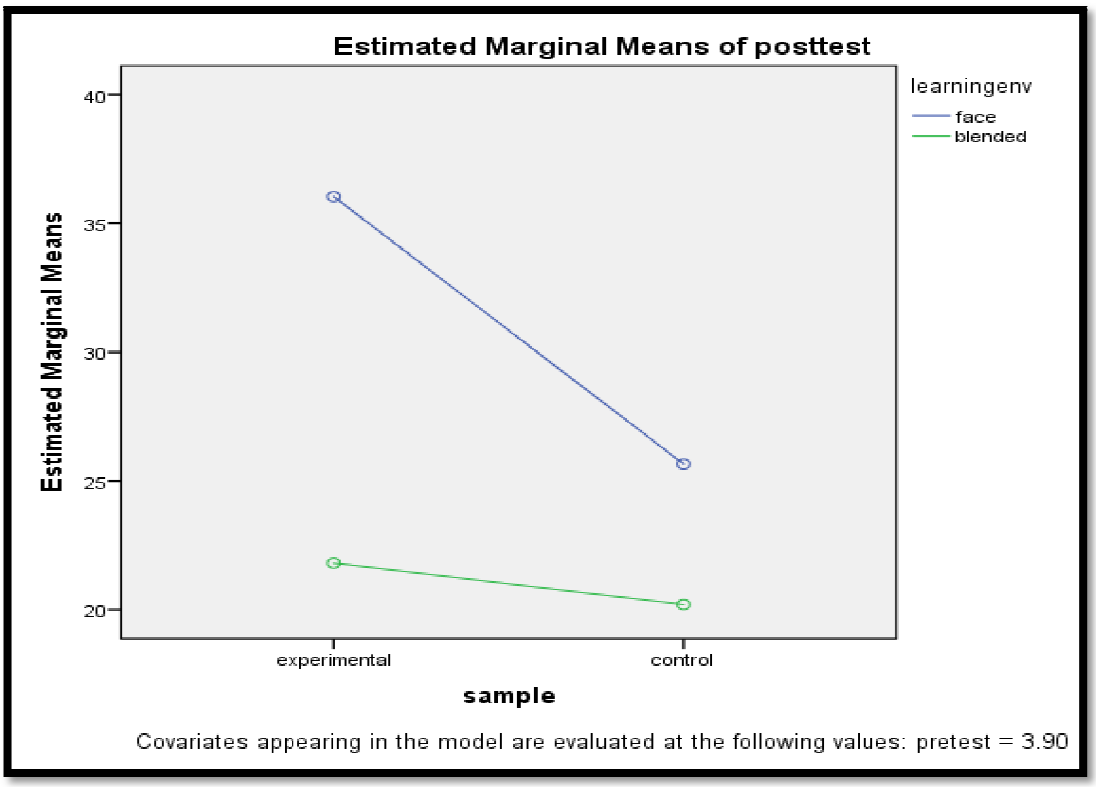
Two-way ANCOVA							
Independent variable	Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
posttest	Learning-env	3211.772	1	3211.772	42.718	.000	.231
	sample	1192.001	1	1192.001	15.854	.000	.100
	Learning-env * sample	633.482	1	633.482	8.426	.004	.056
posttest	geographic	3749.076	2	1874.538	26.075	.000	.271
	sample	720.734	1	720.734	10.025	.002	.067
	sample * geographic	599.632	2	299.816	4.170	.017	.056
postHOTS	sample	179.425	1	179.425	6.246	.014	.042
	gender	865.207	1	865.207	30.121	.000	.175
	sample * gender	.907	1	.907	.032	.859	.000
postLOT	sample	29.014	1	29.014	1.136	.288	.008
	gender	210.460	1	210.460	8.241	.005	.055
	sample * gender	15.221	1	15.221	.596	.441	.004

The above results of two-way ANCOVA analysis of the learning environment across groups indicated that learning environment exerts a highly significant effect on student's achievement scores of the posttests. The F value was 42.718, with zero significance level and a partial eta squared of (0.231). students' scores in face-face learning environment showed a significant higher performance compared to students' scores of blended learning with a mean difference of (9.835) (Table L4 Appendix L). regarding to the sample variable, a significant effect of F= 15.854 and partial eta squared of (0.10) is found which indicated the effect of sample in posttest scores. Pairwise comparisons at Table L4 show that posttest scores of the experimental samples have a higher significant mean difference of (5.994) compared to posttest scores of students at control samples with a significance level of (0.00). Furthermore, the interaction between the two variables of learning environment and sample was significant with an F value of (8.426) and a partial eta squared of (0.056) at a significance of (0.004). This interaction suggests that the effect of learning environment on achievement scores was not the same across

all samples. Table of estimated marginal means of ANCOVA independent variables (Table L4 Appendix L) shows that students in the experimental sample (M = 36.04) scored significantly higher in posttest adjusted scores than students at the control groups (M = 25.67) in face-to-face learning environment. Regarding blended learning environment, adjusted posttest score means approximately equal the experimental (M = 21.82) and control (M = 20.21) groups, indicating a lower difference. The above findings suggest that the intervention was more effective in face-to-face learning environments than in blended learning environments. The following Figure 4 illustrates the above interaction.

Figure 4

Interaction among learning environments and samples

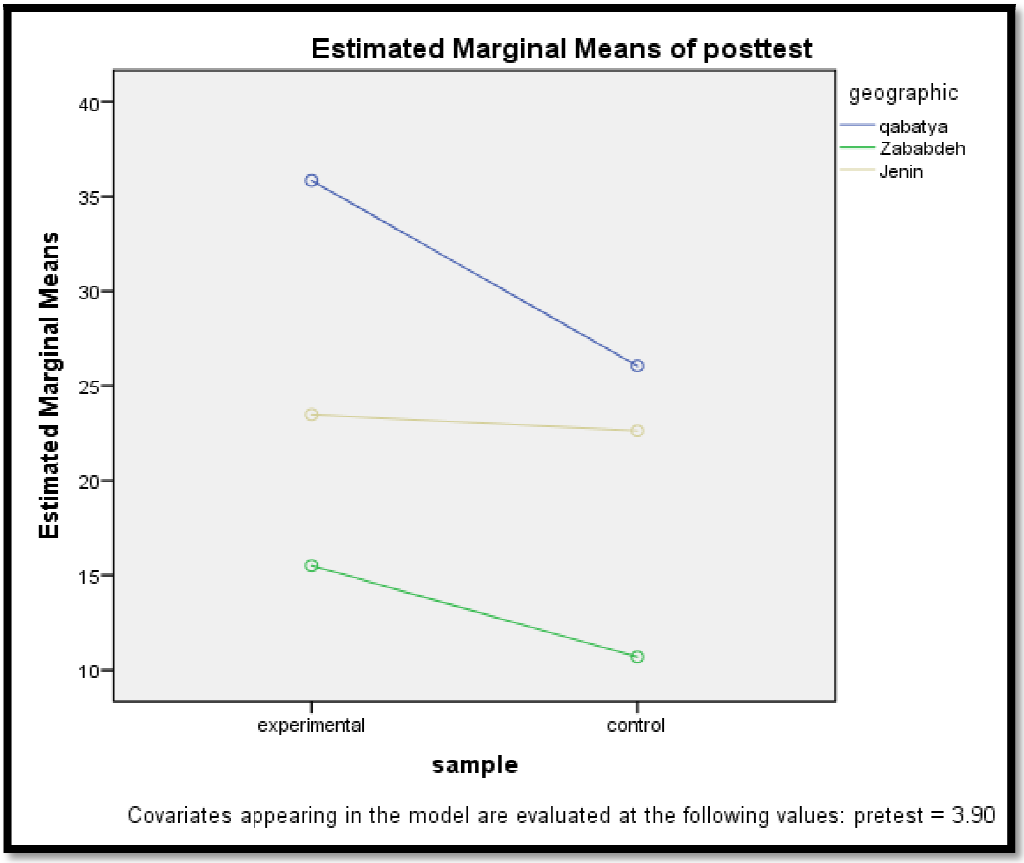


As noted above, both learning environments showed higher scores of posttests within the experimental groups. However, face-to-face learning environments showed a sharper difference among students of both control and experimental groups, suggesting the effectiveness of intervention in face-to-face settings.In addition, Results of two-way ANCOVA analysis of the geographic location across groups indicate that geographic location exerts a highly significant effect on student's achievement scores of the

posttests. The F value was 26.075, with zero significance level and a partial eta squared of (0.271). students' scores in Qabatya school showed a significant higher performance compared to students' scores of Jenin and Zababdeh with a mean difference of (7.891) and (17.844) (Table L4). Besides, students' scores in Jenin school showed a significant higher performance compared to students' scores of Zababdeh with a mean difference of (9.954).Regarding to the sample variable, a significant effect of F= 10.025 and partial eta squared of (0.067) were found which indicated a moderate effect of sample in posttest scores. Pairwise comparisons (Table L4) showed that posttest scores of the experimental student′s samples have a higher significant mean difference of (5.157) compared to posttest scores of students in the control samples with a significance level of (0.002). Furthermore, the interaction between the two variables of geographic location and sample was significant with an F value of (4.350) and a partial eta squared of (0.139) at a significance of (0.001). This interaction suggests that the effect of geographic location on achievement scores was not the same across all samples. Table of estimated marginal means (Table L5) of ANCOVA independent variables show that students in the experimental sample (M = 35.838) scored significantly higher in posttest adjusted scores than students at control groups (M = 26.054) in Qabatya geographic location. regarding Jenin location, adjusted posttest score means were approximate between experimental (M = 23.486) and control (M = 22.624) groups, indicating a lower difference. Regarding Zababdeh, adjusted posttest score means were approximate between experimental (M = 15.514) and control (M = 10.689) groups. The above findings in addition to figure (5) shows that the influence of geographic location was inconsistent across all groups.

Figure 5

Interaction among school geographic locations and samples



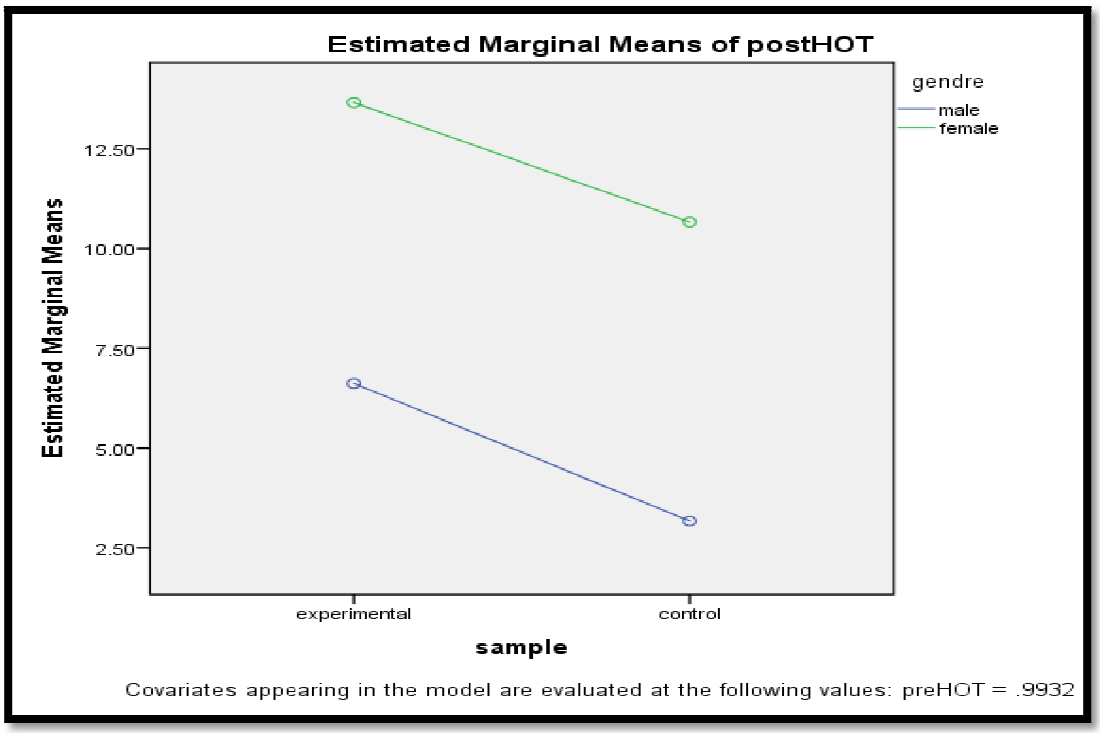
The previous chart shows a higher score of the experimental groups in all three geographic area compared to the control groups, however, Qabatya mean difference of both groups was the sharpest, followed by Jenin. Zababdeh students have a slighter mean difference in favor to experimental group. The geographic location might have a significant effect of the intervention outcomes.

Regarding the fourth hypothesis, that handles the interaction of gender (male/female) and sample (experimental/control) on postHOTS scores results of two-way ANCOVA analysis revealed that the type of the sample has a significant moderate effect on postHOTS scores with an F value of (6.246) and a partial eta squared of (0.042) at a significance level of (0.014) indicating that sample is significantly different in regards to HOTS development across the different students' groups. Pairwise comparisons (Table L4) showed that postHOTS scores of the experimental sample have a higher significant mean difference of (3.222) compared to postHOTS scores of students at control samples with a significance level of (0.014).In addition, gender was a stronger

factor in postHOTS scores with an F value of (30.121) and a partial eta squared of (0.175) at a significance level of less than 0.001. This finding gives a clue that gender has a substantial effect in developing HOTS. Pairwise comparisons (Table L4) showed that postHOTS scores of female student's sample have a higher significant mean difference of (7.296) compared to postHOTS scores of male students with a significance level of (0.000). Furthermore, the interaction between the two variables of gender and sample was not significant with an F value of (0.032) and a partial eta squared of (0.000) at a significance of (0.859). it suggests that gender differences of postHOTS scores among the two experimental and control groups were nearly consistent. Table of estimated marginal means of ANCOVA independent variables (Table L5) showed that male students in the experimental sample (M = 6.623) scored higher in postHOTS adjusted scores than male students in the control groups (M = 3.171). Regarding female students, adjusted postHOTS score means were also higher in favor of experimental sample.The experimental adjusted scores were approximately to (M = 13.662) and control (M = 10.669) groups indicating a lower mean for females in the control sample. The interaction pattern is illustrated in figure (6)

Figure 6

The interaction between gender and sample for postHOTS

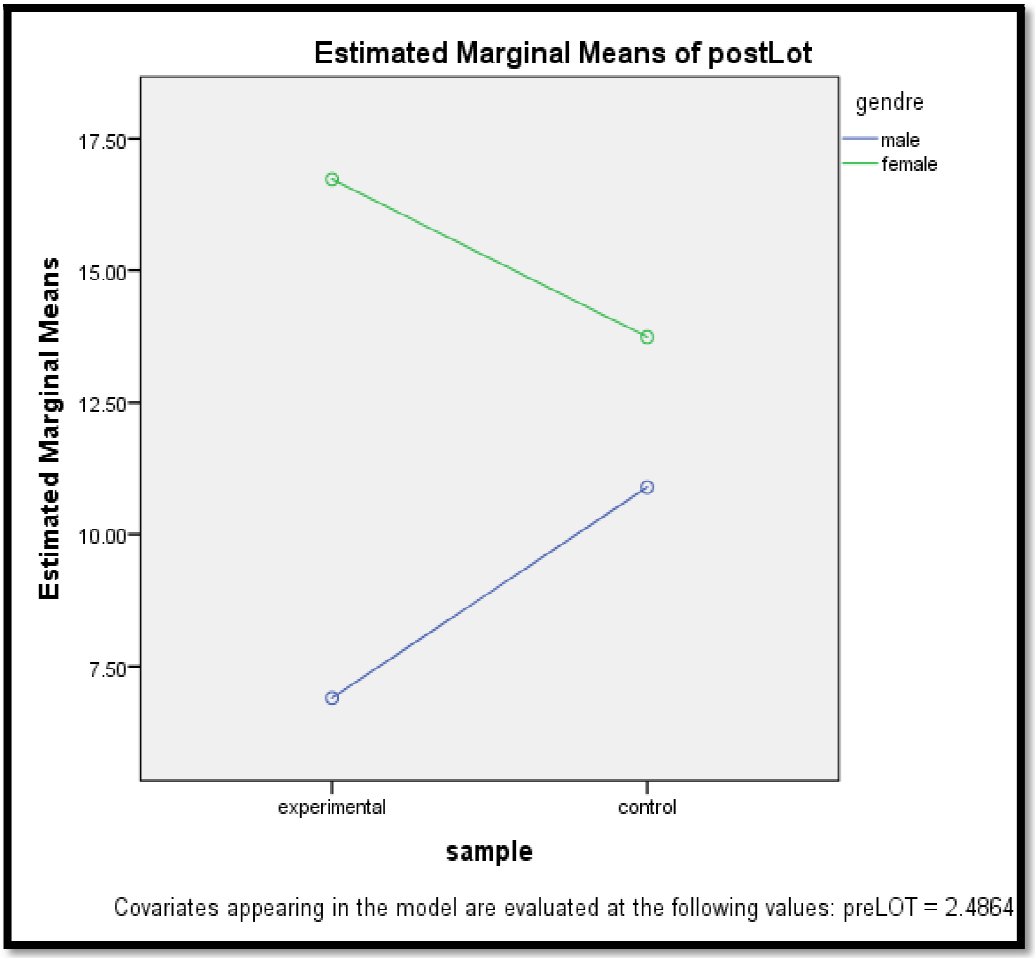


From the above chart, a substantial improvement in HOTS scores of adjusted mean scores for both genders is witnessed.

Regarding the fifth hypothesis which handles the interaction of gender (male/female) and sample (experimental/control) on postLOTS scores results of two-way ANCOVA analysis revealed that the type of the sample had no significant effect on postLOTS since the F value was (1.136) and a partial eta squared of (0.008) at a significance level of (0.288) indicating that sample did not generate differences in regards to LOTS across the different students' groups.In addition, gender was a stronger factor in postLOTS scores with an F value of (8.241) and a partial eta squared of (0.055) at a significance level of (0.005). This finding gives a clue that gender has a substantial effect in developing LOTS. Pairwise comparisons (Table L4) showed that postLOTS scores of female student's sample had a higher significant mean difference of (6.33) compared to postLOTS scores of male students with a significance level of (0.014). Furthermore, the interaction between the two variables of gender and sample was not significant with an F value of (0.596) and a partial eta squared of (0.004) at a significance of (0.441). this finding suggests that gender differences of post LOTS scores among the two experimental and control groups were nearly consistent. Table of estimated marginal means (Table L5) of ANCOVA independent variables showed that male students in the experimental sample (M = 6.904) scored lower in postLOTS adjusted scores than male students in the control groups (M = 10.895). Regarding female students, adjusted postLOTS score means were higher in favor of experimental sample.The experimental adjusted scores were approximately to (M = 16.726) and control (M = 13.738) groups, indicating a lower mean for females in the control sample. The interaction pattern is illustrated in Figure 7.

Figure 7

The interaction among gender and sample for postLOTS scores.



The previous figure shows that despite no significant interaction among gender and sample factors is found, females show a high significant gain in LOTS scores compared to male students due to intervention.

3.2 Results of BMQ

The null hypotheses assumed for the BMQ scores at a=0.05 are:

$H_0$6: There is no significant difference of students' total scores of the biology motivation questionnaire and its subscales scores among experimental and control samples after controlling pre-scores.

$H_0$7: There is nosignificant difference of students' total scores of biology motivation questionnaire and its subscales scores among female and male students within the experimental group after controlling pre-scores.

$H_0$8: There is nosignificant difference in students' total scores of the biology motivation questionnaire and its subscales scores among students of face-to-face and blended learning environment within the experimental group after controlling pre-scores.

$H_0$9: There is nosignificant difference of students' total scores of biology motivation questionnaire and its subscales scores among students from different geographical school locations within the experimental group after controlling pre-scores.

Prior to each hypothesis verification, descriptive statistics were performed, and the main assumptions of the null hypothesis were verified.

3.2.1 Descriptive Statistics

Both pre-total scores and post-total scores of the BMQ were analyzed through SPSS, analysis shows that the average of the total post score was (3.8915) points, with a standard deviation of (0.50971), compared to (3.8986) points with a standard deviation of (0.50406). Other statistical measures are listed in table M1 in Appendix M.

Table 5

Descriptive statistics of post and pre BMQ total scores

			Statistic	Std. Error
total post-scale	Mean		3.8915	.04204
	95% Confidence Interval for Mean	Lower Bound	3.8084	
		Upper Bound	3.9746	
	5% Trimmed Mean		3.9209	
	Median		4.0000	
	Variance		.260	
	Std. Deviation		.50971	
	Minimum		2.30	
	Maximum		4.73	
	Range		2.43	
	Interquartile Range		.61	
	Skewness		-.895-	.200
	Kurtosis		.518	.397
total pre-scale	Mean		3.8986	.04157
	95% Confidence Interval for Mean	Lower Bound	3.8164	
		Upper Bound	3.9807	
	5% Trimmed Mean		3.9329	
	Median		4.0333	
	Variance		.254	
	Std. Deviation		.50406	
	Minimum		2.30	
	Maximum		4.67	
	Range		2.37	
	Interquartile Range		.63	
	Skewness		-1.077-	.200
	Kurtosis		.713	.397

* Negative items (scale of anxiety (AN) were reversed in scores according to (Lang & Sorgo, 2024)

3.2.2 The assumptions of ANCOVA

The main assumptions of ANCOVA analysis were verified prior ANCOVA analysis for each independent variable of the following (sample, gender, learning environment, geographic location). The Normality tests were determined through the Shapiro-Wilk and Kolmogorov-Smirnova tests as shown in table (M2) in Appendix M for all post-scale scores investigated. Results showed that all post- scale scores including the total score are not normally distributed, where nearly the values of Shapiro-Wilk and Kolmogorov-Smirnova tests were zero for all scales which violates the assumptions of Ancona analysis. Other assumptions of Ancona, including homogeneity of variances, homogeneity of regression slopes was satisfied as shown in table (M4) appendix M. assumptions of ANCOVA analysis include homogeneity of variances assumptions, the F values of Levene's test were among control and experimental samples ranged from 0.213 to 6.175 for all the total scores of the BMQ and the other six sub scales scores. The significance value ranged from 0.065 to 0.645. Thus, the assumption of homogeneity is achieved at 0.05 significance level. In addition, female and male groups variances also were homogenous at a significance level of 0.05. The F values of Levene's test ranged from 0.875 to 7.23 at significance levels ranged from 0.086 to 0.898. in addition to that, F values of Levene's test regarding learning environments ranged from 0.017 to 6.71 at significance levels of 0.066-0.898 range for the total scores. The previous values ranges indicate the satisfaction of ANCOVA assumption of homogeneity of variances among face-to-face and blended learning environments. Furthermore, the assumption was satisfied among the three different geographic locations, the F values of Levene's tests of homogeneity ranged from 1.440 to 11.913 at a significance level of 0.052-0.283 range for all BMQ total and subscale scores.

To address the third assumption of ANCOVA analysis, the interaction between the pretest and the independent variables was all higher than a=0.05 as introduced in table of test of between effects (M4) indicating the satisfaction of the ANCOVA assumption of homogeneity of linear regression of slopes.

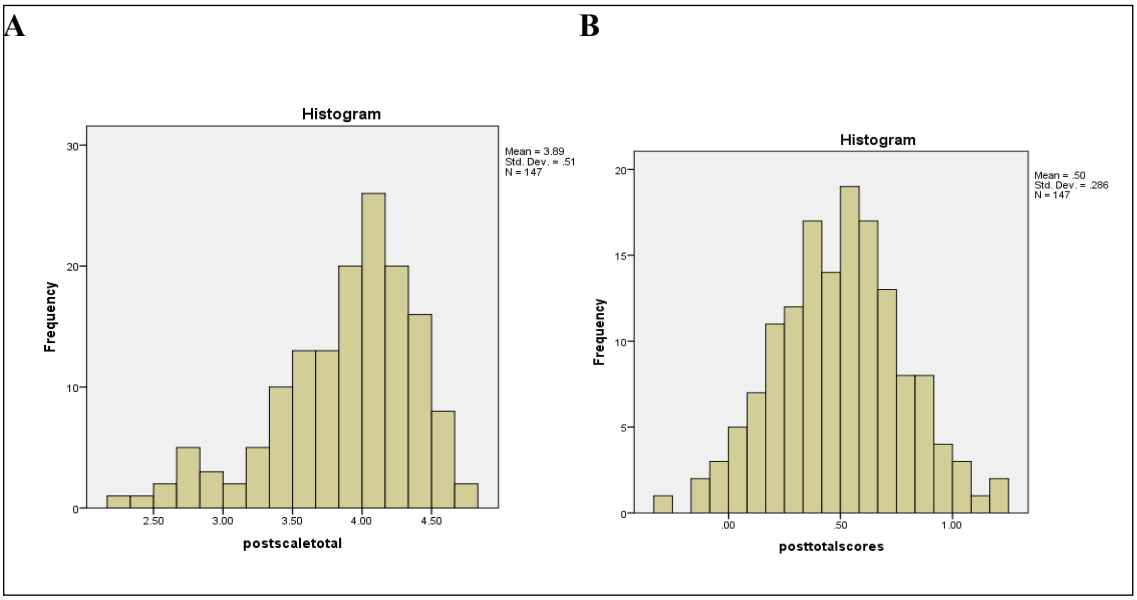
3.2.3 Hypothesis Verifications

Regarding the hypothesis statistical verification, the ANCOVA assumption of normality distribution of data was not achieved. thus, the researcher had four possible routes to follow in data analysis concerning BMQ scores. The first route is to adopt the original

raw data and conduct parametric ANCOVA despite the normality assumption violation since ANCOVA is robust for normality violations especially for large sample size. The second route was to transform the original data using inverse, logarithm or root square formulas as suggested by Roni (2021) since transformation will aid in normalizing the distribution, as noted in figure 8. The two histograms represented below for the raw original post BMQ scores and the inverse transformed data of the post BMQ scores. Additional tests of Normality of transformed scores are also shown in Table M3 appendix M. Normality assumption for transformed scores is achieved.

Figure 8

Histogram of normal distribution of raw post BMQ (A) vs. transformed post BMQ (B)



The third route of data analysis is to use bootstrap ANCOVA which does not demand a normality assumption (Garson, 2012). The fourth route is to use Quade non-parametric ANCOVA since it does not need any assumptions. The researcher performed the analysis using the previous four roots, where results were nearly consistent in terms of significance level among all four routes. Results of the Quade ANCOVA, raw data; and transformed data are displayed in the appendices. The researcher will display the results of bootstrapping ANCOVA, in addition to the other comparisons within this section, for hypothesis testing.

The above-mentioned research hypotheses (H06- H09) were verified. Results for each hypothesis are stated below in table (6).During the previous measures, the Post-scores were the dependent variable, where the fixed factors are (sample, gender, learning

environment, geographical location), and the pre-scores are covariates. Both total scores of BMQ and the six subscales; subscale 1 of Anxiety (AN), subscale 2 of Extrinsic motivation (EM), subscale 3 of intrinsic motivation (IM), subscale 4 of personal relevance (PR), subscale 5 of responsibility (RE), subscale 6 of self-efficacy (SE). Results of bootstrapping ANCOVA using 5000 number of simple samples, 95% bias corrected and accelerated confidence intervals are illustrated in table (6-9) below:

Table 6

ANCOVA analysis of BMQ score and BMQ subscales within experimental and control samples

One-way ANCOVA							
Independent variable/sample		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Total score	Contrast	.003	1	.003	.086	.769	.001
	Error	4.445	144	.031			
AN	Contrast	.009	1	.009	.015	.904	.000
	Error	84.968	144	.590			
EM	Contrast	.935	1	.935	1.722	.192	.012
	Error	78.153	144	.543			
IM	Contrast	.148	1	.148	.290	.591	.002
	Error	73.402	144	.510			
PR	Contrast	.286	1	.286	.323	.571	.002
	Error	127.860	144	.888			
RE	Contrast	.578	1	.578	.813	.369	.006
	Error	102.351	144	.711			
SE	Contrast	.167	1	.167	.549	.460	.004
	Error	43.702	144	.303			

Regarding the sixth null hypothesis, which states that there are no significant differences among BMQ scores and BMQ subscales scores between experimental and control samples due to the intervention at a significance level of a = 0.05. Results showed that the null hypothesis is accepted for all the BMQ total scores and BMQ subscales as shown in table 6 above. The experimental group showed slightly higher non-significant ((p= 0.769) total scores than the control groups. The experimental sample adjusted mean of the total BMQ scores was (3.896) compared to (3.887) within

the control group as shown in table M5 at Appendix M. for the sub scale of anxiety (AN), control sample students showed higher scores of the first subscale of an estimated marginal mean of 3.026 compared to 3.011 for experimental sample students as shown in table (M5 Appendix M). Control sample students showed lower anxiety levels compared to experimental sample students, with a mean difference of 0.015 as shown in table (M6 Appendix M), the difference is not significant since the significance level in ANCOVA analysis was 0.192 as shown in table 6. Control samples also showed non-significant slightly higher scores of the control group for the extrinsic motivation subscale with a mean difference of 0.160 as shown in pairwise comparisons in table (M6). Regarding intrinsic motivation subscale, experimental sample students showed higher non-significant levels of motivation of (4.119) value of estimated marginal mean compared to (4.055) mean of control group students as shown in table (M5). However, all the remaining subscales of personal relevance, responsibility, and self-efficacy showed higher non-significant differences in favor of control groups with a mean difference of (0.088; 0.126:0.068) respectively as shown in table M6.

The seventh, eighth and ninth hypothesis aimed to investigate the effect of intervention towards student's motivation by analyzing the role of gender, learning environment and geographic location in motivation scores within the experimental samples. In gender analysis as an independent variable affecting the postscores of BMQ, Table 7 shows the results of ANCOVA analysis.

Table 7

ANCOVA analysis of BMQ score and BMQ subscales within female and male students within the experimental sample

Independent variable/gender		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Total score	Contrast	.064	1	.064	2.270	.136	.030
	Error	2.057	73	.028			
AN	Contrast	.442	1	.442	.692	.408	.009
	Error	46.637	73	.639			
EM	Contrast	.126	1	.126	.182	.671	.002
	Error	50.600	73	.693			
IM	Contrast	1.676	1	1.676	2.981	.088	.039
	Error	41.043	73	.562			
PR	Contrast	1.200	1	1.200	1.151	.287	.016
	Error	76.121	73	1.043			
RE	Contrast	.738	1	.738	1.007	.319	.014
	Error	53.507	73	.733			
SE	Contrast	.262	1	.262	.825	.367	.011
	Error	23.195	73	.318			

Regarding the seventh null hypothesis, which states that there are no significant differences among BMQ scores and BMQ subscales scores between male and female students due to the intervention within the experimental group at a significance level of a $\geq$ 0.05. Results showed that the null hypothesis is accepted for all the BMQ total scores and BMQ subscales, as shown in table 7 above. The male students showed slightly higher total scores than female students with no significant difference since the significance level 0.136. The male students adjusted mean of the total BMQ scores was (3. 936) compared to (3.848) within the female group as shown in table (M5) at Appendix M. for the sub scale of anxiety, male sample students showed lower scores of the first subscale of an estimated marginal mean of 2.796 compared to 3.045 for female students as shown in table (M5). Male students showed less anxiety levels compared to female students with a mean difference of 0.088 as shown in table (M6), The difference is not significant since the significance level in ANCOVA analysis was 0.408 as shown in table 7. The other remaining subscales analysis also showed A non-significant difference in motivation level between male and female students within the experimental sample as shown in table 7.

Female students also showed non- significant, slightly higher scores of the male group for the extrinsic motivation, Intrinsic motivation, personal relevance, responsibility subscales with a mean difference of (0.122;0.459;0.383;0.173), respectively as shown in pairwise comparisons in table. However, self-efficacy subscale showed higher non-significant scores in favor of male students with a mean difference of (0.130) as shown in table M6.

The eighth study hypothesis handled the difference of two distinct learning environments on BMQ scores among the experimental samples. ANCOVA analysis of BMQ total scores and total subscales is shown in table 8 below. The two learning environments included face-to-face and blended learning environments. Results showed that the null hypothesis is accepted for all the BMQ total scores as shown in table 8 below. The blended learning group showed slightly higher total scores than the face-face learning group with no significant difference sine the significance level 0.254. The blended learning sample adjusted mean of the total BMQ scores was (3.828) compared to (3.877) within the control group as shown in table (M5) at Appendix M. for the sub scale of anxiety), blended learning students showed higher scores of the first subscale of an estimated marginal mean of 3.121 compared to 2.815 for face- to- face students as shown in table (M5). Blended learning students showed lower anxiety levels compared to experimental sample students, with a mean difference of 0.306 as shown in table (M6), the difference is not significant since the significance level in ANCOVA analysis was 0.110 as shown in table 8. However, for the extrinsic motivation sub scale, face to face samples showed a significant higher score of the blended group with a mean difference of 0.579 as shown in pairwise comparisons in table (M6). The significance value was 0.003 with an F value of 9.334 and partial eta square of 0.113 indicating a strong moderate effect of face-to-face learning environment of extrinsic motivation scores.in addition to that, the 95% accelerated confidence interval (0.26, 0.89) indicates a reliable effect since it did not contain zero.

Regarding intrinsic motivation subscale, face-face students showed higher significant levels of motivation of (4.492) value of estimated marginal mean compared to (3.913) mean of blended group students as shown in table (M5). The significance value was 0.001 with an F value of 10.911 and partial eta square of 0.131 indicating a nearly strong effect of face-to-face learning environment of intrinsic motivation scores.in

addition to that, the 95% accelerated confidence interval (0.321, 0.843) indicates a reliable effect since it did not contain zero (Wood, 2005). A similar result was also found in subscale of personal relevance. face-to-face students showed higher significant levels of motivation of (4.210) value of estimated marginal mean compared to (3.533) mean of blended group students as shown in table (M5). The significance value was 0.005 with an F value of 8.341 and partial eta square of 0.103 indicating a nearly moderate effect of face-to-face learning environment of personal relevance motivation scores. in addition to that, the 95% accelerated confidence interval (0.292, 1.058) indicates a reliable effect since it did not contain zero.

However, the subscale of responsibility showed higher non-significant difference among the two-learning environment with a mean difference of 0.207 in the favor of blended learning as shown in table (M6) with a significant level of 0.319 as shown in table 8. The remaining subscale of self-efficacy showed higher non-significant difference in favor of face -to -face student scores with a mean difference of (0.124) at a significance level of 0.367, as shown in table 8.

Table 8

ANCOVA analysis of BMQ score and BMQ subscales according to learning environments

Independent variable/learning environment		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Total scale	Contrast	.038	1	.038	1.322	0.254	.018
	Error	2.083	73	.029			
AN	Contrast	1.628	1	1.628	2.615	.110	.035
	Error	45.451	73	.623			
EM	Contrast	5.750	1	5.750	9.334	.003	.113
	Error	44.976	73	.616			
IM	Contrast	5.590	1	5.590	10.991	.001	.131
	Error	37.128	73	.509			
PR	Contrast	7.929	1	7.929	8.341	.005	.103
	Error	69.392	73	.951			
RE	Contrast	.738	1	.738	1.007	.319	.014
	Error	53.507	73	.733			
SE	Contrast	.262	1	.262	.825	.367	.011
	Error	23.195	73	.318			

The last study hypothesis handled the difference of three distinct school geographic locations (Qabatya, Zabadeh, Jenin) on BMQ scores and BMQ subscale scores. Bootstrapping ANCOVA analysis of BMQ total scores and total subscales are shown in table 9 below.

Table 9

ANCOVA analysis of BMQ score and BMQ subscales according to geographic location

Independent variable/geographic location		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Total scale	Contrast	.083	2	.041	1.458	.239	.039
	Error	2.038	72	.028			
AN	Contrast	2.854	2	1.427	2.323	.105	.061
	Error	44.224	72	.614			
EM	Contrast	5.852	2	2.926	4.695	.012	.115
	Error	44.874	72	.623			
IM	Contrast	6.139	2	3.069	6.042	.004	.144
	Error	36.580	72	.508			
PR	Contrast	8.035	2	4.017	4.175	.019	.104
	Error	69.286	72	.962			
RE	Contrast	1.399	2	.699	.953	.390	.026
	Error	52.847	72	.734			
SE	Contrast	.565	2	.283	.889	.416	.024
	Error	22.892	72	.318			

Results showed that the null hypothesis is accepted for the BMQ total scores as shown. Zababdeh (Academic) school students showed slightly higher total scores than Jenin and Qabatya school students. Univariate analysis showed that the difference is non-significant since the significance level is estimated with 0.239. Zababdeh school adjusted mean of the total BMQ scores was (3.938) compared to (3.862: 3.827) for Jenin and Qabatya school students scores. Pairwise comparisons at table M6 at appendix M showed that the mean difference among Zababdeh and Qabatya is 0.111 and between Zababdeh and Jenin is 0.076 at bias corrected confidence intervals of (-0.041,0.278) and (-0.072, 0.233), supporting the non-significant difference. For the sub scale of anxiety, Jenin school students showed a higher non-significant difference of

anxiety scores with an estimated marginal mean of 3.208 compared to 2.817 and 2.773 for Qabatya and Zababdeh school students respectively as shown in table M5. Jenin students showed lower anxiety levels compared to Qabatya and Zababdeh students with a mean difference of 0.391 and 0.435, respectively, as shown in table M6. The difference is not significant since the significance level in ANCOVA analysis was 0.105 as shown in table 9.

However, for extrinsic motivation sub scale, Qabatya students showed a significant higher score than Jenin and Zababdeh students with a mean difference of 0.601, 0.487 respectively as shown in pairwise comparisons in table (M6). The significance value was 0.012 with an F value of 4.695 and partial eta square of 0.115 indicating a highly moderate effect of Qabatya geographic location in extrinsic motivation scores. in addition to that, the 95% accelerated confidence interval (0.281, 0.992: -0.145,1.163) for Jenin and Zababdeh, respectively. The confidence interval ranges indicated a reliable significant effect among Qabatya and Jenin students since confidence levels did not contain zero.

Regarding intrinsic motivation subscale, Qabatya students showed a significant higher score than Jenin and Zababdeh students, with a mean difference of 0.601, 0.487 respectively as shown in pairwise comparisons in table (M6). The significance value was 0.012 with an F value of 4.695 and a partial eta square of 0.115, indicating a highly moderate effect of Qabatya geographic location on extrinsic motivation scores.in addition to that, the 95% accelerated confidence interval (0.281, 0.992: -0.145,1.163) for Jenin and Zababdeh respectively. The confidence interval ranges indicated a reliable significant effect among Qabatya and Jenin students since confidence levels did not contain zero. A similar result was also found in subscale of personal relevance. Qabatya students showed a significant higher score than Jenin and Zababdeh students with a mean difference of 0.655, 0.773 respectively as shown in pairwise comparisons in table (M6). The significance value was 0.019 with an F value of 4.175 and partial eta square of 0.104 indicating a moderate effect of Qabatya geographic location in personal relevance scores.in addition to that, the 95% accelerated confidence interval (0.276, 1.041: -0.150,1.738) for Jenin and Zababdeh respectively. The confidence interval ranges indicated a reliable significant effect among Qabatya and Jenin students since confidence levels did not contain zero. However, the subscale of responsibility showed

higher non-significant difference of Jenin students among the two other geographic location with a mean difference of 0.296, 0.272 for Zababdeh and Qabatya scores respectively.The significant level of the univariate test was 0.390 as shown in table 9. The remaining subscale of self-efficacy showed also a higher non-significant difference in favor of Zababdeh student scores with a mean difference of (0.032, 0.195) for Qabatya and Jenin scores at a significance level of 0.416 as shown in table 9.

Compared to results of other routes of data analysis discussed earlier, Table 10 shows the significance level of each ANCOVA analysis along with the F value of the test.

Table 10

Significance values and F values for total BMQ scores and subscale scores using four routes of analysis

IV	DV	Raw data ANCOVA		Transformed data ANCOVA		Quade ANCOVA		Bootstrapping ANCOVA	
		sig	**F**	**sig**	**F**	**F**	**P**	**sig**	**F**
sample	total	.772	.084	.639	.220	0.240	.625	0.796	0.086
	AN	.904	.015	.950	.004	0.000	.997	0.904	0.015
	EM	.192	1.722	.377	.786	0.649	.422	0.192	1.722
	IM	.591	.290	.383	.764	0.705	.402	0.591	0.290
	PR	.573	.319	.717	.132	0.050	.824	.5710	0.323
	RE	.369	.813	.291	1.124	1.094	.297	0.369	0.813
	SE	.460	.549	.603	.272	0.263	.609	0.460	0.549
gender	Total	.136	2.270	.061	4.338	0.002	.964	0.136	2.270
	AN	.408	.692	.436	.613	0.796	.375	0.408	.692
	EM	.671	.182	.817	.054	0.140	.709	0.671	.182
	IM	.088	2.981	.214	1.572	0.786	.378	0.088	2.981
	PR	.287	1.151	.611	.262	0.337	.563	0.287	1.151
	RE	.562	.339	.911	.012	0.001	.969	0.319	1.007
	SE	.254	1.322	.671	.182	0.352	.555	0.367	0.825
learning env.	Total	.634	.228	.427	.637	0.056	.813	0.254	1.322
	AN	*.110*	*2.615*	*0.056*	*3.757*	*4.335*	*.041*	*0.110*	*2.615*
	EM	.003	9.334	.002	10.791	11.431	.001	0.003	9.334
	IM	.001	10.991	.000	13.518	13.997	.000	0.001	10.991
	PR	.005	8.394	.007	7.793	8.503	.005	0.005	8.394
	RE	.319	1.007	.161	2.008	2.704	.104	0.319	1.007
	SE	.367	.825	.399	.720	0.298	.587	0.367	.825
geography	Total	.239	1.458	.421	.876	0.035	.966	0.239	1.458
	AN	*0.105*	*2.323*	*.054*	*3.033*	*3.491*	*.036*	*0.105*	*2.323*
	EM	.006	5.573	.005	5.599	5.845	.004	0.012	4.695
	IM	.004	6.042	.002	6.792	6.913	.002	0.004	6.042
	PR	.019	4.175	.025	3.883	4.226	.018	0.019	4.175
	RE	.390	.953	.351	1.063	1.482	.234	0.390	.953
	SE	.416	.889	.455	.797	0.454	.637	0.416	.889

Regarding the previous results, all significant values of bootstrapping ANCOVA analysis were proved to be also significant by raw data ANCOVA analysis, transformed

data ANCOVA analysis, and Quade ANCOVA as shown in bold rows. This consistency supports the above findings. Applying two or more methods of data analysis to the same dataset within a study is known as data-analysis triangulation, that is necessary to strengthen the validity and the credibility of findings (Schlunegger et al., 2024).However, two total subscales (Anxiety within learning environment score analysis and Anxiety within geographic location score analysis) were only significant through Quade ANCOVA analysis and non- significant through other tests. The values of significance are near to margin limit of 0.05 value as noted in italic rows above. Pairwise comparisons were consistent among Quade ANCOVA and bootstrapping ANCOVA for the first sub scale of Anxiety of geographic location variable and for the first subscale of Anxiety for the learning environment as shown in (appendix O). Additional statistics of transformed data ANCOVA is also available at Appendix N.

Chapter Four

Discussions and conclusions

4.1 Discussions

4.1.1 Discussions of the Achievement Test

Former studies that handled the integration of bioinformatics within high school biology or science curriculum documented the use of distinct assessment tools, the most recurrent tools used included observations, questionnaires, surveys for certain skills and competencies, interviews, and focus groups (Sari et al., 2022). Yet, the use of achievement tests as an assessment tool to evaluate the impact of bioinformatics-based activities on student achievement is seldom. This study represents one of the few studies inspecting the role of bioinformatics on student achievement. Upon comparing experimental and control samples, a significant difference in achievement test scores in favor of the experimental group are found. Bioinformatics activity-based intervention improved the achievement scores of the experimental sample students compared to the control sample students. A similar study of Machluf (2017) student performance after the implementation of bioinformatics activities was classified into levels in accordance with question type and its cognitive level. The study revealed that high average achievement scores were found in multiple-choice questions in addition to questions that handle the use of procedural or situational knowledge and questions with low cognitive levels. Meanwhile, open-ended questions, questions that require the use of declarative knowledge, and questions of high cognitive level had significantly lower average achievements.

In a study of Bednarski and colleagues (2005), the achievement test is composed of nineteen multiple choice questions regarding bioinformatics terms, databases and tools, although no significant difference was found among pre and post test scores, yet the average of pretest was 42% while the average of posttest was 77% indicating a gain in knowledge of bioinformatics tools due to the course. Similar results are found in a higher educational context. For example, Gao & Gou (2023) explored that the implementation of CURE course of bioinformatics undergraduate students has evaluated the learning outcomes. A final examination was performed at the end of the course, the results of the exam were compared to the results of an exam a year earlier

using two tailed Mann Whitney U test. A significant increase of approximately five points in mean scores in regard for bioinformatics course-based design. Another example, Fumagalli and colleagues (2024) had used the exam of two sections, true/false test of 12 items equally divided among metagenomic and bioinformatics, and an open-ended question as an evaluation tool to assess metagenomic and bioinformatics manipulation on students' understanding of the scientific process. Answers on the true-false test revealed a range of 6-11 correct answers. Where most of students' scores were between 75% and 100%. Students showed nearly equal distribution of correct answers among questions of bioinformatics and metagenomics, with a slightly higher accuracy in metagenomics, suggesting the positive role that bioinformatics and metagenomics activities might encounter in student achievement. These finding aligns well with numerous studies that investigated the use of Information and Communication technology (ICT) based activities, for example, Owusu and colleagues (2023) revealed that utilization of ICT tools in genetics science teaching for high school students improved their achievement scores compared to control sample students due to the elevation of students' understanding of genetic concepts. Scholarly articles that handle the impact of ICT on student achievement are numerous. It is believed that ICT within biology education can elevate students' cognitive growth through enhancing students' motivation and involvement, increasing concept understanding and retention, foster student -student and student-teacher interactions, and positively affects students' attitudes toward learning (Kilag et al., 2023). In addition, it is believed that ICT use inside or outside school have a positive direct effect on cognitive-motivational engagement in ICT in addition to self-determination in technology use, which will eventually exert a positive impact on academic achievement (Li & Zhu, 2023).

Regarding the learning environment, results indicated a significant difference in the post-test for the two study groups of face-to-face learning environment and blended learning environment in favor to the face-to-face group. The finding is supported by Harper and colleagues (2024) who compared students' outcomes in a first year of undergraduate biological sciences at British higher education institutions at 2018/2019 (face to face) and 2020/2021 (blended learning). Results revealed that more than half of the modules were significantly and negatively affected by the transition from face-to-face into blended learning. However, contradicted results are found in many other studies, including the meta-analysis of 44 studies performed by Kazui & Yalçınii(2022)

where hybrid learning was concluded to have a high positive level on academic achievement compared to the traditional learning approach.In addition, Tong and colleagues (2022) performed a quasi-experimental design to compare the academic achievement, learning attitudes and self-study skills of 44 students used blended learning model as experimental group and 46 students used traditional methods as control group. Achievement test in addition to student opinion survey and observations were used. Results showed that blended learning has a significant difference over traditional classes in regard to student's achievement scores. Results of student opinion survey and observations were confirmatory to the above findings where an increase in student-teacher interactions is witnessed, and increase in learning attitudes and self-study abilities was revealed. The former findings are supported by Barfi and colleuges (2023) that attributed the significant difference of blended learning had over face-face learning to the online discussions that students participate in which allow them to have to explore the topic through fully and increase their understanding. However, the results of this research, where face-face learning scored higher achievements, should be studied within the Palestinian context. Farrah and colleagues (2025)who discussed challenges of blended and online learning in Palestine that included poor internet connectivity and a lack of class interaction. Such limitations might explain the significant interaction between learning environment and sample scores since the intervention outcomes were not consistent among the two distinct learning environments. Further analysis should be conducted on blended learning environments to optimize the intervention outcomes.

Geographic location also revealed that there is a significant difference in the average achievement of students in the post-test scores between students from the Qabatya area and students compared to students from Zababdeh and Jenin Schools, in favor of the Qabatiya School. The above two results indicate the impact of geographic location on student's academic achievement. The previous results are supported by findings from several results, including the study of Kinik & Cetin (2025) who proved that geographical location had a significant direct impact among students with low achievement scores in mathematics exams. In addition, a statistical difference with significant value was found in the achievement mean scores of students from Urban and rural school areas (Agbaje & Awodun, 2014). in addition to student achievement scores, school location was revealed to be one of the main determinants of student's perceptions of difficult concepts in chemistry as reported by Oladejo and his colleagues (2023)

asserting the importance of school location in educational outcomes. However, a significant interaction among geographic location and sample was found. Indicating that the intervention had different outcomes due to geographic locations.

The above three schools investigated all belong to Jenin County, where Qabatya and Zababdeh schools belong to Qabatya directorate of education and higher education, meanwhile, Jenin secondary schools belong to the Jenin-directorate of education and higher education. During the academic year of 2024-2025, Qabatya schools had a safe and continuous educational path while the other remaining schools had to cease face-to-face learning for two months due to political circumstances, which might interpret the above results, since war subjected schools are well documented to have lower scores of achievements (Khattab et al., 2025). In addition to that, income level of the area where the school located was considered an important factor in determining school outcomes which might influence school funding and instrumentation (Guijarro-Garvi et al., 2024) Further investigations are needed to analyze the interaction between geographic location and students' outcomes in order to optimize intervention outcomes.

Comparisons of the post test scores also revealed that gender has a significant effect on post HOTS and LOTS scores, where female students post HOTS and LOTS scores were significantly higher than male students scores. However, the findings also support that there is no significant interaction between gender and both HOTS and LOTS postscores. This suggests a consistent outcome of the intervention among both genders. Although females were significantly higher than males within their posttest scores.These findings are contradicted to other findings of ICT facilitated education in regards to achievement scores of male and female students.For example, a quasi-experimental research was conducted by Cheruiyot (2019) to study the influence of computer assisted teaching for biology science classes among male and female students. A twenty-item achievement test was used for pre and post protocols. Results showed that gender had no significant effect on the use of computer although it has aided students in achieving higher scores.A similar study for Ogunlowo and his research group (2024) showed a strong relationship between ICT and performance of high school biology students where both male and female students had a noticeable difference in the male and female students taught with ICT based strategies. In addition, Eya and his colleagues' (2024) studied the impact of gender on students' achievement in biology in a technology-enhanced learning

environment. Results show that both male and female students have a significant higher achievement scores than control group students. In addition, female students had higher achievement mean scores than male students with no significant difference.

In a study ofUzezi (2019) that compared the biology achievement test scores of Computers based test and paper-based test scores. Compared to paper-based tests, computer-based tests show a significantly higher score. While male and female student scores of the computer-based tests had no significant difference. Splitting the posttest scores into two halves (LOTS and HOTS) have aided the researchers to investigate the gender variable since the overall posttest score across the two genders didn't sustain the ANCOVA assumptions, while HOTS and LOTS scores satisfied all assumptions. HOTS and LOTS scores were significantly higher for female students than male students, with no significant interaction between gender and the sample. In simpler words, high achievement scores of females over males are also witnessed in control samples, the intervention caused both gender scores to elevate. Similar findings are presented in different studies. For example, Nair and colleagues showed that female students significantly higher than male students in answering both LOTS and HOTS questions (2019).

In addition, Anggraini& Pratiwi(2019) revealed that female students have a higher percentage than male in four HOTS indicators. Rahayuningsih & Jayanti (2019) delivered a more detailed study that analyzed HOTS into separated analysis, evaluation and creation levels revealed that males have higher analysis abilities while females have higher evaluation abilities with equal abilities of creation.Another study of Riadi et al (2019) showed that female students were better than male students in nearly all thinking skill except for creation level, with no interaction between gender and thinking skills. Focusing on the Palestinian context, will also yield similar findings. In a study of Makkawi (2011), Tawjihi (national k-12 exam) test score analysis of two successive academic years (2005-2007) revealed that the majority of students with high achievement scores were females. Interviews among female students revealed that they had supportive families, encouraging teachers and school support. Another supporting study for Amer (2013) also confirmed that female students in the scientific stream performed better than male students in the literary stream. Students mother′s level of education was a contributing factor. Gern (2017) discussed the reasons of high

achievement scores among female students at UN schools compared to male students. The researcher argues that differences in future imagination among female student as a result of social -economic and political reasons might be the interpretation for such phenomena. The above findings might explain the lack of interaction among gender and sample type in this research, since females scores usually are higher than male scores, the intervention elevated the both gender scores where females were the out performants.

4.1.2 Discussions of BMQ Results.

Motivation towards biology learning prior and after the intervention was also investigated. The researchers intended to investigate motivation since it is well known that motivation affects achievement. Many theories suggest a reciprocal relation between the both, yet the mechanism is not fully understood (Vu et al., 2022). This study used BMQ in its translated Arabic version. The six subscales of the BMQ are anxiety, extrinsic motivation, intrinsic motivation, self-efficacy, personal relevance and responsibility. Intrinsic motivation implies for curiosity and desire that drives to pursue an activity, extrinsic motivation is represented by rewards by surroundings that drives you to perform or pursue a certain action. Self -efficacy is the feeling that any student has regarding his ability to carry out an action.Personal relevance is used to predict the relevance of biology learning to personal goals such as careers. While responsibility is the sense that the students have toward the control of their own learning. Anxiety is usually referred to test or assessment anxiety. It is often used to describe the tension towards grading in biology (Lang & Sorgo, 2024).

Distinct and numerous studies have been conducted on school students to investigate student motivation towards biology, or to evaluate the effectiveness of versatile teaching approaches or educational interventions towards biology motivation (Gibbens, 2019). Results of the current study showed that the intervention had no significant difference among experimental and control samples for BMQ total scores and BMQ subscales scores. Similar findings were found in distinct similar research. An intervention of digital game based and inquiry-based learning program was implemented in biology curriculum for eighth-grade students. Students' inquiry skills and motivation were assessed in both experimental and control groups. Effects of the intervention were significant for inquiry skills with a moderate effect size while

motivation showed non-significant differences among experimental and control groups (Bonus et al., 2024). An additional similar finding is also documented by Reece & Butler (2017) who conducted a quasi-experimental research to analyze conceptual understanding, attitudes and motivation within two biologically active learning strategies contexts, including graphic organizer-worksheet activities and case study activities.Significant learning gains and attitudinal measures were observed for both groups. However, results using Mann-Whitney-U-test showed no significant difference between group differences were found for all scales of BMQ.

Furthermore, a regional initiative two-year elective intervention program known as 'Discover, Understand, Implement, and Transfer' for secondary school students was designed and implemented to increase students′ participation in STEM careers. student's motivation was evaluated by using students who didn't participate in the classes as a control. Results showed that participating in the intervention protocol didn't increase student's motivation towards science (Ologe & Shittu, 2012). Another study that coupled achievement and motivation scores based on an intervention is a study of Uzun and Şen (2023) who implemented a quasi-non-equivalent experimental approach to investigate the effect of learning environment based on STEM in science curriculum on student's achievement and motivation towards science. Results showed that achievement scores of the experimental STEM based learning protocol had higher significant achievement scores compared to control group. However, motivation scores among both groups had no significant differences. According to Hecht and colleagues (2019) intervention outcomes may be influenced by environmental factors, societal factors or unpredicted effects that might either strengthen or weaken the intervention intended outcomes. According to Williams and Williams (2011), there are five role players that impact student motivation including the student, the teacher, the content, the methodology and the environment. One of the theories that might explain motivation is the goal orientation theory. This theory addresses the goals that affects student's engagement in distinct activities. Studies adopting this theory showed that a strong correlation among adolescent students adopt for science along with their parents and their science teachers. In simpler words, emphasizing or de-emphasizing a goal in science by a teacher or a parent might lead that students become less or more motivated. Other environmental factors might play a role in motivation including school culture and peer relations (Fortus & Touitou, 2021). Such determinants might play a role in

delaying the appearance of significant effect of the intervention. Since the intervention does not control such mediating factors. In addition to that, the duration of intervention might affect the successfulness of the intervention outcomes. For example, the interventions that includes shorter durations yielded somewhat larger effect sizes than interventions with longer durations (Slavin & Lake, 2009).

Since no significant difference among experimental and control group of all six motivational constructs is found, the researchers analyzed the experimental group students for their pre and post scores of total BMQ scores and BMQ scale scores using pre-scores as covariates. According to gender, no significant differences are found among female and male students either at BMQ total scores or BMQ subscale scores. The previous results are confirmed by a meta - analysis performed by Lesperance and colleague's (2022). In their study, nearly 71 effects sizes were synthesized from different 20 primary studies. The study revealed that the interventions had significant positive effects on the two genders, in addition, there was no significant difference between the two genders in regards to the intervention outcomes of the affective motivational factors. The study also revealed that other moderators, including grade level, school subject and duration, have no significant effects. A similar finding was found by Reizer and colleagues (2025) in a STEM based two distinct interventions revealed that the two interventions have no significant differences across gender or with distinct grade levels. In addition to that, no gender differences were found among sixth graders towards science motivation after implementing of a student-centered module of bionics along with a zoological garden and an exhibition (Marth & Bogner, 2017).

Results also indicate no significant differences between females and males in regards to BMQ subscales. Males showed lower anxiety levels compared to females but with no significant value. Similar results in the direction and contradicted in significance are shown in different studies, for example, a study of Basco & Olea (2013) on freshman biology students state and trait anxiety showed a significant difference of anxiety levels across gender. The researcher suggest that such a difference might be of biological origin. Another study that investigated test anxiety among introductory biology students in Norway. Female students expressed higher significant test anxiety levels compared to male students (Cotner et al., 2020).Results of this research also showed that female students have higher non-significant levels of motivation subscales of Intrinsic

motivation, extrinsic motivation, personal relevance، and responsibility.Similar significant findings were found within the intrinsic, extrinsic interest subdimensions were found using “Academic Motivation Scale for Learning Biology” among 564 high school biology students in turkey (Kisoglu, 2018).

A similar finding related to high school students who were assessed through motivational regulation scale for their motivation towards biology. Female students from ninth to twelfth grades showed higher significant extrinsic and intrinsic regulations compared to male students of the same academic levels (Ozbas, 2016). Further studies suggest that certain intervention protocols might aid in reducing the gender gap in self-determination motivation that normally exists among male and female students. In a study of Grobmann and colleague's (2023), where the treatment of autonomy supportive teaching protocol aided in the reduction in self-determined motivation among male students and female students. Regarding self-efficacy subscale, male students were found to have higher non-significant levels compared to female students. Relevant studies showed that males have higher scores of self- efficacies than female students, but with a significant difference. For example, a study of Mohammad and colleague's (2014) showed that self-efficacy of tenth grade male biology students were significantly higher than self-efficacy of female students.Similar finding is found in science classes, were self-efficacy levels of male students than females. One explanation might be that male students tend to develop skills in scientific aspects while females focus more on language and social skills (İnce, 2023). Most of the previous results resemble findings of other researches with direction, and deviate in significance. the presence of non-significant differences findings is highly frequent. In educational settings, including school classes, many interacting factors are difficult to control such as student-teacher interaction, teacher deviation from intervention protocol, and distinct learners' backgrounds. Such factors can increase error variances in the study design lowering the effect size for the intervention, especially when researchers underestimate the proper sample size needed to find the effect of intervention reliably (Edelsbrunner & Thurn, 2024). Another explanation might support the effect of the intervention to reduce the gender gap that normally exists among motivational constructs between males and females transforming the findings from significant to non-significant values upon

intervention. Further studies should be conducted with equal sample sizes among male and female students to verify the intervention across gender.

Regarding learning environment, results of BMQ total scores showed that the blended learning group had slightly higher total scores than the face-face learning group with no significant difference. results are contradicted with findings of other studies. A study of Dwiastuti and colleagues (2021) revealed that using blended learning in an invertebrate classification course had a significant difference of student's motivation in blending learning settings in addition to significant effect of blended learning on students critical thinking skills.

Another similar research which compared among traditional face-face learning, blended learning and social network supported learning in terms of student's academic outcomes and motivation towards science for seventh graders. results showed that blended learning protocols increased student's academic success and motivation compared to face-face learning. Comparison of social networking supported learning wasn’t meaningful compared to face-face settings (Akgunduz & Akınoglu, 2017).Regarding practical exercises, virtual laboratories and face-face laboratories in an introductory biology course showed a decline in students' motivation towards science between the beginning and the end of the semester with no significant difference across the both learning settings. Having on line virtual experiments might be a replacement for face-face exercises (Reece & Butler, 2017). According to Roziqoh and colleagues (2025), on line learning might not always have a significant effect on students' motivation. on line settings might not directly affect student's motivation.Regarding anxiety scale, blended learning students showed less anxiety levels compared to face-to-face students with no significant difference. It is documented that relative and moderate levels of anxiety can enhance student's performance (B. Li et al., 2024). Sharma & Sarkar (2020) had used an online role in fighting anxiety questionnaire on high school students taught by blended learning settings.73% of the students showed that blended learning aided in reduction of anxiety levels towards achievement tests. Supporting evidence is also shown in the work of Aldalalah &Gasaymeh(2014) who found that students having high anxiety were less interested in participating in blended learning where a significant difference between anxiety level and competency is found. However, the intervention lowered the difference towards students' attitudes of blended learning.

Regarding extrinsic motivation sub scale, face-to-face students showed a significant higher score of the blended group students. A result that seems to contradict with other studies. In a study that investigated motivational orientation among blended learning, didactic teaching and web- based e- learning programs, results showed that blended learning had higher significant difference than other groups in extrinsic motivation and self-efficacy (Balakrishnan et al., 2021).

Regarding intrinsic motivation subscale, face-face students also showed higher significant levels of motivation compared to blended learning. The current results are also contradicted to relevant study's findings. For example, in a study that included the investigation of intrinsic learning constructs medical education among blended and face-face environments. Results showed that in students' had higher intrinsic motivation in blended learning than in face-face settings (Jawaid et al., 2024). Zhou & Zhang (2024) argue that online learning designed activities should be tailored, continuously improved and revised to be more effective in producing effect.Personal relevance subscale also showed a significant difference in favor to face-face learning. According to self-determination theory, distinct forms of motivation can co-occur with different outcomes depending to the autonomy degree experienced. Making assignments more relevant to students' life in STEM initiatives can improve students functioning through elevating motivation (Johansen et al., 2023). Self-relevance is documented to have higher scores in blended learning environment. In a study of Osman & Hamza (2020) students showed higher levels in self-relevance, attention, satisfaction and confidence after participating in 10-week blended learning class.Blended learning also caused a higher non-significant motivation level in the responsibility subscale compared to face-to-face learning. Similar findings of relevant researches confirmed that blended learning application increases learning independence and students' sense of responsibility toward their own learning (Riwayani & Harahap, 2022).

The remaining subscale of self-efficacy showed higher non-significant difference in favor of face-to-face student scores. A contradicted result to other findings of similar researches. For example, a blended course for high school students of a vocational school showed positive effects of blended learning on self-efficacy and achievement (Budhyani et al., 2022). However, other studies reported no significant difference

among face-face and blended learning in self-efficacy. For example, Thai and colleague's (2020) compared four learning environments, including face-to-face, blended, e-learning and flipped classrooms on third students' of animal and human physiology course. No significant difference was found in regards of self-efficacy in the four distinct learning environments. Additionally, Jackson (2020) compared students' motivational subscales in face-face and virtual hybrid labs in an introductory biology course and found no significant difference in motivational subscales including self-efficacy.

Motivation towards learning is also documented to be affected by school geographic locations.Fourth and fifth science grade students who live in rural environments with high- income families have higher motivation towards learning science (Kenar et al., 2016). In the current study, Zababdeh is the nearest geographic location for the university school of Academic education, the school is private school where students of high-income families are registered. This can explain the effect of school geographic location on motivational scores. Both Jenin and Qabatya schools are public schools that have a diverse dissection of economical statues of student's families. Significant differences among groups are found in extrinsic, intrinsic and personal relevance subscales in favor to Qabatya school. Qabatya school had also the highest achievement scores among other schools. Within experimental sample, Qabatya had the highest achievements, extrinsic, intrinsic and personal relevance among other samples. The mentioned results assert the strong association between motivational constructs and achievement. It is documented that Intrinsic motivation is steadily associated with academic achievement (Lemos & Verissimo, 2014). Results show that intrinsic, extrinsic motivation and academic performance are positively correlated (Ayub, 2010). Regarding responsibility subscale, Jenin school had the highest non-significance scores compared to other schools. During the implementation of the intervention, this school had a severe closure due to Israeli closure, certain students lost their homes and other students had to evacuate their homes and search for substitute. Some students had no internet connection. Schools were postponed for 2 months. It is noticeable that the students who had such circumstances had higher responsibility toward their learning. Regarding the sixth subscale, Zababdeh students the highest non -significant scores in self- efficacy. Zababdeh students were only male students. this outcome is expected

since the sample of Zababdeh had no variability in gender.Further analysis should be performed to study the interaction pattern across gender and geographic location.

4.2 Conclusions

To the best of the researcher's knowledge, this nonequivalent quasi experimental study represents the first Palestinian trial to integrate bioinformatics within biology eleventh grade biology textbook. Although the designed experiments were given as extracurricular activity. The design was aligned with the eleventh textbook that can be used in the future as intra-curricular activities. Results showed that a significant increase in achievement scores was demonstrated among experimental sample. In addition, a significant interaction was found among posttest scores of both experimental and control samples along with learning environment and geographic location. While gender had no interaction along with post LOTS and HOTS scores of both samples. The intervention outcomes were more obvious on cognitive outcomes represented by achievement scores, compared to affective outcomes represented by motivation. motivation had no significant difference among both experimental groups. Within the experimental sample, Intrinsic, extrinsic and personal relevance had higher significant levels in face-face learning environments and Qabatya school geographic location. Optimization of intervention protocols to capture affective outcomes in the future should reconsider the duration of implementation, the learning environment, the school location, the sample size and assessment appropriate timing.In addition, other detectable affective aspects such as attitudes, interest, perceptions, engagement are advised to be performed.

Bioinformatics seems to be a promising approach that will enable students to visualize genes and their products, manipulate proteins, amino acid and nucleotide sequences, determine mutations and their possible effects, examine the relatedness of living organisms, identify DNA fingerprint along with other skills. Integration of this science will offer the students to experience learning through inquiry -based learning, problem-based learning and game-based learning protocols. This constructivist and experiential approach will allow students to have authentic skills more related to their lives and their successive careers including STEM careers. in addition, using the biological databases will help students to improve their twenty first century skills that aims to prepare a student who is well-equipped with competencies necessary to cope with current era.

4.3 Research Limitations

During research intervention and application, many limitations had faced the researcher. The first limitation was the lack of schools that contained two eleventh grade classes, most schools of scientific branches had only one section of the eleventh grade which limited the sample to certain schools. The second limitation was the availability of teachers who are welling by choice to undergo the training sessions of bioinformatics in order to apply the intervention. Another limitation through the intervention was the invasive occupation constrictions to Jenin area, and the compulsory evacuation of student's families from Jenin camp (students at Jenin secondary girls' school) to other areas as emigrants with no stable internet connection which postponed the study of the unit for nearly two months.

Limitations in regards to the research design also exist. As Andrade (2021) notes, even when researchers use statistical controls or matching techniques, unmeasured or unknown confounders may persist, limiting the strength of causal claims. In this research, schools were single sex schools, each of a distinct geographic location, and distinct learning environment. According to Theobald (2018), using a whole school class, group level characteristics are fixed and cannot be separated from school's identity. Such structural features cannot be separated within intact classes Thus, student gender, school's geographic location, and learning environment are confounded with the school identity or the school settings. Therefore, the analyses involving these variables should be interpreted as reflecting combined school-level contextual influences, instead of individual student level.

4.4 Recommendations

The findings of the current study reflect bioinformatics as a promising tool for improving biology educational out-comes; however, practical implementation should take into consideration school instrumentation, teachers' competencies, students′ socioeconomical status and school closure due to occupation. The following recommendations stem from the findings of the current study:

1. Biology teachers are advised to integrate bioinformatics experiments as an extracellular activity for biology students in genetics, heredity, and classification units to enhance students cognitive outcomes.

2. Biology supervisors are advised to held training sessions for biology teachers to integrate bioinformatics in biology classes.
3. Biology supervisors and teachers are advised to design bioinformatics experiments and activities that aligns well with biology textbook content
4. Curriculum designers at the ministry of education and higher education should reconsider the reform of the curriculum based on bioinformatics science.
5. Policy makers, school administrators are advised to create practical solutions for school infrastructures necessary for bioinformatics and technology enhanced learning protocols.

4.5 Suggestions

The following suggestions aim to optimize the intervention protocol for yielding higher educational impacts of integrating bioinformatics

1.Future intervention studies including extracurricular and intra-curricular bioinformatics integration should be conducted to have a closer look of the effect of bioinformatics on educational outcomes.
2. Researchers are advised to investigate the effect of bioinformatics integration within biology text book on student's achievement scores for different student grades, among the two genders at public and private schools.
3. Researchers are advised to investigate the effect of bioinformatics integration within biology text book on student's motivation scores for different student grades, among the two genders at public and private schools at different assessment timing.
4. Researchers are advised to investigate the effect of bioinformatics integration within biology text book on students' affective outcomes such as attitudes, engagement, interest for different student grades, among the two genders at public and private schools.
5. Researchers are advised to investigate the effect of bioinformatics integration within biology text book on students twenty first century skills and technological skills for different student grades, among the two genders at public and private schools

List of Abbreviations

Abbreviation	Meaning
ADDIE	Analyze, Design, Develop, implement and Evaluate
AN	Anxiety
ANCOVA	Analysis of Covariance
BMQ	Biology Motivation Questionnaire
CVI	Content Validity index
CVR	Content Validity ratio
DNA	Deoxyribonucleic Acid
ELT	Experiential learning theory
EM	Extrinsic motivation
GENI-ACT	Genomics Education National Initiative-Annotation Collaboration Toolkit
GPA	Grade Point Average
HOTS	High Order Thinking Skills
ICT	Information and Computer technology
IM	Intrinsic Motivation
ISEF	International Science Engineering Fair
LOTS	Low Order Thinking Skills
MOOCS	Massive Open Online Courses
NGSS	Next Generation Science Standards
NIBLSE	The Network for integrating Bioinformatics into Life Sciences Education
PLN	Personal Learning networks
PR	Personal Relevance
RE	Responsibility
RNA	Ribonucleic Acid
SE	Self-Efficacy
SMQ	Science Motivation Questionnaire
SPSS	Statistical Package for the Social Sciences
STEM	Science, Technology, Engineering, Mathematics.
TPACK	Technology, Pedagogy and Content knowledge

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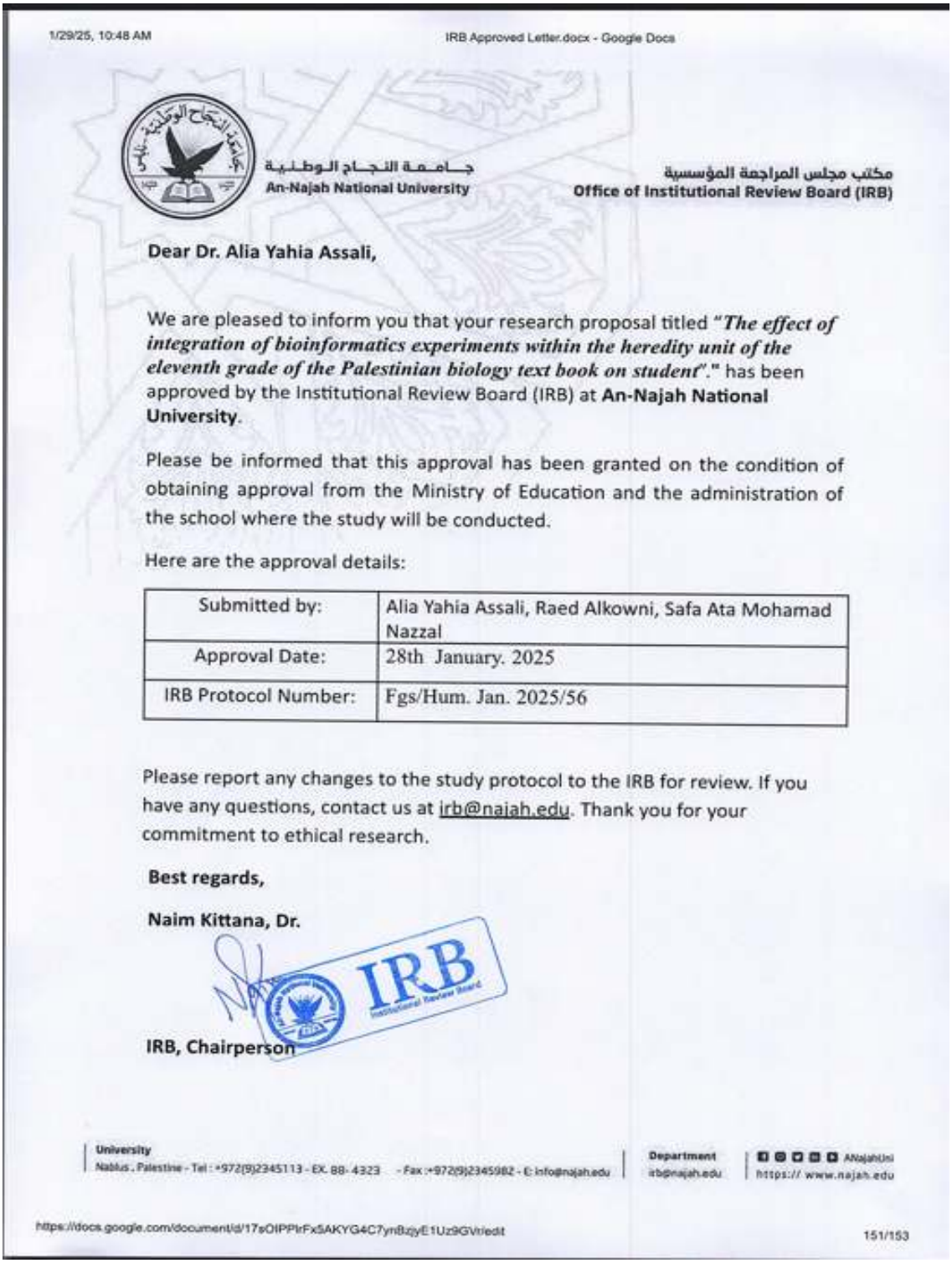
Appendices

Appendix A

Institutional Review Board (IRB)



1/29/25, 10:48 AM IRB Approved Letter.docx - Google Docs

جـــامـعـة النـجـاح الـوطـنـيـة
An-Najah National University

مكتب مجلس المراجعة المؤسسية
Office of Institutional Review Board (IRB)

Dear Dr. Alia Yahia Assali,

We are pleased to inform you that your research proposal titled "***The effect of integration of bioinformatics experiments within the heredity unit of the eleventh grade of the Palestinian biology text book on student***"." has been approved by the Institutional Review Board (IRB) at **An-Najah National University**.

Please be informed that this approval has been granted on the condition of obtaining approval from the Ministry of Education and the administration of the school where the study will be conducted.

Here are the approval details:

Submitted by:	Alia Yahia Assali, Raed Alkowni, Safa Ata Mohamad Nazzal
Approval Date:	28th January. 2025
IRB Protocol Number:	Fgs/Hum. Jan. 2025/56

Please report any changes to the study protocol to the IRB for review. If you have any questions, contact us at irb@najah.edu. Thank you for your commitment to ethical research.

Best regards,

Naim Kittana, Dr.

IRB Institutional Review Board

IRB, Chairperson

University
Nablus, Palestine - Tel: +972(9)2345113 - EX. 88-4323 - Fax: +972(9)2345982 - E: info@najah.edu

Department
irb@najah.edu

ANajahUni
https:// www.najah.edu

https://docs.google.com/document/d/17sOIPPlrFx5AKYG4C7ynBzjyE1Uz9GVr/edit

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Appendix B

Task facilitation model

بسم الله الرحمن الرحيم

State of Palestine
Ministry of Education & Higher Education
National Centre for Examination, Measurement and Educational Evaluation.

دولة فلسطين
وزارة التربية والتعليم العالي
المركز الوطني للامتحانات والقياس والتقويم التربوي

الرقم: و ت /2376/1/12
التاريخ: 2025/2/18م

السيد مدير عام التربية والتعليم/ جنين المحترم
السيد مدير عام التربية والتعليم/ قباطية المحترم
تحية طيبة وبعد،،

الموضوع: تسهيل مهمة الباحثة صفاء عطا محمد نزال

نهديكم أطيب تحية، ونرجو منكم التكرم بتسهيل مهمة الباحثة المذكورة أعلاه من **جامعة النجاح الوطنية** حيث تقدمت بطلب تسهيل مهمة لمركز البحث والتطوير التربوي لإجراء دراسة بعنوان: "**أثر دمج أنشطة إثرائية من المعلوماتية الحيوية في وحدة الوراثة في كتاب العلوم الحياتية للصف الأول ثانوي من المنهاج الفلسطيني على تحصيل الطلبة ودافعيتهم**". وستوزع الباحثة **رابط استبيان** محوسب على عينة من طلبة الصف الأول ثانوي العلمي في مدارس مديريتي جنين وقباطية. تكرماً بالإيعاز لمن يلزم بتسهيل المهمة.

وتفضلوا بقبول فائق الاحترام والتقدير،،،

م. جهاد دريدي
/ رئيس المركز الوطني للامتحانات والقياس والتقويم التربوي

نسخة: الأخ مدير عام مركز البحث والتطوير التربوي المحترم.
د. علياء العسالي المحترمة المشرفة على الدراسة.
الباحثة صفاء نزال المحترمة- بريد إلكتروني ommaliknazzal@gmail.com
د. مطر.

Appendix C

Content Analysis

Figure C1

Content analysis in terms of knowledge constructs

تحليل وحدة الوراثة بدلالة عناصر المعرفة للصف الأول ثانوي العلمي/ العلوم الحياتية ف2

الفصل	الدرس	المفاهيم	الحقائق	المبادئ و التعميمات	القوانين	النظريات
الأول الوراثة المندلية و الغير مندلية	1- 1 مندل و علم الوراثة	**علم الوراثة:** العلم الذي يبحث في الية انتقال الصفات الوراثية من الاباء الى الأبناء صفة نقية: صفة تحتوي على نسختين متماثلتين من الجينات (سائد نقي او متنحي نقي) **تلقيح ذاتي:**انتقال حبوب اللقاح من متك زهرة إلى ميسم نفس الزهرة . **تلقيح خلطي:** انتقال حبوب اللقاح من متك زهرة إلى ميسم زهرة اخرى **أفراد الجيل الأول:** الأبناء الناتجين من تلقيح الزهرة الأم مع الأب **أفراد الجيل الثاني:** الأبناء الناتجين من التلقيح الذاتي لأفراد الجيل الأول. **الطراز الجيني:** تعبيرٌ بالرّموز عن الجينات الوراثيّة للكائن الحيّ التي تحملها كروموسوماته التي تحدّد صفةً معيّنة **الطراز الشكلي:** وصفٌ بالكلمات للصفة التي تظهر على الكائن الحيّ	-الحمض النووي الذي يرثه الشخص يؤدي إلى ظهور صفات معينة - يعد مندل واضع حجر الأساس لعلم الوراثة -غطى مندل الأزهار بأكياس حرير لمنع التلقيح الخلطي -دورة حياة البازيلاء قصيرة. -نبتة البازيلاء زراعتها سهلة. -نبتة البازيلاء قابلة للتلقيح الذاتي و الخلطي. -قد يتشابه الطراز الشكلي لصفة ما لكن ليس بالضرورة ان يتشابه الطراز الجيني نفسه. -إنّ ظهور الصّفة في النبات سببُه عواملُ داخليّةٌ الجينات .على تُحمل الكروموسومات 2 إنّ الصفة الوراثيّة يحدّدها عاملان (جينان) على الزوج الكروموسومي	-عند تلقيح نباتي بازيلاء أحدهما سائد نقي و الاخر متنحي فإن أفراد الجيل الأول سيكونون 100% سائد خليط, و عند التلقيح الذاتي لأفرا الجيل الول ستظهر نسبة 75% سائد الصفة، 25% متنحي الصفة، و تعمم هذه النتيجة على جميع الصفات المتضادة لنبتة البازيلاء التي تخضع للسيادة التامة - عند تلقيح نباتي بازيلاء سائد الصفة خليط مع متنحي الصفة فإن نسبة 50% سائد الصفة، 50% متنحي الصفة ستظهر و تعمم هذه النتيجة على جميع الصفات المتضادة لنبتة	قانون انعزال الصفات: زوج العوامل الداخلية (الجينات) تنفصل عشوائيا عند تكوين الجاميتات أثناء عملية الإنقسام المنصف	-----

Figure C2

Classification of cognitive objectives of the heredity unit

فصل / درس	تذكر	فهم	تطبيق	تحليل	تقويم	تركيب
1-5	-أن يعدد الطالب صعوبات دراسة الصفات الوراثية لدى الانسان - ان يذكر الطالب بعض طرق دراسة الصفات الوراثية لدى الانسان. -أن يوضح المقصود شجرة العائلة. -أن يبين اهمية دراسة التوائم المتطابقة.	-أن يفسر الطالب الاختلافات الدقيقة بين التوائم المتطابقة	**-أن يرسم شجرة عائلة لصفة ما.**	ان يميز بين مكونات سجل النسب. - ان يتتبع سجل النسب الوراثي ويفسره (3) - ان يوضح الفرق بين التوائم المتطابقة وغير المتطابقة	- ان يستدل من اسئلة وراثية على نمط الوراثة (3).	-ان يصمم شجرة عائلة لصفة وراثية ويتتبع توارثها.
	4	1	1	5	3	1
فصل / درس	تذكر	فهم	تطبيق	تحليل	تقويم	تركيب
1-6	- ان يعدد الطالب بعض الامراض الوراثية -ان يوضح المقصود بالمرض الوراثي -ان يوضح الأعراض التي تظهر على مرضى متلازمة داون. - ان يوضح الأعراض التي تظهر على مرضى الثلاسيميا.	أن يفسر الطالب الية حدوث متلازمة داون. أن يفسر الطالب الية حدوث مرض الثلاسيميا. أن يفسر الطالب سبب تسمية الثلاسيميا بفقر دم	أن يحدد نسبة الإصابة بمرض الثلاسيميا. أن يحل أسئلة وراثية على مرض الأنيميا المنجلية. ان يحل مسائل وراثية على أنيميا التفول.	- ان يستدل من خريطة الكروموسومات على جنس الشخص المصاب بمتلازمة داون. أن يقارن الطالب بين خلايا الدم الحمراء لشخص طبيعي و خلايا دم	- ان يقييم اهمية الفحص الطبي قبل الزواج - ان يقييم وراثيا خطورة زواج الاقارب	-ان يصمم الطالب مطوية عن أحد المراض الوراثية بغرض التوعية لها.

Table C1

Distribution of the levels of cognitive objectives across the unit.

lesson	creating	evaluating	analyzing	applying	understanding	remembering	total
1−1	1	1	4	6	7	15	34
1−2	3	1	4	3	3	5	19
1−3	3	8	5	12	5	15	48
1−4	2	1	1	1	2	2	9
1−5	1	3	5	1	1	4	15
1−6	1	2	3	3	6	6	21
2−1	0	0	0	0	5	2	7
2−2	0	1	5	3	2	5	16
2−3	0	0	0	2	3	2	7
2−4	1	1	0	0	1	2	5
total	12	18	27	31	35	58	181

Additional information might be requested from authors.

Appendix D

Digital bioinformatics course objectives

Table D1

The alignment of the main objectives of the bioinformatics experiments with the original content of the unit.

Lesson subtitle	Experiment #	The intervention main objective
Mendel & Heredity	1	The classical section defines dominant and recessive genes and compares between them using alphabetical symbols.In addition, the section aids students to write the genotype/phenotype of a specific trait. This activity allows students to identify the biological databases, to search genome databases by accession number, and to compare the nucleotide sequence of both dominant and recessive genes. Students will also explain the concept of gene after manipulating gene sequences
	2	This experiment investigates the relationship between gene structure and gene function in tomatoes. Students are encouraged to explore the function of specific gene through google search. Then students will annotate the enzyme name through NCBI nucleotide database. Students will verify if other organisms have the same gene and the same gene function.
Mendelian inheritance in human	3	The classical section gives the human eye color as an example of mendelian inheritance. the experiment allows students to explore genome data viewer database, and to search for one of the genes responsible for eye color determination, and to determine the gene loci (short/long arm of chromosome), and to find its adjacent genes, in addition, the database will allow students to visualize genetic map of human and other organisms.
Sex-linked traits	4	The classical section compares between X and Y chromosome through two figures. The activity will allow students to visualize both X and Y chromosome, to compare between the length of their constituting nucleotides, the number of genes and their functions.
	5	Students would be able to use nBLAST database in order to find the best match for a nucleotide (gene) inquiry. The inquiry is specific to one of the sex chromosomes linked genes. Students should explore the gene function, the gene locus, and students should verify the presence of the gene in females and males of different organisms.
Sex linked diseases	6	The classical section represents different diseases caused by sex-linked genes and their mode of transmission. This experiment concentrates on hemophilia disease and allows

		students to search Blast x database using a nucleotide sequence foe an X linked gene. the students would be able to find the best match for the resultant protein sequence and students will be able to visualize the protein three-dimensional structure.
	7	The textbook demonstrates the difference between normal blood cells and thalassemia blood cell through a figure. The current experiment allows students to explore the protein database (Uniport) and to search the database for the hemoglobin normal alpha and normal beta subunit and how they are bonded in normal cells.
	8	The current unit explores the function of genes and their mode of transmission. The homology between living organisms regarding their genes is not mentioned. The current experiment allows student to build a phylogenetic tree based on hemoglobin gene homology for a restricted type of living organisms using Clustalo.
	9	Students will be able to build a phylogenetic taxonomic tree for any specific protein sequence using Uniport site. Students are encouraged to freely develop a phylogenetic tree for organisms of their choice and to explain the results.
	10	The textbook explains the difference between sickled red blood cells and normal red blood cells through a figure. The activity aims to allow students to explore the cause of sickle cell anemia, and to differentiate between normal and mutant sequence through a bioinformatics electronic game.
Human genome project	11	The unit explains the human genome project through a genetic map figure. This activity allows students to explore human, mice, chimpanzee, horse, chicken and dog genomes for the presence of growth hormone. Students should compare all previous genomes for the total number of chromosomes for each organism, and the growth hormone gene loci using genome data viewer. Students will also be able to explore plants for the presence of growth hormone
Polymerase chain reaction-DNA fingreprint	12	The textbook mentions one of the uses of PCR as DNA fingerprints without explaining examples. The activity aims to allow students to determine the component of sausage piece through DNA fingerprint sequences by Blast search.
	13	Final assessment

Appendix E

Intervention material

Figure E1

Table of contents of bioinformatics activities

فهرس المحتويات

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Figure E2

Sample of the designed material, experiment 2

تجربة في المعلوماتية الحيوية (2): الجينات و صفات الكائنات الحية.

الهدف: أن يحدد الطالب العلاقة بين تركيب الجينات و صفات الكائنات الحية.

مقدمة: في أحد التجارب العلمية، قام فريق من العلماء بتعطيل أحد الجينات المسؤول عن إنتاج أنزيم يدعى Phytoene Desaturase (*PDS*) في بعض ثمار البندورة الناضجة الخضراء اللون (الشكل A). و بعد أسبوعين، كانت النتائج كما هو موضح في الشكل(B) .

A

B

1- بعد قراءتك للتجربة السابقة، ما هي وظيفة الأنزيم (*PDS*)؟

2- أي الثمار في الشكل B هي التي تم تعطيل الجين فيها وفقا لوجهة نظرك؟

3- ما أهمية الجين الذي تم تعطيله؟

4- باستخدام موقع Google، ابحث عن وظيفة الأنزيم، هل تتطابق مع وجهة نظرك السابقة؟

5- برأيك، هل هناك ثمار لنباتات أخرى تحتوي على نفس الجين؟ أعط مثالا

6- للتأكد من إجابتك، قم بالبحث عبر موقع NCBI عن الإنزيم السابق في مربع البحث الرئيسي مع اختيار Nucleotide من بين الخيارات بجانب مربع البحث الرئيسي.

7- قم باختيار أحد النتائج و جد كل من اسم النبات العلمي، اسم النبات الشائع، و تسلسل النيوكليوتيدات الخاص بالجين و دونها على ملف word.

Additional information is detailed may be requested from the authors

Appendix F

Teachers training sessions

Figure F1

Zoom training session with teacher Alaa Salahat

Figure F2

Sample of students HomeWorks delivered to teachers

تجربة في المعلوماتية الحيوية (١١): جين هرمون النمو

الهدف: أن يجد الطالب موقع الجين الخاص بهرمون النمو في الجينوم الخاص بعدة كائنات حية.
مقدمة: تكاثفت جهود العلماء لتحديد الخريطة الجينية للعديد من الكائنات الحية. في هذا التمرين سنقوم بتحديد عدد الكروموسومات الكلي في كل من (الشمبانزي، الفار، الحصان، الدجاج، الإنسان، الكلب)
الإجراءات:
١.قم بالدخول إلى الموقع genome data viewer من خلال https://www.ncbi.nlm.nih.gov/gdv/
٢.اختر أحد الكائنات الحية السابقة من خلال الشجرة الظاهرة، ثم ضع في مربع البحث growth hormone
٣.حدد موقع الجين و عدد الكروموسومات للكائن الحيه حيث يمثل الشكل الظاهر في الشاشة عدد الكروموسومات n مضافاً له كروموسوم جنسي. قم بتعبئة الجدول التالي:

عدد الكروموسومات	اسم الكائن الحي	موقع جين هرمون النمو
46	الإنسان	الكروموسوم ١٧
40	الفار	الكروموسوم ١١
78	الدجاج	الكروموسوم ١
64	الحصان	الكروموسوم ٩
78	الكلب	الكروموسوم ٩

السؤال ٤: هل النباتات تمتلك نسخة من هذا الجين؟

لا، النباتات لا تمتلك جين هرمون النمو (growth hormone gene) لأن هذا الجين خاص بالكائنات الحيوانية لتنظيم نمو الجسم، بينما تعتمد النباتات على هرمونات نباتية مثل الأوكسين والسيتوكينين لتنظيم نموها.

Appendix G

SMQ

Figure G1

The copyright to use SMQ

Science Motivation Questionnaire (SMQ) © 2006 Shawn M. Glynn and Thomas R. Koballa, Jr.

Permission and Directions: Educators who wish to use the Science Motivation Questionnaire © 2006 by Shawn M. Glynn & Thomas R. Koballa, Jr., for research and teaching have permission to do so if they cite the Glynn & Koballa (2006) and Glynn et al. (2009) references below and comply with the fair use of this copyrighted and registered questionnaire. This permission extends to the discipline-specific SMQ versions such as the Biology Motivation Questionnaire (BMQ), Chemistry Motivation Questionnaire (CMQ), and Physics Motivation Questionnaire (PMQ) in which the words biology, chemistry, and physics are respectively substituted for the word science. In any use of the SMQ, its versions, and translations to other languages, permission is contingent upon citing the Glynn & Koballa (2006) and Glynn et al. (2009) references. Educators also have permission to reproduce the SMQ, its versions, and its translations—for fair use in research and teaching; in part or in whole; in print, online, or other media—if they clearly include the copyright notice "© 2006 Shawn M. Glynn and Thomas R. Koballa, Jr." with the reproduction. The website http://www.coe.uga.edu/smq/ provides downloadable articles and information on the SMQ administration, components (subscales), scoring, reliability, validity, and interpretation.

Glynn, S. M., & Koballa, T. R., Jr. (2006). Motivation to learn college science. In J. J. Mintzes & W. H. Leonard (Eds.), Handbook of college science teaching (pp. 25-32). Arlington, VA: National Science Teachers Association Press.

Glynn, S. M., Taasoobshirazi, G., & Brickman, P. (2009). Science Motivation Questionnaire: Construct validation with nonscience majors. Journal of Research in Science Teaching, 46, 127-146.

Science Motivation Questionnaire (SMQ) © 2006 Shawn M. Glynn and Thomas R. Koballa, Jr.

In order to better understand what you think and how you feel about your high school science courses, please respond to each of the following statements from the perspective of: "When I am in a college (or high school) science course…"

[Response Scale: O Never O Rarely O Sometimes O Usually O Always]

01. I enjoy learning the science.
02. The science I learn relates to my personal goals.
03. I like to do better than the other students on the science tests.
04. I am nervous about how I will do on the science tests.
05. If I am having trouble learning the science, I try to figure out why.

Appendix H

SMQ validation

Table H1

List of experts for SMQ content validity

#	Expert Name	Degree	Major	Work place	Phone number / e-mail
1	Mazoz Jaber Jameel Alawneh	professor	Measurement evaluation&	QOU	0597926048
2	Yousef Thiab awwad	professor	Mental health	QOU	0599671905
3	Mohammad Dabous	Assossiate professor	Measurement evaluation	Istiqlal University	mohammad.dabous@pass.ps
4	Mohammad abu Kaff	Assistant professor	sociology	Istiqlal University	mohamadabukf@pass.ps
5	Nadia Abu Zaher	Assossiate professor	Political sciences	Istiqlal University	Nadia.abuzaher@pass.ps
6	Sahar Odeh	doctor	Curriculum design	Ministry of Education	0597950740
7	Rehab Saadi	Assossiate professor	Mental Health	Istiqlal University	dr-rihab.alsadi@pass.ps

Table H2

Pearson correlation coefficients for the BMQ

Item #	Item	**correlation coefficient (item/total)**	**correlation coefficient (item/scale)**
Scale 1: **Anxiety (AN)**			
1	I am nervous about how I will do in biology assessments.	.348**	.506**
2	I hate taking biology assessments.	.395**	.782**
3	I become anxious when it is time to sit a biology assessment.	.350**	.795**
4	I worry about failing biology assessments	.356**	.819**
5	I am concerned that the other students are better at biology.	.439**	.735**
	Scale 2: **Extrinsic motivation (EM)**		
6	Achieving a good biology grade is important to me	.483**	.682**
7	I think about how biology will affect my overall subject or certificate endorsement.	.544**	.653**
8	I think about how learning biology can help my career.	.616**	.801**
9	I think about how learning biology can help me get a good job.	.662**	.725**
10	I like to do better than the other students in biology assessments	.583**	.700**
	Scale 3: **Intrinsic motivation (IM)**		
11	Understanding biology gives me a sense of accomplishment	.743**	.786**
12	I find learning biology interesting.	.783**	.872**
13	I enjoy learning biology.	.780**	.870**
14	I like biology that challenges me	.667**	.800**
15	The biology I learn is more important to me than the grades I receive.	.575**	.686**
	Scale 4: **Personal relevance (PR)**		
16	The biology I learn is relevant to my life.	.638**	.767**

17	I think about how the biology I learn will be helpful to me.	.733**	.862**
18	The biology I learn has practical value for me.	.705**	.872**
19	I think about how I will use the biology I learn.	.658**	.824**
20	The biology I learn relates to my personal goals.	.617**	.771**
	Scale 5: **Responsibility (RE)**		
21	I prepare well for the biology assessments.	.480**	.710**
22	If I am having trouble learning biology, I try to figure out why.	.641**	.770**
23	I put enough effort into learning biology	.659**	.745**
24	I use strategies that ensure I learn biology well.	.591**	.729**
25	It is my fault if I do not understand the biology ideas.	.550**	.647**
	Scale 6: **Self-efficacy (SE)**		
26	I believe I can earn ‘excellence' grades in the biology course.	.716**	.890**
27	I believe I can master the knowledge and skills in the biology course.	.720**	.845**
28	I am confident I will do well on the written and practical biology assessments.	.724**	.913**
29	I am confident I will do well in the biology assessments.	.722**	.888**
30	I expect to do as well as or better than other students in a biology course.	.641**	.814**

Table H3

Pearson correlation coefficients and reliability (Cronbach a) for each scale of BMQ

Scale #	**Scale**	**correlation coefficient to total degree**	**Cronbach a**
1	Anxiety (AN)	58**4.	0.785
2	Extrinsic motivation (EM)	.761**	0.755
3	Intrinsic motivation (IM)	.858**	0.861
4	Personal relevance (PR)	.817**	0.875
5	Responsibility (RE)	.747**	0.703
6	Self-efficacy (SE)	.811**	0.918
Total questionnaire			0.927

Appendix I

Arabic version of BMQ

Table I 1

The translated version of BMQ in Arabic language

الرقم	الفقرة	الدرجة				
		غالبا جدا	غالبا	أحيانا	نادرا	أبدا
المجال الأول: القلق						
1	أشعر بالتوتر بشأن أدائي في اختبارات مبحث الأحياء.					
2	أكره الخضوع لاختبارات مبحث الأحياء.					
3	يزداد قلقي عندما يقترب وقت جلوسي لاختبارات مبحث الأحياء.					
4	ينتابني القلق بشأن رسوبي في اختبارات مبحث الأحياء					
5	أشعر بالقلق من أن الطلاب الآخرين أفضلمني في مبحث الأحياء.					
المجال الثاني: الدافع الخارجي						
6	أعتبر الحصول على درجة جيدة في مبحث الأحياء أمر مهم بالنسبة لي.					
7	أفكر في كيفية تأثير درجة مبحث الأحياء على معـدلي العام.					
8	أعتقد أن تعلم علم الأحياء يساعدني في مسيرتي المهنية.					
9	دراستي لعلم الأحياء تساعدني في الحصول على وظيفة جيدة.					
10	أحب أن أكون متميزا عن الطلبة الآخرين في اختبارات مبحث الأحياء.					
المجال الثالث:الدافع الداخلي						
11	يمنحني فهم مبحث الأحياء شعورًا بالإنجاز.					
12	أعتقد أن تعلم مبحث الأحياء مثير للاهتمام.					
13	أستمتع بتعلم مبحث الأحياء.					
14	أحب من مبحث الأحيـاء المحتـوى الـذي يشـعرني بالتحدي.					
15	اعتبر تعلم مبحث الأحياء أكثر أهمية بالنسبة لـي مـن الدرجات التي أحصل عليها.					

المجال الرابع:الأهمية الشخصية						
16	يمس علم الأحياء الذي أتعلمه جوانب من حياتي.					
17	أفكر في كيف أن مبحث الأحياء الذي أتعلمه سيكون مفيدًا لي.					
18	إن مبحث الأحياء الذي أتعلمه له قيمة عملية بالنسبة لي.					
19	أفكر في استخدامات مبحث الأحياء الذي أتعلمه.					
20	إن مبحث الأحياء الذي أتعلمه يتعلق بأهدافي الشخصية.					
المجال الخامس: المسؤولية.						
21	أستعد جيدًا لاختبارات مبحث الأحياء.					
22	إذا كنت أواجه صعوبة في تعلم مبحث الأحياء فإنني أسعى لمعرفة السبب.					
23	أبذل جهدًا كافيًا في تعلم مبحث الأحياء.					
24	أستخدم استراتيجيات علمية تضمن لي تعلم مبحث الأحياء بشكل جيد.					
25	اعتبر نفسي مخطئا إذا لم أفهم أفكار مبحث الأحياء.					
المجال السادس: الكفاءة الذاتية						
26	أستطيع الحصول على درجات متميزة في مبحث الأحياء.					
27	يمكنني إتقان المعارف والمهارات في مبحث علم الأحياء.					
28	أثق بأنني سأنجح في الاختبارات الكتابية والعملية في مبحث الأحياء.					
29	أتقبأنني سأنجح في تقييمات مبحث الأحياء.					
30	أتوقع أن أحصل على نتائج أفضل من بقية الطلبة في مبحث الأحياء.					

Table I2

Arabic Language Experts

#	Expert Name	Degree	Major	Work place	Phone number/e-mail
1	Amal Abu oun	Doctor	Arabic Language	Qabatya Directorate	00972599292735
2	Hassan Nazzal	bachelor	Arabic Language	Qabatya Directorate	00972568674222

Appendix J

Achievement Test Validation

Table J1

List of experts for content validity

#	Expert Name	Degree	Major	Work place	Phone number/ e-mail
1	Hazem abu Jazr	Master	Biology/ curriculum design	Ministry of education	00972562501075
2	Mamoun Qadan	bachelor	Biology	supervisor-Tulkarm	00972566204041
3	Sahar Odeh	doctor	Curriculum design	Ministry of education	00970597950740
4	Talal freihat	doctor	Learning and teaching	Yamoun s. Boy school	00970599351060
5	Shahd bani naem	master	Biology	Jenin s. girl school	00970592746279
6	Maram Fyad	master	Biology	Methloon s. girl school	
7	Faten Sadeq	bachelor	Biology	Zababdeh s. girl school	00972599744711

Table J2

Content validity values of the test represented by CVR

item #	sum sum items	CVR	Item #	sum	CVR	Item #	sum	CVR
1	14	1	15	14	1	29	13	0.86
2	14	1	16	14	1	30	12	0.86
3	13	0.86	17	14	1	31	14	1
4	14	1	18	13	0.86	32	14	1
5	13	0.86	19	13	0.86	33	14	1
6	14	1	20	14	1	34	14	1
7	14	1	21	13	0.86	35	14	1
8	14	1	22	13	0.86	36	14	1
9	13	0.86	23	13	0.86	37	14	1
10	14	1	24	14	1	38	14	1
11	13	0.86	25	13	0.86	39	14	1
12	14	1	26	13	0.86	40	13	0.86
13	14	1	27	14	1	41	13	0.86
14	14	1	28	14	1			

Note: The total CVI is 0.949

Table J3

Achievement test reliability statistics

		y1	y2
y1	Pearson Correlation	1	.745**
	Sig. (2-tailed)		.000
	N	35	35
y2	Pearson Correlation	.745**	1
	Sig. (2-tailed)	.000	
	N	35	35

**. Correlation is significant at the 0.01 level (2-tailed).

Table J4

Descriptive statistics needed to calculate Cronbach alpha

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
y1	35	.00	21.00	12.8429	4.70727	22.158
y2	35	.00	18.50	9.9286	4.43108	19.634
x	35	.00	39.50	22.7714	8.53741	72.887
Valid N (listwise)	35					

Table J5

Discrimination and difficulty levels for test items

Item	Difficulty	Diff. level	Discrimination	Disc. level
q1 (1.5)	0.914	Easy	0.174	Poor
q2 (1.5)	0.229	Hard	0.337	Moderate
q3 (1.5)	0.257	Hard	0.055	Poor
q4 (1.5)	0.543	Moderate	0.334	Moderate
q5 (1)	0.871	Easy	0.389	Moderate
q6 (1)	0.786	Moderate	0.578	Good
q7 (1)	0.5	Moderate	0.419	Good
q8 (1)	0.557	Moderate	0.444	Good
q9 (1)	0.343	Moderate	0.466	Good
q10 (1)	0.014	Hard	0.046	Poor
q11 (1)	0.471	Moderate	0.32	Moderate
q12 (1)	0.357	Moderate	0.378	Moderate
q13 (1)	0.486	Moderate	0.288	Moderate
q14 (1)	0.214	Hard	0.064	Poor
q15 (1.5)	0.743	Moderate	0.591	Good
q16 (1.5)	0.21	Hard	0.445	Good
q17 (1)	0.629	Moderate	0.567	Good
q18 (1)	0.4	Moderate	0.626	Good
q19 (1.5)	0.114	Hard	0.024	Poor
q20 (1)	0.886	Easy	0.448	Good
q21 (1)	0.4	Moderate	0.599	Good
q22 (1.5)	0.6	Moderate	0.599	Good
q23 (3)	0.514	Moderate	0.413	Good
q24 (3)	0.581	Moderate	0.612	Good
q25 (4)	0.525	Moderate	0.39	Moderate
q26 (2.5)	0.703	Moderate	0.314	Moderate
q27 (2.5)	0.411	Moderate	0.315	Moderate
q28 (2)	0.357	Moderate	0.44	Good
q29 (1)	0.443	Moderate	0.228	Moderate
q30 (1.5)	0.038	Hard	0.29	Moderate
q31 (1.5)	0.448	Moderate	0.418	Good
q32a (1.5)	0.048	Hard	0.235	Moderate
q32b (1.5)	0.21	Hard	0.38	Moderate

Appendix K

Achievement test

اختبار تحصيل قبلي/بعدي

الصف الأول ثانوي العلمي

السؤال الأول ضع دائرة حول رمز الإجابة الصحيحة:(6)

1. أي منالعيون التالية تعتبر عيونا غير ملونة

أ: الخضراء ب: العسلية ج: السوداء د: الزرقاء

2. ما التقنية المستخدمة في إنتاج عدد كبير من النسخ من الحمض النووي في المختبر ؟

أ: زراعة الأنسجة ب: تضاعف DNA ج: تفاعل البوليميريز د: الاستنساخ

3. ما الخلية المستخدمة في عملية الاستنساخ من الكائن المراد استنساخه؟

أ: بويضة مخصبة ب: بويضة غير مخصبة ج: خلية جسمية د: خلية جذعية

4.ما نسبة النباتات بيضاء الأزهار الناتجة من تلقيح ذاتي لنبات بازيلاء أرجواني الأزهار غير نقي؟

أ: 25% ب: 50% ج: 75% د: 100%

وضح المقصود بما يلي:

5. بالصفة السائدة:(1)

6. السيادة الغير تامة: (1)

7. سجل النسب:(1)

اذكر وظيفة واحدة لكل من:

8. جين SRY:(1)

9. عوامل التخثر:(1)

10. النسخة الطبيعية من الجين المسبب لعمى الألوان:(1)

اذكر ما يلي:

11. نص قانون مندل الأول.(1)

12. أول صفة قام مندل بدراستها على نبتة البازيلاء ؟(1)

فسر ما يلي:

13. سبب قيام مندل بقص الأسدية في تجاربه؟(1)

14. يعبر عن الصفة الوراثية برمزين؟(1)

15. يصعب الحصول على سلالات غير نقية من نبات شب الليل؟(1.5)

16. تستخدم ذبابة الخل في الدراسات الوراثية؟(1.5)

17. وجود اختلافات دقيقة بين التوائم المتطابقة؟(1)

18. سبب زيادة فرصة مرضى الأنيميا المنجلية للسكتات الدماغية؟(1)

19. استخدام درجة الحرارة (55–60)س في مرحلة الترابط في تفاعل البوليميريز؟(1.5)

وضح ما يلي:

20. الأعراض الظاهرة على مرضى متلازمة داون؟(1)

21. تأثير صبغة الميلانين في لون العين البشرية؟(1)

22. اعط مثال على عامل بيئي خارجي يؤثر على ظهور الصفات الوراثية لدى الحيوانات وقم بتفسيرأثر العامل السابق؟ (1.5)

23. لديك مربع بانيت الاتي الذي يمثل توارث صفة البذور الصفراء في البازيلاء، ادرس الشكل جيدا و أجـــب عما يليه؟ (3)

ص	س	جاميتات الاباء
ل	AA	ع
aa	م	و

أ. حدد الطراز الجينيللاباء؟ ب. حدد الطراز الشكلي للاباء؟

ج. برأيك، هل الصفة السائدة دوما الأكثر انتشارا؟ دعم إجابتك بأدلة؟

24. ولد طفل لإحدى العائلات شحمة أذنه ملتحمة لوالدين كلاهما حر الشحمة، اجب عما يلي:(3)

أ. ما الطراز الجيني للطفل؟ ب. ما احتمال إنجاب طفل حر الشحمة لهذه العائلة؟

ج–ناقش صحة هذه العبارة: ظهور طفل شحمة أذنه ملتحمة لوالدين حرين الأذنين تعني دوما أن كلا الوالـــدين يحملان الصفة بشكلسائد غير نقي.

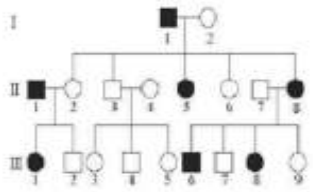
25. تزوج رجل مصاب بمرض عمى الألوان من إمرأة مجهولة الطراز الشكلي لمرض عمى الألـــوان فأنجبـــا طفلة مصابة بعمى الألوان و طفلا سليما من عمى الألوان، أجب عما يلي:(4)

أ. اكتب الطرز الجينية للأبناء ب. اكتب الطرز الشكلية و الجينية للاباء

ج. اذا علمت أن الأب المصاب بمرض عمى الألوان أيضا سليم من نزف الدم، اكتب الطراز الجيني للأب.

26. برأيك، في الفرع السابق هل الأم مؤهلة لقيادة السيارة؟دعم إجابتك في بتفسير علمي(2.5)

27. لديك سجل نسب يمثل توارث لأحد الأمراض الوراثية، ادرسه ثم أجب عما يليه؟(2.5)



أ. ما الطراز الشكلي للأم (I) ب. ما احتمال انجاب طفلذكر مصاب من الأبوين (II(3،4

ج. هل صفة المرض سائدة ام متنحية؟ لماذا؟

28؟ بتقدم شاب أمه و أبوه غير مصابين بمرض الثلاسيميا و لديه أخت مصابة بمرض الثلاســيميا لخطبـــة إحدى الفتيات و عائلتها بأكملها غير مصابة بمرض الثلاسيميا.(2)

ا. اكتب الطرز الجينية للشاب مستعينا برموز مناسبة؟

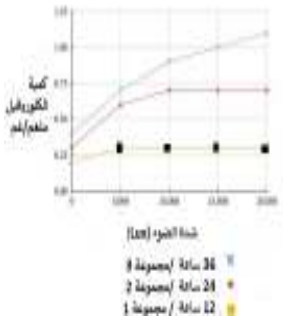
ب. قارن بينتركيب خلايا الدم لكل من الشاب و اخته؟

29. هل تنصح الفتاة بإجراء فحص الثلاسيميا ؟ فسر إجابتك؟(1)

30. تتبع من خلال مخطط عملية الاستنساخ في النبات؟(1.5)

31. قارن **في الشكل المجاور، تعرضت 3 مجموعات من النباتات تنتمي إلى نفس النوع ألى مستويات مختلفة من شدة الضوء، حيث تعرضت المجموعة الأولى إلى مستوى الشدة الموضح لمدة 12 ساعة، و المجموعـــة**

الثانية إلى المستوى الموضح لمدة 24 ساعة، و المجموعة الثالثة إلى المستوى الموضح لمـــدة 36 ســـاعة. يوضح التمثيل البياني كمية الكلوروفيل التي قامت هذه النباتات بتصنيعها.(1.5)



أ. ما هي المجموعة التي قامت بتصنيع أكبر كمية من الكلوروفيل؟

ب. ما هي المجموعة التي لديها أوراق أقل اخضرارا؟

ج. لخص العلاقة بين مدة التعرض للضوء و لون النبات للمجموعة الثانية.

32. أ: من خلال دراستك للجينوم البشري، ارسم خريطة كروموسومات لذكر إنسان موضحا عـــدد الجينـــات التقريبي على كل كروموسوم؟(1.5)

ب: **قارن بين الخلايا الجذعية الجنينية و البالغة من حيث قدرتها على التمايز؟**(1.5)

انتهت الأسئلة/ تمنياتي للجميع بالتوفيق

Appendix L

Result statistics of the achievement test

Table L1

Descriptive statistics of posttest scores among different groups

Dependent Variable:posttest				
	group	Mean	Std. Deviation	N
Sample	experimental	26.84	11.710	76
	control	22.08	8.273	71
Learning env.				
face	experimental	35.91	8.914	27
	control	25.92	6.222	24
	Total	31.21	9.192	51
blended	experimental	21.85	9.976	49
	control	20.13	8.558	47
	Total	21.01	9.300	96
sample	geographic	Mean	Std. Deviation	N
experimental	qabatya	35.91	8.914	27
	Zababdeh	17.35	7.986	10
	Jenin	23.00	10.194	39
	Total	26.84	11.710	76
control	qabatya	25.92	6.222	24
	Zababdeh	12.50	6.276	10
	Jenin	22.19	7.950	37
	Total	22.08	8.273	71
Dependent Variable postHOTS				
sample	gender	Mean	Std. Deviation	N
experimental	male	6.8500	4.81923	10
	female	13.6094	5.95783	64
	Total	12.6959	6.23776	74
control	male	3.3500	3.16272	10
	female	10.6587	5.01757	63
Dependent Variable: postLOTS				
sample	gender	Mean	Std. Deviation	N
experimental	male	9.5000	6.41613	10
	female	15.4766	5.72687	64
	Total	14.6689	6.13282	74
control	male	9.1500	4.41619	10
	female	13.3254	4.07110	63
	Total	12.7534	4.33584	73

Table L2

Normality tests of posttests

variable	sample	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
posttest	whole	.052	147	.200*	.990	147	.407
sample	experimental	.082	76	.200	.990	76	.798
	control	.064	71	.200*	.985	71	.579
Learning environment	Face-face	.071	51	.200*	.966	51	.148
	blended	.064	96	.200*	.985	96	.360
Geographic location	Qabatya	.071	51	.200*	.966	51	.148
	Zababdeh	.103	20	.200*	.947	20	.329
	Jenin	.058	76	.200*	.990	76	.796
Gender/Post LOTS	male	.132	20	.200*	.968	20	.704
	female	.051	127	.200*	.993	127	.770
Gender/Post HOTS	male	.175	20	.111	.906	20	.054
	female	.051	127	.200*	.993	127	.770

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table L3

Test of between subject effects of posttest

Type of ANCOVA	Independent variable	Tests of Between-Subjects Effects						Levene's Test of Equality of Error Variances	
		Source	Type III Sum of Squares	df	Mean Square	F	Sig.	F	Sig
One way	Sample	group	81.594	1	81.594	.810	.370	17.748	0.000
		pretest	352.497	1	352.497	3.498	.064		
		group * pretest	253.004	1	253.004	2.510	.115		
Two way	Geog. location	geographic * pretest	122.592	2	61.296	.894	.411	1.532	.184
		sample * geographic * pretest	382.406	2	191.203	2.788	.065		
		sample * pretest	167.926	1	167.926	2.449	.120		
Two way	Learning environment	sample * pretest	8.612	1	8.612	.117	.733	2.296	0.081
		Learning-env * pretest	73.393	1	73.393	.997	.320		
		sample * learning-env * pretest	156.369	1	156.369	2.125	.147		
Two way	Gender	gender * preLOT	36.474	1	36.474	1.430	.234	.194	..661
		sample * preLOT	24.654	1	24.654	.967	.327		
		sample * gender * preLOT	.741	1	.741	.029	.865		
Tow way	Gender	gender * preHOT	43.693	1	43.693	1.508	.222	1.963	.122
		sample * gender * preHOT	8.421	1	8.421	.291	.591		
		sample * preHOT	.026	1	.026	.001	.976		

Table L4

Pairwise comparisons of posttest scores

Independent variable	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
						Lower Bound	Upper Bound
Sample	experimental	control	4.817*	1.657	.004	1.542	8.093
	control	experimental	-4.817-*	1.657	.004	-8.093	-1.542
Two way ANCOVA							
Geographic location	qabatya	Zababdeh	17.844	3.266	.000	9.930	25.758
		Jenin	7.891	1.631	.000	3.939	11.843
	Zababdeh	qabatya	-17.844-	3.266	.000	-25.758-	-9.930-
		Jenin	-9.954-	3.619	.020	-18.723-	-1.184-
	Jenin	qabatya	-7.891-	1.631	.000	-11.843-	-3.939-
		Zababdeh	9.954	3.619	.020	1.184	18.723
Sample	experimental	control	5.157	1.629	.002	1.937	8.377
	control	experimental	-5.157-	1.629	.002	-8.377-	-1.937-
Learning environment	face	blended	9.835	1.505	.000	6.860	12.810
	blended	face	-9.835-	1.505	.000	-12.810-	-6.860-
Sample	experimental	control	5.994	1.505	.000	3.018	8.970
	control	experimental	-5.994-	1.505	.000	-8.970-	-3.018-
Gender/postLOT	male	female	-6.333-	2.622	.017	-11.516-	-1.150-
	female	male	6.333	2.622	.017	1.150	11.516
Sample	experimental	control	-.502-	2.622	.849	-5.685-	4.682
	control	experimental	.502	2.622	.849	-4.682-	5.685
Gender/postHOT	male	female	-7.269-	1.324	.000	-9.887-	-4.651-
	female	male	7.269	1.324	.000	4.651	9.887
Sample	experimental	control	3.222	1.289	.014	.674	5.771
	control	experimental	-3.222-	1.289	.014	-5.771-	-.674-

Table L5

Estimated marginal means of post test scores

Interaction	Learning-env	sample	Mean	Std. Error	95% Confidence Interval	
					Lower Bound	Upper Bound
Learning-env * sample	face	experimental	36.035[a]	1.670	32.735	39.336
		control	25.665[a]	1.773	22.160	29.170
	blended	experimental	21.824[a]	1.239	19.375	24.273
		control	20.206[a]	1.265	17.705	22.707
sample * geographic	experimental	Qabatya	35.838a	1.634	32.607	39.069
		Zababdeh	15.514a	3.566	8.464	22.565
		Jenin	23.486a	1.494	20.533	26.439
	control	Qabatya	26.054a	1.740	22.615	29.493
		Zababdeh	10.689a	3.546	3.679	17.699
		Jenin	22.624a	1.501	19.656	25.592
sample * gender post HOTS	experimental	male	6.623	1.720	3.223	10.023
		female	13.662	.673	12.331	14.994
	control	male	3.171	1.710	-.210-	6.552
		female	10.669	.675	9.334	12.004
sample * gender post LOTS	experimental	male	6.904a	4.152	-1.305-	15.112
		female	16.726a	1.162	14.428	19.024
	control	male	10.895a	2.888	5.184	16.605
		female	13.738a	.749	12.257	15.220

Table L6

Robust Tests of Equality of Means

posttest				
	Statistic[a]	df1	df2	Sig.
Welch	8.176	1	135.205	.005

a. Asymptotically F distributed.

Table L7

Ranks ofMann-Whitney U test

	Group	N	Mean Rank	Sum of Ranks
posttest	experimental	76	83.51	6347.00
	Control	71	63.82	4531.00
	Total	147		

Table L8

Mann-Whitney U test	posttest
Mann-Whitney U	1975.000
Wilcoxon W	4531.000
Z	-2.803-
Asymp. Sig. (2-tailed)	.005

a. Grouping Variable: group

Table L9

Quade Nonparametric Analysis of Covariance

F	DFH	DFE	P Value
8.140	1	145	.005

Table L10

Pairwise Comparisons of Groups

Comparison	t	DF	P Value
1 vs. 2	2.853	145	.005

Appendix M

BMQ statistics

Table M1

Descriptive statistics of BMQ post scores.

	N	Range	Minimum	Maximum	Mean		Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic
Prescale 1	147	3.20	.80	4.00	3.0463	.05701	.69126	.478
Prescale 2	147	3.80	1.20	5.00	3.9605	.07064	.85645	.734
Prescale 3	147	4.00	1.00	5.00	3.8466	.07867	.95381	.910
Prescale 4	147	4.00	1.00	5.00	3.6299	.08119	.98436	.969
Prescale 5	147	3.80	1.20	5.00	3.7585	.06476	.78512	.616
Prescale 6	147	4.00	1.00	5.00	4.3170	.06484	.78613	.618
postscale 1	147	3.60	.40	4.00	3.0181	.06296	.76338	.583
postscale 2	147	3.40	1.60	5.00	4.1168	.06074	.73642	.542
postscale 3	147	3.80	1.20	5.00	4.0881	.06023	.73025	.533
postscale 4	147	4.00	1.00	5.00	3.8172	.07741	.93856	.881
postscale 5	147	3.80	1.20	5.00	3.8467	.06957	.84351	.712
postscale 6	147	2.40	2.60	5.00	4.4619	.04568	.55383	.307
Valid N (listwise)	147							

Table M2

Normality tests of post scales of BMQ

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Post-scale-total	.101	147	.001	.942	147	.000
postscale1	.123	147	.000	.926	147	.000
postscale2	.158	147	.000	.900	147	.000
postscale3	.166	147	.000	.905	147	.000
postscale4	.114	147	.000	.922	147	.000
postscale5	.151	147	.000	.906	147	.000
postscale6	.190	147	.000	.866	147	.000
a. Lilliefors Significance Correction						

Table M3

Normality tests of transformed data (inverse transformation).

	sample	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
posttotalscores	1	.046	76	.200*	.996	76	.997
	2	.058	71	.200*	.994	71	.976
prescaletotalscores	1	.044	76	.200*	.996	76	.998
	2	.050	71	.200*	.994	71	.980
prescale1scores	1	.084	76	.200*	.980	76	.288
	2	.106	71	.064	.972	71	.113
prescale2scores	1	.084	76	.200*	.977	76	.177
	2	.074	71	.200*	.967	71	.062
pre3scores	1	.101	76	.052	.977	76	.188
	2	.076	71	.200*	.976	71	.191
pre4scores	1	.069	76	.200*	.977	76	.182
	2	.075	71	.200*	.978	71	.248
pre5scores	1	.064	76	.200*	.984	76	.436
	2	.089	71	.200*	.980	71	.309
pre6scores	1	.139	76	.001	.949	76	.004
	2	.166	71	.000	.922	71	.000
postscale1scores	1	.110	76	.054	.969	76	.061
	2	.074	71	.200*	.975	71	.163
postscale2scores	1	.095	76	.089	.958	76	.013
	2	.112	71	.072	.966	71	.051
post3scores	1	.106	76	.053	.957	76	.071
	2	.098	71	.085	.979	71	.283
postscale4scores	1	.074	76	.200*	.966	76	.093
	2	.080	71	.200*	.972	71	.107
post5scores	1	.083	76	.200*	.988	76	.692
	2	.072	71	.200*	.985	71	.531

* This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table M4

Tests of between subject effect of bootstrapping ANCOVA.

Type of ANCOVA	Independent variable	scale	Tests of Between-Subjects Effects						Levene's Test of Equality of Error Variances	
			Source	Type III Sum of Squares	df	Mean Square	F	Sig.	F	Sig
One way	sample	Total score	sample	.002	1	.002	.061	.806	.630	.429
			prescaletotal	33.022	1	33.022	1063.027	.000		
			sample * prescaletotal	.003	1	.003	.082	.775		
		AN	sample	.911	1	.911	1.550	.215	.655	0.420
			prescale1	.120	1	.120	.204	.652		
			sample * prescale1	.917	1	.917	1.560	.214		
		EM	sample	.983	1	.983	1.814	.180	6.175	0.065
			prescale2	.083	1	.083	.154	.695		
			sample * prescale2	.650	1	.650	1.199	.275		
		IM	sample	.143	1	.143	.278	.599	1.800	0.182
			sample * prescale3	.086	1	.086	.169	.682		
			prescale3	4.378	1	4.378	8.539	.004		
		PR	sample	.608	1	.608	.685	.409	1.132	0.298
			prescale4	.632	1	.632	.711	.400		
			sample * prescale4	.903	1	.903	1.017	.315		
		RE	sample	.410	1	.410	.577	.449	.213	0.645
			prescale5	.955	1	.955	1.343	.248		
			sample * prescale5	.658	1	.658	.925	.338		
		SE	sample	.023	1	.023	.077	.782	0.280	0.598
			prescale6	.887	1	.887	2.906	.090		
			sample * prescale6	.052	1	.052	.172	.679		
One way	gender	Total score	prescaletotal	13.090	1	13.090	458.940	.000	2.670	0.107
			gender	.010	1	.010	.346	.558		
			gender * prescaletotal	.003	1	.003	.109	.742		
	gender	AN	gender	1.773	1	1.773	2.894	.093	0.136	0.714
			prescale1	1.054	1	1.054	1.720	.194		
			gender * prescale1	2.529	1	2.529	4.128	.046		
		EM	prescale2	.095	1	.095	.136	.713	.875	0.353
			gender	.329	1	.329	.472	.494		
			gender * prescale2	.441	1	.441	.634	.429		

		IM	gender	.081	1	.081	.142	.707		
			prescale3	.258	1	.258	.453	.503		
			gender * prescale3	.005	1	.005	.009	.926		
		PR	gender	.070	1	.070	.066	.798	7.230	
			prescale4	.518	1	.518	.493	.485		
			gender * prescale4	.520	1	.520	.495	.484		
		RE	gender	4.969	1	4.969	7.385	.008		.552
			prescale5	4.090	1	4.090	6.077	.016		
			gender * prescale5	5.545	1	5.545	8.241	.005		
		SE	gender	.181	1	.181	.563	.456	3.186	0.086
			prescale6	.762	1	.762	2.365	.128		
			gender * prescale6	.126	1	.126	.392	.533		
		Total score	mode	.000	1	.000	.007	.933	0.017	.898
			prescaletotal	24.035	1	24.035	774.140	.000		
			mode * prescaletotal	.001	1	.001	.019	.889		
		AN	mode	.249	1	.249	.395	.531	.906	0.344
			prescale1	.285	1	.285	.452	.503		
			mode * prescale1	.062	1	.062	.098	.755		
		EM	mode	2.493	1	2.493	4.121	.046	5.410	0.063
			prescale2	.397	1	.397	.656	.421		
			mode * prescale2	1.412	1	1.412	2.334	.131		
		IM	mode	.936	1	.936	1.830	.180	5.044	0.082
			prescale3	.074	1	.074	.145	.705		
			mode * prescale3	.282	1	.282	.550	.461		
		PR	mode	1.028	1	1.028	1.069	.305	6.717	0.066
			prescale4	.274	1	.274	.285	.595		
			mode * prescale4	.158	1	.158	.164	.686		
		RE	mode	.014	1	.014	.019	.892	1.035	.312
			prescale5	3.435E-5	1	3.435E-5	.000	.995		
			mode * prescale5	.001	1	.001	.001	.969		
		SE	mode	.072	1	.072	.225	.637	.186	0.668
			prescale6	.157	1	.157	.491	.486		
			mode * prescale6	.115	1	.115	.359	.551		
		Total score	geography	.013	2	.007	.231	.795	1.440	0.224
			prescaletotal	11.633	1	11.633	400.763	.000		
			geography * prescaletotal	.006	2	.003	.108	.897		

		AN	geography	1.725	2	.863	1.441	.244	1.284	.283
			prescale1	.474	1	.474	.791	.377		
			geography * prescale1	2.337	2	1.169	1.953	.149		
		EM	geography	3.371	2	1.685	2.764	.070	6.769	0.78
			prescale2	.449	1	.449	.737	.394		
			geography * prescale2	2.196	2	1.098	1.801	.173		
		IM	prescale3	.092	1	.092	.177	.676	11.913	0.052
			geography	.808	2	.404	.777	.464		
			geography * prescale3	.201	2	.100	.193	.825		
		PR	geography	1.389	2	.694	.710	.495	6.494	0.081
			prescale4	.582	1	.582	.595	.443		
			geography * prescale4	.811	2	.405	.414	.662		
		RE	geography	4.624	2	2.312	3.411	.039	2.309	0.170
			prescale5	3.049	1	3.049	4.497	.037		
			geography * prescale5	5.393	2	2.697	3.978	.023		
		SE	geography	.214	2	.107	.331	.720	2.178	0.121
			prescale6	.481	1	.481	1.483	.227		
			geography * prescale6	.187	2	.093	.288	.751		

Table M5

Bootstrap ANCOVA estimated marginal means.

DV	sample	Mean	Std. Error	95% Confidence Interval		Bootstrap for Mean Bias 001. -.001-	Std. Error 091. .086	BCa 95% Confidence Interval Lower 2.819 2.849	Upper 3.193 3.188
				Lower Bound	Upper Bound	bias	St. Error	BCa 95% Confidence Interval Lower	Upper
Total score	experimental	3.896	.020	3.856	3.935	.000	.044	3.811	3.979
	control	3.887	.021	3.846	3.928	.000	.044	3.801	3.972
AN	experimental	3.011	.088	2.837	3.185	.001	.091	2.819	3.193
	control	3.026	.091	2.846	3.206	-.001-	.086	2.849	3.188
EM	experimental	4.040	.085	3.873	4.207	.002	.094	3.846	4.226
	control	4.199	.087	4.026	4.372	-.002-	.075	4.054	4.336
IM	experimental	4.119	.082	3.957	4.281	.001	.086	3.942	4.290
	control	4.055	.085	3.888	4.223	-.001-	.080	3.900	4.201
PR	experimental	3.775	.108	3.561	3.988	.001	.116	3.536	4.000
	control	3.863	.112	3.642	4.084	-.002-	.102	3.664	4.057
RE	experimental	3.786	.097	3.594	3.977	-.001-	.097	3.586	3.970

	control	3.912	.100	3.714	4.110	.000	.100	3.710	4.112
SE	experimental	4.429	.063	4.304	4.554	.000	.064	4.305	4.556
	control	4.497	.065	4.367	4.626	.000	.063	4.366	4.616
Total score	male	3.936	.054	3.828	4.044	-7.819E-5	.090	3.763	4.121
	female	3.848	.021	3.807	3.889	.001	.060	3.721	3.971
AN	male	2.796	.275	2.247	3.345	-.006-	.278	2.330	3.318
	female	3.045	.100	2.846	3.243	.002	.100	2.846	3.241
EM	male	1	3.934	.266	3.403	4.465	-.004-	.331	3.225
	female	2	4.056	.103	3.852	4.261	-.001-	.099	3.854
IM	male	3.720	.246	3.229	4.211	-.021-	.405	2.920	4.422
	female	4.179	.093	3.994	4.364	.002	.082	4.017	4.340
PR	male	3.441	.331	2.781	4.101	-.003-	.481	2.426	4.382
	female	3.824	.126	3.572	4.075	.002	.115	3.593	4.045
RE	male	3.628	.276	3.078	4.179	.009	.368	2.910	4.375
	female	3.801	.106	3.590	4.013	.002	.097	3.602	3.994
SE	male	4.547	.179	4.191	4.904	-.001-	.134	4.292	4.794
	female	4.418	.070	4.279	4.556	-.001-	.070	4.276	4.553
Total score	face-face	3.828	.033	3.762	3.895	.000	.063	3.698	3.951
	blended	3.877	.024	3.828	3.926	.001	.063	3.747	4.001
AN	face-face	2.815	.152	2.512	3.117	-.001-	.137	2.527	3.072
	blended	3.121	.113	2.896	3.345	.000	.114	2.887	3.345
EM	face-face	4.413	.152	4.111	4.716	-.003-	.113	4.177	4.618
	blended	3.835	.112	3.611	4.059	.001	.121	3.582	4.078
IM	face-face	4.492	.139	4.215	4.770	-3.041E-5	.091	4.302	4.669
	blended	3.913	.103	3.708	4.117	.001	.112	3.677	4.140
PR	face-face	4.210	.188	3.835	4.585	-.001-	.129	3.951	4.442
	blended	3.533	.139	3.255	3.811	.001	.154	3.209	3.835
RE	face-face	3.645	.165	3.316	3.975	-.001-	.146	3.355	3.913
	blended	3.852	.123	3.608	4.096	.001	.128	3.567	4.109
Subscale6	face-face	4.515	.109	4.297	4.732	.000	.095	4.329	4.698
	blended	4.391	.081	4.230	4.552	.001	.087	4.210	4.569
Total score	Qabatya	3.827	.033	3.761	3.893	.000	.064	3.695	3.950
	Zababdeh	3.938	.054	3.830	4.046	.001	.090	3.767	4.123
	Jenin	3.862	.027	3.808	3.916	.001	.064	3.729	3.989
AN	Qabatya	2.817	.151	2.516	3.118	-.001-	.139	2.525	3.076
	Zababdeh	2.773	.270	2.234	3.312	.004	.266	2.288	3.365
	Jenin	3.208	.128	2.953	3.463	7.162E-5	.127	2.942	3.452
EM	Qabatya	4.413	.153	4.108	4.717	-.003-	.113	4.176	4.617
	Zababdeh	3.926	.253	3.422	4.429	-.002-	.329	3.233	4.538
	Jenin	3.812	.126	3.560	4.064	.002	.132	3.527	4.079
IM	Qabatya	4.498	.139	4.221	4.776	-2.144E-5	.090	4.315	4.670
	Zababdeh	3.694	.234	3.226	4.161	-.004-	.400	2.865	4.462
	Jenin	3.964	.114	3.737	4.192	.003	.106	3.744	4.180
PR	Qabatya	4.211	.189	3.834	4.588	-.002-	.128	3.952	4.443
	Zababdeh	3.438	.318	2.804	4.073	.000	.480	2.417	4.387
	Jenin	3.556	.157	3.243	3.870	.003	.160	3.222	3.869
RE	Qabatya	3.642	.165	3.312	3.972	-.002-	.147	3.353	3.910
	Zababdeh	3.618	.275	3.070	4.167	-.004-	.368	2.892	4.375
	Jenin	3.914	.139	3.637	4.191	.005	.136	3.627	4.188
SE	Qabatya	4.514	.109	4.297	4.732	.000	.095	4.330	4.697
	Zababdeh	4.546	.178	4.190	4.902	.003	.135	4.269	4.823
	Jenin	4.351	.090	4.171	4.532	.001	.102	4.129	4.562

Table M6

Bootstrapping ANCOVA pairwise comparisons

Independent variable/sample	(I) group	(J) group	Mean Difference (I-J)	bias	St.error	Sig 2-tailed	BCa 95% Confidence Interval	
							LU	
Total score	experimental	control	.009	1.140E-5	.029	.776	-.047	.068
	control	experimental	-.009-	1.140E-5	.029	.776	-.066	.046
AN	experimental	control	-.015-	.002	.124	.898	-.268	.244
	control	experimental	.015	-.002	.124	.898	-.217-	.247
EM	experimental	control	-.160-	.004	.119	.188	-.405-	.088
	control	experimental	.160	-.004	.119	.188	-.067-	.380
IM	experimental	control	.063	.003	.115	.579	-.159-	.300
	control	experimental	-.063-	-.003-	.115	.579	-.294-	.154
PR	experimental	control	-.088-	.002	.155	.574	-.395-	.220
	control	experimental	.088	-.002-	.155	.574	-.214-	.392
RE	experimental	control	-.126-	-.001-	.142	.383	-.402-	.150
	control	experimental	.126	.001	.142	.383	-.156-	.410
SE	experimental	control	-.068-	-1.284E-6	.089	.455	-.236-	.106
	control	experimental	.068	1.284E-6	.089	.455	-.109-	.238
Total scale	male	female	.088	-.001-	.077	.248	-.054-	.235
	female	male	-.088-	.001	.077	.248	-.249-	.068
AN	male	female	-.249-	-.008-	.306	.409	-.774-	.336
	female	male	.249	.008	.306	.409	-.427-	.836
EM	male	female	-.122-	-.003-	.345	.724	-.846-	.542
	female	male	.122	.003	.345	.724	-.525-	.818
IM	male	female	-.459-	-.023-	.415	.274	-1.280-	.260
	female	male	.459	.023	.415	.274	-.362-	1.377
PR	male	female	-.383-	-.004-	.497	.432	-1.400-	.571
	female	male	.383	.004	.497	.432	-.561-	1.395
RE	male	female	-.173-	.006	.379	.633	-.937-	.596
	female	male	.173	-.006-	.379	.633	-.560-	.902
SE	male	female	.130	-5.698E-5	.149	.367	-.159-	.420
	female	male	-.130-	5.698E-5	.149	.367	-.430-	.172
Total scale	face-face	blended	-.048-	-.001-	.038	.216	-.120-	.024
	blended	face-face	.048	.001	.038	.216	-.029-	.127
AN	face-face	blended	-.306-	-.001-	.180	.098	-.662-	.033
	blended	face-face	.306	.001	.180	.098	-.048-	.678
EM	face-face	blended	.579	-.004-	.163	.001	.261	.885
	blended	face-face	-.579-	.004	.163	.001	-.915-	-.233
IM	face-face	blended	.580	-.001-	.139	.000	.321	.843
	blended	face-face	-.580-	.001	.139	.000	-.867-	-.299
PR	face-face	blended	.677	-.002-	.200	.002	.292	1.058
	blended	face-face	-.677-	.002	.200	.002	-1.084	-.263
RE	face-face	blended	-.207-	-.002-	.197	.307	-.578-	.163
	blended	face-face	.207	.002	.197	.307	-.192-	.600
SE	face-face	blended	.124	-.001-	.130	.346	-.123-	.365
	blended	face-face	-.124-	.001	.130	.346	-.383-	.149
Total score	Qabatya	Zababdeh	-.111-	-.001-	.080	.163	-.271-	.035
		Jenin	-.035-	-.001-	.038	.371	-.107-	.036

	Zababdeh	Qabatya	.111	.001	.080	.163	-.041-	.278
		Jenin	.076	.000	.076	.325	-.072-	.233
	Jenin	Qabatya	.035	.001	.038	.371	-.042-	.112
		Zababdeh	-.076-	.000	.076	.325	-.224-	.065
AN	Qabatya	Zababdeh	.044	-.006-	.313	.895	-.614-	.601
		Jenin	-.391-	-.002-	.184	.041	-.761-	-.022
	Zababdeh	Qabatya	-.044-	.006	.313	.895	-.615-	.640
		Jenin	-.435-	.004	.300	.152	-.986-	.207
	Jenin	Qabatya	.391	.002	.184	.041	.017	.767
		Zababdeh	.435	-.004-	.300	.152	-.191-	.975
EM	Qabatya	Zababdeh	.487	-.002-	.346	.157	-.145-	1.163
		Jenin	.601	-.006-	.173	.002	.281	.922
	Zababdeh	Qabatya	-.487-	.002	.346	.157	-1.218	.183
		Jenin	.114	-.004-	.359	.754	-.601-	.779
	Jenin	Qabatya	-.601-	.006	.173	.002	-.977-	-.232
		Zababdeh	-.114-	.004	.359	.754	-.797-	.635
IM	Qabatya	Zababdeh	.805	.004	.410	.061	.031	1.634
		Jenin	.534	-.003-	.136	.001	.280	.795
	Zababdeh	Qabatya	-.805-	-.004-	.410	.061	-1.666	-.003
		Jenin	-.271-	-.007-	.418	.514	-1.117	.523
	Jenin	Qabatya	-.534-	.003	.136	.001	-.811-	-.259
		Zababdeh	.271	.007	.418	.514	-.526-	1.126
PR	Qabatya	Zababdeh	.773	-.001-	.495	.120	-.150-	1.738
		Jenin	.655	-.004-	.205	.003	.276	1.041
	Zababdeh	Qabatya	-.773-	.001	.495	.120	-1.825	.232
		Jenin	-.118-	-.003-	.510	.809	-1.140	.872
	Jenin	Qabatya	-.655-	.004	.205	.003	-1.069	-.234
		Zababdeh	.118	.003	.510	.809	-.864-	1.136
RE	Qabatya	Zababdeh	.024	.001	.395	.951	-.714-	.769
		Jenin	-.272-	-.007-	.204	.192	-.656-	.104
	Zababdeh	Qabatya	-.024-	-.001-	.395	.951	-.848-	.788
		Jenin	-.296-	-.008-	.394	.455	-1.051	.494
	Jenin	Qabatya	.272	.007	.204	.192	-.134	.700
		Zababdeh	.296	.008	.394	.455	-.501-	1.057
SE	Qabatya	Zababdeh	-.032-	-.004-	.166	.837	-.351-	.277
		Jenin	.163	-.001-	.141	.260	-.109-	.432
	Zababdeh	Qabatya	.032	.004	.166	.837	-.297-	.368
		Jenin	.195	.003	.167	.235	-.138-	.537
	Jenin	Qabatya	-.163-	.001	.141	.260	-.447-	.121
		Zababdeh	-.195-	-.003-	.167	.235	-.527-	.129

Table M 7

Raw data ANCOVA of BMQ

One way ANCOVA							
Independent variable/sample		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Total score	Contrast	.003	1	.003	.084	.772	.001
	Error	4.442	143	.031			
AN	Contrast	.009	1	.009	.015	.904	.000
	Error	84.968	144	.590			
EM	Contrast	.935	1	.935	1.722	.192	.012
	Error	78.153	144	.543			
IM	Contrast	.148	1	.148	.290	.591	.002
	Error	73.402	144	.510			
PR	Contrast	.283	1	.283	.319	.573	.002
	Error	126.957	143	.888			
RE	Contrast	.578	1	.578	.813	.369	.006
	Error	102.351	144	.711			
SE	Contrast	.167	1	.167	.549	.460	.004
	Error	43.702	144	.303			
Independent variable/gender		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Total score	Contrast	.064	1	.064	2.270	.136	.030
	Error	2.057	73	.028			
AN	Contrast	.442	1	.442	.692	.408	.009
	Error	46.637	73	.639			
EM	Contrast	.126	1	.126	.182	.671	.002
	Error	50.600	73	.693			
IM	Contrast	1.676	1	1.676	2.981	.088	.039
	Error	41.043	73	.562			
PR	Contrast	1.200	1	1.200	1.151	.287	.016
	Error	76.121	73	1.043			
RE	Contrast	.251	1	.251	.339	.562	.005
	Error	53.995	73	.740			
SE	Contrast	.038	1	.038	1.322	.254	.018
	Error	2.083	73	.029			
Independent variable/mode		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Total scale	Contrast	.007	1	.007	.228	.634	.002
	Error	4.440	144	.031			
AN	Contrast	1.628	1	1.628	2.615	.110	.035
	Error	45.451	73	.623			

EM	Contrast	5.750	1	5.750	9.334	.003	.113
	Error	44.976	73	.616			
IM	Contrast	5.590	1	5.590	10.991	.001	.131
	Error	37.128	73	.509			
PR	Contrast	8.071	1	8.071	8.394	.005	.104
	Error	69.234	72	.962			
RE	Contrast	.738	1	.738	1.007	.319	.014
	Error	53.507	73	.733			
SE	Contrast	.262	1	.262	.825	.367	.011
	Error	23.195	73	.318			
Independent variable/geography		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Total scale	Contrast	.083	2	.041	1.458	.239	.039
	Error	2.038	72	.028			
AN							
EM	Contrast	6.795	2	3.398	5.573	.006	.137
	Error	42.678	70	.610			
IM	Contrast	6.139	2	3.069	6.042	.004	.144
	Error	36.580	72	.508			
PR	Contrast	8.035	2	4.017	4.175	.019	.104
	Error	69.286	72	.962			
RE	Contrast	1.399	2	.699	.953	.390	.026
	Error	52.847	72	.734			
SE	Contrast	.565	2	.283	.889	.416	.024
	Error	22.892	72	.318			

Table M8

Raw data pairwise comparisons

Independent variable/ sample	**(I) group**	**(J) group**	**Mean Difference (I-J)**	**Std. Error**	**Sig.[b]**	**95% Confidence Interval for Difference[b]**	
						Lower Bound	**Upper Bound**
Total score	experimental	control	.008	.029	.772	-.049-	.066
	control	experimental	-.008-	.029	.772	-.066-	.049
AN	experimental	control	-.015-	.127	.904	-.266-	.236
	control	experimental	.015	.127	.904	-.236-	.266
EM	experimental	control	-.160-	.122	.192	-.400-	.081
	control	experimental	.160	.122	.192	-.081-	.400
IM	experimental	control	.063	.118	.591	-.169-	.296

	control	experimental	-.063-	.118	.591	-.296-	.169
PR	experimental	control	-.088-	.156	.573	-.395-	.220
	control	experimental	.088	.156	.573	-.220-	.395
RE	experimental	control	.126	.140	.369	-.150-	.403
	control	experimental	-.126-	.140	.369	-.403-	.150
SE	experimental	control	-.068-	.091	.460	-.248-	.113
	control	experimental	.068	.091	.460	-.113-	.248
Total scale	male	female	.088	.058	.136	-.028-	.204
	female	male	-.088-	.058	.136	-.204-	.028
AN	male	female	-.249-	.299	.408	-.844-	.347
	female	male	.249	.299	.408	-.347-	.844
EM	male	female	-.122-	.286	.671	-.693-	.448
	female	male	.122	.286	.671	-.448-	.693
IM	male	female	-.459-	.266	.088	-.989-	.071
	female	male	.459	.266	.088	-.071-	.989
PR	male	female	-.383-	.357	.287	-1.094-	.328
	female	male	.383	.357	.287	-.328-	1.094
RE	male	female	-.173-	.297	.562	-.765-	.419
	female	male	.173	.297	.562	-.419-	.765
SE	male	female	.118	.194	.545	-.268-	.504
	female	male	-.118-	.194	.545	-.504-	.268
Total scale	Face-face	Blended	-.015-	.031	.634	-.076-	.046
	Blended	Face-Face	.015	.031	.634	-.046-	.076
AN	Face-face	Blended	-.306-	.189	.110	-.683-	.071
	Blended	Face-Face	.306	.189	.110	-.071-	.683
EM	Face-face	Blended	.579	.189	.003	.201	.956
	Blended	Face-Face	-.579-	.189	.003	-.956-	-.201-
IM	Face-face	Blended	.580	.175	.001	.231	.928
	Blended	Face-Face	-.580-	.175	.001	-.928-	-.231-
PR	Face-face	Blended	.686	.237	.005	.214	1.159
	Blended	Face-Face	-.686-	.237	.005	-1.159-	-.214-
RE	Face-face	Blended	-.207-	.206	.319	-.618-	.204
	Blended	Face-Face	.207	.206	.319	-.204-	.618
SE	Face-face	Blended	.124	.136	.367	-.148-	.395
	Blended	Face-Face	-.124-	.136	.367	-.395-	.148
Total score	Qabatya	Zababdeh	-.111-	.065	.277	-.270-	.048
		Jenin	-.035-	.043	1.000	-.141-	.071
	Zababdeh	Qabatya	.111	.065	.277	-.048-	.270
		Jenin	.076	.060	.637	-.072-	.223
	Jenin	Qabatya	.035	.043	1.000	-.071-	.141
		Zababdeh	-.076-	.060	.637	-.223-	.072
AN	Qabatya	Zababdeh	.044	.311	1.000	-.718-	.806
		Jenin	-.391-	.197	.154	-.875-	.093

	Zababdeh	Qabatya	-.044-	.311	1.000	-.806-	.718
		Jenin	-.435-	.308	.486	-1.189-	.320
	Jenin	Qabatya	.391	.197	.154	-.093-	.875
		Zababdeh	.435	.308	.486	-.320-	1.189
	Qabatya	Zababdeh	.044	.311	1.000	-.718-	.806
EM		Jenin	.606	.310	.163	-.154-	1.367
	Zababdeh	Qabatya	.643	.198	.005	.157	1.128
		Jenin	-.606-	.310	.163	-1.367-	.154
	Jenin	Qabatya	.036	.297	1.000	-.692-	.765
		Zababdeh	-.643-	.198	.005	-1.128-	-.157-
	Qabatya	Zababdeh	-.036-	.297	1.000	-.765-	.692
IM		Jenin	.805	.278	.015	.122	1.487
	Zababdeh	Qabatya	.534	.180	.012	.092	.976
		Jenin	-.805-	.278	.015	-1.487-	-.122-
	Jenin	Qabatya	-.271-	.261	.907	-.910-	.368
		Zababdeh	-.534-	.180	.012	-.976-	-.092-
	Qabatya	Zababdeh	.271	.261	.907	-.368-	.910
PR		Jenin	.773	.373	.125	-.141-	1.687
	Zababdeh	Qabatya	.655	.246	.028	.053	1.257
		Jenin	-.773-	.373	.125	-1.687-	.141
	Jenin	Qabatya	-.118-	.357	1.000	-.993-	.756
		Zababdeh	-.655-	.246	.028	-1.257-	-.053-
	Qabatya	Zababdeh	.118	.357	1.000	-.756-	.993
RE		Jenin	.024	.319	1.000	-.758-	.805
	Zababdeh	Qabatya	-.272-	.217	.645	-.805-	.261
		Jenin	-.024-	.319	1.000	-.805-	.758
	Jenin	Qabatya	-.296-	.312	1.000	-1.059-	.468
		Zababdeh	.272	.217	.645	-.261-	.805
	Qabatya	Zababdeh	.296	.312	1.000	-.468-	1.059
SE		Jenin	-.032-	.210	1.000	-.546-	.482
	Zababdeh	Qabatya	.163	.142	.763	-.185-	.512
		Jenin	.032	.210	1.000	-.482-	.546
	Jenin	Qabatya	.195	.200	.997	-.295-	.685
		Zababdeh	-.163-	.142	.763	-.512-	.185
	Qabatya	Zababdeh	-.195-	.200	.997	-.685-	.295

Table M9

Estimated marginal means of raw data ANCOVA

DV	sample	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Total score	experimental	3.896	.020	3.856	3.935
	control	3.887	.021	3.846	3.928
AN	experimental	3.026	.091	2.846	3.206
	control	3.026	.091	2.846	3.206
EM	experimental	4.040	.085	3.873	4.207
	control	4.199	.087	4.026	4.372
IM	experimental	4.119	.082	3.957	4.281
	control	4.055	.085	3.888	4.223
PR	experimental	3.773	.108	3.560	3.987
	control	3.861	.112	3.640	4.082
RE	experimental	3.786	.097	3.594	3.977
	control	3.912	.100	3.714	4.110
SE	experimental	4.429	.063	4.304	4.554
	control	4.497	.065	4.367	4.626
Total score	male	3.936	.054	3.828	4.044
	female	3.848	.021	3.807	3.889
AN	male	2.796	.275	2.247	3.345
	female	3.045	.100	2.846	3.243
EM	male	3.934	.266	3.403	4.465
	female	4.056	.103	3.852	4.261
IM	male	4.179	.093	3.994	4.364
	female	3.720	.246	3.229	4.211
PR	male	3.441	.331	2.781	4.101
	female	3.824	.126	3.572	4.075
RE	male	3.628	.276	3.078	4.179
	female	3.801	.106	3.590	4.013
SE	male	4.547	.179	4.191	4.904
	female	4.418	.070	4.279	4.556
Total score	Face-face	3.882	.025	3.833	3.931
	Blended	3.897	.018	3.861	3.932
AN	Face-face	2.815	.152	2.512	3.117
	Blended	3.121	.113	2.896	3.345
EM	Face-face	4.413	.152	4.111	4.716

	Blended	3.835	.112	3.611	4.059
IM	Face-face	4.492	.139	4.215	4.770
	Blended	3.913	.103	3.708	4.117
PR	Face-face	4.221	.191	3.840	4.601
	Blended	3.534	.140	3.255	3.814
RE	Face-face	3.645	.165	3.316	3.975
	Blended	3.852	.123	3.608	4.096
SE	Face-face	4.515	.109	4.297	4.732
	Blended	4.391	.081	4.230	4.552
Total score	Qabatya	3.827	.033	3.761	3.893
	Zababdeh	3.938	.054	3.830	4.046
	Jenin	3.862	.027	3.808	3.916
AN	Qabatya	4.455	.153	4.149	4.761
	Zababdeh	3.849	.269	3.311	4.386
	Jenin	3.812	.125	3.563	4.062
EM	Qabatya	4.455	.153	4.149	4.761
	Zababdeh	3.849	.269	3.311	4.386
	Jenin	3.812	.125	3.563	4.062
IM	Qabatya	4.498	.139	4.221	4.776
	Zababdeh	3.694	.234	3.226	4.161
	Jenin	3.964	.114	3.737	4.192
PR	Qabatya	4.211	.189	3.834	4.588
	Zababdeh	3.438	.318	2.804	4.073
	Jenin	3.556	.157	3.243	3.870
RE	Qabatya	3.642	.165	3.312	3.972
	Zababdeh	3.618	.275	3.070	4.167
	Jenin	3.914	.139	3.637	4.191
SE	Qabatya	4.514	.109	4.297	4.732
	Zababdeh	4.546	.178	4.190	4.902
	Jenin	4.351	.090	4.171	4.532

Appendix N

Transfromed data statistics

Table N1

Descriptive statistics of BMQ transformed scores

DV	sample	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Total score	experimental	.504	.014	.477	.532
	control	.495	.014	.466	.524
AN	experimental	.495	.032	.432	.559
	control	.498	.033	.433	.564
EM	experimental	.477	.031	.415	.539
	control	.517	.033	.453	.581
IM	experimental	.516	.031	.454	.578
	control	.476	.033	.412	.541
PR	experimental	.489	.032	.426	.552
	control	.506	.033	.440	.571
RE	experimental	.475	.032	.411	.539
	control	.524	.034	.458	.591
SE	experimental	.480	.030	.421	.539
	control	.502	.031	.442	.563
Total score/gender	male	.522	.021	.480	.564
	female	.475	.008	.458	.491
AN	male	.424	.098	.229	.618
	female	.507	.036	.435	.578
EM	male	.456	.097	.264	.649
	female	.481	.037	.406	.555
IM	male	.401	.097	.207	.595
	female	.533	.037	.460	.606
PR	male	.444	.094	.257	.631
	female	.496	.036	.424	.567
RE	male	.482	.091	.301	.663
	female	.471	.035	.402	.541
SE	male	.457	.034	.390	.524
	female	.472	.013	.446	.498
Total score	Face-face	.466	.023	.420	.512
	Blended	.489	.017	.455	.523
AN	Face-face	.412	.054	.304	.519
	Blended	.542	.040	.462	.622
EM	Face-face	.621	.054	.513	.730
	Blended	.398	.040	.318	.479
IM	Face-face	.675	.054	.568	.782
	Blended	.428	.040	.349	.507
PR	Face-face	.609	.054	.502	.716

	Blended	.423	.040	.343	.502
RE	Face-face	.411	.054	.304	.519
	Blended	.507	.040	.427	.586
SE	Face-face	.518	.052	.415	.621
	Blended	.464	.038	.387	.540
Total score	Qabatya	.465	.023	.419	.512
	Zababdeh	.525	.038	.449	.600
	Jenin	.480	.019	.443	.518
AN	Qabatya	.412	.054	.305	.518
	Zababdeh	.413	.095	.223	.602
	Jenin	.575	.045	.484	.666
EM	Qabatya	.621	.055	.512	.730
	Zababdeh	.455	.091	.274	.635
	Jenin	.384	.045	.294	.475
IM	Qabatya	.676	.054	.569	.784
	Zababdeh	.390	.091	.209	.572
	Jenin	.437	.044	.349	.525
PR	Qabatya	.609	.054	.501	.716
	Zababdeh	.444	.090	.265	.624
	Jenin	.417	.045	.328	.507
RE	Qabatya	.4109	.21870	27	1.00
	Zababdeh	.4770	.38096	10	3.00
	Jenin	.5148	.28463	39	4.00
SE	Qabatya	.518	.052	.415	.621
	Zababdeh	.534	.085	.365	.704
	Jenin	.445	.043	.360	.531

Table N2

Pairwise comparisons of BMQ transformed scores

Independent variable /sample	(I) group	(J) group	Mean Difference (I-J)	Std. Error	Sig.[b]	95% Confidence Interval for Difference[b]	
						Lower Bound	Upper Bound
Total score	experimental	control	.009	.020	.639	-.030-	.049
	control	experimental	-.009-	.020	.639	-.049-	.030
AN	experimental	control	-.003-	.046	.950	-.094-	.088
	control	experimental	.003	.046	.950	-.088-	.094
EM	experimental	control	-.040-	.045	.377	-.130-	.049
	control	experimental	.040	.045	.377	-.049-	.130
IM	experimental	control	.040	.045	.383	-.050-	.129
	control	experimental	-.040-	.045	.383	-.129-	.050
PR	experimental	control	-.017-	.046	.717	-.107-	.074
	control	experimental	.017	.046	.717	-.074-	.107
RE	experimental	control	-.050-	.047	.291	-.142-	.043
	control	experimental	.050	.047	.291	-.043-	.142
SE	experimental	control	-.022-	.043	.603	-.107-	.062
	control	experimental	.022	.043	.603	-.062-	.107
Total scale	experimental	control	.047	.023	.041	.002	.093
	control	experimental	-.047-	.023	.041	-.093-	-.002-
AN	male	female	-.083-	.106	.436	-.294-	.128
	female	male	.083	.106	.436	-.128-	.294
EM	male	female	-.024-	.104	.817	-.232-	.183
	female	male	.024	.104	.817	-.183-	.232
IM	male	female	-.132-	.105	.214	-.341-	.078
	female	male	.132	.105	.214	-.078-	.341
PR	male	female	-.052-	.101	.611	-.253-	.150
	female	male	.052	.101	.611	-.150-	.253
RE	male	female	.011	.098	.911	-.184-	.206
	female	male	-.011-	.098	.911	-.206-	.184
SE	male	female	-.015-	.036	.671	-.087-	.056
	female	male	.015	.036	.671	-.056-	.087
Total scale	Face-face	blended	-.023-	.029	.427	-.082-	.035
	Blended	Face-face	.023	.029	.427	-.035-	.082
AN	Face-face	blended	-.130-	.067	.056	-.264-	.004
	Blended	Face-face	.130	.067	.056	-.004-	.264
EM	Face-face	blended	.223	.068	.002	.088	.358
	Blended	Face-face	-.223-	.068	.002	-.358-	-.088-
IM	Face-face	blended	.247	.067	.000	.113	.381
	Blended	Face-face	-.247-	.067	.000	-.381-	-.113-
PR	Face-face	blended	.186	.067	.007	.053	.319
	Blended	Face-face	-.186-	.067	.007	-.319-	-.053-
RE	Face-face	blended	-.095-	.067	.161	-.230-	.039
	Blended	Face-face	.095	.067	.161	-.039-	.230
SE	Face-face	blended	.055	.064	.399	-.074-	.183
	Blended	Face-face	-.055-	.064	.399	-.183-	.074
Total score	Qabatya	Zababdeh	-.059-	.045	.191	-.149-	.030

		Jenin	-.015-	.030	.623	-.075-	.045
	Zababdeh	Qabatya	.059	.045	.191	-.030-	.149
		Jenin	.044	.042	.295	-.039-	.128
	Jenin	Qabatya	.015	.030	.623	-.045-	.075
		Zababdeh	-.044-	.042	.295	-.128-	.039
AN	Qabatya	Zababdeh	-.001-	.109	.993	-.218-	.216
		Jenin	-.163-	.070	.023	-.303-	-.023-
	Zababdeh	Qabatya	.001	.109	.993	-.216-	.218
		Jenin	-.162-	.108	.138	-.379-	.054
	Jenin	Qabatya	.163	.070	.023	.023	.303
		Zababdeh	.162	.108	.138	-.054-	.379
	Qabatya	Zababdeh	-.001-	.109	.993	-.218-	.216
EM		Jenin	.166	.106	.123	-.046-	.378
	Zababdeh	Qabatya	.237	.071	.001	.095	.378
		Jenin	-.166-	.106	.123	-.378-	.046
	Jenin	Qabatya	.071	.102	.489	-.132-	.273
		Zababdeh	-.237-	.071	.001	-.378-	-.095-
	Qabatya	Zababdeh	-.071-	.102	.489	-.273-	.132
IM		Jenin	.286	.108	.010	.071	.501
	Zababdeh	Qabatya	.239	.070	.001	.100	.378
		Jenin	-.286-	.108	.010	-.501-	-.071-
	Jenin	Qabatya	-.047-	.101	.647	-.248-	.155
		Zababdeh	-.239-	.070	.001	-.378-	-.100-
	Qabatya	Zababdeh	.047	.101	.647	-.155-	.248
PR		Jenin	.165	.105	.122	-.045-	.375
	Zababdeh	Qabatya	.192	.070	.008	.052	.331
		Jenin	-.165-	.105	.122	-.375-	.045
	Jenin	Qabatya	.027	.101	.790	-.174-	.228
		Zababdeh	-.192-	.070	.008	-.331-	-.052-
	Qabatya	Zababdeh	-.027-	.101	.790	-.228-	.174
RE		Jenin	-.066-	.104	.530	-.273-	.142
	Zababdeh	Qabatya	-.104-	.072	.150	-.248-	.039
		Jenin	.066	.104	.530	-.142-	.273
	Jenin	Qabatya	-.039-	.103	.708	-.244-	.166
		Zababdeh	.104	.072	.150	-.039-	.248
	Qabatya	Zababdeh	.039	.103	.708	-.166-	.244
SE		Jenin	-.016-	.100	.869	-.215-	.182
	Zababdeh	Qabatya	.073	.067	.284	-.061-	.207
		Jenin	.016	.100	.869	-.182-	.215
	Jenin	Qabatya	.089	.095	.353	-.101-	.279
		Zababdeh	-.073-	.067	.284	-.207-	.061
	Qabatya	Zababdeh	-.089-	.095	.353	-.279-	.101

Table N3

Results of one-way ANCOVA of transformed BMQ scores.

One way ANCOVA							
Independent variable/sample		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**	**Partial Eta Squared**
Total score	Contrast	.003	1	.003	.220	.639	.002
	Error	2.138	144	.015			
AN	Contrast	.000	1	.000	.004	.950	.000
	Error	11.230	144	.078			
EM	Contrast	.059	1	.059	.786	.377	.005
	Error	10.814	144	.075			
IM	Contrast	.057	1	.057	.764	.383	.005
	Error	10.823	144	.075			
PR	Contrast	.010	1	.010	.132	.717	.001
	Error	11.068	144	.077			
RE	Contrast	.089	1	.089	1.124	.291	.008
	Error	11.441	144	.079			
SE	Contrast	.018	1	.018	.272	.603	.002
	Error	9.618	144	.067			
Independent variable/gender		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Total score	Contrast	.019	1	.019	4.338	.061	.056
	Error	.322	73	.004			
AN	Contrast	.050	1	.050	.613	.436	.008
	Error	5.989	73	.082			
EM	Contrast	.005	1	.005	.054	.817	.001
	Error	6.667	73	.091			
IM	Contrast	.138	1	.138	1.572	.214	.021
	Error	6.392	73	.088			
PR	Contrast	.022	1	.022	.262	.611	.004
	Error	6.225	73	.085			
RE	Contrast	.001	1	.001	.012	.911	.000
	Error	5.793	73	.079			
SE	Contrast	.002	1	.002	.182	.671	.002
	Error	.818	73	.011			
Independent variable/mode		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Total scale	Contrast	.009	1	.009	.637	.427	.009
	Error	1.022	73	.014			
AN	Contrast	.296	1	.296	3.757	.056	.049
	Error	5.744	73	.079			
EM	Contrast	.859	1	.859	10.791	.002	.129
	Error	5.812	73	.080			
IM	Contrast	1.020	1	1.020	13.518	.000	.156
	Error	5.510	73	.075			
PR	Contrast	.603	1	.603	7.793	.007	.096

	Error	5.645	73	.077			
RE	Contrast	.155	1	.155	2.008	.161	.027
	Error	5.639	73	.077			
SE	Contrast	.052	1	.052	.720	.399	.010
	Error	5.235	73	.072			

Independent variable/geographic location		Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Total scale	Contrast	.024	2	.012	.876	.421	.024
	Error	1.006	72	.014			
AN	Contrast	.469	2	.235	3.033	.054	.078
	Error	5.570	72	.077			
EM	Contrast	.898	2	.449	5.599	.005	.135
	Error	5.774	72	.080			
IM	Contrast	1.036	2	.518	6.792	.002	.159
	Error	5.494	72	.076			
PR	Contrast	.608	2	.304	3.883	.025	.097
	Error	5.639	72	.078			
RE	Contrast	.166	2	.083	1.063	.351	.029
	Error	5.628	72	.078			
SE	Contrast	.115	2	.057	.797	.455	.022
	Error	5.172	72	.072			

Appendix O

Quade ANCOVA Statistics

Table O1

Results of Quade ANCOVA

DV	test	P value	DFE	DFH	F
sample	Total scale	.625	145	1	0.240
	AN	.997	145	1	0.000
	EM	.422	145	1	0.649
	IM	.402	145	1	0.705
	PR	.824	145	1	0.050
	RE	.297	145	1	1.094
	SE	.609	145	1	0.263
gender	Total scale	.964	74	1	0.002
	AN	.375	74	1	0.796
	EM	.709	74	1	0.140
	IM	.378	74	1	0.786
	PR	.563	74	1	0.337
	RE	.969	74	1	0.001
	SE	.555	74	1	0.352
Mode	Total scale	.813	74	1	0.056
	AN	.041	74	1	4.335
	EM	.001	74	1	11.431
	IM	.000	74	1	13.997
	PR	.005	74	1	8.503
	RE	.104	74	1	2.704
	SE	.587	74	1	0.298
Geographic location	Total scale	.966	73	2	0.035
	AN	.036	73	2	3.491
	EM	.004	73	2	5.845
	IM	.002	73	2	6.913
	PR	.018	73	2	4.226
	RE	.234	73	2	1.482
	SE	.637	73	2	0.454

Table O2

Results of pairwise comparisons of Quade ANCOVA

Independent variable	Test	P VALUE	df	T	COMPARISON
Sample	Total scale	.625	145	.490	1 vs. 2
	Subscale 1	.997	145	.003	1 vs. 2
	Subscale 2	.422	145	-.806	1 vs. 2
	Subscale 3	.402	145	.840	1 vs. 2
	Subscale 4	.824	145	-.223	1 vs. 2
	Subscale 5	.297	145	-1.046-	1 vs. 2
	Subscale 6	.609	145	-.513	1 vs. 2
Gender	Total scale	.964	74	-.045	1 vs. 2
	Subscale 1	.375	74	-.892	1 vs. 2
	Subscale 2	.709	74	-.374	1 vs. 2
	Subscale 3	.378	74	-.887	1 vs. 2
	Subscale 4	.563	74	-.581	1 vs. 2
	Subscale 5	.969	74	-.039	1 vs. 2
	Subscale 6	.555	74	.593	1 vs. 2
Mode	Total scale	.813	74	-.237	1 vs. 2
	Subscale 1	.041	74	-2.082	1 vs. 2
	Subscale 2	.001	74	3.381	1 vs. 2
	Subscale 3	.000	74	3.741	1 vs. 2
	Subscale 4	.005	74	2.916	1 vs. 2
	Subscale 5	.104	74	-1.644	1 vs. 2
	Subscale 6	.587	74	.546	1 vs. 2
geography	Total scale	.950	73	-.062	1.00 vs. 3.00
		.796	73	-.260	1.00 vs. 4.00
		.906	73	-.118	3.00 vs. 4.00
	Subscale 1	.886	73	-.144	1.00 vs. 3.00
		.016	73	-2.476	1.00 vs. 4.00
		.114	73	-1.599	3.00 vs. 4.00
	Subscale 2	.089	73	1.724	1.00 vs. 3.00
		.001	73	3.396	1.00 vs. 4.00
		.552	73	.598	3.00 vs. 4.00
	Subscale3	.024	73	2.312	1.00 vs. 3.00
		.001	73	3.593	1.00 vs. 4.00
		.902	73	.124	3.00 vs. 4.00
	Subscale 4	.095	73	1.693	1.00 vs. 3.00
		.006	73	2.843	1.00 vs. 4.00
		.812	73	.239	3.00 vs. 4.00
	Subscale 5	.516	73	-.652	1.00 vs. 3.00
		.089	73	-1.721	1.00 vs. 4.00
		.594	73	-.535	3.00 vs. 4.00
	Subscale 6	.808	73	-.243	1.00 vs. 3.00
		.458	73	.747	1.00 vs. 4.00
		.437	73	.782	3.00 vs. 4.00

Appendix P

Certificate of acceptance of the research extracted from the dissertation

Research title: The effect of integration of bioinformatics experiments within heredity unit of Palestinian biology eleventh grade textbook on student's motivation towards learning biology

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تأليف:
صفاء عطا محمد نزال ، د. علياء يحيى العسالي، أ.د. رائد عبدالله الكوني
جامعة النجاح الوطنية-فلسطين

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إعداد
صفاء عطا محمد نزال

إشراف
د. علياء العسالي
أ. د. رائد الكوني

قدمت هذه الأطروحة استكمالاً لمتطلبات الحصول على درجة الدكتوراه في التعلم والتعليم،
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عداد

صفاء عطا محمد نزال

إشراف

د. علياء العسالي

أ. د. رائد الكوني

الملخص

هدفت هذه الدراسة إلى استقصاء أثر دمج تجارب المعلوماتية الحيوية في كتاب الأحياء للصف الحادي عشر على تحصيل الطلبة ودافعيتهم نحو تعلم الأحياء في فلسطين. وقد استُخدم المنهج شبه التجريبي ذو التصميم غير المتكافئ لتنفيذ الدراسة. تألفت عينة الدراسة من (76) طالبًا وطالبة من الصف الحادي عشر في المجموعة التجريبية، الذين خضعوا لتدخل تعليمي قائم على أنشطة المعلوماتية الحيوية، و(71) طالبًا وطالبة من الصف الحادي عشر في المجموعة الضابطة، الذين تلقوا التدريس بالطريقة التقليدية. ولقياس تحصيل الطلبة ودافعيتهم، استُخدم اختبار تحصيلي في الأحياء تم التحقق من صدقه وثباته، بالإضافة إلى مقياس دافعية تعلم الأحياء (BMQ I). كما استُخدم اختبار كوايد (Quade) وتحليل التباين المصاحب ثنائي الاتجاه (Two-Way ANCOVA) لتحليل نتائج الاختبار التحصيلي، في حين استُخدم تحليل التباين المصاحب بطريقة إعادة المعاينة (Bootstrapping ANCOVA) لتحليل نتائج مقياس الدافعية.

أظهرت النتائج تفوقًا ذا دلالة إحصائية في متوسطات درجات الاختبار التحصيلي البعدي لدى طلبة المجموعة التجريبية مقارنةً بطلبة المجموعة الضابطة. كما كشفت نتائج تحليل التباين المصاحب ثنائي الاتجاه عن وجود فروق ذات دلالة إحصائية في درجات التحصيل البعدي تعزى إلى التفاعل بين نوع العينة وكل من بيئة التعلم والموقع الجغرافي. في المقابل، لم تُظهر النتائج فروقًا ذات دلالة إحصائية في درجات مهارات التفكير العليا (HOTS) أو مهارات التفكير الدنيا (LOTS) في الاختبار البعدي تعزى إلى التفاعل بين نوع العينة والنوع الإجتماعي.

وفيما يتعلق بدافعية الطلبة، أظهرت نتائج تحليل التباين المصاحب بطريقة إعادة المعاينة عدم وجـود أثـر ذي دلالة إحصائية للتدخل التعليمي على الدرجة الكلية لمقياس دافعية تعلم الأحياء أو على أبعاده الفرعية تبعًا لنـوع العينة والجنس. ومع ذلك، ظهرت فروق ذات دلالة إحصائية في أبعاد الدافعية الداخلية، والدافعيـة الخارجيـة، وملاءمة التعلم للذات، تعزى إلى كل من بيئة التعلم والموقع الجغرافي داخل المجموعة التجريبية، وذلك لصالح مدرسة قباطية وبيئة التعلم الوجاهي.

وبصورة عامة، تشير نتائج الدراسة إلى أن دمج تجارب المعلوماتية الحيوية أسهم في تحسين القدرات المعرفية لدى الطلبة، في حين لم يُحدث أثرًا واضحًا ذا دلالة إحصائية على دافعية الطلبة نحو تعلم الأحيـاء. وتوصـي الدراسة بإجراء بحوث مستقبلية لتطبيق نماذج تدخل تعليمية مختلفة قائمة على المعلوماتية الحيوية، قد تسهم في تعزيز دافعية الطلبة مع الحفاظ على التحسن الملحوظ في مستوى التحصيل الدراسي.

الكلمات المفتاحية: تعليم الأحياء، المعلوماتية الحيوية، الإنجاز، الدافعية، منهج الأحياء، المنهـاج الفلسـطيني، المنحى التكاملي STEM.