TEACHING SCIENCE TO REDUCE GENETIC DISEASES WITHIN THE BEDOUIN COMMUNITY IN ISRAEL

Amal Abu-Saad
Moshe Barak
Ben-Gurion University of the Negev, Israel

ABSTRACT

The research study examined how teaching science may help in addressing a socio-health problem among the Bedouin population living in the Negev in southern Israel. This population is characterized by a tradition of consanguineous marriage, causing a high prevalence of genetic diseases. We developed a 24-hour program for teaching the subjects of Heredity and Genetics in the context of Consanguinity and genetic Diseases (HGCD) in junior high schools in the Bedouin society. The program adopted the educational concepts of Problem-Based Learning (PBL), the Story-Driven Contextual Approach (SDCA), and the Theory of Planned Behaviour (TPB). Data were collected in experimental classes (n=258) and control classes (n=152) from an exam on HGCD and from teachers' guidance. The findings indicate that students from the experimental classes excelled over students in the control classes in terms of their scientific knowledge and behavioural intentions regarding genetic diseases and consanguineous marriage.

Keywords: Bedouin society, Consanguineous marriages, Hereditary disease, Science education

INTRODUCTION

One of the most important goals of science education is to impart to school graduates the knowledge, skills and values essential for integrating into the world around them, to cope with problems in life, to ask questions, and to examine beliefs and values in an informed manner. A school graduate is often required to make wise decisions on subjects such as health, study and employment, given cultural and moral values. However, conventional science studies take place according to a standard curriculum that relates only slightly to the students' social and cultural backgrounds, and rarely helps in coping with the unique difficulties and needs of specific ethnic groups within the population.

The aim of the current research study was to examine to what extent and how science studies in school could help in coping with a social-health problem among the Bedouin population living in the Negev in southern Israel. This population is characterized by a tradition of consanguineous marriage, causing a high incidence of genetic diseases (Treister-Goltzman & Peleg, 2015). Singer, Davidovitch, Abu Fraiha, and Abu Freha (2020) provide a comprehensive and updated picture about the issue of consanguinity and genetic diseases among the Bedouin population in the Negev. They note that the high rate of consanguinity among the Bedouin results in a high prevalence of recessive genetic and multifactorial disorders, as well as a high infant mortality rate. Various genetic diseases are prevalent among the Bedouin, exemplifying how extensive the impact of consanguinity is on the community.

These researchers reviewed the efforts made in recent decades to tackle this task, and argue that the Ministry of Health, Ministry of Education and different social associations should

plan and manage programmed interventions. These programs should work intensively to further educate and raise awareness about consanguinity and its potential harms, increase trust and collaboration between the community and the public health system, expand screening and premarital consultations, and create a genetic bank (specific mutations/whole genome) for the Arab Bedouin community.

The present study, which deals with part of the recommendations mentioned above, included the development, implementation and evaluation of a 24-hour study program in the subjects of genetics and heredity within the framework of science studies in junior high school. Within the study, we examined the knowledge that students acquired by studying the program, and the impact of learning the program on students' behavioural intentions regarding the issue of consanguineous marriage, as will be shown in the following reporting of this work. Thus, the study aimed not only at assessing students' knowledge and perceptions after learning the experimental program, but also at identifying the factors that might help or hinder the achievement of the program's goals.

LITERATURE REVIEW

The Bedouin Population in the Negev – Economic, Social and Cultural Aspects

The Bedouin population in the Negev is a traditional Muslim society and is an integral part of the Arab minority in Israel. Following the establishment of the State of Israel in 1948, this population numbered about 12,000; today, totals about 250,000 inhabitants. As of the late 1960s, a large part of the Bedouin population has been undergoing accelerated modernization initiated by the establishment, moving from semi-nomadic life to permanent settlement and urbanization. Today, about half of the population lives in seven communities, all of which are at the bottom of the socio-economic scale of localities in Israel (Abu-Saad, 1995; Abu-Saad, Litwick & Abu-Saad, 2004).

Bedouin Marriages within the Family

One of the major social problems among the Bedouin population is the tradition of marriage between relatives (consanguineous marriage), which is usually defined in the literature as marriage between first cousins or between spouses of another high kinship. In many Islamic countries in North Africa, West Asia and South, as well as in areas where there is a Muslim majority such as Northeast and Central India and Asian countries that formerly belonged to the Soviet Union, marriage is usually between first cousins. Minorities from different religions living in a Muslim environment have also embraced consanguineous marriage, including Christian Buddhists, Persian Jews and Druze (Bittles, Mason, Greene & Rao, 1991). The proportion of consanguineous marriages among the Bedouin population in the Negev is far higher than the rates reported for other groups in the Arab population in eastern and northern Israel (Jaber, Bailey-Wilson, Haj-Yehia, & Hernandez 1994; Jaber, Romano, & Shohat, 1997; Jaber, Helpern, & Shohat 1998; Jaber et al., 2005).

There are various explanations for the marriage practice between cousins, and specifically the marriage practice of a daughter to her father's brother. Khuri (1970) reviewed the explanations and divided them into cultural and functional. Cultural explanations refer to modesty and respect for a family, with such a marriage ensuring the supervision of the wife by her family, which guarantees her father's respect. This makes it clear that such a marriage preserves social relations within the family. An example of functional explanation is keeping the family property. Raz and Atar (2004) conducted a study to elicit attitudes of Bedouins in Israel concerning cousin marriage and genetic counselling by interviewing 49 Bedouin

respondents. The results revealed that the majority of respondents confirmed the traditional and social role of cousin marriage. The main reasons given in this context were clan solidarity, interpersonal compatibility, preservation of family property, parental authority and social protection for women. The majority of respondents also associated cousin marriage with genetic diseases. Regarding genetic testing, the majority of respondents preferred the option of premarital carrier matching, which was intended to reduce stigmatization, especially of women. Prenatal genetic testing was rejected on religious grounds.

Relationship Between Consanguineous Marriages and Hereditary Diseases

A consanguineous marriage may increase the incidence of various hereditary diseases. Impaired genes may be found in different family members, although the disease is not expressed (carriers, heterozygotes). However, the disease may be found in the offspring of these carriers (Pedersen, 2002). For example, both parents may be carriers of a defective gene for Galactosemia (the inability to digest lactose sugar found in milk). Although the parents are seemingly healthy, a child born to them may get Galactosemia.

Pedersen (2002) points out that over time, the prevalence of consanguineous marriages, especially those of first cousins, had increased steadily. The highest proportion of consanguineous marriages was found among men of the youngest age group (24 years), and reached 74%, and only 26% were married to women outside the family. Jaber, Helpern, and Shoat (2000) calculated that the risk of genetic disease due to consanguineous marriage is 2.5 times higher than in a population that does not practice this marriage pattern. Bittles (2001) concludes that first-cousin couples have a 4.4% risk of offspring mortality starting from the embryonic period (including late-term abortion) until they reach infancy.

According to Hamamy (2012), consanguinity is a deeply rooted social trend among one-fifth of the world population mostly residing in the Middle East, West Asia and North Africa, as well as among emigrants from these communities now residing in North America, Europe and Australia. The mounting public awareness about the prevention of congenital and genetic disorders in offspring is driving an increasing number of couples contemplating marriage and reproduction in highly consanguineous communities to seek counselling on consanguinity. Primary healthcare providers are faced with consanguineous couples demanding answers to their questions on the anticipated health risks to their offspring. Preconception and premarital counselling on consanguinity should be part of the training of healthcare providers particularly in highly consanguineous populations.

Shawky, Elsayed, Zaki, El-Din and Kamal (2013) pointed out that consanguineous marriages are significantly higher regarding many genetic diseases, suggesting that couples may have deleterious lethal genes inherited from a common ancestor, and when transmitted to their offspring, they can lead to prenatal, neonatal, child morbidity or mortality. Therefore, public health education and genetic counselling are highly recommended in our community.

Aims of Science Education in the Context of Increasing Health Literacy

One of the aims of the education system in general, and science education in particular, is to reinforce the health literacy of students, which is defined as an individual ability to acquire and understand basic information in the field of health and health services, and the ability to implement the knowledge gained in ways that enhance health. In Bedouin schools in Israel, students' academic achievements are low, and the conventional learning programs are not tailored to the unique needs of Bedouin society and culture.

The curriculum is determined by the Ministry of Education, without sharing the community's educational staff, and lacking in the program content and values that express the Arab culture. This is especially important in light of the fact that Bedouin populations have a high incidence of hereditary defects compared to other populations. The linking of science

studies to genetic diseases and heredity is integrated into the general trend of the education system to emphasize the issue of health education as a central issue in learning processes. Teaching such a program must ensure the respect of tradition along with the transfer of updated and correct information. Several studies (Shoham-Vardi, Weiner, Weitzman, & Levcovich, 2004; Weitzman, Shoham-Vardi, Elbedour, Belmaker, & Siton, 1999, Weitzman, Shoham-Vardi, Elbedour, Belmaker, Siton, & Carmi 2000) have indicated that suspicion and recoil exist regarding genetic and prenatal tests. This suspicion stems from a lack of knowledge, little understanding of the concept of disease, and religious objections to the execution of abortions in the case of embryos diagnosed as being damaged.

The current study included the development, implementation and evaluation of a program for teaching the subjects of Heredity and Genetics in the context of Consanguinity and genetic Diseases (HGCD) in Bedouin society within the framework of science education in schools. One of the questions that the current research is trying to answer is whether teaching students about the health risk of consanguineous marriage may lead to a change in their positions regarding the tradition of long-term behavioural intentions, as will be discussed in the next section.

Theory of Planned Behaviour

Health education intends to make people change their lifestyles. The HGCD program examined in the current study aims at achieving this goal by increasing students' awareness of the danger involved in consanguineous marriage and by presenting other possibilities as a substitute for the tradition of marriage with cousins or within the family. In this study, students' positions, behavioural intentions and knowledge relating to marriage and genetic diseases were examined pre and post teaching the new program. To examine the program's impact on the future behaviour of students on consanguineous marriage, we used the theory of planned behaviour (TPB), suggested by Ajzen (1985, 1991), which has been applied to a variety of fields, for example, management, adverting campaigns and healthcare. According to TPB, human action is guided by three kinds of considerations, as illustrated in Figure 1.

- **Attitude toward the behaviour** – the degree to which a person has a favourable or unfavourable evaluation of the expected behaviour.
- **Subjective norms** – beliefs about whether most people approve or disapprove of the expected behaviour.
- **Perceived behavioural control** – beliefs about the ease or difficulty of performance of the expected behaviour.

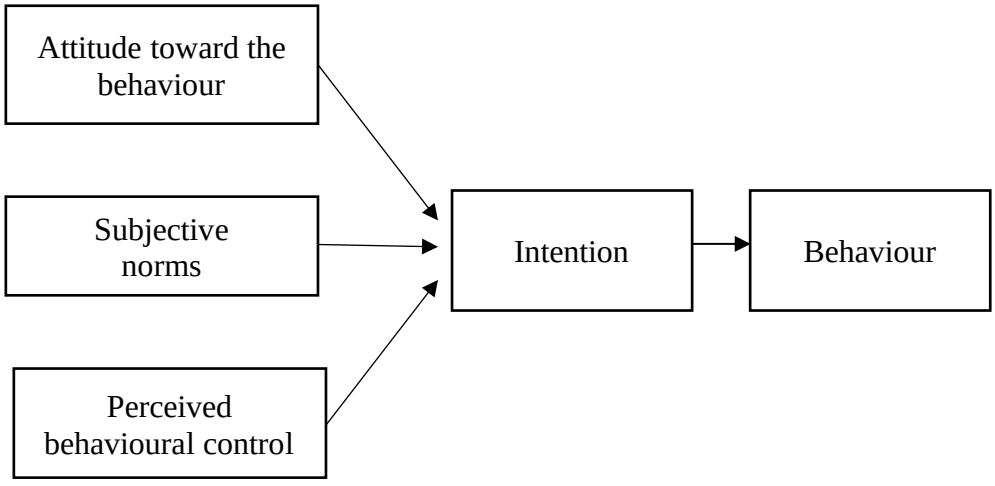

Figure 1: The Theory of Planned Behaviour (TPB)

The aspect of 'perceived behavioural control' plays a central role in the TPB model because it includes self-efficacy - beliefs about one's ability to succeed in performing the expected behaviour. The theory of planned behaviour is particularly relevant to the current study because one of the objectives of the HGCD program under discussion was to influence students' behaviour as future adults. We can work to strengthen the three factors that influence students' intentions at school age to take the right steps and decisions in the future. To this end, we designed the program in light of the learning theories and preferred pedagogies that are guiding science education today, as presented in the following section.

Learning from Story

As previously mentioned, the HGCD program was designed to teach genetics issues in the context of the problem of consanguineous marriage, which is very common in Bedouin society. The program initially included a story from the situations of students' daily lives as a starting point for learning the basic concepts of genetics and changing students' misconceptions. Presenting this problem raises almost all of the basic concepts of genetics in the context of the students' world. The researcher Klassen (2006, 2007), who wrote about the importance of context learning and storytelling in science teaching, identified five types of 'contexts' in teaching science:

1. Social context
2. Theoretical context
3. Practical context
4. Affective context
5. Historical context

On the basis on these five types of contexts, Klassen suggested the following model of the story-driven contextual approach (SDCA), illustrated in Figure 2.

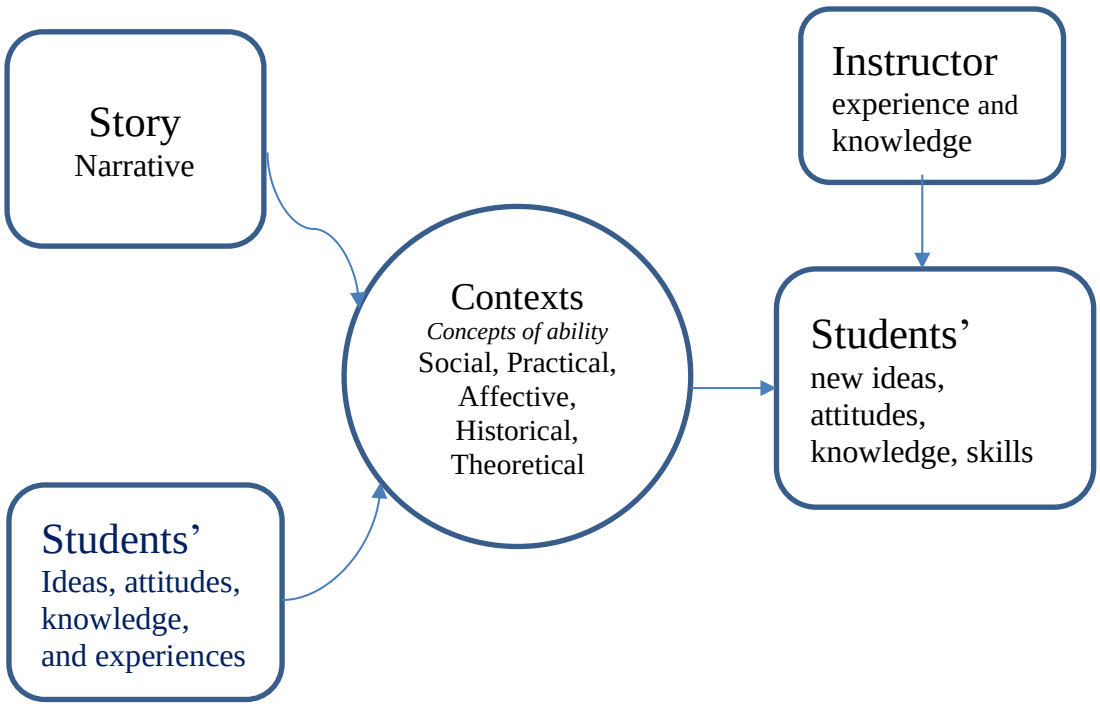

Figure 2: Model for science teaching: The Story-Driven Contextual Approach (SDCA) (after Klassen, 2006, p. 55).

In the SDCA model described in Figure 2, students' engagement in the learning processes is influenced by their ideas, attitudes, knowledge, and prior knowledge and experience. The teacher (instructor) introduces the topic learned through storytelling, and in this way, encourages students to participate actively in learning. The story gives initial motivation and a good start to the learning process. The teacher contributes to the learning process of his/her knowledge and experience, and learning occurs through the learners' activity in the class in which they acquire new knowledge, attitudes and skill. The HGCD program's study of hereditary and genetics issues was linked to a story about a disease that broke out in the family for genetic reasons. This approach aimed at bringing the learner and learning closer to the life of the students from the emotional and social perspective, thereby increasing their motivation to learn the subject.

Problem-Based Learning

The HGCD program developed in this study partially adopted the concept of problem-based learning (PBL), which is an instructional model derived from the constructivist framework (Hmelo-Silver, 2004, Hmelo-Silver, Duncan, & Chinn, 2007, Savery, 2006). In PBL, students learn about a subject by investigating an open-ended problem. This instructional method provides the teacher with tools to teach basic concepts and scientific principles, while developing students' skills through problem solving and critical thinking. Teaching science and technology using the PBL approach increases student motivation because learning takes place by addressing problems and topics that are close and meaningful to the learners' world and daily life (Dewy, 1938).

DESIGN AND METHODOLOGY

Objectives and Research Questions

The current study comprised the development, implementation and evaluation of the HGCD program on the issues of heredity and genetics, which was taught within the framework of science studies in junior high school. The program is unique in that the issues are taught in the context of the phenomenon of consanguineous marriage, which is common in Bedouin society, and its implications on the genetic aspect and the emergence of hereditary diseases (the program is detailed in the following section). The general purpose of the study was to examine the effect of teaching the HGCD program on students' knowledge about the issues of heredity and genetics, and their perceptions about consanguineous marriage, through counselling and conducting pre-clinical examinations. The study adopted mixed method research design, combining quantitative and qualitative methods. According to Creswell and Plano (2007), the combined use of quantitative and qualitative approaches provides a better understanding of research problems than either approach alone (Greene, 2005). Specifically, the research intended to answer the following questions:

1. What are the students' achievements in studying heredity and genetics issues in the context of consanguineous marriage in Bedouin society regarding their knowledge about genetics and heredity, hereditary diseases, and the consequences of consanguineous marriage?
2. How does learning about heredity and genetics in the context of consanguineous marriage affect students' behavioural intentions relating to consanguineous marriage, such as willingness to marry a spouse within the family and readiness to use genetic counselling?
3. What are the factors that might help or hinder achieve the program's goals?

Development of the Heredity and Genetics in the context of Consanguinity and genetic Diseases (HGCD) program

The development of the experimental HGCD program included preparing a booklet that expanded on the issues associated with hereditary diseases, consanguineous marriage, genetic counselling and prenatal examinations. As previously mentioned, the experimental curriculum emphasized linking the subject to the students' world. The booklet included, for example:

- A story about married cousins having a sick child who had consulted with a physician who explained the nature of the child's injury and the connection to the fact that they were cousins.
- A description of a group of hereditary diseases that can appear more frequently in spouses related to the family.
- An explanation of the relationship between consanguineous marriage and the appearance of hereditary diseases.
- Learning about genetic counselling and prenatal tests in the event of a suspected pregnancy with a defective fetus.

A small part of the experimental booklet included text from the standard curriculum that was also relevant to the new program, for example, explanations about hereditary diseases, what causes them and how to prevent them.

Ethical Considerations

The researchers paid attention to the ethical aspects of the research in accordance with university and government requirements, as described below.

1. It is important to note that the subject of genetics and heredity is studied as part of the middle school science curriculum and was not a new subject or an addition to the standard curriculum. In the control classes, the subject was taught with the help of a recognized textbook. In the experimental classes, emphasis was placed on changing the way the subject was taught, but sometimes the teachers in these classes also used the regular textbook.

2. The HGCD program was developed in consultation with a panel of experts regarding the scientific, educational, cultural and religious aspects of the program, including:
   - Biology teachers in schools that participated in the research.
   - The genetic advisor from the Genetic Institute in the central hospital in the Negev.
   - A professor from the Department of Epidemiology at Ben-Gurion University of the Negev.
   - A professor from the Department of Science and Technology Education at Ben-Gurion University of the Negev.
   - Educational counsellors in the schools.
   - School principals.
   - Religious advisors.
   - The head of the project to reduce infant mortality funded by the Ministry of Health, held in the Faculty of Health Sciences at Ben-Gurion University of the Negev.

3. The experts discussed questions such as how to address the gap between religious beliefs, social customs and health implications. Instructions for teachers were to discuss these issues in the class by general example, but not to address specific cases in the students' families and not to advise students whether or how to talk with their family about topics discussed in the science class.

4. In order to enable all members of the expert panel (some of whom do not speak Arabic) to examine the learning booklet, the materials were written in Hebrew and only then translated into Arabic.

Method and Tools

Setting and sampling

We conducted the experimental research by examining the impact of studying the HGCD program on students' knowledge and attitudes regarding genetics and heredity. The experimental population comprised eight classes from two schools (n=258) that studied the program for 12 weeks (a total of 24 hours of study during three months). Two experienced biology teachers taught the experimental HGCD program under the guidance of the researchers. The control group comprised four classes from the same schools (n=152) that studied the subjects of heredity and genetics according to the standard curriculum, also for 12 weeks (24 hours of study). The two teachers in the control classes were also very experienced in teaching biology.

For the study, we selected two large schools that characterize the Bedouin population. The students in the experimental and control groups had similar characteristics in terms of socio-economic background, educational achievement and motivation to learn. The four teachers who taught in the experimental and control classes also had similar backgrounds and experience in teaching science and educational work in the school.

Data Collection

Quantitative data were collected by administering a questionnaire comprising eight demographic questions and 35 items that were divided into four subscales A, B, C, D, as detailed below. Qualitative data were collected through the researcher's close work with the teachers. The researcher met weekly with each teacher personally to discuss what happened in the class and to decide together how to cope with questions and problems that may have arisen while teaching the new program.

Demographic Questionnaire

This questionnaire included eight items in which the student was asked to write his/her name, the school's name and classroom, where he studied, as well as gender, the number of siblings in his/her family, details about family closeness between father and mother, if this existed, and how many children the student would like to have in the future. We compared the socio-demographic indicators of students in the experimental and control classes by applying χ^2 tests for categorical answers and *t*-tests for continuous variables. No significant differences between the two groups (alpha level $p<0.05$) were observed regarding all variables in the questionnaire.

The Subject-matter Exam

The exam comprised four subscales (categories) A-D as detailed below.

Subscale A: Questions on genetics and heredity

This section comprised 11 multi-choice questions that examined students' knowledge about genetics and heredity. For example:

In a family having a disease that harms a gene related to the X chromosome:

a. Boys have a greater chance of getting sick[1].
b. Girls have a greater chance of getting sick.
c. There is the same chance for boys and girls to get sick.
d. I don't know.

Subscale B: Questions on hereditary disease

This section comprised eight multi-choice questions about genetic diseases, their transfer, and the incidence of disease among infected spouses. For example:

A hereditary recessive disease is:

a. A situation in which a child receives a dominant active gene from each parent, but the genes become inactive in the child.
b. A situation in which a child receives the active recessive gene from each parent and then has two inactive genes.
c. A situation in which a child receives a dominant gene from one parent and a recessive gene from the other parent, and then both his genes are inactive.
d. I don't know.

Subscale C: Questions on the consequences of intermarriage

This section comprised nine multi-choice questions about the risks involved in consanguineous marriages, genetic tests and genetic counselling. For example:

For which of the following couples could genetic counselling contribute to the greatest extent?

a. Every couple.
b. Couples who are not related but already have one child who is sick with an inherited disease.
c. Couples who are related but whose families are not known to have any genetic diseases.
d. I don't know.

Subscale D: Questions about behavioural intentions regarding consanguineous marriage

This questionnaire comprised seven items in which the students were asked to relate to their marriage intentions, the possibility of marrying a spouse from the family and the number of children they wanted in the future. Two examples follow:

Jamila and Muhammad are cousins about to become engaged. Shortly before announcing their engagement, a sick brother of Muhammad was born, and the two feared that they would also bear sick children. What do you think they should do?

a. Cancel the engagement and marry spouses who are not related.

[1] Correct answers are underlined.

b. Perform a genetic match test, if this test exists, and decide on the engagement according to the test results.
c. Get married, and if sick children are born – it's from Allah.
d. Get married and perform a test for each pregnancy, and if a serious disease is discovered, consider terminating the pregnancy.

When the time comes, and you are about to get married, how do you relate to the possibility of marrying a relative?

a. It doesn't matter to me.
b. I would actually be interested in marrying a cousin.
c. I would try to avoid this or marry a cousin who is as distant a relative as possible.
d. I would try to avoid this entirely.

Testing the reliability of the test questions according to the internal consistency of the scores

For this examination, we calculated each student's overall score in each of the subscales A, B, C, D of the questionnaire, as described above. We divided the grades of students from the entire sample (experimental + control groups, n=410) into four quarters according to the overall score. Then, we checked the percentage of correct answers to each question in the upper quarter compared to the lower quarter, with the aim of examining whether there were questions that high-achieving students had difficulty in answering or questions that low-achieving students answered successfully.

We carried out this examination manually to closely observe the distribution of students' answers to the different questions. Of the 35 questions in the questionnaire, we found two questions (23 and 26) that did not distinguish between the high- or low- achievers. These questions were too difficult for all of the students and were removed from the data analysis. In the next section, we compare students' achievements in the pre- and post- course exam regarding the experimental and control classes.

RESULTS

Following below are the quantitative findings from the subject matter exam and the attitude questionnaire (subscales A-D), as well as points from the quantitative findings collected from the field.

Quantitative Findings from the Knowledge Exam and Perceptions Questionnaire

Findings from Subscale A about Genetics and Heredity

As previously mentioned, this section comprised eight multi-choice questions. Accordingly, the students' scores in this section were in the range of 0-8. The findings in the pre- and post- course exam are presented in Table 1 and Figure 3. These findings show that in the pre-course exam, the mean scores in the experimental and control classes were quite similar (no significant difference). In the post-course exam, however, the mean score of the students in the experimental exam was significantly higher than that of the control class. A statistically significant difference between the mean scores in the pre- and post- exam was observed only in the experimental group.

Table 1: Findings from Subscale A about genetics and heredity. Mean score - range of 0-8.

	Pre-course			Post-course			*t*-test paired
Group	**n**	**Mean**	**SD**	**n**	**Mean**	**SD**	
Experimental	258	5.488	2.154	258	6.515	2.180	p*<0.000
Control	152	5.361	2.057	152	5.625	2.304	p<0.133
t-test unpaired		p<0.334			p*<0.001		

* p<0.05

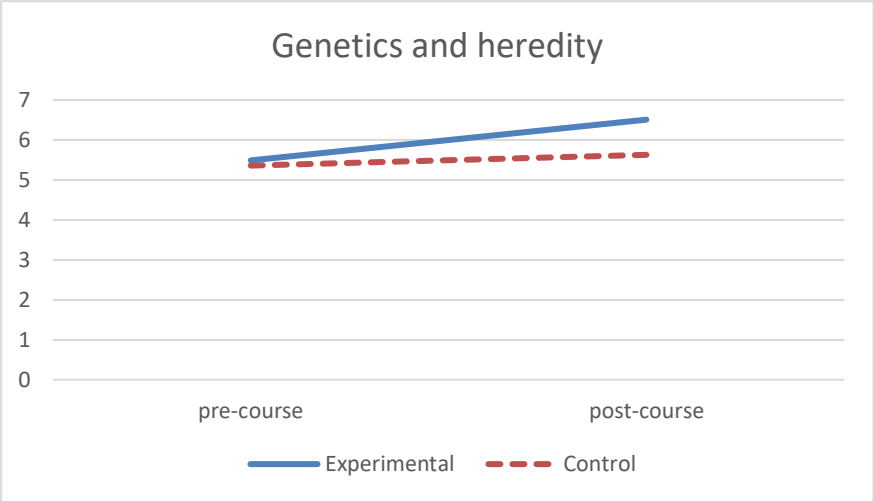

Figure 3: Mean scores in the exam about genetics and heredity (range 0-8)

Findings from Subscale B about Hereditary Disease

This section in the exam comprised eight multi-choice questions and the students' scores were in the range of 0-8. The findings in the pre-and-post course exam in the experimental and control classes are presented in the Table 2 and in Figure 4.

Table 2: Findings from Subscale B about hereditary disease. Mean score in the range of 0-8

	Pre-course			Post-course			*t*-test paired
	n	Mean	SD	n	Mean	SD	
Experimental	258	2.845	1.621	258	4.131	1.694	p*<0.000
Control	152	2.796	1.566	152	3.171	1.525	p*<0.006
t-test unpaired		p<0.560			p*<0.01		

* p<0.05

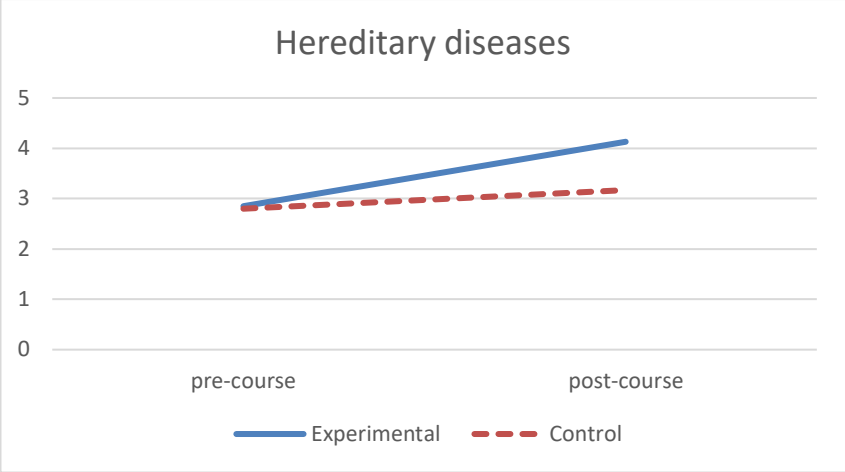

Figure 4: Mean scores in the exam about hereditary diseases (range 0-8)

The findings in Table 2 and Figure 4 show that in the pre-course exam, the mean scores in the experimental and control classes were quite similar, with no significant difference. In the post-course exam, however, students in the experimental classes excelled over students in the control classes, exhibiting a significant grade difference. In both groups, the mean score in the final exam was significantly higher than that in the pre-course exam.

Findings from Subscale C about the Consequences of Consanguineous Marriage

As previously mentioned, this section in the exam comprises nine multi-choice questions, and the mean score is in the range of 0-9. Students' mean scores in the pre- and post-exams are shown in Table 3 and Figure 5.

Table 3: Findings from Subscale C about the consequences of consanguineous marriage. Mean score in the range of 0-9

	Pre-course			**Post-course**			***t*-test paired**
	n	Mean	SD	n	Mean	SD	
Experimental	258	2.910	1.681	258	3.833	1.741	$p^*<0.000$
Control	152	3.078	1.728	152	3.250	1.746	$p<0.282$
t-test unpaired		$p<0.765$			$p^*<0.001$		

* $p<0.05$

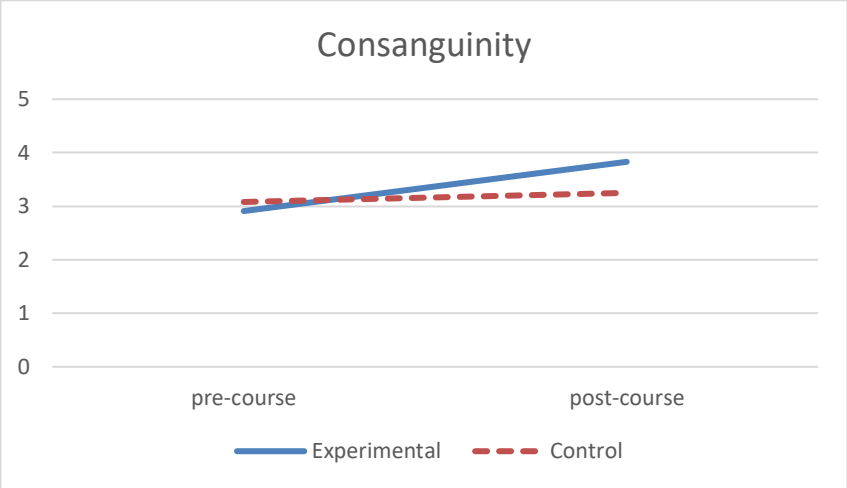

Figure 5: Mean scores in the exam about consequences of consanguinity (range 0-9)

The findings presented in Table 3 and Figure 5 show that the students' mean grade in the post-course exam was significantly higher than the grade in the pre-course exam. In the control group, in contrast, there was no significant difference between in the mean score pre and post the course. Likewise, the experimental group scores were close to those of the control group in the pre-course exam, and significantly higher than the second group's scores in the post-course exam.

Findings from Subscale D about Behavioural Intentions related to Consanguineous Marriage

As previously mentioned, this part of the questionnaire comprised seven questions in which the students were asked to relate to their marriage intentions, the possibility of marrying a spouse from the family and the number of children they wanted in the future. In analysing the students' answers, we determined whether a student's answer was correct or incorrect, relating to what he/she had learned in the course. Since, in this category, there were meaningful gaps in students' answers to the different questions, we present three specific examples of questions and answers. The χ^2 test was used to compare the percentage of correct answers between the two groups.

Example 1

Question: Cousins are engaged and one of them has a sick brother. What do you think they should do? Expected answers: to undergo genetic testing before getting married and decide about getting married based on the test results; to perform a test during each pregnancy and if a serious disease is discovered, consider terminating the pregnancy.

Before studying the course, 63.6% of the students in the experimental group and 57.2% in the control group answered this question correctly. The χ^2 test indicated no significant difference between the findings in both groups ($p<0.204$). In the post-course answers to the same question, the percentage of students who answered correctly increased to 76.4% in the experimental class but remained at 67.1% in the control group. In this case, the χ^2 test indicated that the difference between both groups was statistically significant ($p<0.042$).

Example 2

Question: Ahmed is from a family that has no recessive diseases. Fatma is from another family that has two sick brothers with serious heredity diseases. Should they get engaged? The correct answer is that if they get married, there is no chance that they will have sick children with this recessive disease.

Before studying the course, 27.5% of the students in the experimental group and 36.8% in the control group answered this question correctly (χ^2 test, $p<0.049$). After studying the course, the percentage of students who answered the question correctly increased to 34.5% in the experimental group and decreased to 30.9% in the control group (χ^2 test, $p<0.458$). In the present case, in the pre-course questionnaire, there was a statistically significant difference between the two groups in favour of students in the control group. After studying the course in the experimental/conventional method in each group, the percentage of correct answers increased in the experimental group and decreased in the control group, so there was no longer a significant difference between the percentages of correct answers in both groups.

Example 3

Question: Musa and a Karima are cousins. Musa has a sick uncle and Karima has a sick sister with the same disease. They want to get married. Whom should they consult with before the marriage? The expected answers: consult with the hospital's genetic counselling unit or with a qualified religious leader.

In the pre-course questionnaire, 72.4% of the students in the experimental group and 74.4% in the control group answered this question correctly (χ^2 test, $p<0.649$). After learning the course, the percentage of students who answered this question correctly increased to 86.8% in the experimental group and changed to 73.0% in the control group (χ^2 test, $p<0.001$). These findings indicate that before studying the course, the percentage of correct answers was very similar to the experimental and control classes, with no statistically significant difference. After studying the course, in contrast, the percentage of correct answers increased considerably in the experimental group but did not change in the control class.

In conclusion, the findings described in this section demonstrate that the HGCD program developed in this study contributed more than the conventional curriculum to providing knowledge and improving students' perceptions and intendent behaviour regarding the issues of genetics, heredity and marriage within the family in Bedouin society.

Qualitative Findings from the Researcher's Work with Teachers

The researcher's weekly meetings with the two teachers from the experimental classes provided a great deal of information about the teaching and learning of the experimental program. Below, we briefly present a number of points raised in this part of the study.

1. The issue of genetics is quite complex, and the teachers needed considerable time to explain the subject scientifically. In this case, technological aides such as videos and simulation could help illustrate the subject.

2. In the first lessons, many students argued with the teacher and expressed opinions that genetic disease is from God, and that a person in not involved in the decision of the creator. It took a long time to face the dangers associated with consanguinity, because tradition among the Bedouin conflicts with science. Examples of issues that had influenced the gradual change in the students' perceptions include the following:
    - A story about married cousins who gave birth to a sick child.

- Consultation with a physician who explained the nature of the injury affecting the child and connection to the fact that they were cousins.
- A description of a group of hereditary diseases that can appear more frequently in spouses who are relatives.
- Learning about genetic counselling and prenatal examinations in the event of concern for pregnancy with a defective fetus.

3. The subject of genetic counselling prior to marriage is very difficult to study since according to Bedouin tradition, the two people who are engaged do not meet before they get married.

4. If the female is carrying a defective gene, people may think that she is ill, which will harm her chance of marrying. The teachers had difficulty convincing the students that thee genetic tests are completely confidential.

5. Learning about pre-natal genetic tests, which could recommend terminating a pregnancy, is also very problematic since it contradicts religious beliefs.

6. The booklet for students included a detailed explanation of the need to carry out genetic tests as soon as possible in pregnancy so that the pregnancy could still be terminated if necessary, and when religious beliefs allow it.

It should be noted that according to the standard curriculum taught in the control classes, which is intended for the entire population, the issues of genetics and heredity are only taught in general, without specific reference to the context of Bedouin society, as shown above.

DISCUSSION

Teaching the Subject of Heredity and Genetics in the Context of the Bedouin Students' World

In the Introduction and Literature sections of the current study, we mentioned that the issues of heredity and genetics are important in science education in junior and senior high schools. However, these issues, like many others in science studies, are usually taught in schools in a general manner without a meaningful link to the students' world. In the conventional pedagogy in the science class, students learn merely from the teacher's explanations, reading the textbook and memorizing. In the current study, we developed the HGCD program for teaching heredity and genetics to students in the Bedouin population in Israel in the context of the phenomenon of consanguineous marriage, which is prevalent in this population. The program comprised 24 school study hours within the science education curriculum in junior high schools.

In the current research, we sought to examine to what extent and how the new program affected the scientific knowledge the students gained about heredity and genetics, hereditary diseases and the consequences of consanguineous marriage, and students' perceptions and behavioural intentions in the future on the issue of consanguineous marriage, genetic counselling and conducting prenatal genetic tests. We assessed the two aspects mentioned above in comparison with the knowledge and perceptions of students in a control group, who studied the issues of heredity and genetics according to the standard textbook proposed by the Ministry of Education. As mentioned in the Introduction, the study aimed not only at assessing

the change in students' knowledge and perceptions after learning the experimental program, but also at identifying the factors that may help or hinder the realization of the program's objectives.

View of the Findings in Light of the Educational Literature

In the literature review, we mentioned that educational scholars widely agree with the need to tie the school's world to the students' world. Dewey (1938) emphasized the need to provide students with school activities that encourage them to explore subjects by interacting with the surrounding environment. In the program developed and explored in the current study, the issues of genetics and heredity were taught with direct reference to the high rate of hereditary diseases in Bedouin society due to the phenomenon of consanguineous marriage. We can safely say that nearly every Bedouin student has been exposed to this problem among his family members, friends or neighbours. Thus, the study of the subject of genetics and heredity in the current study differed greatly from conventional science studies at school. The experimental program adopted the pedagogy of learning from the story-driven contextual approach (SDCA) (Klassen, 2006) and problem-based learning (PBL) (Savery, 2006), as noted in the literature review in this article. For example, already at the beginning of the HGCD program, the students were exposed to the story of a case of marriage between cousins and the appearance of an inherited disease in a child born to them, even though the parents were healthy. The story also said that the couple had gone to a doctor afterwards and received an explanation of what had happened. In presenting this problem, almost all the fundamental concepts of genetics and heredity related directly to the students' world.

The HGCD program was designed to address the five types of context that Klassen (2006) identified, as illustrated in Figure 2: social context, theoretical context, practical context, affective context, and historical context. This approach contributed greatly to the students' interest and engagement in learning the subject. Accordingly, we found that the students' achievements in the experimental classes were significantly higher in comparison to the achievements of students in the control classes, who learned the subjects of heredity and genetics according to the conventional curriculum, which relates only little to the backgrounds of students coming from different ethnic or social groups.

Impact on Behavioural Intentions

The HGCD program developed and examined in the current study aimed not only at providing students with scientific knowledge about genetics and heredity, but also at reducing consanguineous marriage, which is common in Bedouin society, in order to reduce the rate of genetic diseases in this society. Since the program was targeted at young junior high school students, it was not possible to test their actual behaviour about relatives. Consequently, the way to achieve this goal was by changing the 'behavioural intentions' as described in the TPB model (Ajzen, 1985, 1991) and shown in Figure 1.

The findings from the questionnaire the students answered and the teachers' reports about the discussions that took place in class indicated that the program the students learned had influenced three factors that might shape their behaviour in the future on the issue of consanguineous marriage according to the TPB model. These are listed and explained below:

1. **Attitude toward the behaviour** - It was found that after the students learned the scientific aspects related to the danger of consanguineous marriage, they internalized the severity of the existing risk in marrying relatives and noted the caution with which this subject should be treated.

2. **Subjective norms -** In the study of genetics, heredity and genetic diseases due to consanguineous marriage, the students also discussed the social aspects of the phenomenon, the tension between tradition and scientific knowledge, and the need to consult with religious scholars and doctors, who are well versed in the subject.
3. **Perceived behavioural control** - The students were confident in their ability to take the desired behaviour, perhaps contrary to tradition and social pressure.

These findings go hand in hand with the modernization process that the Bedouin community is undergoing, such as strengthening the status of women in the family and community, and encouraging sons and daughters to excel in their studies to acquire a higher education.

Factors Hindering the Teaching of the HGCD Program

Finally, it is important to note two barriers that hindered to some extent teaching the HGCD program and achieving the program's goals. First, the current study faced the limitations of applying problem-based learning (PBL) in the class. In PBL, the students are expected to investigate an authentic subject or problem and suggest a solution, with priority being given to independent learning and collaborative work. However, the educational literature is increasingly aware of the failure of constructivist-oriented instructional methods such as discovery, and problem-based and inquiry-based teaching (Kirschner, Sweller, & Clark, 2006; Barak & Assal, 2018). Instructional approaches that place strong emphasis on guiding the learning process in the class are more effective in learning a new subject. PBL becomes effective when learners have sufficiently high prior knowledge to provide 'internal guidance.' Much work is required to prepare low-achieving students from deprived areas, as in the current case, to learn through PBL.

Second, the current study exposed the need to consider carefully how to address possible conflicts between scientific knowledge, on the one hand, and tradition, culture or religious faith among the local community, on the other hand. In the current study, for example, questions arose as to how to discuss issues in the class such as consanguineous marriage, the need to perform genetic tests or terminate pregnancy, or the status of women in the family in Bedouin society. It is essential to prepare teachers to deal with these issues and guide them very closely, at least during the first time of teaching the HGCD program or similar subjects in a conservative or religious society.

CONCLUSIONS

Society expects that school will help solve many social and health problems, such as nutrition habits, the need for physical activity, smoking, alcohol consumption, animal treatment, environmental preservations, or cautious driving. The findings of the current research show that in order for science education to contribute to a specific purpose in one theses areas, school studies must be tied in a profound and meaningful way to the students' world, their natural environment, the family's behavioural patterns, and the influence of religion and tradition. This was the idea behind developing the HGCD program that was examined in this study, which imparted significant scientific knowledge to the students and influence their intentions about consanguineous marriage and genetic diseases. On the other hand, the students in the control classes who studied the same subjects with the standard textbook intended for the entire population improved less their knowledge and conceptions about the issue of consanguineous marriage.

The current study was guided by three educational models – the story-driven contextual approach (SDC) (Klassen, 2006), the theory of planned behaviour (TPB) (Ajzen, 1985, 1991), and problem-based learning (PBL) (Savery, 2006). It is suggested to conduct further research

to examine to what extent and how these three models might help in designing additional teaching programs for the science class, and to also address issues such as environmental preservation or the prevention of typical diseases in modern society. In any event, the emphasis on such programs and the teaching method must be adapted very carefully to students' educational and social backgrounds.

Address for correspondence: Moshe Barak, Department of Science and Technology Education, Ben-Gurion University of the Negev, Be'er Sheva, Israel.
https://orcid.org/000-0002-5935-0983 Email:< mbarak@bgu.ac.il >

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