

Using Virtual Simulation Program via Flipped Classroom to Develop Genetic Problem Solving and Future Thinking Skills Among Secondary Stage Students

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Abstract: The research aimed at using virtual simulation program via flipped classroom to develop genetic problem solving and future thinking skills among secondary stage students. It was relied on integrating virtual simulation programs and inverted classes because both are modern teaching strategies that fit with the nature of the current era and the spread of distance learning, especially after the Corona pandemic, and because they are appropriate to the nature of the dependent variables represented in solving problems and skills of future thinking, which require immersion and engagement in the learning process to acquire skill. The participants were a group of students (N=85) girls enrolled on the third-year secondary stage at Beshia governorate, scientific section, in the first semester of 2021/2022, distributed into two groups: the control (N=42) and the experimental (N=43). The instruments were: (1) a test of genetic problems solving skills (prepared by the researcher) and (2) a test of future thinking skills (prepared by the researcher). The researcher followed the quasi-experimental method to the experimental design with the two groups: the control group (taught by the usual way) and the experimental group (taught by using virtual simulation programs via flipped classrooms), and the pre/post-application of the dependent variables (genetic problem-solving skills and future thinking skills). Results showed that using virtual simulation program via flipped classroom had a positive effect on developing genetic problem solving and future thinking skills. It's recommended to train teachers and students on using virtual simulation programs in teaching and learning biology courses.

Keywords: Virtual, Simulation, Flipped Classroom, Genetic, Problem Solving, Future, Thinking, Biology

1. Introduction

Genetics is one of the main branches in the biology curriculum at the secondary stage. It's one of the sciences that require a high level of mental and cognitive abilities to analyze and realize relationships. It relates the history of the past to the fact of the present and the expectations of the future. The matter is to evoke the development of thinking skills to solve problems and predict future.

Thinking skills are varied in the field of science instruction such as problem solving and future thinking skills. They are considered as one of the scientific thinking patterns and the most important goals of teaching science and scientific education. It requires processing the

information that is acquired and applied it in the future. The importance of developing future thinking skills is emphasized by the National Science Education Standards (NSES) in the United States of America. Hicks [59], Caliph [18], Carin [58], Hafez [10], and Hani [11], indicated that developing future thinking skills have become necessary to train learners on imagination, creativity, and to solve future problems that may be unclear, and provide innovative solutions.

Tolba [36], Altister et. al [57], Tsai and Lin [65], Hassan [12], Al Darabkeh [20], and Al Qarni [47] have assured the necessity to adopt future thinking skills and develop them to

bring the absent future perspective in the curricula. It helps the learner be able to develop his ideas to not only analyze and interpret the event but also predict it in the future. This in turn will affect their decisions in the present and future. Zitoun [28], Abu shuqair and Akl [3] have defined it as a type of thinking through which events can be used to give a conception for 20 or 30 years in the future.

There are many classifications of future thinking skills by researchers, as Abdel Rahim [37], Al-Huwaiti [16] and Al-Khatib and Al-Ashkar [17] who classified them into: planning, future problems solving, imagination, and prediction. While Zaki [26], Al-Hassan, Al-Sadiq and Al-Habashi [13], Abdel-Majid [39], Al-Danasori [21], and Al-Nawasra [53] have divided them into: imagination, decision-making, visualization, prediction and solving future problems. Al-Harbi [11] added the skill of analyzing future situations.

Problem solving skills are not less important than future thinking skills. Both of them complete each other. They are the most needed skill in biology curricula to develop problem solving and future thinking skills. This needs many scientific issues that require thinking to solve, especially in the current time with the spread of technology, and problems related to biotechnology, genetic engineering, the spread of destructive viruses and biological wars. This evokes the need to develop genetic problem-solving skills and identify their foundations to avoid falling into future problems to predict and propose creative solutions to them in the future. Hence, this is the goal of the current research.

There are many teaching methods, models and strategies through which problem-solving and future-thinking skills can be developed in the field of science education and learning, indicated by studies such as: White [67], El Shafei [32], Abdel Moneim, Madi, and Ketfan and Shawn . But in the light of blending technological development, its applications in the educational process and COVID-19 which turned education into blended or distance learning, virtual simulation programs via flipped classroom were used as an attempt to achieve the goal of the research. Many studies have been concerned with virtual simulation and flipped classrooms in science, which have proven their effectiveness in developing thinking skills, such as: Elhosan and Elabeed [14], Radi [23], Abdel-Fattah [38], Al-Saadi [30], Othman [41], Al-Shuaili and Ammar [35], Ibrahim and Ahmed [1], Al-Badri [59], Al-Turki [9], Mukhtar [51], Al-Saudi, Qandil and Al-Sheikh [31], Al-Shami and Al-Qadri [33], Al-Khamisi and Abu Al-Hamael [19], Hama and Hasso [15], Yassin [56].

2. Method

2.1. Research Problem

The research problem was felt through the following justifications:

1. The urgent need to develop genetic problem solving and future thinking skills through science instruction. It was

mentioned in the recommendations of conferences e.g. The Scientific Third Conference for the Egyptian Association of Scientific Education and Damascus university conference concerning preparing and developing future teachers in 2015.

2. Researches and studies which have assured the importance of developing genetic problem-solving skills such as Madi [50], Abu Oriban [4], Jalal [68]; studies on future thinking skills such as: Zankour [27], Al-Khatib and Ashkar [17], Al-Harbi [11], and Zaki [26].
 3. There was a weakness in genetic problem-solving skills among secondary stage students as shown by the studies of Madi [50], Abu Raya [2], Abu Oriban [4]. Additionally, there was weakness in future thinking skills as indicated by Abu Safiya [54], Abdel Moneim [40], Abdel Majid [39], and Al Qarni [47].
 4. What was imposed by the current age and its changeable and continuous innovations and technological developments, whose reflections should be effectively and clearly be demonstrated in the educational process to achieve multiple important variables such as thinking skills. These skills were classified by Al-Rahili [25], Abu Asr and Abu Al-Hadid [5], into genetic problem solving and future thinking skills. This is what the current research seeks to achieve, through the use of virtual simulation programs via flipped classrooms, which have proven their effectiveness in developing some thinking skills, as indicated by the studies of: Rashid [22], Al- Rubaian [24], and Katfan and Shawn [49].
 5. There is a lack of Arab studies that deal with the genetics in biology courses and developing thinking compared by the foreign studies. The majority of studies focused on achievement, developing genetic concepts and correcting alternative conceptions e.g. Haroun [61], Madi [50] and Yassin [56].
- Most of the aims and recommendations of the studies emphasized on the use of virtual learning with its different forms and electronic environments in science instruction such as Lage, Platt and Treglia. [62], Akl & Abu Musa [42], Abdel Fattah [38], Eid [43], Farjoun [46], Farsi [45], Othman [41], Al Saadi [30], White [67], Nagel [63], Singh [63], Al-Hussan and Al-Obeid [14], Mukhtar [51], and Al-Ghamdi and Flemban [44].
6. Most projects assured on the necessity of using virtual learning and developing thinking skills, for example the project of King Abdullah for Education Development as pointed (Ministry of Education Site-Project of King Abdullah for Education Development, [52] which seeks to help learners at secondary stage acquire predicting and challenging future skills. Additionally, the project (Semmlabs) of the French Leil 1 as pointed by Tracey [65].
 7. The university of AL-Quds open university in Palestine prepared a training workshop around turning the scientific experiments in labs into virtual experiments in

order to develop thinking skills, problem solving and future prediction.

In the light of what was previously mentioned, the research problem was "the low level in genetic problems solving and future thinking skills in biology course among secondary stage students". To address the problem, the main question was rephrased: "What is the effect of using virtual simulation programs via flipped classrooms on developing genetic problem solving and future thinking skills in biology among secondary stage students at Besha Governorate?"

2.2. Research Questions

1. What is the effect of using virtual simulation programs via flipped classrooms on developing genetic problem solving skills in biology course (3) among secondary stage girl students at Besha Governorate?
2. What is the effect of using virtual simulation programs via flipped classrooms on developing future thinking skills in biology course (3) among secondary stage girl students at Besha Governorate?

2.3. Aims of the Research

1. Investigating the effectiveness of using virtual simulation programs via flipped classrooms in developing genetic problem-solving skills in the units of material and genetics of biology course.
2. Investigating the effectiveness of using virtual simulation programs via flipped classrooms in developing future thinking skills in the units of material and genetics of biology course.

2.4. Hypotheses of the Research

1. There was a statistically significant difference at the level (0.05) among the mean scores of the experimental and control group students in the post application of genetic problem-solving skills test in favor of the experimental group.
2. There was a statistically significant difference at the level (0.05) among the mean scores of the experimental group students in the pre-post applications of genetic problems solving skills test in favor of the post-application.
3. There was a statistically significant difference at the level (0.05) among the mean scores of the experimental and control group students in the post application of future thinking skills test in favor of the experimental group.
4. There was a statistically significant difference at the level (0.05) among the mean scores of the experimental group students in the pre-post applications of future thinking skills test in favor of the post-application.

2.5. Significance of the Research

1. Paying experts' and stakeholders' attention to develop science curriculum in general and biology to have the futuristic view and contribute to develop problem

solving and future thinking skills.

2. Directing researchers' interests to conduct researchers and studies in different educational stages for developing problem solving and future thinking skills.
3. This research is considered as a call for meeting requirements of developing science curricula through problems sensitivity that teachers face and predict them in the future.
4. Giving teachers and educational supervisors the priority to develop thinking skills such as problem solving and future thinking skills.

2.6. Delimitations of the Research

The research was delimited on the following

- a. The three chapters: the seventh (sexual reproduction and Mendelian genetics), the eighth (complex genetics and human genetics, and the ninth (molecular genetics) in the biology course (3) in the third grade of secondary for the first semester of 2021/2022, through which it is possible to develop future thinking skills. This is because it is the basis for genetics, and molecular biology. Through its content, the skills of solving genetic problems and future thinking skills can be developed.
- b. Using the free (PHET) software program supported by the university of Colorado in the United States to include virtual experiments that fit with the selected content, provided by some YouTube videos to use flipped classrooms where there are specialized scientific channels such as Khan Academy.
- c. Genetic problems solving skills, includes identifying the genetic state to which the problem belongs, expressing with symbols about the genes that represent the characteristics of the genetic state, expressing the phenotypes of the parents (shape), writing the genotypes of the parents, conducting crossbreeding among the parents, and genetic interpretation.
- d. Future thinking skill include anticipation, prediction, future genetic problem solving, and visualization.

2.7. Definition of Terms

2.7.1. Genetic Problem-Solving Skills

Tolba [36] defined them as the ability of the learner to determine the given data and what is required from the scientific problem, and to use mathematical skills to reach the solution.

It can be operationally defined as the mental processes that lead the student to think and enable her to: determine the genetic state to which the problem belongs, make crosses among the parents, write the genetic and morphological patterns for them, and interpret the crosses. It can be measured by the score that the third-year secondary student achieve in the test prepared for that.

2.7.2. Future Thinking Skills

Hassan [12] defined it as a set of mental processes and thinking skills that aim to: predict future problems and

variables, formulate new hypotheses, search for unfamiliar solutions, and propose possible future ideas with the aim of developing a preliminary vision of what the phenomenon will be in the future.

It can be operationally defined as the set of mental processes practiced by the third-grade secondary school students that enable them to practice the skills of anticipation, prediction, visualization, and solving future genetic problems. It can be measured by the score that the student can achieve in the future thinking skills test.

2.7.3. Virtual Simulation Programs

Abu Shqair and Akl [3] defined them as open virtual teaching and learning environments through which the laboratory reality in science is simulated and the theoretical dimension is linked to the practical one. Thus, thinking skills are developed and learners are free to make learning decisions.

2.7.4. Flipped Classroom

Al-Shurman [34] and Al-Kahili Khalifa [48] refer to flipped classroom as “a learning environment” in which teachers reflect what is happening in the classroom, with the tasks and assignments required from the learners at home, by pre-preparing the topic of the lesson through videos published on a social learning network and viewed by students at home through their smartphones. Then, time is devoted to discussion, workshops and research projects.

3. Theoretical Framework

3.1. Genetic Problem-Solving Skills

Genetic problem-solving skills are considered as one of the difficulties that teachers and learners face in biology curricula. The nature of the genetic problem differs from its peer in other branches of science such as chemistry and physics because it is related to the life of living organisms and genetic conditions and phenomena. It needs analysis and conclusions for generations, as well as prediction and expectations of the results that are obtained without actually waiting for the inheritance of generations.

Ambosaidi et al [6] pointed to the need for the availability of both cognitive requirements such as facts, concepts and laws that help the learner process and store information to solve the problem. It requires strategies for solving, including the actions taken by the teacher and the learner during the learning process in order to reach a solution. These strategies included the use of experimentation, deduction, trial and error, as well as the use of graphics, tables, and figures as helpful strategies.

Abu Oreiban, [4] and Abu Raya [2] pointed to the multiplicity of the importance of developing problem-solving skills among learners, as it improves comprehension, analysis and inference skills. They help develop the ability to think in various types and styles, as well as understand facts, concepts and the relationships among them, infer new relationships from processing previous information, and develop

independence, self-reliance, and self-confidence.

Problem solving is difficult for learners due to the presence of a number of factors that depend on which the student's ability to solve the problem. The most important of which are the possession of mathematical skills and the ability to solve and use symbols, the linguistic context and the use of lexis in presenting the problem, which determines the extent of its clarity, the data given on the problem and which results are in the solution. Some teachers are limited to solve examples in the textbook without application and practice.

Zeitoun [28] explained some procedural methods to help teachers develop genetic problem-solving skills. They include developing tools and models that show how information is stored by an individual, and how to analyze and realize these methods and models in different problematic situations, in addition to focus on how the learner solves the problem, his detailed procedural steps, whether through what he says or writes while he is engaged in solving the problem. Zeitoun's model [29] was adopted in this research to solve the genetic problem that the learner should be able to master when solving the genetic problem, and a model can be presented through the following figure:

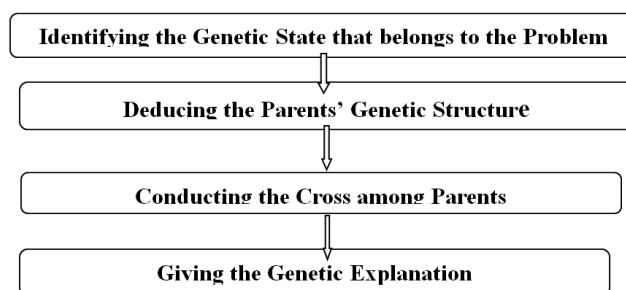


Figure 1. Zeitoun's Model for Steps of Solving Genetic Problems.

Some Arab studies have been concerned with developing genetic problem-solving skills, in light of what the researcher has tackled. The study of Madi [50] aimed to identify the effect of using cognitive conflict schemes in developing the concepts of heredity and the skills of solving genetic problems among tenth grade students in Palestine. Additionally, Abu Raya [2] investigated the effect of the flipped classroom strategy in developing some concepts of heredity and the skills of solving problems associated with it among (47) female students of the first year of secondary school. The genetics problem solving skills in the life sciences for tenth grade students in Gaza. The study of Abu Oreiban [4] also investigated the effectiveness of using infographics (fixed - movable) in developing genetic problem-solving skills in life sciences for tenth graders in Gaza, and Jalal's study [86], which aimed to investigate teaching biology using the REACT strategy for improving achievement, skills of solving genetic problems and the motivation towards learning among (82) female students of the first year of secondary school. All of which recommended the need to develop these skills among teachers and learners.

3.2. Future Thinking Skills

Future thinking skills, identified by Akl and Abu Musa [42] and Abu Shukair and Akl [3], as a set of operations that learners perform among themselves and each other and between them and the teacher. The aim is realizing and confronting future problems accurately and quickly. These skills are: anticipation, prediction, visualizing and solving future problems. Jones et. al. [60] defined it as an organized process through which an exploration of the future takes place by analyzing and evaluating reality and envisioning solutions for the future.

Therefore, future thinking is based on some principles mentioned by Abd Al-Rahim [37] which is predicting the future an important skill, although it is unknown. This can take place through interaction between individuals and different experiences, as the future can be studied through expectations. Planning for the future begins from analyzing and link between the events of the present to predict what will happen in the future.

Accordingly, Zangour [27] indicated that future thinking passes through some stages that the learner should undertake to acquire his skills, which are: reconnaissance as an attempt to understand and analyze what surrounds him; contemplation and planning by proposing various possible alternatives to a problem or perception, developing a plan to bridge the gap between reality problems and predict solutions to them in the future, implementing what was planned through possible strategies, setting indicators for evaluation, and modifying the course of the plan to achieve the goals.

There are many classifications of future thinking skills. The current research adopted Hafez's classification (2015), which classified it into four main skills, each of which has sub-skills as shown below:

3.2.1. Anticipation Skill

Anticipation skill: is the ability to form and guess of future events on the basis of past events and experience. It means thinking about what will happen in the future. It includes: exploratory prediction, normative expectation, and calculated expectation.

3.2.2. Prediction Skill

Prediction skill: is very close to the previous skill, but the prediction skill depends on speculation or guessing more than anticipation. Prediction depends on thinking more about the future and its events based on assumptions and includes: making personal choices, postulate hypotheses, distinguishing among them, and identifying the extent of its suitability.

3.2.3. Visualization Skill

Visualization skill: is determined by forming integrated images of future events, and the learner should enjoy creativity and imagination. It includes setting priorities, recognizing viewpoints, analyzing controversies, and asking

questions.

3.2.4. Future Problem-Solving Skill

Future Problem-Solving skill: is the ability to analyze and develop strategies to solve a complex problem. It includes accessing information, taking notes, setting standards, defining and applying procedures, evaluating alternatives, and making judgments.

Akl and Abo-Mosa [42] indicated that it is possible to develop future thinking skills through the use of strategies based on various direct and indirect modern technologies. This research aims at using of virtual simulation and flipped classrooms.

Several studies aimed at developing future thinking skills through technology, such as: Ibrahim [1], Abu Safiya [54], Al Shafi'i [32], Hani [55], Al Darabkeh [20], Ketfan and Shawn (2020).

3.3. Virtual Simulation Programs via Flipped Classrooms

The development in the teaching and learning processes led to the development in information and communication technology, which was reflected in the integration of technology into education. The learner becomes to be the focus of the educational process, with the aim of developing various skills, including problem solving and future thinking.

Carin [58] and Nagel [63] have pointed out that flipped learning or flipped classroom is that what is traditionally done in class is now done at home, and what was traditionally done at home as homework is completed in class.

While Al-Kahili [48] and Elsharman [34] refer to it as a teaching and learning strategy in which educational technology (videos) is used to replace traditional learning so that the learner watches the videos at home and discusses them with the teacher in the classroom while performing various activities.

Al-Ghamdi and Flemban [44] and Al-Kahili [48] pointed out the importance of using flipped classrooms, enhancing thinking skills, increasing communication and interaction between the teacher and the learner, and effectively using modern technology and integrating it into the educational process. The student can learn alone according to his abilities and construct meaningful learning, providing class time for activities and tasks, during which several strategies are activated, such as virtual simulation.

Compensation for the lack of materials and laboratory experiment equipment using virtual laboratories is considered as one of the most important advantages of learning in flipped classrooms. It is the basis of the experimental treatment of this research using some virtual simulation programs that present the concepts of genetics and experiments to practice solving genetic problems during the asynchronous flipped classroom. A sample of the virtual program (PHET) through two figures 2 and 3.

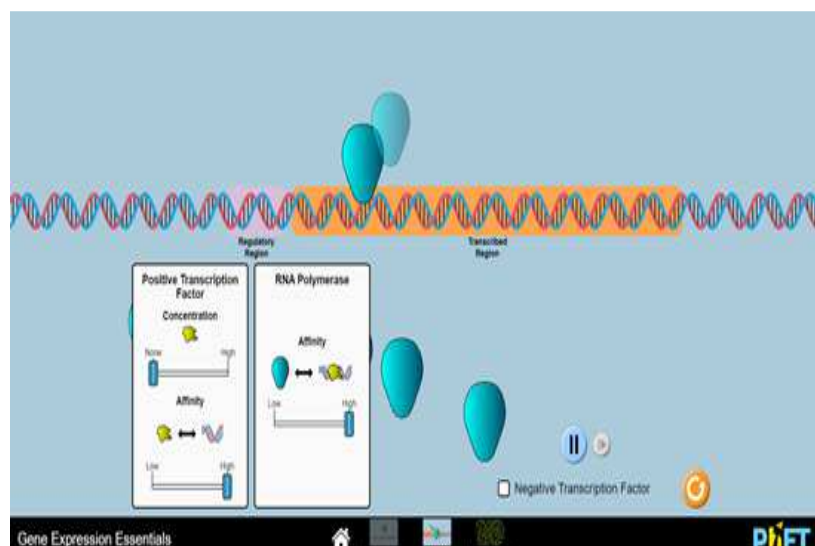


Figure 2. Genetic Inheritance.



Figure 3. Genetic and Shape Style for Parents.

Many studies have been concerned with teaching and learning science using flipped classrooms to develop thinking skills, including Al-Turki and Al-Subai'i study [9] which aimed to develop critical thinking and environmental awareness in the middle stage. Al-Rabeen [24] aimed to develop critical thinking for middle school students. Eid's study [43] in the development of achievement, and the study of Al-Shami and Al-Qadri [33] aimed at acquiring the physical concepts and the attitude towards the subject.

As previously mentioned, simulation is one of the strategies that can be successfully applied in flipped classrooms. In the light of distance learning, virtual simulation can achieve many of the desired learning outcomes, to which this research aims. The process of choosing a learning style is an end in itself. The integration of the usual methods of teaching, such as simulation with technological innovations, in virtual learning programs that arose mainly to simulate reality in order to avoid harm, as in laboratories, and to embody cognitive experiences that are difficult to obtain. Some studies have indicated its importance, such as the study of Frgoun [46].

Both Al-Farsi [45] and Bedou [7] indicated that virtual learning programs are one of the applications of educational technology, which is an artificial or imaginary learning

environment that is an alternative to and simulates real reality. The learner lives in an imaginary environment that interacts, shares and deals with it through his senses with the help of electronic devices.

Virtual learning is characterized by several characteristics. The most important of which is facilitating experiences and making them understandable to the student, saving time and effort and creating a new model in the field of education, better than real and embodying imagination. The learner sees information moving in front of him, living in and coexisting with it and presenting education in attractive way that contains fun, entertainment and excitement, and increases the learner's motivation and desire. He can be back to materials and devices any time Elbedou [7].

Many studies aimed at using electronic and virtual computer programs in teaching such as: Al-Radi [23], Al-Saadi [30], and Ambo Saidi and others [6], Al-Shuaili and Ammar [35], Al-Bultan [8], Mokhtar [51]. They have proven its effectiveness in learning biology, as in the study of Yassin [56].

4. Research Methodology

The current research followed the quasi-experimental method to the experimental design with the two groups: the

control group (taught by the usual way) and experimental group (taught by using simulation programs via virtual classrooms), and the pre/post-application of the dependent variables (genetic problem-solving skills and future thinking skills).

4.1. Sample of the Research

A group of students (N=85) girls enrolled on the third-year secondary stage at Besha governorate, scientific section, distributed into two groups: the control (N=42) taught using the usual method and the experimental (N=43) taught using virtual simulation programs via flipped classrooms.

4.2. Instruments of the Research

- A test of genetic problem-solving skills (prepared by the researcher).
- A test of future thinking skills (prepared by the researcher).

4.3. Research Procedures

4.3.1. First

Reviewing literature, and previous studies related to the variables of the research.

4.3.2. Second: Determining the Research Sample

a random group of (85) female students from the third grade of secondary school in Bisha governorate, with scientific specialization, divided into two groups, one of them is a control group (N=42) female students taught by the usual way, and the other is an experimental group (N=43) female student in the eighth secondary school taught using virtual simulation programs through flipped classrooms.

4.3.3. Third: Preparing Research Materials and Instruments

Preparing the materials of the research: were Worksheets

and Teacher's Guide of virtual simulation programs via flipped classrooms.

The worksheets have been prepared so as to develop genetic problem-solving and future thinking skills. A question is asked about problem identification, visualization or prediction as future thinking skills after performing the activity attached to the worksheet, which develops one of the problem-solving skills. The validity of the virtual simulation program (PHET) has been verified. Virtual simulation (PHET) was described in detail in the teacher's guide. YouTube videos associated with each of the genetic experiments on the program were prepared, which contribute to the development of research variables. WhatsApp groups were made for communication between groups and teachers. The worksheets and the teacher's guide were presented to the jury to verify their validity for application.

1. Preparing a test for solving genetic problems according to:

1) *Identifying the objective of the test:* is measuring to what extent secondary stage students master genetic problem-solving skills in biology.

2) Measuring the Validity of the Test:

a. *The validity of the Jury:* the test was submitted in an initial form (items=25) questions to verify its suitability for measuring what was set for and (2) questions were omitted as they weren't suitable for the purpose set for them.

b. *Interior Reliability:* The test was applied to a sample of (100) secondary school female students. Pearson's correlation coefficients were calculated between the test items and the total score of the test. The correlation coefficients ranged between (0.385) and (0.769), and this means that the test items measure what they were designed for. This is illustrated by the following table:

Table 1. Coefficients of Interior Consistency for the test items of Genetic Problem-Solving.

Skill	Item N.	Item relation to Skill Score	Item relation to Total Score	Skill	Item N.	Item relation to Skill Score	Item relation to Total Score
Identifying the genetic state	1	(**),0,673	(**),0,639	Writing Genetic Styles/Forms	13	(**),0,474	(**),0,455
	2	(**),0,590	(**),0,542		14	(**),0,604	(**),0,612
	3	(**),0,782	(**),0,616		15	(**),0,438	(**),0,412
	4	(**),0,523	(**),0,425		16	(**),0,617	(**),0,506
Expressing genetics by symbols	5	(**),0,682	(**),0,613	Conducting Parents' Cross breeding	17	(**),0,678	(**),0,510
	6	(**),0,523	(**),0,425		18	(**),0,631	(**),0,478
	7	(**),0,441	(*)0,392		19	(**),0,599	(**),0,713
	8	(**),0,724	(**),0,565		20	(**),0,769	(**),0,478
Writing Genetic Styles or forms	9	(**),0,610	(**),0,558	Genetic Explanation	21	(**),0,717	(**),0,490
	10	(**),0,690	(**),0,641		22	(**),0,769	(**),0,455
	11	(**),0,587	(**),0,603		23	(**),0,412	(*)0,358
	12	(**),0,521	(**),0,412		24	(**),0,526	(**),0,423

The relationship of skills to each other and the total score of the test was also calculated. All the test skills were related to each other at the level of significance (0.01), and all skills were related to the total test score, as shown in the following table:

Table 2. The Relationship between Genetic Problem-Solving Skills with each other's and with the total score of the test.

Skills	Identifying the genetic state	Symbols expression on genes	Symbols expression on genetic forms	Symbols expression on the genetic styles	Parents' cross breeding	Genetic explanation	Total
Identifying the genetic state	1	0,683	0,825	0,748	0,487	0,460	0,726
Symbols expression on the genes	-	1	0,742	0,748	0,486	0,513	0,730
Symbols expression on the genetic forms	-	-	1	(**),0,754	(**),0,525	(**),0,591	(**),0,863
Symbols expression on the genetic styles	-	-	-	1	(**),0,648	(**),0,431	(**),0,748
Parents' cross breeding	-	-	-	-	1	(**),0,748	(**),0,751
Genetic explanation	-	-	-	-	-	1	(**),0,778
Total	-	-	-	-	-	-	1

2. *Reliability of the Test:* was calculated using the Alpha Cronbach and the half-segmentation methods. The overall reliability of the test was (0.79), which is a highly reliable

coefficient. As for the reliability of each skill, the reliability coefficients ranged between (0.52) and (0.80), and this indicates that the test has an acceptable degree of reliability.

Table 3. Reliability Coefficient of Genetic Problems Solving Test with Alpha Cronbach and the Half-Segmentation Methods.

N.	Skills of the Test	Alpha Cronbach	Half-Segmentation	
			Pearson's Coefficient between the two halves	Reliability coefficient after correction with Spearman-Brown Equation
1	Identifying the Genetic State	0.66	0.67	0.8
2	Symbols Expression on the Genes	0.71	0.58	0.73
3	Symbols Expression on the Genetic Forms	0.69	0.65	0.79
4	Symbols Expression on the Genetic Styles	0.66	0.52	0.68
5	Parents' Cross Breeding	0.73	0.56	0.72
6	Genetic Explanation	0.73	0.61	0.72
7	Total	0.8	0.67	0.79

3. *Measuring the Easiness and Difficulty Coefficient for the Test Items:*

The coefficients of easiness and difficulty were calculated for the test items. All the items had acceptable coefficients of easiness and difficulty, as they ranged between the acceptable limits for the coefficients of easiness and difficulty, as the coefficients of difficulty for the test ranged between (0.48 and 0.67), while the coefficients of easiness ranged between (0.34 and 0.51), which are acceptable values for the

coefficients of difficulty and easiness. This is illustrated by table 4.

4. *Measuring the Discrimination Coefficients of the Test Items:* the discrimination coefficients were calculated for the test items, and ranged between (0.39 - 0.61). It is known that the acceptable discrimination coefficients ranged from (0.30 to 0.70), which made them have acceptable discrimination coefficients, and this is illustrated by the table 4:

Table 4. Difficulty, Easiness, and Discrimination Coefficients for the Test Items.

Item	Difficulty	t	Easiness	Discrimination	Item	Difficulty	Easiness	Discrimination	Item	Difficulty	Easiness	Discrimination
1	0.53		0.47	0.61	9	0.64	0.36	0.58	17	0.53	0.47	0.53
2	0.59		0.41	0.49	10	0.55	0.45	0.49	18	0.66	0.34	0.6
3	0.67		0.39	0.5	11	0.51	0.49	0.55	19	0.53	0.47	0.53
4	0.48		0.52	0.53	12	0.59	0.41	0.56	20	0.48	0.52	0.59
5	0.65		0.35	0.54	13	0.49	0.51	0.61	21	0.57	0.43	0.41
6	0.57		0.43	0.47	14	0.64	0.36	0.56	22	0.65	0.35	0.49
7	0.66		0.34	0.39	15	0.57	0.43	0.4	23	0.49	0.51	0.48
8	0.62		0.38	0.41	16	0.66	0.34	0.49	24	0.67	0.39	0.61

5. *Measurements of Test Time:-*

The test time is estimated by calculating the average time between the first female student's answer and the last female student who has completed the test answer as a whole. The test time is estimated (55) minutes.

6. *The Final Form of the Test:* It consisted of (24) items distributed into five sub-skills: (Identifying the genetic state to which the problem belongs, expressing the codes or symbols of genes, expressing the genotypes of the parents, expressing the phenotypes of the parents, making crosses breeding among parents, interpreting the genetic results).

7. *Scoring the Test:* The test was corrected in the light of (ONE) mark for one right answer and (ZERO) for the wrong answer. The total score of the test (24) marks and the minimum score was (zero).

4.3.4. Preparing the Test of Future Thinking Skills

The Objective of the Test: is to measure to what extent secondary stage girl students master future thinking skills.

1. *Measuring the Validity of the Test:*

The validity of the Test: the test was presented to the jury in its initial form and consisted of (16) items to verify its validity for what was measured. The jury admitted that the test is valid.

2. *Validity of Interior Consistency:* The test was administered to a sample of (100) secondary stage female students, and the Pearson correlation coefficients were calculated between the test items and

the total score of the test. The correlation coefficients ranged between (0.325) and (0.739), and this means that the test items measure for what it was developed. This is illustrated in the following table.

Table 5. *Coefficients of Interior Consistency for Future Thinking Test.*

Skill	Item N.	Its relation to the degree of skill	Its relation to the total score	Skill	Item N.	Its relation to the degree of skill	Its relation to the total score
Anticipation	1	(**)0,591	(**)0,645	Genetic Future Problem Solving	9	(**)0,441	(*)0,392
	2	(**) 0,688	(**)0,643		10	(**)0,614	(**)0,612
	3	(**)0,633	(**)0,575		11	(**)0,538	(**)0,513
	4	(**)0,599	(**)0,713		12	(**)0,617	(**)0,506
Prediction	5	(**)0,523	(**)0,425	Visualization	13	(**)0,678	(**)0,510
	6	(**)0,532	(**)0,455		14	(**)0,631	(**)0,478
	7	(**)0,724	(**)0,565		15	(**)0,690	(**)0,673
	8	(**)0,739	(**)0,455		16	(**)0,523	(**)0,325

The relationship of the skills with each other's and the total score of the test was measured. All skills were related to each other's at sig. level (0.01). All the skills relate to the total score of the test, as shown in the following table:

Table 6. *The Relationship of future thinking skills with each other's and the total score of the test.*

Skills	Anticipation	Prediction	Genetic Future Problem Solving	Visualization	Total
Anticipation	1	(**) 0,731	(**)0,825	(**)0,758	(**) 0,711
Prediction	-	1	(**)0,752	(**) 0,756	(**) 0,731
Genetic Future Problem Solving	-	-	1	(**) 0,721	(**)0,841
Visualization	-	-	-	1	(**)0,769
Total	-	-	-	-	1

3. *The Reliability of the Test:* was calculated using the Alpha Cronbach and the half-segmentation methods. It was found that the reliability of the test was (0.73), which is a high reliable coefficient. As for the reliability

of each skill, the reliability coefficients ranged between (0.66) and (0.71). This indicates that the test has an acceptable degree of reliability.

Table 7. *Reliability Coefficients of Future Thinking Skills Test with Alpha Cronbach.*

N.	Test Dimensions	N. of Items	Alpha Cronbach
1	Anticipation	3	0.66
2	Prediction	4	0.71
3	Genetic Future Problem Solving	5	0.69
4	Visualization	4	0.66
////	Total	16	0.73

4. *Measuring the Easiness and Difficulty Coefficient for the Test Items:-*

The coefficients of easiness and difficulty of the test items were calculated. All the test items had acceptable coefficients of easiness and difficulty. They ranged between the acceptable limits for the coefficients of easiness and difficulty, as the coefficients of difficulty for the test ranged between (0.48 and 0.67), while the coefficients of easiness ranged between (0.34

and 0.51), which are acceptable. This is illustrated by Table 8.

5. *Measuring the Discrimination Coefficients of the Test Items:* The discrimination coefficients were calculated for the test items, and ranged between (0.33 - 0.62). It is known that the acceptable discrimination coefficients ranged from (0.30 to 0.70), which made them have acceptable discrimination coefficients, and this is illustrated by the table 8.

Table 8. *Difficulty, Easiness, and Discrimination Coefficients for the Future Thinking Test Items.*

Item	Difficulty	Easiness	Discrimination	Item	Difficulty	Easiness	Discrimination	Item	Difficulty	Easiness	Discrimination
1	0.57	0.43	0.5	9	0.63	0.37	0.66	17	0.5	0.5	0.62
2	0.6	0.4	0.45	10	0.53	0.47	0.48	18	0.64	0.36	0.59
3	0.53	0.47	0.5	11	0.66	0.34	0.53	19	0.54	0.46	0.63
4	0.48	0.52	0.54	12	0.59	0.41	0.49	20	0.52	0.48	0.49
5	0.63	0.37	0.59	13	0.5	0.5	0.58	21	0.61	0.39	0.51
6	0.55	0.45	0.53	14	0.61	0.39	0.63	22	0.67	0.33	0.55
7	0.66	0.34	0.39	15	0.51	0.49	0.66	23	0.55	0.54	0.6
8	0.67	0.33	0.44	16	0.55	0.45	0.59	24	0.67	0.33	0.49

6. Test Time: The test time is estimated by calculating the average time between the first female student's answer and the last female student who has completed the test answer as a whole. The test time is estimated (60) minutes.
7. The Final Form of the Test: It consisted of (16) items distributed into four sub-skills: (Anticipation, prediction, future solving problems, and visualization). *Scoring the Test*: The test was corrected in the light of the number of student's responses, (4) scores for each question, as each response represents only one mark with omitting repeated responses which weren't related to the topic.

The scores of the test ranged from (zero as a minim score and 64 as a maximum score).

4.3.5. Fourth: Implementation of Research Experiment

The procedures Came as Following:

Pre-administering of the instruments to ensure the homogeneity of the two groups, by applying the "t" test for the independent groups, measuring the significance of the differences among the mean scores of the research sample before applying the tests of genetic problems solving and future thinking skills in order to ensure the homogeneity of the control and experimental groups, as shown in the table 9.

Table 9. The Significance of Differences among the Mean Scores of the Study Sample in the Pre-test of Genetic Problems Solving (df=83).

N.	Genetic Problems Solving Skills	N.	Means	Standard Deviation	Differences in the Mean	"T" Value	Sig. 0.05
1	Identifying the Genetic State	Control 43 Experim. 42	6.1 6.4	1,21 1,09	0.3	0,57	0,191 Not sig.
2	Symbols Expression on the Genes	Control 43 Exper. 42	5.8 6.83	0,99 2,33	1,03	0,30	0,265 Not sig.
3	Symbols Expression on the Genetic Forms	Control 43 Exper. 42	6.07 8.01	1.06 2,31	1,94	0,57	0,185 Not sig.
4	Symbols Expression on the Genetic Styles	Control 43 Exper. 42	4.94 7.33	0.65 2.98	2,93	0,89	0,293 Not sig.
5	Parents' cross breeding	Control 43 Exper. 42	7.81 7.59	1.1 1,99	0,22	1,21	0,334 Not sig.
6	Results Interpretation	Control 43 Exper. 42	5.84 7.67	1,05 3,67	1,75	1,34	0,178 Not sig.
////	Total	Control 43 Exper. 42	5.33 7.81	3,86 3,98	2.48	0,07	0,433 Not sig.

Table 10. The Significance of Differences among the Mean Scores of the Study Sample in the Pre-test of Future Thinking Skills (df=83).

N.	Future Thinking Skills	N.	Means	S.D.	Differences of Means	"T" Value	Sig. 0.05
1	Anticipation	Contr. 43 Exper. 42	0,76 0,74	0,63 0,43	0,02	0 0,59	0,109 Not sig.
2	Prediction	Contr. 43 Exper. 42	1,01 1,00	0,56 0,80	0,01	0,39	0,323 Not sig.
3	Problems Solving	Contr. 43 Exper. 42	0,66 1,00	0,12 0,31	0,03	0,50	0,354 Not sig.
4	Visualization	Contr. 43 Exper. 42	0,71 0,69	0,07 0,74	0,02	1,00	0,238 Not sig.
////	Total	Contr. 43 Exper. 42	0,77 0,79	0,5 0,39	0.02	0,93	0,122 Not sig.

Results of Tables 9 and 10 showed that there weren't statistically significant differences among the scores on the experimental and control groups. This signifies that the two groups were homogenies.

- 1) Preparing Teacher's Guide to teach by the program and flipped classroom. The worksheets of activities, practiced by experimental group students in the sessions, are shown procedurally in details in the appendices of the Teacher's Guide.
- 2) Using the asynchronous flipped classroom, where the students watch the educational videos that were sent via WhatsApp the day before the session, apply what they learned by the virtual simulation program (PHET). Then, the student takes notes and inquiries,

and is free to repeat any part of the lesson while watching the video, and the practice of solving genetic problems through the virtual application. The appointment of meeting takes place between the teacher and the students once a week through the (ZOOM) program by the agreement among them. The simultaneous flipped classroom was used during the regular sessions in the academic schedule to have the students' questions and implement the worksheets, and then develop Genetic problems-solving and future thinking skills.

- 3) Post-administering the instruments of the study to the experimental and control groups, collecting and analyzing data and interpreting results.

5. Results of the Research

5.1. Verifying the First and Second Hypotheses

Verifying the findings of the first and second hypotheses to answer the first question, which states, “What is the effect of using virtual simulation programs via the flipped classrooms in the biology course (3) on developing future thinking skills among third-year secondary school girls students in Bisha

governorate?

The t-test of independent samples was used to find the differences among the mean scores of the control and experimental groups, and the mean scores of the two applications, the pre and posttest of genetic problems solving skills. The size effect of (η^2) of the independent variable on genetic problem-solving skills (the dependent variable) was measured as shown in tables 10 and 11 as follows:

Table 11. Findings of “t” test to measure the differences of means among the scores of the research sample in the posttest of Genetic Problem-Solving Skills.

N.	Genetic Problems Solving Skills	N.	Mean	S.D.	Differences of Means	“T” Value	Sig. 0.05	η^2
1	Identifying the Genetic State	Control 43 Exper. 42	6.1 11.54	1.21 1.09	4.3	0.57	0.00 Sig.	0.198 effective
2	Symbols Expression on the Genes	Control 43 Exper. 42	5.8 11.99	0.99 2.33	1.51	0.30	0.00 Sig.	0.144 effective
3	Symbols Expression on the Genetic Forms	Control 43 Exper. 42	6.07 13.64	1.06 2.31	4.88	0.57	0.00 Sig.	0.265 effective
4	Symbols Expression on the Genetic Styles	Control 43 Exper. 42	4.94 12.97	0.65 2.98	8.39	0.89	0.00 Sig.	0.243 effective
5	Parents’ cross breeding	Control 43 Exper. 42	7.81 13.08	1.1 1.99	5.78	1.21	0.00 Sig.	0.198 effective
6	Results of Interpretation	Control 43 Exper. 42	5.84 12.68	1.05 3.67	5.83	1.34	0.00 Sig.	0.231 effective
////	Total	Control 43 Exper. 42	7.33 13.71	3.86 3.98	5.48	1.07	0.00 Sig.	0.256 effective

Table 12. Findings of “T” test to measure the differences of Means among the scores of the research sample in the pre-posttest of Genetic Problem-Solving Skills.

N.	Genetic Problems Solving Skills	N.	Mean	S.D.	Differences of Means	“T” Value	Sig. 0.05
1	Identifying the Genetic State	Pre 42 Post 42	6.4 11.54	1.21 1.09	5.05	8.57	0.00 Sig.
2	Symbols Expression on the Genes	Pre 42 Post 42	6.83 11.99	0.99 2.33	5.16	12.30	0.00 Sig.
3	Symbols Expression on the Genetic Forms	Pre 42 Post 42	8.01 13.64	1.06 2.31	5.63	9.57	0.00 Sig.
4	Symbols Expression on the Genetic Styles	Pre 42 Post 42	7.33 12.97	0.65 2.98	5.64	8.89	0.00 Sig.
5	Parents’ cross breeding	Pre 42 Post 42	7.59 13.08	1.1 1.99	5.49	10.21	0.00 Sig.
6	Results of Interpretation	Pre 42 Post 42	7.67 12.68	1.05 3.67	5.01	11.34	0.00 Sig.
////	Total	Pre 42 Post 42	7.81 13.71	3.86 3.98	5.90	12.06	0.00 Sig.

Tables 11 and 12 showed that the value of calculated (T) is greater than its value in the table at the level of significance (0.05). This signified that there was a statistically significant difference among the mean scores of the control and experimental group in the posttest of future thinking skills in favor of the experimental group that taught virtual simulation programs via flipped classrooms. There was a statistically significant difference among the mean scores of the experimental group in the pre/posttest of future thinking skills in favor of the post-application.

Hence, the first hypothesis which stated that “there was a statistically significant difference at the level (0.05) among the mean scores of the control and experimental groups in the posttest of genetic problem-solving skills in favor of the experimental group” was accepted. The second hypothesis

which stated that “there was a statistically significant difference at the level of (0.05) among the mean scores of the experimental group in the pre/posttest of the genetic problem-solving skills in favor of the post application” was validated.

In order to identify the effect size of the independent variable (virtual simulation programs) by which the experimental group taught, and the (usual method) by which the control group taught on the dependent variable (scores of the skill, and the total score of genetic problem-solving skills). (η^2) was measured and the total score of the test reached (0.256), thus the effect size is considered greater. These results were supported through the studies of: Abu Oriban (2017), Abu Raya (2017), and Jalal (2021) which aimed to use technological tools and environments in developing genetic problem-solving skills.

5.2. Verifying the Third and Fourth Hypotheses

Presenting the findings for the third and fourth hypotheses to answer the second question which stated, "What is the effect of using virtual simulation programs via flipped classrooms in biology course (3) on developing future thinking skills among third-grade secondary school girls students in Bisha governorate?"

The T-test was used for independent samples to find differences among the mean scores of the control and experimental groups, and the average scores of the pre/posttest of future thinking skills in its sub-skills. η^2 was used to measure the size of the effect of the independent variable on the dependent variable. This is illustrated by findings of the two tables 13 and 14 as follows:

Table 13. Findings of "T" test to measure the differences of Means among the scores of the research sample in the posttest of Future Thinking Skills.

N.	Future Thinking Skills		N.	Mean	S.D.	Differences of Means	"T" Value	Sig. 0.05	η^2
1	Anticipation	Control	43	0,53	0,65	0,91	0,99	0,00	0,238
		Exper.	42	1,44	2,98			Sig.	
2	Prediction	Control	43	0,45	1,1	0,98	1,06	0,00	0,269
		Exper.	42	1,34	1,99			Sig.	
3	Problem Solving	Control	43	0,49	1,05	0,83	0,99	0,00	0,298
		Exper.	42	1,32	2,67			Sig.	
4	Visualization	Control	43	0,4	1,66	1,09	1,06	0,00	0,255
		Exper.	42	1,49	1,06			Sig.	
////	Total	Control	43	0,52	0,85	0,91	2,31	0,00	0,297
		Exper.	42	1,43	1,79			Sig.	

Table 14. Findings of "T" test to measure the differences of Means among the scores of the research sample in the pre-posttest of Future Thinking Skills.

N.	Future Thinking Skills		N.	Mean	S.D.	Differences of Means	"T" Value	Sig. 0.05
1	Anticipation	Pre	42	0,74	0,65	0,70	1,83	0,00
		Post		1,44	2,98			Sig.
2	Prediction	Pre	42	1,00	1,1	0,34	1,25	0,00
		Post		1,34	1,99			Sig.
3	Problem Solving	Pre	42	1,00	1,05	0,32	1,26	0,00
		Post		1,32	2,67			Sig.
4	Visualization	Pre	42	0,69	1,66	0,80	1,33	0,00
		Post		1,49	1,06			Sig.
////	Total	Pre	42	0,79	0,79	0,55	0,98	0,00
		Post		1,43	1,33			Sig.

Tables 13 and 14 showed that the value of calculated (T) is greater than its value in the table at the level of sig. (0.05). This signified that there was a statistically significant difference among the mean scores of the control and experimental group in the posttest of future thinking skills in favor of the experimental group that taught virtual simulation programs via flipped classrooms. There was a statistically significant difference among the mean scores of the experimental group in the pre/posttest of future thinking skills in favor of the post-application.

Hence, the third hypothesis which stated that "there was a statistically significant difference at the level (0.05) among the mean scores of the control and experimental groups in the posttest of future thinking skills in favor of the experimental group" was accepted. The fourth hypothesis which stated that "there was a statistically significant difference at the level of (0.05) among the mean scores of the experimental group in the pre/posttest of the future thinking skills in favor of the post application" was validated.

In order to identify the effect size of the independent variable (virtual simulation programs) by which the experimental group taught, and the (usual method) by which the control group taught on the dependent variable (scores of the skill, and the total score of future thinking skills). (η^2)

was measured and the total score of the test reached (0.29). Thus, the effect size is considered greater. These results were confirmed through the studies of: Abu Safiya (2010), Hani (2016), Darbaka (2018), Akl and Abu Musa (2019), and Ketfan and Shawn (2020).

6. Discussion and Results Interpretation

Tables 11 and 12 showed the effectiveness of using virtual simulation programs in developing genetic problem-solving skills. It is clear that the size of their effect is greater on those skills which was calculated through measuring the significance of the differences among the mean scores of the control and experimental group. This can be attributed to learning in an interesting, attractive and selective virtual learning environments via flipped classrooms that gave a real opportunity to learn, acquire knowledge, and to practice some skills that students lacked, especially in the secondary stage. There is a prevailing belief among teachers that students can learn abstract concepts easily in this stage without taking into account the mental processes of processing information to benefit from previous experiences in generating new information.

Consequently, students' utilization for the (PHET)

program and watching videos at home before attending the session, gave them the freedom to experiment, try and make mistakes, and watch the results of their choices, whether for genetic qualities and formal patterns through virtual simulation. This helped in identifying genetic cases and making crosses among parents easily. Virtual simulation programs via flipped classrooms meet the individual differences among students, and make them more effective and involved in class discussions, which allow them to transfer and exchange experiences for further clarification and more convergence of skills.

It is also clear from the findings of tables 13 and 14 the effectiveness of using virtual simulation programs in developing future thinking skills (Anticipation - visualization - prediction - solving future problems). The effect size was greater on these skills through measuring the significance of the mean scores of the control and experimental group and calculating the Eta square (η^2). This can be attributed to the fact that the virtual simulation learning via flipped classroom is an interesting, attractive and selective environment, taking into account individual differences, and giving an adequate and real opportunity to practice thinking skills, reflection, creativity and imagination based on analyzing and criticizing reality and then predicting future solutions to solve problems, which are called future thinking skills, as one of the objectives of this research.

Therefore, students' using (PHET) program and watching videos at home before attending the class increases their organization of information and taking the responsibility that leads them to think of future solutions for the problems that need to be solved, especially within the current conditions of the spread of the Corona. The whole world tried to address the spread of this virus, and virtual simulation programs allow this without happening with the examples and questions posed in the worksheets. It has grown to have the ability to think about the future by interacting with the content with interest. This emerged from posing questions by the students during the application, all of which link the present and the future through the practice of thinking.

7. Recommendations of the Research

1. Designing synchronous and asynchronous e-learning environments to develop problem-solving and future thinking skills in biology.
2. Developing students' and teachers' attitudes towards studying biology curricula through modern technology.
3. Reinforcing problem-solving and future-thinking skills in biology curricula.
4. Activating the blended and distance learning in developing different thinking skills in biology curricula.
5. Enriching biology curricula with virtual simulation labs.
6. Training teachers and students on using virtual simulation programs.

8. Suggestions of the Research

1. The effect of using flipped classrooms on developing

productive thinking skills in biology courses.

2. The effectiveness of virtual simulation programs in developing some thinking skills in biology.
3. Developing biology curricula at the secondary stage in light of problem-solving and future thinking skills.
4. Attitudes of secondary school biology teachers towards the use of virtual simulation programs.
5. Obstacles for using virtual laboratories in teaching biology courses at the secondary stage.
6. A training program to develop thinking skills and attitude towards using virtual simulation programs among students and teachers.

9. Summary

The aim of the research is to investigate the effect of using virtual simulation programs across flipped classrooms in the biology course (3) in developing genetic problem-solving skills and future thinking among a sample of (43) female students of the third year of secondary school specializing in scientific courses, which represents the experimental group, and (42) students with the same The class taught in the usual way represents the control group, and the genetic problem solving skills test and the future thinking skills test were applied to the two groups, before and after, The study followed the experimental approach, where the students of the experimental group were taught using virtual simulation programs through flipped classrooms, and the control group was taught in the usual way in the classroom, and the results reached the effectiveness of using virtual simulation programs through flipped classrooms in developing genetic problem solving skills and future thinking, and the research recommended the need to train Teachers and students develop genetic problem-solving skills and future thinking using modern teaching strategies and methods that are appropriate to the nature of the current era, such as virtual simulation and flipped classrooms.

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