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Genetic Literacy for Students in Faculties of Education in Universities

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ABSTRACT

Genetic literacy is the capacity to obtain, process, understand, and use genetic information. It is highly imperative in life science students; the current study was conducted to assess genetic literacy in students. The goals of the current project are (1) to assess the Genetic Literacy of life sciences students in education colleges, and (2) to identify how Genetic Literacy changes according to variables of academic level, gender, and different universities in education students in universities of the Furat Al-Awsat. To achieve the project's goals, the two researchers used the analytical-descriptive method using the steps such as an examination prepared to assess the impact of the variables of interest. Experts then reviewed it to confirm its legitimacy, clarity, and suitability to the target audience. The testing timing was then inferred using a trial on a sample consisting of 40 students that belong to the target audience. The test was then applied to a sample of 395 students in the second semester of the academic year 2020-2021. The sample was randomly selected from the universities of Al-Qādisiyyah, Karbala, and Kufa. The statistical packages, SPSS-26, and Microsoft tool, Microsoft Excel, were used to process the collected data and show that education-department students of the selected universities did not possess Genetic Literacy. Varying gender did not have a statistically clear impact on Genetic Literacy. Differences in genetic literacy were identified between 3rd and 4th-level students and their 1st and 2nd counterparts. The researchers concluded the necessity of integration among the contents of education and genetic literacy applied to the size, type, and quality of the material and activities in the curriculum. They also suggested that further studies must be made to study the relationship between students' level of genetic literacy and that of educators.

Keywords: *Literacy Genetic Literacy, Students in Faculties of Education*

INTRODUCTION

Iraq and the rest of the Arabic and Islamic world face local, regional and international challenges that make development a must-take strategic choice. Iraq is not alienated from the

world, and its culture and civilization allow it to be open and adaptive to every culture out there. Though it faces challenges, some of which are: the increasing amount of knowledge, population, technological, political, economic, and social variables.

Individuals in the current generation face many obstacles and changes that are of significant impact such that they have no choice but to focus on genetic and educational development. The reason is that those obstacles create an accelerating change in the future that makes each individual overthinks about their future.

Education curriculums in Iraq must educate students scientifically, including genetic knowledge, skills, practices, values, and tendencies. They must also renew their background in the latest scientific inventions and discoveries and then relate them to corresponding applications. It can be achieved by connecting natural and life sciences to technical education and the information revolution (Muller, 2012).

What is the level of genetic literacy of life sciences students in humanities colleges departments in the universities of Furat Al-Awsat in Iraq?

The answer to this question requires answering the following question first:
Is the genetic literacy in the target audience impacted by gender, education level, and university (in Al-Qādisiyyah, Babel, Karbala, Kufa)? (Allison, Miller, Oliver, Michaelson, & Tiropanis, 2012).

Importance of this Research

The world has observed significant changes and discoveries in the areas of life sciences since the beginning of the last century. Space has been conquered, and the world has become like a small village. The Internet spread worldwide, and the term 'uneducated' has started to call those who do not know how to use a computer. All these significant changes made educators and decision-makers care more and spend more time preparing students and designing better education material syllabus.

Education in general and scientific education specifically face many impactful challenges resulting from modern civilization and development in scientific, economic, genetic, and social aspects of life. This revolution of change is mainly due to the accelerating technological Development (Alzamili & Mohammed, 2019). These changes made educators and decision-makers take steps to improve curriculums, especially science curriculums. In addition, the national committee is responsible for training the science teachers to adapt to the pace of rapid changes in information technology and to give students new skills of research and information processing. Science teachers suggested several steps to prepare teachers to understand several areas, such as pollution, genetic sciences and their applications in society, workplace, manufacturing, and healthcare, and how to design and conduct research in life sciences (Mohammed, 2017). Many national and international scientific committees have endorsed this strategy. The following is an illustrative example.

An example that illustrates the educational development effort is the first conference of education in Mansoura University in Egypt on the 11th and 12th of April, 2006. The conference's title was 'Development of educational curriculum to fulfill the emerging requirement for development and face globalization's challenges. Another example is the conference conducted in the college of technology and mathematics in the university of Al-Qādisiyyahin Iraq on the 6th and 7th of April, 2009 under the title 'Educational terms is the core of Scientific Development.' Similarly, a seminar was held from the preceding, the researchers believe that all the previous conferences called for the need to focus on scientific literacy focusing on the content of academic subjects. It confirms the extent of global and Arab interest in scientific literacy that makes it a primary goal of science education that the preparers of the content of

science curricula seek to achieve and disseminate to all individuals in society. Therefore, it has become one of today's colleges' tasks to provide quality-focused scientific knowledge and a new teaching style different from the traditional pattern with which students are accustomed to in our curricula. One that focuses on preparing generations for practice-heavy learning (applied knowledge) and the mindset of production and enhancing awareness among all members of society about the interrelationships between science, technology, and society. The main goal of teaching style is to achieve scientific and genetic literacy in all dimensions for individuals, which cannot be achieved without the coexistence with those issues that have been produced by science and its technical applications. The outcome would then be individuals that are scientifically and genetically enlightened that can make appropriate decisions regarding the problems and issues they face in their society (Al-Khattat, Al-Muhja, & Mohammed, 2019; Boerwinkel, Yarden, & Waarlo, 2017).

What has been discussed so far was summarized by the researchers as follows:

1. This research is the first of its kind in Iraq to scientifically assess genetic literacy in students of natural sciences in education faculties in universities of Furat Al-Awsat.
2. This research may very likely ignite interest in other researchers in the subject of genetic and scientific literacy since not enough research has been done in this area.

Research Aims

The current research aims at assessing the genetic literacy in students of Biology Departments in universities of Furat Al-Awsat. Identifying how genetic literacy differs with varying academic levels, gender, and universities in education schools of Furat Al-Awsat.

Research Limits

This research was limited to students of Biology Departments in education schools in universities of Al-Furat Al-Awsat (University of Al-Qādisiyyah, University of Babel, University of Karbala', Kofah).

Defining Terms

Since the researchers did not find an explicit definition of genetic literacy, they will make a procedural definition and then extract the theoretical definition from it.

Literacy:

Understanding the scientific method to understand the contemporary innovations and different relationships of concepts leads to the benefit and good performance of the individual and the group) Vincent, 2003). It is the ways and methods by which a person expresses the extent of his understanding of the world. In other words, it is a picture of the integrated life of individuals in which the components of the language an individual uses go along with the actions they perform, the values they adopt, and the beliefs they uphold, which in return distinguishes them from other individuals in general and those of his culture (Al-Khattat et al., 2019).

Genetic:

It is the study of traits transmitted from one generation to another and from parents to children. Geneticists are those specialized in this field, and they are interested in the causes and mechanisms of these transfers, which are the foundations of variation and similarities that exist in all living organisms (Turney, 2017).

The researchers believe that genetic literacy is the tool by which an individual achieves a correct understanding of genetics, forms tendencies towards genetic issues and problems, and confronts the genetic changes they are exposed to in their environment and society.

Genetic literacy - operationally:

The ability to understand the nature of genetics and scientific knowledge and its application while interacting with aspects of science in a way consistent with the values involved in it. Moreover, it is to understand and appreciate the interrelationship between genetics, technology, and society and enable the individual to solve genetic problems and make modern decisions concerning himself (Kaye & Korf, 2013; Silawati & Mulyati, 2021).

Departments of Biology Departments:

These are four primary stages of the faculties of education, in this case, in the universities of the Middle Euphrates, Qadisiyah, Babylon, Karbala, Kufa.

Theoretical background and Previous Studies:

The Concept of Scientific Literacy

The concept of scientific literacy was first used to refer to the ability to read and write. The opposite of the English word (literacy) is illiteracy, which in the Arabic language means the (*Ommi*) referring to the individual who cannot read, write or perform simple arithmetic operations. With the world's progress, though, this concept is no longer appropriate in our current age (Laugksch, 2000). That is because the concept of illiteracy no longer means lack of knowledge of reading, book, and simple arithmetic operations but rather goes beyond that. Nowadays, it means the individual's lack of knowledge of the latest developments in science and technology and inability to understand their foundations and methods of dealing with them (DA Roberts, 2013). Given that definition, literacy means that it is the attainment of a level of knowledge and skills that enables the individual to interact well with all areas of life (Alzamili & Mohammed, 2019).

Another way to define literacy is the individual's familiarity with an appropriate amount of scientific knowledge and their understanding of the nature of science, the correct role of the devices being used around them, as well as the acquisition of some positive attitudes towards science and its applications (Edey & Donald, 1994). From the previous discussions, the researchers define *scientific literacy* as the individual's familiarity with an appropriate amount of scientific knowledge and skills and their uses in understanding the nature of science and the environment, interpreting daily phenomena and events, and realizing the interrelationship between science, technology, society, and the environment, which in return makes them able to participate effectively in the life of contemporary society (D. A. Roberts, 2013).

Dimensions of Scientific Literacy

Through the researchers' review of the literature and previous studies on this subject, they found many opinions about the dimensions of scientific literacy, and the following is a summary of these opinions consisting of seven dimensions of scientific literacy:

- Understanding of the nature of science
- Knowledge of the basic concepts of science
- Use of the scientific method
- Interacting in a way consistent with the values of science
- Understanding the relationship between science, technology, and society
- Possession of scientific interests and tendencies

● Possession of manual skills related to science and technology
(Riojas-Cortez, Huerta, Flores, Perez, & Clark, 2008).

Genetic Literacy

Scientific literacy varies from general scientific literacy to a special one, meaning that general scientific enlightenment includes several particular literacies such as technical literacy, physical literacy, chemical literacy, biological literacy, technological literacy, health literacy, environmental literacy, educational literacy, nutritional literacy, civil literacy and other types (Maarschalk, 1986; Samerski, 2014). The Egyptian Association for Curricula and Teaching Methods has used the term literacy in various scientific fields under the so-called qualitative literacy, such as chemical literacy, physical literacy, environmental literacy, biological literacy, and others (Jennings, 2004). From the above, the researchers see that genetic literacy is part of general scientific literacy, and it has become necessary to pay attention to this type of literacy of the individual, especially since genetics is the cornerstone of biology. It overlaps with several other fields, including medicine, agriculture, and biotechnology.

The Dimensions of Geneticist Literacy

According the definition of genetic literacy and the dimensions of scientific enlightenment discussed, the dimensions of genetic literacy to which the current research is committed can be summarized as Table 1:

Table 1. Dimensions of genetic literacy

Dimension	Description
1st Dimension	The history and development of the concept and definition of heredity.
2nd Dimension	The genetic structure and function of the cell, which includes the molecular structure of DNA, DNA replication, RNA replication, chromosomes, hereditary traits, and acquired traits.
3rd Dimension	Genetic laws and codes
4th Dimension	The transfer of traits from parents to their offspring, such as height and baldness. The main factor here is the gene. The gene is the basic unit of heredity in living organisms, and it makes up the chromosomes found in the cell. The other main factor is the allele. The allele is a copy or alternative form of the gene, and when the copies of the gene differ, they are known as alleles and genetic traits, such as physical traits like height and sex-influenced traits.
5th Dimension	Health Genetics: diseases that are genetically transmitted, their causes, and their symptoms.
6th Dimension	Blood Inheritance: Includes topics like inbreeding, genetic diseases, emphasizing examination before marriage, early marriage, late marriage, compatibility of the marrying couples, and offspring health.
7th Dimension	Genetic Technology: Includes the concept like genetic engineering, its importance, the general steps of it, production of genetically modified animals, genetically modified foods, and cloning.
8th Dimension	Reproductive Heredity: including artificial insemination, sex determination in humans, and prenatal genetic diagnosis.
9th Dimension	Mutations and Gene Therapy: includes mutations, natural exposure to mutagenic factors, chemical and physical mutagens, gene therapy, and its types (Al-Khattat et al., 2019).

METHOD

The research community and its sample

Research community: the research community means all the entities where the phenomenon studied by the researcher applies, that is, all individuals, people, and things that are the subject of the research problem (Barreiro & Albandoz, 2001).

In this case, it is the student community of Biology Departments in the universities of the Middle Euphrates, which reached (1505) male and female students. section explains the rationale for the application of specific approaches, methods, procedures or **techniques** used to identify, select, and analyze information applied to understand the research problem/project, thereby, allowing the readers to critically evaluate your project's/study's overall validity and reliability.

Research sample:

The researchers relied on simply randomly selecting a sample that was available to choose from; the sample was chosen so that every individual in the community has the same chance of selection. The sample was chosen from Biology Departments of the colleges of education in the universities of the Middle Euphrates (Karbala, Kufa, and Qadisiyah), and it included 395 male and female students in the faculties of education for the universities of the Middle Euphrates for the academic year 2020-2021. It is essential to mention that the reason for choosing the sample mentioned above is that they are more able and willing to answer questions and read paragraphs as they have acquired enough information in the prior academic stages.

The Research tool:

The researchers prepared a genetic literacy test according to the following steps:
Determine the purpose of the test:
The test aims to identify the extent to which students of Biology Departments have acquired genetic literacy.

Specify the dimensions of the test:

The dimensions of the test have been determined based on the dimensions that were identified in the analysis tool, which turned out to be nine dimensions: the historical development of heredity, the genetic structure of the cell, hereditary rules, genetic traits, healthy heredity, blood inheritance, genetic technology, reproductive heredity, mutations, and gene therapy.

Test content

The researchers formulated the paragraphs of the genetic enlightenment test on a multiple-choice style, which is one of the preferred types of objective questions because:

1. It measures mental goals that most objective questions fail to measure.
2. This type of question facilitates statistical analysis and is characterized by high reliability and validity due to factual correction.
3. The effect of guessing the correct answer is reduced to a minimum.
4. This type covers a large part of the content of the scientific material to be tested.
5. Clarity of questions and ease of answering them. (Stevens, 1946)

Drafting test items

In formulating the test paragraphs, the researchers committed that each paragraph should have four alternatives, only one of which is the correct answer.

The initial form of the genetic literacy test

The researchers prepared a test for genetic literacy by looking at the literature on scientific literacy, including tests on different dimensions of scientific literacy and previous studies concerned with building tests for scientific and scientific literacy in general. That includes the study of Farraj, 1992, and the study of Abu Sultan, 2001. The researchers utilized several paragraphs from those previous studies with some modification in the formulation, deletion of some alternatives, and addition of others. The test in its initial form included 45 items distributed over the nine dimensions of genetic literacy identified above. Different weights were given to different questions, which corresponded to the proportions of analysis reached by the researcher from analysing the content of the study materials.

Face Validity

The validity is reached through an expert's judgment on the degree of representation for the measured trait, Nevo, 1985. Ebel, 1992, indicates that the best way to verify the face validity is that a group of specialists evaluate the validity of the paragraphs to measure what was prepared to be measured (Ebel & Frisbie, 1972). To ensure the validity of the selection, the genetic literacy scale was initially presented to a group of experts specialized in life sciences and the field of science teaching methods. It helped to explore their opinions about the validity of each test item, which include: their relationship and comprehensiveness to the issues that were set to be measured, the extent of the validity of the test paragraphs linguistically and scientifically, the accuracy of formulating the alternatives for each of the test paragraphs, and the appropriateness of the test paragraphs to the level of the students. The analysis results showed that most of the test items had obtained expert agreement except for some deleted items and other added items.

The first exploratory application of the test was in two stages:

The first stage of the exploratory application:

To ensure the clarity of the test paragraphs, diagnose ambiguous paragraphs and test instructions, and calculating the time required to answer the test paragraphs fully, the researchers applied the test in its initial form on 3/14/2021 on an exploratory sample consisting of 40 students that were selected from the faculties of education for the department of life sciences in the universities of the Middle Euphrates (Al-Qadisiyah, Karbala, Kufa). The testing process began electronically, with no time restrictions to complete the test. It turned out that the test paragraphs and the answer choices were clear, and the time taken to answer the test was about 35 minutes. That time was calculated by taking the average of the time taken by the first and last five students to finish answering.

The second exploratory application phase:

After the researchers confirmed the clarity of the test paragraphs and their instructions and the appropriateness of test timing and to verify the psychometric properties of the test paragraphs, it was applied a second time to an exploratory sample consisting of 395 students who were randomly selected from the faculties of education for the Department of Life Sciences at the Middle Euphrates University on 3/18/2021 through 27/3/ 2021. The researchers informed the students of applying the test a week before its application, and the researchers themselves supervised the test.

Test Grading

● One point was assigned to each question, giving the full mark (one point) for each question answered correctly, and zero points for each question answered incorrectly, left unanswered, or answered with more than one answer choice. The total score for those tests ranged from zero as the minimum and 45 as the maximum, and the grading was done electronically.

● Determining the psychometric properties of the test:

● The objective of determining the psychometric characteristics of the test, or what is known as statistically analysing the test paragraphs, is to improve it and know its validity for application. The efficacy of the answer alternatives was also assessed with these psychometric properties.

Difficulty Factor for Items

A *paragraph's difficulty coefficient* is defined as the percentage of students who answered the paragraph correctly to the total number of students who attempted it (Reckase, 1985). When this definition was applied to each paragraph, the results showed that all the difficulty coefficients of the paragraphs ranged between 0.21-0.79, and thus the number of paragraphs remained 47, as Bloom et al., 1983, considers that the paragraphs are acceptable since their difficulty coefficient ranged between 0.20-0.80 (van de Watering & van der Rijt, 2006).

Items Discrimination Coefficient

The discrimination coefficient means the ability of the item to distinguish between students with higher and lower levels in the trait being measured by the test (Black, Dickson, & Blue, 2021). To confirm the appropriateness of the test, the upper and lower extreme samples with a percentage of (27%) as the best two groups to represent the sample (Pedraza, Sachs, Ferman, Rush, & Lucas, 2011), and the number of students in each group turned out to be (107). By applying the equation for the discrimination coefficient, the results showed that all paragraphs ranged between (0.21 - 0.68), except for paragraphs (19) and (43) were not within the required criterion, so they were excluded from the test list. Consequently, the number of test items became (45) items. In short, the items whose discriminatory strength ranged between (0.20- 0.80) were considered reasonable in terms of their appropriateness, thus were kept as a part of the test.

Effectiveness of Wrong Alternatives (Effectiveness of destruction)

The effectiveness of destruction is the ability of the wrong alternatives to attract students from the lower level to choose them as the correct answer. An alternative that does not get chosen by any higher or lower-level students is considered ineffective and must be replaced by a more appropriate one. In fact, the more a wrong alternative is chosen and ignored by the lower and higher-level test-takers, respectively, the more effective it is considered to be (Gipps & Murphy, 1994). On the other hand, when an alternative is not chosen by either the higher or lower-level test-takers, it must be replaced as it is also considered ineffective. Therefore, the researchers took these concepts into account and found out that the lower-level students primarily chose the wrong answer choices, and that is why they concluded the effectiveness of the wrong answer alternatives and decided to keep them.

Internal Consistency Validity

The validity of internal consistency is defined as that each test item must follow the same tendency that the test answers follow in general. In other words, for the test answers to be considered internally consistent (Mohammed & Abd Oun, 2020), the answers to a group of test items that test for a similar tendency or can be considered to test for a specific general tenancy must be consistent – follow the same tendency. It can be checked by comparing the answer to each question with the general tendency of the test taker as shown by their answers to the rest of the questions (Wrisley, Marchetti, Kuharsky, & Whitney, 2004). This consistency is what is meant by the internal consistency validity, which was checked by calculating the Pearson correlation coefficients of each dimension of the test and the t-values and comparing the calculated values with the predicted ones at a statistical significance value of 0.05, degree of freedom of 393, amounting to at-value of +/- 1.96. Calculated results were more significant than the tabular ones, which means that the results are statistically conclusive.

Reliability

The stability of the test is an essential condition of the measurement tools, and the fixed test is the test that measures the phenomenon with an acceptable degree of accuracy; the stability of the test means that it gives identical results in its measurement of an aspect of behavior if that test is used more than once and if it is used in different ways (Alzamili & Mohammed, 2020; P. Roberts & Priest, 2006). The stability of the genetic literacy test has been verified using the Kuder- Richardson Formulas 2020 method (Abed, 2016). This method is one of the most appropriate methods for extracting the stability of a test in cases of objective tests with specific answers whose paragraphs have one correct answer and whose other alternatives are worth zero points (Zimmerman, 1972). After calculating the stability coefficient in this way, it was found to be equal to (0.83), and this indicates that the stability coefficient and the test are appropriate since a test is considered appropriate when the stability coefficient is more than 0.67.

The final form of the genetic literacy test

The test in its final form consists of (46) paragraphs where each item is worth one point. Thus, the maximum grade of the test becomes (46) points, and the hypothetical mean is (23) points.

The ultimate application

After completing the test's validity, reliability, and psychometric characteristics, the researchers applied the test in its final form to the primary research sample, which consisted of (395) male and female students.

RESULTS & DISCUSSION

Result

The first objective:

To identify the acquisition of genetic literacy by students of the life sciences departments of the faculties of education. To verify this goal, the researchers used the One-Sample t-test to compare the arithmetic mean of the sample (23.13) with a standard deviation of (7.65) with the hypothetical mean of the test (23). It was found that the calculated t-value (0.349) is smaller than the tabular t-value at the level of significance (0.05) and degree of freedom (393), which is (±1.96). It means accepting the null hypothesis, which indicates that the students of the life sciences departments do not possess the genetic enlightenment as shown in Table 2.

Table 2. The results of a single-sample T-test for genetic literacy

Significance & Conclusion	Sample Size	Hypothetical Mean	Mean	Standard Deviation	Calculated t-value	Tabular Size	Sample Size	Sample
Insignificant – They do not possess genetic literacy	395	23	23.13	7.65	0.349	1.96	395	Students of Biology Departments in faculties of education in universities of the Middle Euphrates

Table 2 shows that the students of the life sciences departments do not have genetic enlightenment. This result can be explained because the content of the lectures studied by these students that were analyzed indicates their lack of genetic literacy, especially the subjects in the first and second grades. It is reflected by the students' low level of genetic literacy, while it is

assumed that the students enjoy a high degree of genetic literacy. This result is consistent with many other studies, including the study of Alameddin, 2007, which dealt with biological literacy, and Farraj, 1992, which dealt with scientific literacy.

The second objective:

To identify the variation of genetic literacy among students of the departments of life sciences in the universities of the Middle Euphrates according to the variables of gender (females - males), grade (first - second - third - fourth), and university (Qadisiyah - Karbala – Kufa). For this goal, the researchers used the Three-way ANOVA, and the results are shown in Table 3:

Table 3. The results of the analysis of three-way ANOVA for the variation of genetic literacy according to the variables of sex, grade, and university

Source	Type III Sum of Squares	df	Mean Square	F	Sig
Corrected Model	3736.005[a]	23	162.435	3.118	.000
Intercept	42481.148	1	42481.148	815.428	.000
Sex	68.828	1	68.828	1.321	.251
Stage	394.042	3	131.347	2.521	.058
University	248.268	2	124.134	2.383	.094
Sex * Stage	73.821	3	24.607	.472	.702
Sex * University	36.240	2	18.120	.348	.706
Stage * University	403.873	6	67.312	1.292	.260
Sex * Stage * University	588.771	6	98.128	1.884	.083
Error	19327.884	371	52.097		
Total	216583.000	395			
Corrected Total	23063.889	394			

a. R Squared = .162 (Adjusted R Squared = .110)

Sex (Gender):

It turned out that the calculated F-value amounted to (1.321), which is smaller than the tabular F-value at the level of significance (0.05) and the degree of freedom (1-393), which is (3.84). That means that there are no differences in genetic literacy due to gender.

Stage:

It turned out that the calculated value (F) amounted to (2.821), which is greater than the tabular value at the level of significance (0.05) and the degree of freedom (3-391), which is (2.6). It means that there are differences in genetic literacy due to the class, and to know the source of the difference, the researchers resorted to the test (LSD), the least significant difference - LSD, its calculated value reached (2.17), and the results were as in the Table 4. Figure 1 illustrates this as well.

Table 4. The results of the post-analysis in comparison with the calculated LSD value for the mean differences in genotype by grade

Stage	Academic Level	1st level	2nd level	3rd level	4th level	Value LSD
Academic Level	Mean	17.50	18.99	23.31	24.27	
1st Level	17.50	-	-1.49	-5.81*	-6.76*	
2nd Level	18.99	-	-	-4.32*	-5.27*	1.6
3rd Level	23.31	-	-	-	-0.95	
4th Level	24.27	-	-	-	-	

*a value is conclusive at significance value of 0.05

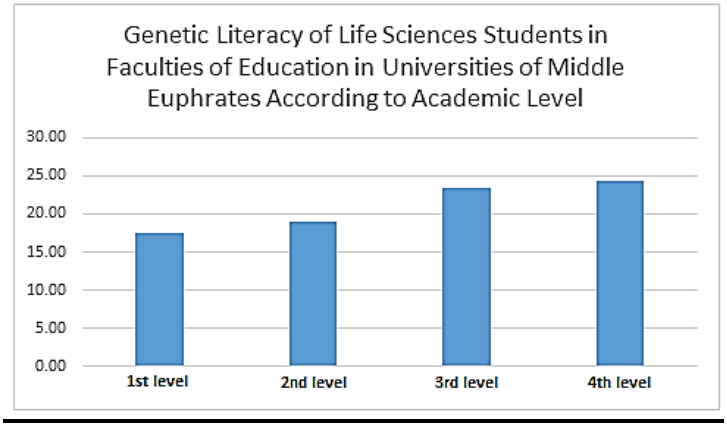

Figure 1. Comparison of Genetic Literacy of Life Sciences Students in Faculties of Education in Universities of Middle Euphrates According to Academic Level

University:

It turns out that the calculated value (F) amounted to (2.383), which is smaller than the tabular value at the level of significance (0.05) and the degree of freedom (2-392), which is (3.00), which means that there are no differences in genetic enlightenment due to the university where the student studies. It can be explained by the lack of books that deal with scientific literacy in general and genetic literacy in particular in the public libraries of the university, in addition to the department's libraries' lack of certain essential books.

*Interaction of Sex * Class:*

It turned out that the calculated F value amounted to (0.472), which is smaller than the tabular F value at the level of significance (0.05) and the degree of freedom (3-391), which is (2.6), which means that there are no differences in genetic literacy due to to the interactions of gender and academic level of the students. This result can be expressed by the fact that the teaching of genetics in the initial stages of life sciences departments depends to a large extent on recitation and lecture, which may lead to the formation of a false perception among students that genetics is just the central concept and easy to memorize, and therefore the student's thinking is limited to memorization only.

*The Interaction of Sex * University:*

It turned out that the calculated value (F) amounted to (0.348), which is smaller than the tabulated value at the level of significance (0.05) and the degree of freedom (2-393), which is (3.00), which means that there are no differences in genetic enlightenment due to the interactions of gender and the university where the student studies. This result can be expplicated by the fact that the student is left free to attend lectures without supervision, which reduces the benefit that students can obtain, as he is limited in his studies to what is mentioned in the book without benefiting from the discussions that take place in the lectures.

*Class * University Interaction:*

It turned out that the calculated value (F) amounted to (1.292), which is smaller than the tabular value at the level of significance (0.05) and the degree of freedom (6-389), which is (2.10), which means that there are no differences in genetic enlightenment due to the interactions of the class and the university in which the student studies. This result can be interpreted by the fact that there are reasons that lead to the difficulty of conducting activities

that help in acquiring genetic information, including the lack of financial capabilities, the increase in the number of students in one school stage, and the lack of sufficient time to enhance such type of literacy.

*Interaction of Gender * Sex * University:*

It turned out that the calculated value (F) amounted to (1.884), which is smaller than the tabular value at the level of significance (0.05) and the degree of freedom (6-389), which is (2.10), which means that there are no differences in genetic literacy due to the interaction of gender, grade, and university where the student studies. This result can be described by the fact that the main reason for the low level of students is the superficial treatment of the content of the subjects of the life sciences departments for some dimensions of genetic literacy. In other words, it is not in-depth that allows students to study and understand these dimensions. That is in addition to the lack of classroom activities and books containing genetic literacy in university libraries.

CONCLUSION

Through this study, the researchers reached conclusions that the genetic literacy among students of life sciences at Middle Euphrates universities. The level of genetic literacy among third-level students is less than the required sufficiency limit. After the genetic structure of the cell, he obtained the highest percentage of contribution to achieving the final result of the genetic literacy test. There are no statistically significant differences in the level of genetic literacy between the different genders.

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