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A Novel Expert System to Assist High School Students in Selecting their Appropriate University Program: A Case Study of Hebron University

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Abstract:

Information and Communication Technology (ICT) became a measure of the level of progress of an organization and shows its ability to compete. There is no doubt that the applications of Artificial Intelligence (AI) have contributed to a technological progress in various fields among which is expert systems, which is defined simply as the system that replaces or assists a human expert in a complex task that requires specialized knowledge. The fundamental purpose of the present study is to propose and develop an expert system to guide high school students in choosing the appropriate university major at Hebron University as a case study. In addition, the system uses both rules and machine learning algorithms to analyze the student's characteristics and abilities and to display the best university programs that suit his personality. The results showed that 85% of the students were satisfied with using the system and recommended using it.

Keywords- High School Students, University Program, Expert System, Hebron University, GPA, Market Demand, Holland Theory, Machine learning, Decision Tree Classification (DTC).

نظام إلكتروني خبير حديث لمساعدة طلبة الثانوية العامه في اختيار التخصص الجامعي المناسب: دراسة حالة جامعة الخليل

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الملخص:

أصبحت تكنولوجيا المعلومات والاتصالات (ICT) مقياسًا لمستوى تقدم المنظّمة، وتظهر قدرتها على المنافسة. لا شكّ في أنّ تطبيقات الذكاء الاصطناعيّ (AI) قد أسهمت في تحول تكنولوجي في مجالات مختلفة من بينها الأنظمة الخبيرة، التي تُعرَّف ببساطة على أنها النظام الذي يحلّ محلّ خبير بشريّ أو يساعده في مَهمةٍ معقدةٍ تتطلب معرفةً متخصّصةً. والغرض الأساسيّ من الدراسة الحالية هو اقتراح وتطوير نظام برمجيّ خبير لتوجيه طلاب المدارس الثانوية في اختيار التخصّص الجامعيّ المناسب في جامعة الخليل باعتبارها دراسة حالة. بالإضافة إلى ذلك، يستخدم النظام كلًّا من القواعد وخوارزميات التعلّم الآليّ لتحليل ميول الطالب وقدراته وعرض أفضل البرامج الجامعية التي تناسب شخصيته. أظهرت النتائج أنّ (85٪) من الطلاب راضون عن استخدام النظام وأوصَوْا باستخدامه.

الكلمات المفتاحية: طلاب المدارس الثانوية، البرنامج الجامعيّ، النظام الخبير، جامعة الخليل، المعدل التراكميّ، طلب السوق، نظرية هولند، التعلّم الآليّ، خوارزمية تصنيف شجرة القرار (DTC).

Introduction

Rapid progress in the field of Information and Communications Technology (ICT) has made information technology a lifestyle and an indispensable tool. Technology became a measure of the level of progress of an organization and shows its ability to compete. There is no doubt that the applications of Artificial Intelligence (AI) have contributed to a technological progress in various fields among which are expert systems, which has grown from a mere idea into a practical reality contributing to the development of many systems. The expert

system can be defined simply as the system that replaces or assists a human expert in a complex task that requires specialized knowledge. Recently, the use of expert systems has spread around the world and in various sectors including the educational sector. Simsek et al (Simsek et al., 2019) discussed the use of expert systems in individual online exams. Moreover, the research conducted by Supriyanto et al (Supriyanto et al., 2019) investigated developing an expert system that aims at providing career guidance for the students.

Usually, students choose their major without any scientific bases or international standards which can help them in determining the specialization that suits their personality and takes into account current market demand (Mundra et al., 2014). Students select the major they wish to study according to their high school branch in which they studied for their high school and according to the grade point average (GPA). However, students were facing some difficulties in choosing the major that will determine their career in the future. Further, the selection process may be affected by many factors including tendencies, personality traits, the demand of the local market, and other influential factors, such as friends and family or the social status of the specialty (Jassem & Helou, 2014; Mundra et al., 2014). As a result, the process of choosing a major becomes even harder. The researchers found that 48.8% of Hebron University students were influenced by the opinions of their parents when choosing their university major, 36.4% were influenced by the opinions of their friends. Yet, it can be notified that our country is in dire need of development to catch up with the technological revolution. This can be illustrated in the fact that, until now, there is no electronic system approved by the Palestinian Ministry of Education and Higher Education to help high school students in choosing their university majors. Therefore, the present study aims at shedding light on an expert software system that helps students in the process of choosing the appropriate university major. It also takes into account market demand which depends on international standards and statistical indicators.

The development of such a system will be of major benefits to the students, as they will not have to follow traditional methods such as consulting family or

friends when choosing their university major. Thus, through this system, they can get to know their personality and the specialization that suits them best, and this will definitely reduce their tension and the possibility choosing a specialty that might not be suitable for them. Moreover, through this system, students can view details about the job opportunities available in the market, and the specializations that are required for the market demand.

Research Objectives

As mentioned previously, the fundamental purpose of the present study is to propose and develop an expert software system to guide high school students. The detailed objectives of the current research include the following aspects:

1 Determine the factors that affect the student choice of their university program from the student viewpoint.
2 Investigating student opinion towards developing an expert system that helps high school students in choosing their university program.
3 Developing and testing the novel expert system that helps high school students choose their university program.

Literature Review

Several previous studies have investigated expert systems implementation to solve the problems which high school students face. Thus, one of these problems is the process of choosing a university specialization. This will be discussed in this section.

Naser et al. (Naser et al., 2008) developed a rule-based expert system to measure the capabilities of students who intend to enroll at Al-Azhar University in Gaza. Their expert system is developed using visual basic and C Language Integrated Production System (CLIPS) to build the rules and facts that will be stored in the knowledge base. Yet, CLIPS does not support graphical interfaces, so their system was designed as a desktop application, accordingly, it is not easily accessed. Moreover, their system focused on analyzing students' abilities such as intelligence and finding a college or major that suits their abilities only.

Albakri et al. (Albakri et al., 2017) discussed the problem of choosing the appropriate university major for high school students wishing to enroll in

Palestine Polytechnic University (PPU). The researchers indicated that 7% of students are influenced by their family's opinion when they choose their university major, and 21% of them think that the financial aspect has an impact on their choice of major. Their research did not address an actual analysis of the requirements of the Palestinian market, and did not employ machine-learning algorithms in their proposed expert system.

Hayadi et al. (Hayadi et al., 2018) proposed a solution to the problem of choosing university specialization among students of higher education in Indonesia. The research pointed out that many students do not know their abilities and personalities and prefer to listen to the opinions of their families or friends when choosing their university major. Many students do not prefer to go to a psychologist to discuss their intelligence capabilities. Therefore, researchers believed that modern technologies can be applied to develop an expert system to determine the appropriate specialization for higher education students. In addition, the researchers presented their design for the expert system, relying on the Unified Modeling Language (UML) process and Microsoft Access as a database. To design the system interfaces, it was used the Microsoft Visual Studio program. Although their research is characterized by simplicity, yet, its final result provides the student with an explanation of his capabilities such as his level of intelligence. Besides, it represents an alternative or assistant system for a psychological guide. However, the researchers do not give the student details about his personality or the specialty that suits him.

A research conducted by Bakkar (Bakkar, 2018) provides a roadmap for economic and developmental work in the upcoming years in Saudi Arabia. Bakkar's work provides a full explanation of the most important university disciplines and diplomas in line with the Kingdom's ambitious directions for the year 2030. The Kingdom of Saudi Arabia has adopted this vision to set out the general policies, objectives, goals, and commitments to be a leading model at all levels. In the system, the researcher has linked all the career paths presented in his study with the Discover platform which is the largest Saudi platform to help students choose their path after high school. The platform provides two metrics

to help students discover their inclinations through the Arab Scale for Professional Attitudes (ACIA). They also can discover the students' ability through The Arab Scale for Multiple Intelligences (AMIAS).

The system proposed by Ween (https://ween.ps/universities) provides high school graduates or undergraduate students with easily accessed information on the specializations offered by Palestinian universities. Ween's system offers some study plans and conditions for admission to certain specializations in Palestinian universities. However, this system is still under development. The system provides information regarding the appropriate specialization of the students based on their GPA without taking into account their wishes, tendencies, and abilities.

Fiarni et al. (Fiarni et al., 2019) Produce a rules-based system that helps students choose a sub-discipline of Information Systems. The researchers developed a decision support system (DSS) based on the decision tree algorithm. The researchers first extracted information systems graduate's data regarding their academic performance and professional career history to support the selection of a minor major in information systems. They found that the student's competence and behaviour affect his choice of major. Fiarni et al. research is another important starting point in enriching the research in the field of academic data mining because the researchers used machine learning tools in developing their application.

However, the expert system of the present research provides details about the student's personality type, the specialization that suits his abilities, informs students of the jobs that they can choose in the future, and provides details about the labour market. Furthermore, our expert system is characterized by being easily used and accessed via the Internet. Moreover, our expert system is a complex system, consists of two parts, the first is rule-based, and the second is machine learning-based, which is detailed in the follows sections.

Research Methodology

Figure 1 shows the methodology used in the research. The first stage in this methodology aimed at identifying the most important factors affecting the choice

of high school students for their university major by reviewing literature review and distributing a questionnaire published to students of HU to find out the factors that affected their choice of specialization. Another questionnaire is published for graduates in order to analyze the needs of the Palestinian market for university majors. After that, the researchers analyzes the results of the questionnaires and presents them in the form of tables and charts, which reflects upon the importance of the Descriptive-Analytical Methodology (DAM) methodology. The DAM tends to study the phenomenon as existed in practice. It is concerned with an accurate description and is expressed qualitatively to reflect upon its characteristics. In addition, it is quantified by giving a digital description by displaying numbers and tables which demonstrate the extent of this phenomenon, its size, or degree of association with other phenomena. Moreover, the DAM is used in collecting and analyzing data. The following stages represent the steps of developing expert systems, which is represented in knowledge elicitation, and extracting the rules to move to the implementation stage, where the extracted knowledge is stored in the knowledge base, and accessed through the inference engine that uses the rules extracted. Furthermore, in this stage, the machine-learning model is implemented by creating a data set and using machine-learning algorithms. Finally, the testing phase is necessary to improve the implementation. All of these stages will be discussed in details in the following sections.

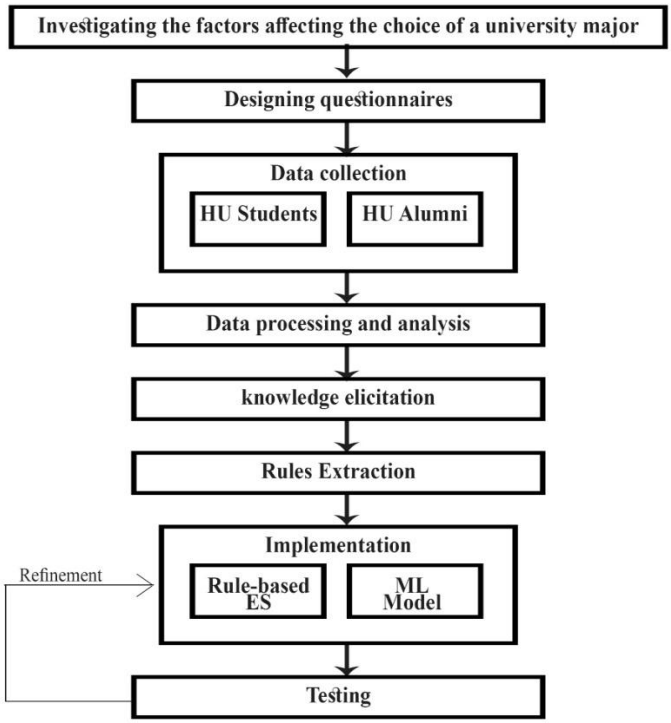


Figure 1. Research Methodology.

Methods

Proposed model

Our expert system is addressing the scope of specializations at Hebron University, which contains 12 colleges that give bachelors and diploma degrees. This system will analyze the abilities and desires of the students to suggest to them the best university program (s) that matches their personalities.

After the data have been represented in a set of models and decision tables to retrieve the required knowledge, the next step is to implement the system in a way that achieves its primary goal that helps high school students choosing their university program. This will be done by using the infrastructure presented in Figure 2 that shows the main components of our expert system. It should be noted that our system is a combined system, which means that it consists of the integration of the following two systems:

- Rules-based expert system.
- Machine-Learning-based expert system.

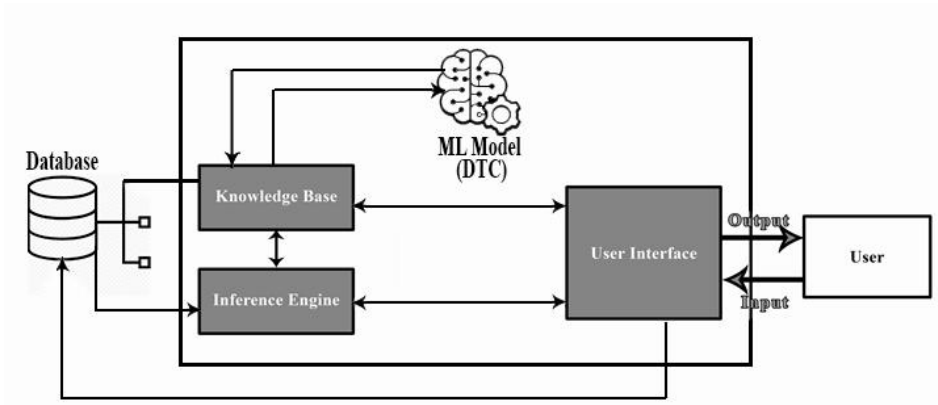


Figure 2. Basic Components of our Expert System**.**

Rules-based expert system

This type of expert system runs a series of (If-Then)-based rules to arrive at a specific conclusion to solve the problem according to the data given to the system. These systems can simulate the ability of human experts to make decisions. they are designed to solve problems in a way that mimics what humans do by exploiting encoded human knowledge or experience (Engin et al., 2014). Our system analyses the most important criteria that have a significant role in guiding student's choice to the right university program. These criteria can be summarized as follow:

1. **The personality test:** The test is based on Holland's theory (Holland, 1987) of personality analysis. At the end of this test, the expert system suggests the program (s) that fit the student's personality within the disciplines of HU. According to Holland, individuals can be characterized by their resemblance to each of the six personality types (Mumme, 1997; Salah, 2010): Realistic (R), Investigative (I), Artistic (A), Social (S), Enterprising (E), and Conventional (C). Holland's theory proposed that everyone has a unique blend of many types. People fulfill

two of the six characteristics primary and secondary as shown in the matrix in Table 1.

Table 1. Matrix Character Codes According to Holland's Theory**.**

Primary		Secondary					
		R	I	A	S	E	C
R		RR	RI	RA	RS	RE	RC
I		IR	II	IA	IS	IE	IC
A		AR	AI	AA	AS	AE	AC
S		SR	SI	SA	SS	SE	SC
E		ER	EI	EA	ES	EE	EC
C		CR	CI	CA	CS	CE	CC

2. **Student's GPA and the branch of high school:** This factor determines the university's requirements (Admission and enrollment criteria).
3. **Palestinian market:** This factor determines the needs of the Palestinian market of specializations at HU. This lies in the work of collecting real data regarding the graduating students who work in Palestinian institutions, companies, centers, and the specializations that have high market demand.

This part of the expert system depends on two basic components, as shown in Figure 2.

1- Knowledge base, which contains the main Holland personality types.
2- Inference engine is the mind of the expert system as it works to interpret and analyze the rules stored in the knowledge base.

It should be noted that the expert system handles many cases as follow:

- **Equalities:** In the case that the results of the analysis of the questions that the student answered were equal between three or more types of characters, the expert system has been developed to work on asking more questions, and in the end, this equality will be solved.
- **Randomness:** In the case that the student answers randomly to the questions, the system deals with this case by displaying the majors offered for characters consisting of two identical letters, such as RR, CC, etc.

- **Programs details:** after completing the previous analysis, the student will receive the programs (s) that suit his/her personality. Further, the student can view details about this program (s), such as proposed jobs for graduates, unemployment rates, salary rates, and charts.

Figure 3 shows the sequence of operations that the system goes through when the student enters the personality analysis page.

Machine learning model

Machine learning (ML) is a type of artificial intelligence that allows software applications to become more accurate at predicting outcomes without being explicitly programmed to do so (Géron, 2019; Hilbert et al., 2021). In addition, ML algorithms had to evolve and provide us with the keys to classifying and analyzing input data. So, our expert system uses ML to dynamically produce the output based on the input data comprising features with some specific characteristics.

In our expert system, the Decision Tree Classification (DTC) algorithm was used, which is one of the most famous supervised machine learning algorithms, dividing dataset like a tree, as it sorts the tree from the root to some leaf nodes up to the decision (Puica & Florea, 2013; Sarker, 2021). This is perhaps the most important advantage of the algorithm, it breaks down the complex decision-making process into a set of simpler decisions, thus, providing an easy-to-interpret solution (Budhiraja & Mago, 2018; Chourasia, 2013). Python language was used to implement the machine-learning model in our expert system.

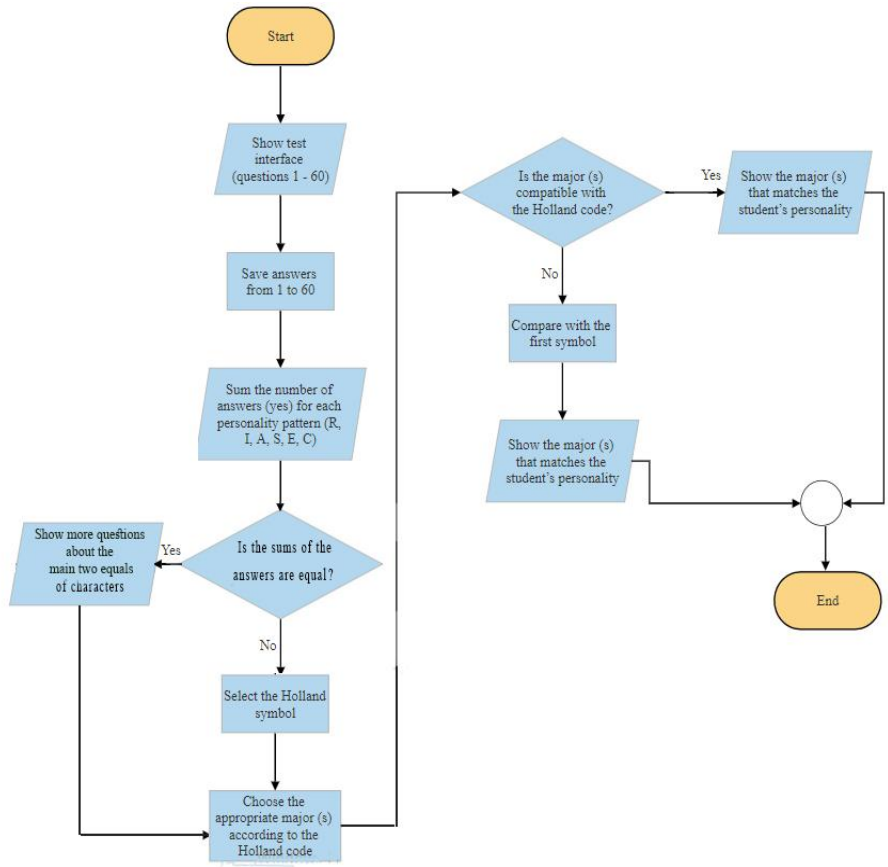


Figure 3. Rule- Based Expert System Development Flowchart

Dataset Description

Our expert system analyzes user entered inputs: student GPA, high school branch, student character, which is obtained in the form of Holland code resulted from student answers. These entries have been placed as a dataset in a CSV file, which consist of 2520 records. Table 2 shows a portion of the dataset.

Table 2. Sample of the Dataset.

Branch	GPA	Personality	Class	Program (s)
0	1	1	A	Computer Science
0	1	2	B	Plant Production & Protection Electrical Installations Engineering (Two years) Protected agriculture and nurseries (Two years)
0	1	3	C	Media Maintenance and Building Restoration (Two years)
0	1	4	D	Pharmacy Physical Training Electrical Installations Engineering (Two years)
0	1	5	E	Computer Science- Mobile Programming Tourism and Antiquities Mobile Phone Technology (Two years)/
0	1	6	F	Computer Science Mobile Phone Technology (Two years)

The first column shows the high school branch, and it is expressed in a numerical variable as follows: 0 represents the scientific branch, 1 represents the humanities branch, 2 represents the commercial branch, 3 represents the agricultural branch, 4 represents the industrial branch.

The second column in the dataset indicates the high school GPA, and it was also expressed in a numerical variable according to the following: 1 represents for 100>GPA>=90, 2 represents for 90>GPA>=85, 3 represents for 85>GPA>=80, 4 represents for 80>GPA>=75, 5 represents for 75>GPA>=70, 6 represents for 70>GPA>=65, 7 represents for 65>GPA>=50.

The third column indicates the Holland symbol for the student's character. Shown in Table 2. It is expressed numerically from 1 to 36.

The fourth column in the dataset shows a text symbol representing HU major (s) that corresponds to the entries in the previous three columns. This column represents the output of the DTC analysis.

The last column represents the actual program (s) that each symbol expresses. As the output of machine learning analysis is the text code mentioned in the previous column, the inference engine searches in the knowledge base in the class field to display the program (s) that represent this text code.

Decision Tree Classification (DTC)

In order to analyze these inputs and obtain the best results, the Decision Tree Classification (DTC) algorithm is used. It divides data like a tree as it sorts the tree from the root to some leaf nodes up to the decision (Sarker, 2021). Nodes in a decision tree can be categorized into two types; the first is the Decision Node, which has many branches to reach the decision. The second type is the Leaf Node, which is the output of those decisions and does not contain any other branches. The decision nodes are divided into sub-nodes according to the specified conditions in a process called splitting. The splitting process results in a set of internal nodes that represent the features of the dataset, the branches represent the decision rules, and the outcome is the leaf nodes. This is perhaps the most important advantage of the algorithm, it breaks down the complex decision-making process into a set of simpler decisions, thus, providing an easy-to-interpret solution (Budhiraja & Mago, 2018; Chourasia, 2013). Moreover, Python language was used to implement the machine-learning model in the current expert system Figure 4 shows the sequence of steps the system goes through when it predicts the appropriate program (s) for a student.

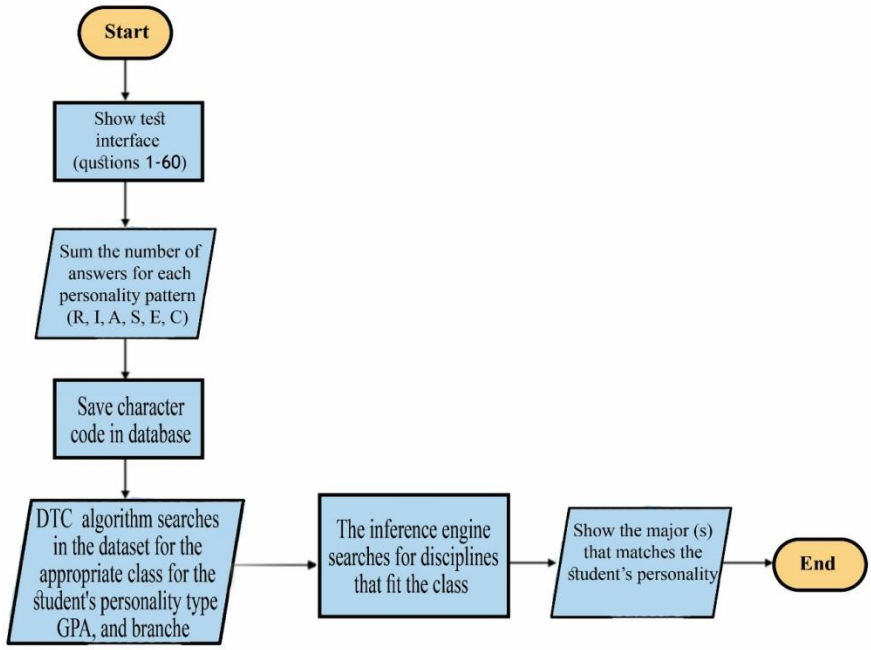


Figure 4. The Flowchart of Machine Learning Process

Results and discussion

The current study results are divided into two parts. The first section is about the results of the study related to the student views on the factors affecting the choice of university major, and their opinion about the development of the current expert system. While the second section relates to the development and testing of the expert system and analysing market demand. The results were as follows:

1. From the viewpoint of the HU students, the process of choosing their university major is highly influenced by the needs of the Palestinian market (70%). Moreover, it is moderately affected by both admission and registration requirements (52) and social conditions (50%).
2. From the viewpoint of HU students, they greatly support (78%) the idea of the thesis and wanted to develop an expert system that would help high school students in choosing the appropriate university major for them.

3. From the viewpoint of high school students wishing to enrol at HU, the system is highly beneficial to them (85%) and helped them choose their university major.
4. The results of the Palestinian market analysis showed the following:
    - The highest unemployment rates in Palestine were among graduates of journalism and media. Where the unemployment rate for males was (60%) and for females (86%).
    - The lowest unemployment rates in Palestine among males were among law graduates (28%). The lowest unemployment rates in Palestine among females were among graduates of the Personal Services major (37%).
    - The highest unemployment rates in the West Bank were among graduates of the majors of Teacher training and education sciences (57%).
    - The lowest unemployment rates in the West Bank were among graduates of personal services majors (16.3%).
    - The highest wage majors in Palestine are natural sciences, mathematics and statistics, and law. The average monthly wage in NIS was 3133, 3084, and 2,943, respectively

The expert system is of great benefit to the student when choosing the university specialization because it works on analyzing the student's personality and abilities in addition to introducing him to market demand. The results of the evaluation process showed that 85% of high school students found the expert system useful to them when choosing their university major, unlike the traditional methods used.

Table 3 shows a comparison between our composite expert system consisting of rule-based system and machine learning-based system.

Table 3. Comparison Between the Current Composite Expert System.

	Rule- based	**Machine learning**
Inputs	GPA, Branch, Holland Code	GPA, Branch, Holland Code
The input is stored in	Database and Knowledge base	Dataset as CSV file
Algorithm	An algorithm based on if- then statements has been developed	DTC
Language	PHP	Python
Output	The specializations offered by HU and suitable for the student's personality. If more than 6 majors appear, they are categorized into major and minor, based on the GPA.	The specializations offered by HU and suitable for the student's personality.
Accuracy of results	100%	98%
Properties	Static	dynamic, categorize, predict

Through the previous table, it is noted that the use of expert systems in higher education institutions is necessary and beneficial to various parties. Machine learning techniques make the system dynamic and able to learn from previous cases, unlike a rule-based system. This lies in the ability of machine learning algorithms to classify and predict. However, this is at the expense of accuracy, as the rules-based system guarantees to obtain the greatest accuracy because it depends on (if-Then) rules pre-determined through decision tables.

A precision testing process is applied to ensure that the expert system achieves its primary objective and provides accurate results. Therefore, part of the system is dedicated to assessing the students' level of satisfaction with the results provided by the system. Moreover, a random sample of the data was collected from high school students wishing to enrol in one of Hebron University's university programs in the first semester of 2021 to apply the testing process.

The researcher chose a sample of 200 high school students to conduct the test process. Table 4 shows the test process questions presented by the system, and an analysis of the students' answers.

Table 4. Evaluation Process Analysis.

Numb	**General Questions**	**Percentage**
1.	Gender	• 64.5% Female • 35.5% Male
	Evaluation Questions	
1.	I think this system is useful for me.	85%
2.	I see that the result of the personality analysis test is logical and realistic.	81%
3.	I believe that the Palestinian Market Analysis pages provided by the system are useful and necessary in choosing my university major.	76%
4.	I believe that the analysis of the admission and registration requirements (such as average, University branch) provided by the system is essential.	83%
5.	I think that the system is easy to use.	90%
6.	I like the system`s design, colors, and icons.	85%
7.	I believe I can trust the results provided from the system.	77%
8.	I advise others to use this system.	86%
9.	If you have any comments or suggestions,	The most important

	please write them below.	suggestions from the students: -Add intelligence tests. -Add in-depth questions in some areas.

The results of the analysis showed that 85% of these students believe that our expert system is useful in choosing their university major. Moreover, 81% of them are satisfied with the results of their personality analysis. In addition, 76% of these students believe that the market needs analysis provided by the system are necessary in the process of choosing their university major. Furthermore, 90% of the students liked the designs and colors of the system. Finely, 86% of the students advise others to use the current expert system.

Conclusions, Future work and Contributions

The researcher through the results of the analysis noted, that there is a great demand by high school students to use our system to direct them. Accordingly, it is necessary to work continuously in updating the system data.

Our expert system has a great benefit to high school students by helping them to choose their appropriate major and the area in which they can innovate. Thus, it contributes to the formation of their promising future and helps universities by:

- Guiding high school students.
- Obtaining statistics and indicators that support and assist in the process of selecting the university major.
- Reducing unemployment rate in some majors.
- Finding specialists in fields within scientific studies and according to the market's needs.

Moreover, our system will contribute to increase the quality of education, in which, with the right choice being present, the number of students transferred or leaving for a particular major will be reduced. Furthermore, this system is important to the community and its institutions since it helps to place the right person in the right place, the matter that would elevate the institution's name and status.

Potential improvement and future work on the system include:

- Developing a mobile application. The students can download the application on their smartphones, thus, accessing the system would be easier.
- Developing the system to include all colleges and majors in all of the Palestinian universities.
- Adding a set of other tests to the expert system such as Intelligence quotient (IQ) tests.
- After applying the system to hundreds of students, more data can be retrieved from their interactions with the system. These data can be structured data, time stamp platform access, scores of a quiz among others.

This research provided many contributions that some future studies will rely on. These contributions are:

- Expert system development: The expert system has been developed under the name (The Path). You can access it through the following link (esaseel.com).
- Dataset: The dataset is useful for conducting more future research. The researchers have developed a feature that allows the user to give feedback on the experience of using the system, and thus the researchers can develop the system so that it can predict the specializations to the student by training the system to deal with similar cases, and thus reduces processing time.

- Market analysis: The system provides indicators about the market needs of the majors offered by Hebron University, such as unemployment rates, salaries, and some proposed jobs in the Palestinian market for graduates of these majors. As shown in Figures 5 and 6.

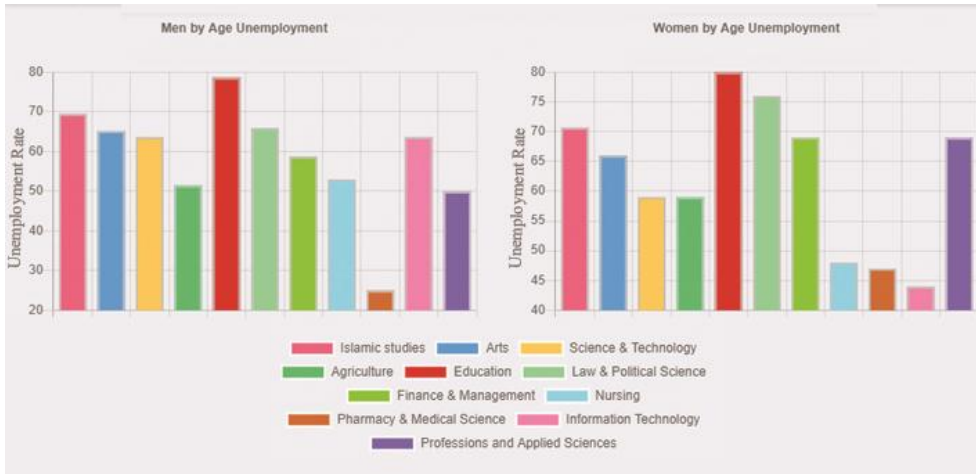
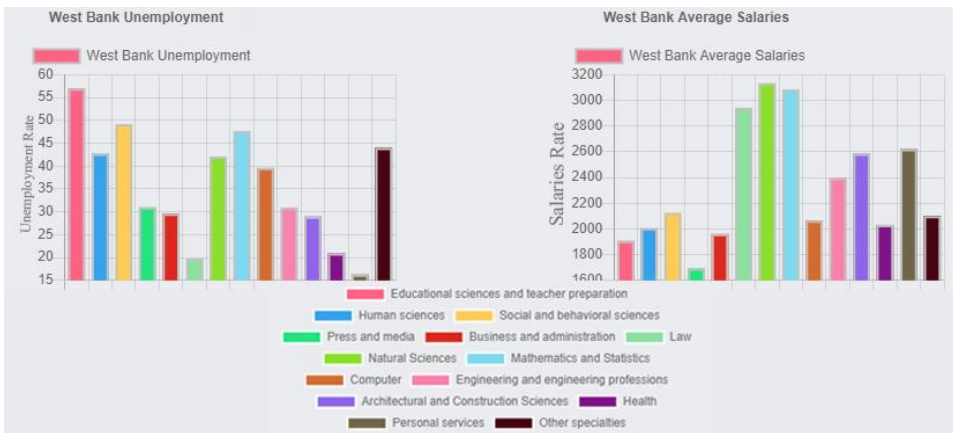


Figure 5. Unemployment Rates According to the Variable of Gender, Field of Study, and Age (20-29) Among Hebron University Graduates.

Figure 6. Unemployment Rates Among Individuals (20-29 years) by Field of Study and Gender of Palestinian Graduates (PCBS, 2020).



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