How can one improve the logistics process of academic orientation? Neural network programming to support the decision-making system in a university career

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ABSTRACT

The student's inappropriate choice university orientation may result in their failure and their changing of the section in search of success in another field. It results in many losses, including effort, time, and private and public money. We aim to find an effective mechanism to support the student's decision to choose one discipline using the Artificial Neural Network (ANN) to explore the student's future based on their skills. According to the profile of each student, the first ANN can predict whether the student may fail in their university curriculum. The second ANN categorizes the student in one of two ways, as a good or a bad candidate for a discipline. Consequently, the proposed logistics process in university orientation programs helps executive management to make appropriate decisions in directing students to the most appropriate choice and to start university studies in the academic specialization most appropriate to the student's abilities.

1. Introduction

Management and control flow are the two pillars of the logistics function. Thus, good management of student orientation to discipline in public universities improves the satisfaction of students and their families and, responds to the need and capacity of public universities. In higher education, flows of students seeking a university discipline are increasingly important; public universities globally consider these flows a current issue. They seek equal access to technical/vocational and higher education. By 2030, equal access for all women and men should be ensured to affordable and quality technical, vocational and tertiary education, including university (UNESCO, 2016).

In the case of the Kingdom of Saudi Arabia [KSA], the flow of students arriving each year in public universities is growing, with an annual average increase of 5%. In September 2018, the number of students in the KSA was 598,414, distributed as follows: 50.84% girls and 49.16% boys.

Saudi universities are aware of the situation, but at the same time, universities have noticed that students are wasting time to complete their university studies. This reality encourages researchers to further study this situation of the flows of students arriving at universities and to seek the elements of the decision to clarify to the public authorities how to manage student flows and establish a better logistics of university orientation (LUO). LOU is based on several interrelated factors: mechanisms of choice, the provisions of the administration, the factors of choice of students and their families, the capacity of universities, and their general policies. Therefore, the Saudi University needs to adopt a particular vision and a logistical policy aimed at helping the flows of new students make a better choice of a university study course more appropriate to their scientific abilities. Thus, this paper seeks to establish this LOU, which will later be a decision support tool for the administration of the university, the student, and their family.

University guidance is one of the most difficult stages for the student and their family because this decision can affect negatively or positively their future (success) and further studies. Several studies have shown that university orientation and the choice of a university discipline is a complicated subject. It is always constrained by several interdependent factors, and it is subject to factors of

influence (Giambona et al., 2011; Luca et al., 2014; Lai and Hsiao, 2014; Sanzana et al., 2015; Patel and Chen, 2017; Protivinsky and Münich, 2018; Sammons et al., 2018). First, several actors influence the process of university orientation: The character of the student and their criteria, the will of their family, the school environment in which the student grew up, the socioprofessional environment, and the political and economic context of the city or country. Second, researchers have distinguished factors of choice influencing academic orientation: personal, family, school, geographic, financial, sex, etc. Several studies have analyzed the results of students' choices in university specialties and the results of these choices at the level of progress in the study (Harackiewicz and Hulleman, 2010; Hassanzadeh et al., 2015; Huybers et al., 2015; Khuwaja et al., 2018).

Tognolini and Andrich (1996) illustrated that universities have to reconcile between different applicants' profiles to be able to compare them and to find an efficient way to choose candidates that fit best the required profiles. Provided that the applicant's number exceeds the available slots, universities must compare the required students' profiles and performances using quantitative analyses. This is possible through aggregating the components of each profile to form a single score from which comparisons among applicants can be made readily (Adams, 1988; Tognolini and Andrich, 1996).

In our opinion, the university orientation process aims to help decision-makers at universities direct students to academic disciplines that are scientifically appropriate to them. This process, which is associated with student's choices, enables all new students to enter a university specialization with a positive impact on their studies and excellence. This stage is subject to a number of conditions and requirements related to the new student and many other conditions related to the required specialization, the chosen faculty or university: (*i*) respect for the rules for each specialty and university, (*ii*) qualifications of the new student, (*iii*) absorptive capacity of each university institution, and (*iv*) previous grades of the student.

This paper aims to support students' decisions to choose the appropriate university specialization according to the degrees obtained in secondary school. In the following section, we offer a thorough literature review; Section 3 then presents the database used and its descriptive statistics. Section 4 describes our research approach and methods; in particular, a brief description of the Artificial Neural Networks (ANN) used is presented and commented. Section 5 presents our quantitative findings and discussions about the results of two ANNs training, and in the final section, we conclude.

In many cases, the student chooses a university specialization that is not suited to their scientific and psychological potential to satisfy personal or societal motives (Allen et al., 2009). This decision may cause them to change their specialization in search of success in another field. In our opinion, the wrong choice is a waste of time, effort and public money. Therefore, we seek through this research to find a practical system based on science using artificial intelligence to help executive leaders and students choose the appropriate and correct specialization for students, thereby contributing actively and seriously to stop the waste of public and private money, as well as time and effort.

2. Literature review

In the managerial literature, several studies have addressed the subject of choosing a university orientation in different ways. Some have directly examined the factors of choice of students and their families. Other studies have focused on the degrees of students before entering the faculties or on the study of the universities' capacities and its impact on students' choices. We believe a vast field of the investigation remains to enrich this subject and to contribute above all to the decision-making process of universities and students using more modern techniques.

2.1. Students' choices in social currents of thought

Several results of studies have introduced the variables intervening in the choices of the orientation of the pupils. The approaches can be summarized to understand the orientations of the students according to the following principles. First, the choice of sectors is strongly conditioned by objective factors, independent of the students and their social origin. This vision is a deterministic conception because students are conscious and strategic actors who reason and evaluate the means to achieve their goals. Second, this vision is individualistic and utilitarian, based on the preferences and usefulness of students and their families. It focuses more on variables related to students' social and academic projects, as well as their rationality. Third, the actor is defined by an identity in terms of social belonging that the student seeks to maintain or consolidate (logic of integration) by a rational strategic logic according to their interests, their resources (strategic logic) and by their ability to "take a step back" to refer to their values (logic of subjectivity). So, according to this vision, the choices of orientation are influenced by belonging groups' norms, by representations of the students, and by the history of the individual. Consequently, it is a social action approach that extends beyond the other two visions (Rezaei et al., 2018).

2.2. Motivations for choosing a university degree

A study conducted by Le Corgne (2014) on students from the University of Paris revealed that 52% of new students adopted two main sources when choosing a university specialization: Grades

obtained previously as well as the advice and guidance of their families. The same study showed that 75% of university students anticipated achieving a Master's degree and had a clear idea of the subject in which they would obtain this diploma at the end of their studies.

Brookhart and Durkin (2003) focused on the student's gender and social status to show their impacts on the choice of specialization. Brookhart and Durkin (2003) explored two axes:

(i) Gender orientation in university programs (gender distribution), considering the school's past students and
(ii) Attendance and pass rates for women's and men's examinations.

They studied the university specializations followed by gender and high school grades using data from the administrative and teaching base of each institution of the University François-Rabelais of Tours in France during the 2013-2014 academic year. Next, the author studied the presence and success of students in the examinations by sex. The results show that women are clearly in the majority with 60%, the gender distribution in university courses is uneven. Indeed, some university programs show a particularly high rate of feminization; for example, the language sciences sector comprises 91% of women compared with 9% of men, while others are heavily masculinized, such as mathematics, which is comprised 76% of men compared with 24% of women. When the authors introduced into the analysis of the students' academic backgrounds, they concluded that the sexual dimension is significantly correlated with the choice of the orientation of each student. At the same time, they noted that men have higher rates of default than women at all levels of education and in all components. These differences by sex are decreasing among students holding a bachelor's degree and years of license. In graduate studies, men fail more than women, but the difference is small and generally not significant. Moreover, the study shows that passing an exam depends on high school grades.

Protivinsky and Münich (2018) introduced the results of admission test scores and teachers' grading of 15-year-old pupils' performance in mathematics and their native language in the Czech Republic. They show, once again, that girls outperform boys in languages, while boys are more qualified at mathematics. This empirical finding is common across countries. They examined the gender differences in mathematics and native language performances and show two important results:

(i) The gender effect in grading is sizeable across the whole performance distribution, and the gender gap is due to the difference in no cognitive skills between the sexes, such as in-class behavior and homework, confounding teachers' grades but not test scores.

(ii) The gap cannot be explained either by students' differing perceptions of exam stress or by students' attitudes towards the subject in question.

Therefore, grades are the main feedback on a student's academic performance and a crucial factor in decision-making about their future academic careers, biased grading may cause inefficiencies in the educational system negatively affecting future labor market careers (Protivinsky and Münich, 2018; Ahmad et al., 2019).

Wei (2016) used a combination of qualitative and quantitative methods to investigate the issue of English essays and discuss the pedagogical implications of the results of their study. The author shows that Chinese students have been far removed from native speakers in their thematic choices since they used fewer current topics and many more interpersonal themes. Concerning American students, Chinese students use more connective complements and fewer conjunctions in textual themes. This linguistic feature is explained by interpersonal factors and the effects of their previous studies.

By developing a new approach to revealed preferences, Conti and Visentin (2015) obtained revealed preferences from science and engineering doctors in two major European universities concerning employment outcomes. The preferred job categories for PhDs are those that are relatively less chosen when the Ph.D. cohort is large and relatively larger when it is small. The authors find that doctoral students value employment in universities and R and D-intensive firms. Moreover, these job classes are preferred to unclassified universities, R and D-intensive firms and public administrations. The choice of Ph.D. is heterogeneous depending on the area of research.

Liaw et al. (2017) surveyed 451 first-year no nursing health care students belonging to four health colleges in Singapore. They used a valid parallel evaluation scale of 35 elements, known as the choice career path and the health care career choice to examine the differences between career choices in health care and nursing perceptions as a career choice for students. The authors show that, compared to their own career choices in health care, students perceive nursing as having greater gender-related stigma, students feel that the nursing profession does not give good qualifications and that their parents do not agree with this type of career, and they think they would be less likely to get support from their parents to continue their nursing care and make their parents proud.

Hedges et al. (2014) wondered why students choose specific modules during their university courses. They surveyed to improve the understanding of the factors contributing to the students' choices of a module by relying on a large set of primary data consisting of business school students. The authors explore various motivational forces behind the choice of the module. They

emphasize the importance of intrinsic motivations that vary from one student to another, which could lead the 737 students surveyed to choose particular majors.

2.3. Strategies, choices, and motivations in KSA universities

In the KSA, most research has focused on the study of preferences and factors of choice of students of medical studies.

Abdulghani (2009) focused on the admission criteria in Saudi medical schools and compares it to admissions criteria in different medical colleges internationally. He sought to evaluate the tools used in the KSA to encourage researchers to determine their validity and reliability. Mehmood et al. (2012) sought to determine the variation in specialty preferences during Saudi medical school training and the perceptions that affect students' specialty choices. The authors surveyed 590 students and learned that men preferred to specialize in surgery, to a lesser degree, in internal medicine and orthopedics, while female students preferred surgery, followed by pediatrics and ophthalmology. The choice of students is explained by several factors such as the lack of competitiveness, the shortage of specialists and the diversity of patients, while the prestige of the specialty and teaching opportunities have a greater impact on the students (Mehmood et al., 2012; Alotaibi, 2019).

Al Subait et al. (2017) investigated the factors that influence career choice in the university. Their study provided valuable information about the reasons for choosing a professional career among Saudi Arabian students. The authors choose six dimensions influencing the students' careers (social status, economy, profession, vocation/service, interest in science/education, and personal background). These dimensions include 23 factors tested among second-year dental medical and nursing students at King Saud University for Health Sciences. The authors concluded that factors related to professional security and personal background influenced the career choices of pre-professional medical, dental and nursing students. The social status of being a doctor, a dentist, or a nurse motivated respectively medical, dental and nursing students. In Particular, dental students when compared to both medical and nursing students were more likely to be motivated by factors related to the profession such as job security and flexible scheduling (Al Subait et al., 2017; Albagawi, 2019).

The majority of studies conducted in the KSA show that the right career choice plays a major role in molding a student's future. Albishri et al. (2012) explained the three admission criteria for Saudi University: High school, the *Qudurat* and the *Tahsely*. Therefore, the students are ranked according to their scores obtained in these three scales and the acceptance for higher education mainly requires three scales. At the end of secondary school, high school grades are calculated cumulatively for the three years spent in high school. The *Tahsely* evaluates basic science knowledge and the English language skills. The *Qudurat* focuses mainly on the student's knowledge of algebra and Arabic language skills. All these grades are taken into consideration, but their weight usually differs from one university to another (Al Subait et al., 2017; Albishri et al., 2012).

In the past, the orientation of students to the Saudi universities was based only on the high school degrees; this policy was not successful because the universities found discrepancies between the previous achievements of students and their abilities to pursue scientific studies. Logically, and as confirmed by the results of previous studies, the high school degrees do not reflect the real scientific capacity of the student and it represents only a personal gain allowing student to have the right to pass the *Tahseely* and the *Qudurats* tests (Abdulghani, 2009; Albishri et al., 2012; Al Subait et al., 2017; Alotaibi, 2019). Thus, the authorities began to reflect on other selection criteria to allow a better orientation of the students.

Besides, several researchers show that the nature of university studies differs originally from high school, and the most famous universities in the world practice other selection criteria. Therefore, the Saudi authorities can no longer rely solely on the high school degrees to select and guide students to universities: It is necessary to explore and know the student's abilities in scientific analysis, literary and mathematical reflection and their accumulation of information.

The admission tests (the *Tahseely* and the *Qudurats*) are organized on a national scale, which makes it possible to ensure the individual capacities of students and to compare the results on a regional and local scale. Thus, the adoption of these three criteria ensures equal opportunities between students and a better orientation to the Saudi universities.

Other research has focused on the determinants of student choice to specialize in tourism using questionnaires, a logit or probit model (Juaneda et al., 2017; Mohammad and Alsaleh, 2013). Their objectives were to determine their motivations or to verify if these motivations differ from those related to the choice of other, more consolidated, diplomas in the field of the social sciences or the pure sciences. Using a logit model, Juaneda et al. (2017) examined the significance of motivational factors, academic performance, gender, and parents' education. Mohammad and Alsaleh (2013) performed a factor analysis to identify the main reasons that students have to study the hotel industry. They showed that social status and job opportunities in Jordan were important factors influencing students to study tourism.

3. Data collection

In our empirical analysis, we focus on the effect of the student's choice on their academic career. Since

we are looking to train the ANN on the profiles of the students, we extract from the database only the students having their high school degrees, *Qudurats*, and *Tahseely*. The initial sample was of 14,802 students; 1,782 students were omitted because they reported some missing statistics. Consequently, our database includes 13020 students who have completed their university studies or who have been studying for a few terms in the faculties of Bisha University in the KSA, during the 2009-2017 period: Faculty of arts and management, faculty of literary education for girls, faculty of education, faculty of scientific education for girls, faculty of science and home economics, faculty of computing and information technology, faculty of applied medical sciences, faculty of science and arts, the business school, the college of community service and continuing education, the community college, the college of literature, the college of home economics for girls, the college of science, and the college of literature.

We analyze students' data from 33 university specializations. For each student, the database includes several pieces of information (Table 1): Registration numbers, specialization field, high school degrees, the *Qudurat*, the *Tahseely*, the campus name, the faculty name, the success or failure of the student per term and the confirmed marks in all courses.

3.1. Distribution of students according to sex and disciplines

Fig. 1 shows that students are registered according to the following proportions: 50.92% in Sciences, 47% in Arts (Human sciences), and 2.08% in Islamic sciences. Thus, the number of registrations in Islamic sciences are in the minority compared to all other disciplines. The boys account for 14.17%, whereas the girls are in the majority with 85.83%. Thus, on average, the University of Bisha has 6 girls for each boy (Fig. 2).

Table 1: List of specializations by branch

Scientific studies(Sciences)	Arts(Human Science)	Social Science	Islamic studies
1) Directed programming			
2) Mathematics			
3) Sciences			
4) Training of schoolteachers–Science section			
5) Training of schoolteachers-Mathematics section		1) Psychology	
6) Physics		2) History	
7) Medical Laboratory Sciences	1) English	3) Geography	1) Guidance and counseling
8) Computer Science	2) Arabic	4) Home Economics	2) Islamic Sciences
9) Computer training program	3) Training of schoolteachers-Arabic language section	5) Library Administration	3) Training of schoolteachers-Islamic Studies section
10) Biology	4) Artistic education	6) Social Studies	4) Islamic studies
11) Learning Resource Centers Program		7) Business Management	
12) Information Systems		8) Commercial studies	
13) Nursing			
14) Medical laboratory			
15) IT (Information Technology)			
16) Information systems programming			
17) Applied programing			

3.2. Distribution of students according to scores obtained before university

In the KSA, Saudi universities rely on one of these rates to accept new students to study in one of its specialties: Weighted or Equivalent ratio. These ratios are used by universities to classify students according to the following equation:

Ratio= % High school + %*Qudurat* + % *Tahseely*   (1)

Each year, the National KSA Evaluation Center [NKEC] studies ratio weightings to help Saudi universities make decisions and weight their success factors in university studies. However, each university chooses the respective weights of the three determinants of university orientation. Therefore, the choice of weights depends on two criteria: The general policy of the university and the scientific studies conducted by the National Measurement Center. Finally, the universities

announce the methods of calculating the ratios and factor weights just before the start of student enrollment.

The respective weights of high school, *Qudurat,* and *Tahsely* vary according to several factors: the importance of the disciplines, the scientific classification of the universities, and the sex of the student. The determinant of these weights is the ability of each of these variables to predict success at the university level.

Fig. 3, Fig. 4, and Fig. 5 respectively show the distribution of students according to their high school degrees, the *Qudurat*, and the *Tahseely*. At this level, we make two observations: First, the mean of all marks obtained by the pupils during the last three years of secondary school (92.11%) is too inflated compared to their linguistic, literary and scientific skills (64.47% and 66.42%). Second, the average student level in science and English language evaluation (*Tahsely*) is almost the same as in algebra and Arabic language skills (*Qudurat*), respectively at

65.07% and 65.77%. However, the actual level of the students and their grades in high school hide the real levels of the students.

3.3. Distribution of students according to the results of the final tests

We have information about the number of students failing during their university studies (Fig. 6 and Fig. 7). The ideal situation is the period during which the student finishes their studies and obtains their diploma in 8 standards terms. However, any failure in exams leads the student to pursue studies for an additional term. Of 13020 students, 5950 students (45.70%) never failed their exams, while 11.14% (1450 students) failed at least once, and on average, during terms of study, students fail almost 3 (3.02) courses (Fig. 7). Students who failed their exams 4 or more times in their university studies constitute 29.34% of the sample against 24.73% of students failing less than 5 times during their university studies (Fig. 7).

In our sample, 1.15% of students succeeded in their university studies in the 8 standard terms (150 students), 31.50% of students finished their studies in 9 terms (4100 students), and 18.43% of students finished in 10 terms (2400 students), while 13.82% (1800 students) spent five and a half years to obtain their degrees (three terms more than standard) (Fig. 6).

To conclude, students at Bisha University lost at least more than one year to obtain their diplomas. This delay is not only a waste of their private time but also a waste of public expenditure.
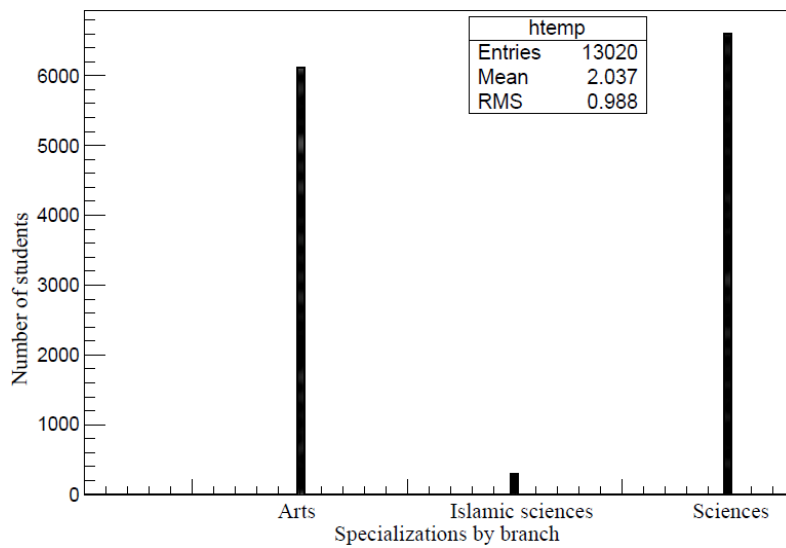

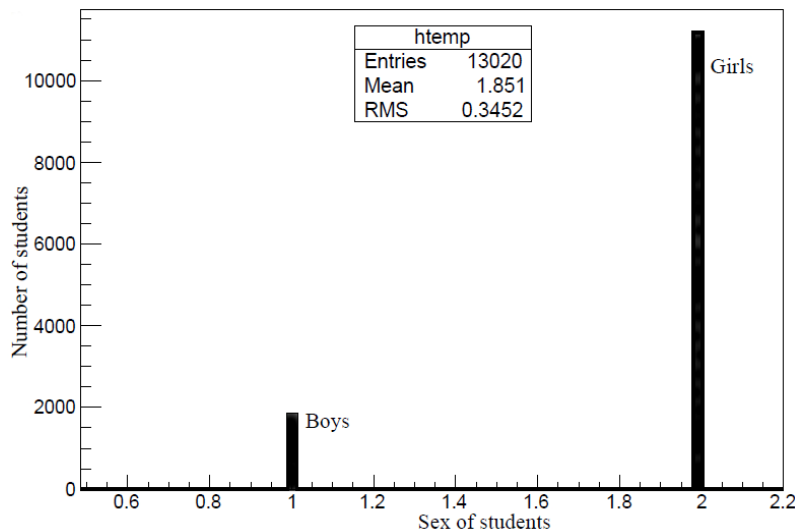**Fig. 1:** Distribution of students by specializations
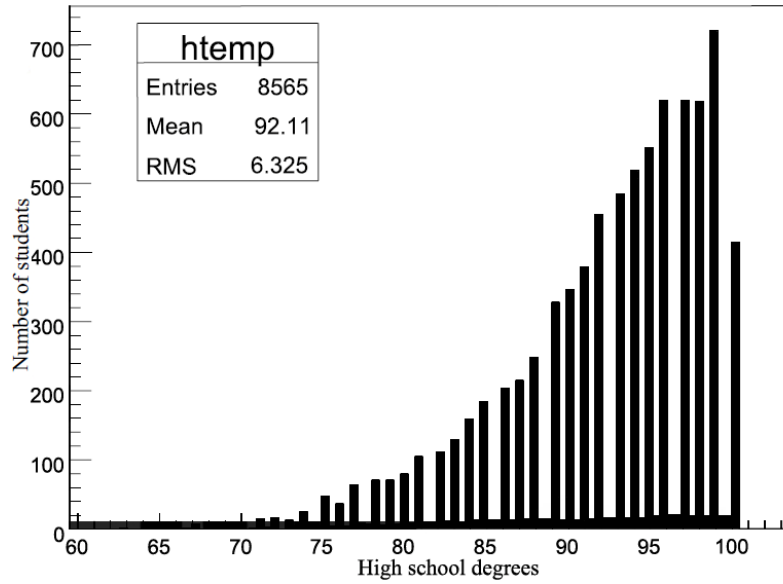

Fig. 2: Distribution of students by sex

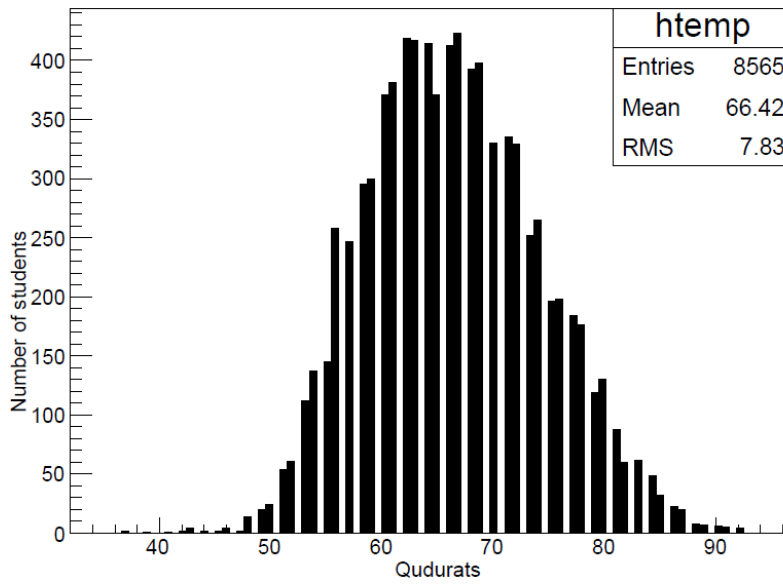**Fig. 3:** Distribution of students according to their high school grades

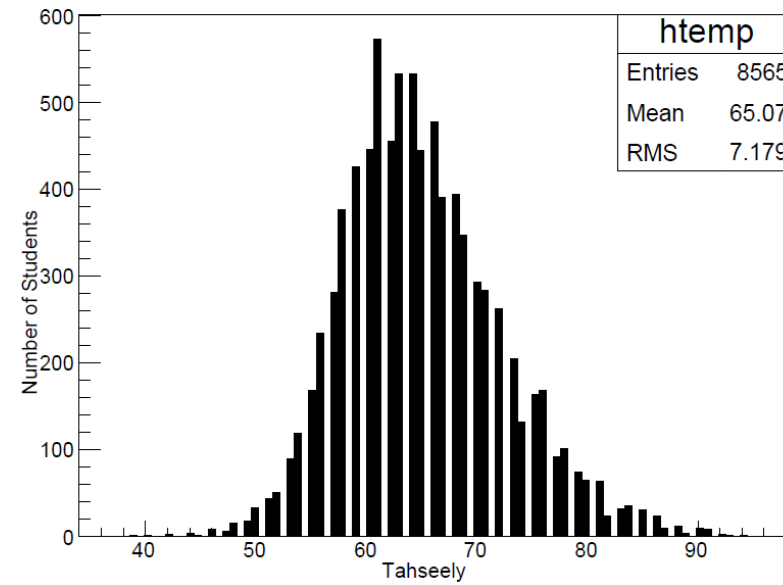**Fig. 4:** Distribution of students according to their *Qudurat* scores

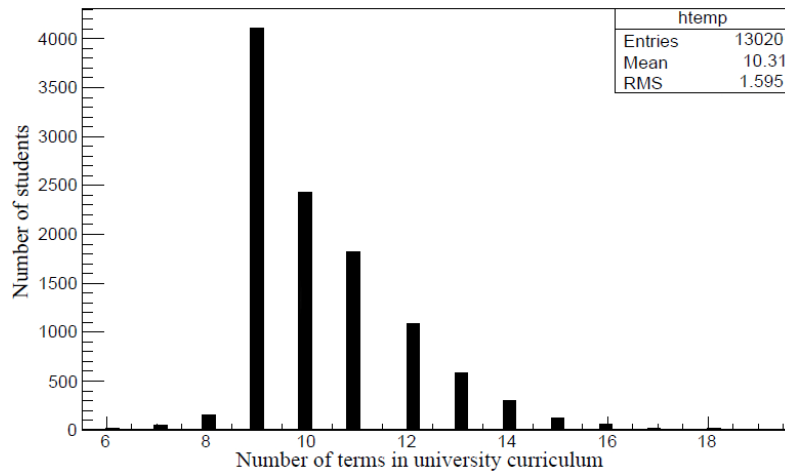**Fig. 5:** Distribution of students according to their *Tahseely* scores

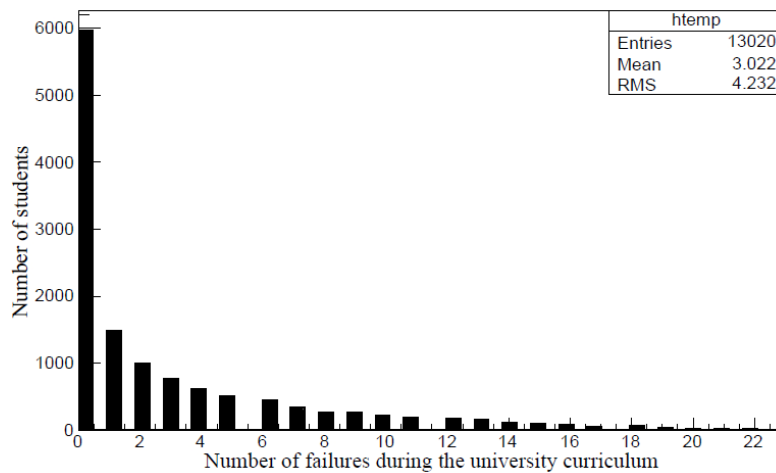**Fig. 6:** Distribution of students according to the number of terms of study

Fig. 7: Distribution of students according to their biannual failures during the university curriculum

4. Research approach and methods

4.1. Brief description of artificial neural networks (ANN)

ANN are nonlinear computational algorithms inspired by biological neural systems. ANNs have been applied in the last years to a wide range of studies in physics, electronics, economics, etc. (Zakaryazad and Duman, 2016; Cao et al., 2015; Ramaiah et al., 2010; Oreski et al., 2012; Panatik et al., 2019). An ANN is composed of input nodes connected to output nodes by a number of hidden layers. The input signals $(x_1, x_2, ..., x_n)$ are transmitted to the input layer. Inputs are normalized, weighted and transmitted to nodes in the next layer. Each node uses a nonlinear information-processing unit called a neuron. Neurons in each layer are connected with other neurons of the neighboring layer(s). Information neuron-to-neuron is propagated using a weight specifying the strength of the interneuron couplings.

The input signal x_j connected to a neuron k, is multiplied by a synaptic weight w_{kj}. The sum of the weighted input signals is used as a parameter of the activation function. The artificial neuron calculation is described by the following equations:

$$u_k = \sum_{j=1}^{n} W_{kj} \cdot x_j \tag{2}$$
$$y_k = \varphi(u_k + b_k) = \varphi(v_k) \tag{3}$$

where w_{kj} are the weights of the connections, b_k is a bias and $\varphi(v) = 1/(1 + exp(-v))$.

To obtain the desired output from the network, the input neurons receive data, normalize them and propagate them successively to nodes in the hidden layers and then to the nodes in the output layer. The adjustment algorithm is referred to as learning or training, considering the comparison between the output of the network and the desired target corresponding to the training sample. One of the methods widely used for its performance is called "learning by epoch". This method consists first in a summation of information for the whole pattern and then updates the weights. Each update minimizes the summed cross-entropy cost function error. The performance of an ANN is given by the accuracy of prediction measured by this error and the convergence of the learning process. We have two curves of errors as an output of the ANN. The first error represents the error calculated for the training sample and the second one corresponds to the error calculated using another independent test sample not used in the training. The goal of the learning process is to minimize the second error characterizing the performance of the ANN to model

new data not used in the training (Zakaryazad and Duman, 2016; Cao et al., 2015; Ramaiah et al., 2010; Oreski et al., 2012).

5. Results and discussions

5.1. First ANN training

Among the different ANN models available in the literature we have chosen to work with a layered ANN type under the supervised training scheme. This type of layered ANN with an appropriate number of hidden units is reliable universal approximators. In this study, we used the root class MultiLayer Perceptron to build our neural network (Brun and Rademakers, 1997).

Up-to-date information can be found by retrieving information from the set of students who pursued studies over the 2009-2017 period. The database will be processed according to the methodology described in Fig. 8 showing two successive ANN training.
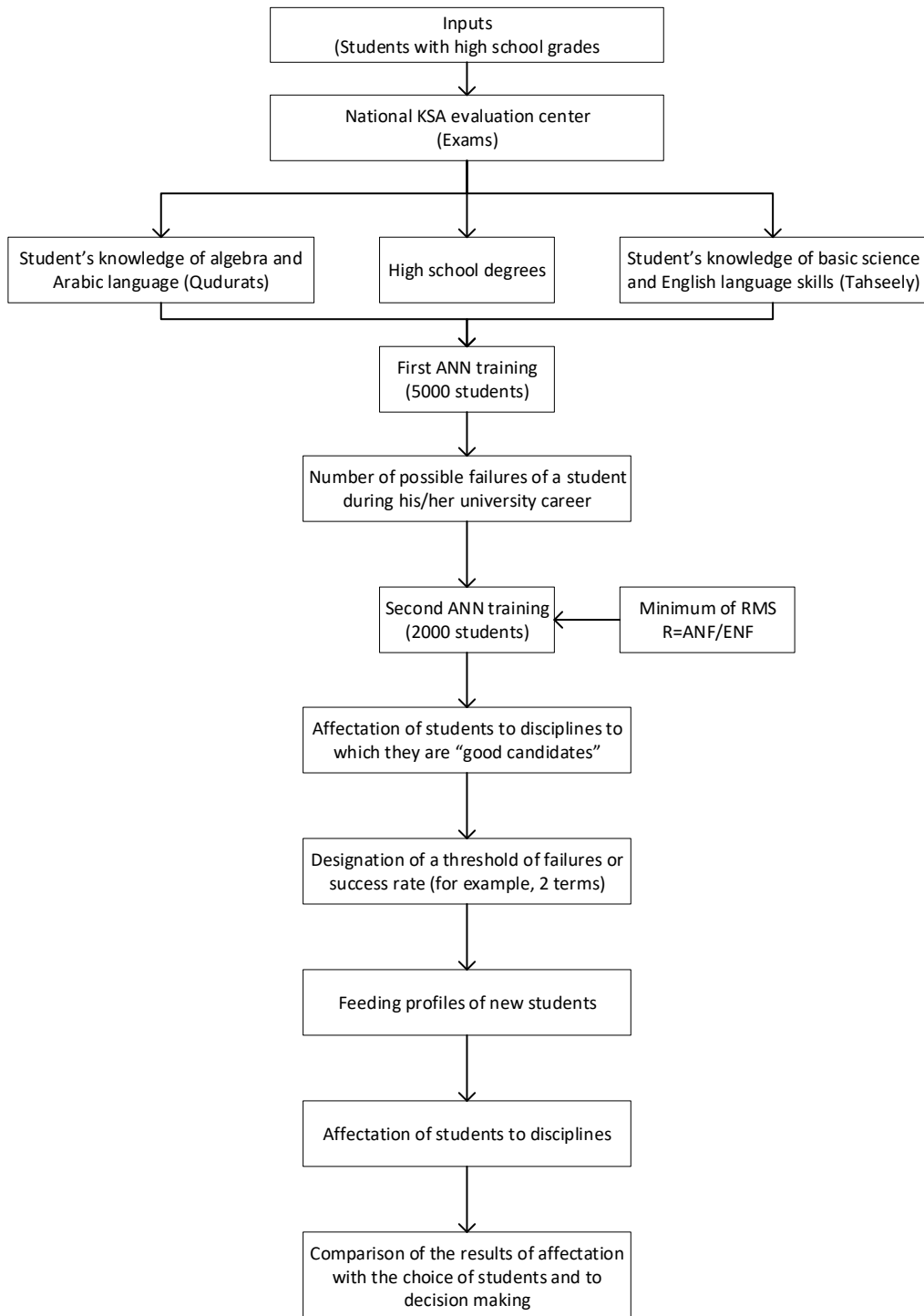
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┌─────────────────────────────────┐
│            Inputs               │
│ (Students with high school grades│
└─────────────────────────────────┘
                │
                ▼
┌─────────────────────────────────┐
│   National KSA evaluation center │
│             (Exams)             │
└─────────────────────────────────┘
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| Student's knowledge of algebra and Arabic language (Qudurats) | High school degrees | Student's knowledge of basic science and English language skills (Tahseely) |

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┌─────────────────────────────────┐
│       First ANN training        │
│        (5000 students)          │
└─────────────────────────────────┘
                │
                ▼
┌─────────────────────────────────┐
│ Number of possible failures of a │
│ student during his/her university│
│             career              │
└─────────────────────────────────┘
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| Second ANN training (2000 students) | ← | Minimum of RMS R=ANF/ENF |

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┌─────────────────────────────────┐
│  Affectation of students to      │
│  disciplines to which they are   │
│       "good candidates"         │
└─────────────────────────────────┘
                │
                ▼
┌─────────────────────────────────┐
│ Designation of a threshold of    │
│ failures or success rate (for    │
│       example, 2 terms)         │
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                │
                ▼
┌─────────────────────────────────┐
│  Feeding profiles of new students│
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│ Affectation of students to       │
│         disciplines             │
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                │
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┌─────────────────────────────────┐
│ Comparison of the results of     │
│ affectation with the choice of   │
│ students and to decision making  │
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Fig. 8: Study process (Discipline choice decision process model)

The crucial point in the construction of the ANN is the architecture of the ANN, the number of layers and nodes in each layer. To determine the number of possible failures of a student, the input layer

contains 3 neurons corresponding to the three variables *Qudurats, Tahseely*, and high school. For every 5000 students and single neuron on the output layer for the number of possible failures of a student during their university career, the correlations between the input variables and the real student school failure are automatically learned during the training of the neural network. The performance of the trained ANN is validated by comparing the ANN results with a second set of data containing 1000 students. The ANN is said to meet the requirements for validation when a good agreement with data is achieved. Using these previous parameters as inputs, the ANN predicts the possible failures of student *i* during their university career.

First, we identified the optimal ANN architecture by trying different numbers of neurons in the hidden layers and based on the statistic measurement of the root mean square error (RMSE) defined by:

$$RMSE = \sqrt{\sum_i^n (X_i - P_i)^2 / n} \tag{4}$$

where X_i is the number of possible failures of student *i* during their university career, and P_i is its predicted value by the neural network. We found that the most appropriate ANN architecture to find the minimum RMSE corresponds to two hidden layers with 6 and 2 nodes (Fig. 9).

Fig. 10 represents the ratio between these two values (R):

$$R = ANF / ENF \tag{5}$$

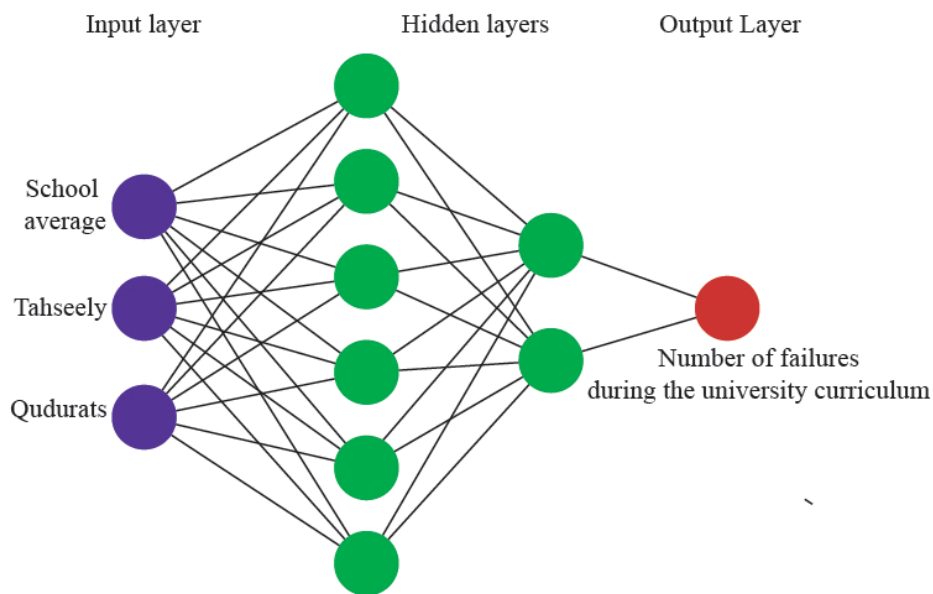where *ANF* is the actual number of failures, and *ENF* is the extended number of failures.

Fig. 9: Most appropriate ANN architecture to find the minimum RMSE
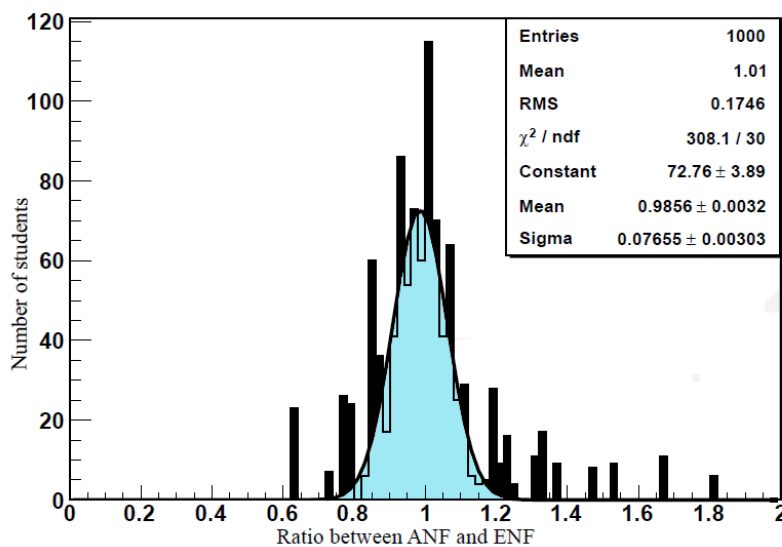

Fig. 10: Ratio between the actual and predicted number of failures

Fig. 10 shows that the two curves (real failures and ANN outputs of predicted failures) have the same trend or the same pace of the spectrum. The curve of the ratios between ANF and ENF is Gaussian and centered approximately 1 ($\mu = 1.01$), with a root mean square error equal to 0.07655 ($\delta = 0.07655$).

This result proves that the failure values predicted by the ANN are close to the real values. This result is confirmed by Table 2, which presents the actual and predicted numbers of failures of 10 randomly selected students from the neural network among 1000 students. Consequently, the currently used ANN can predict with high accuracy the number of failures of students in their university curricula.

Table 2: Actual and predicted numbers of failures of 10 randomly selected students

Students	Actual number of failures	Expected number of failures by ANN	Relative errors (in %)*
1	1	1.185	16.93
2	10	9.994	0.06
3	6	6.494	7.90
4	3	2.958	1.40
5	12	12.246	2.02
6	4	3.210	21.91
7	5	4.941	1.18
8	2	2.305	14.16
9	1	1.055	5.35
10	7	6.999	0.01

After the time-consuming and intensive initial steps necessary to create and train successfully an ANN, analysis is fully automatic and practically instantaneous. As a result, from the test samples, the neural network should estimate the student's failure.

Currently, according to the profile of each student (their scores on the *Qudurats* and the *Tahseely*), the ANN can predict whether the student will fail in their university curriculum or not (Table 2). If the student fails in some courses, the ANN can update their failure (the number of terms repeated).

5.2. Second ANN training

Students who have never failed in their academic studies are good candidates for both disciplines (Arts, Science). Good candidates for Science and the Arts are designated 1 and zero, respectively. First, the ANN is trained using this category of students; then, 2000 students are randomly selected (1000 students from each discipline) to test the ANN. Fig. 11 summarizes the test results, showing that the ANN is currently able to assign students to the discipline for which the student is a good candidate.

Now, the ANN categorize students in two categories (0 and 1). The results presented in Fig. 12 show two peaks at which the maximum number of students is assigned to one of the two disciplines (0 and 1); the minority of remaining students approach one of the two disciplines: either they are close to 1 or zero. These profiles named "fake candidate or bad candidate" do not match either 0 or 1, but they have the quality of being assigned to the nearest discipline (0 or 1).

Finally, the university's administrative department can use this application to test the profiles of new students and rank them as good and bad candidates. More precisely, we can set a threshold (for example 2 terms of failures in the university curriculum) beyond which the student will be a bad candidate for a university course (Fig. 13). In addition, by knowing the profile of the student (the *Qudurats*, the *Tahseely*, high school), the ANN can judge the choice of the student (Fig. 12). If the output approaches 1, the student will be a good candidate for science, otherwise (the output approaches zero), the student will be a good candidate for the Arts.
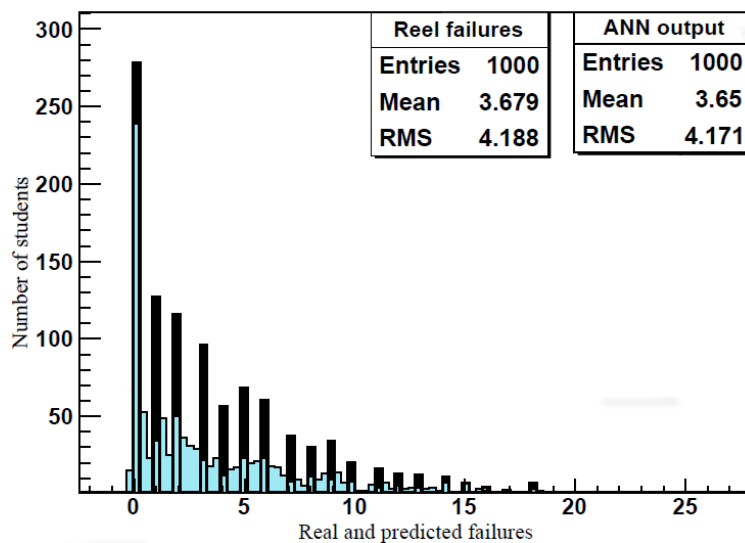
Fig. 11: ANN outputs for 1000 students coming from the literary discipline and 1000 students coming from the sciences
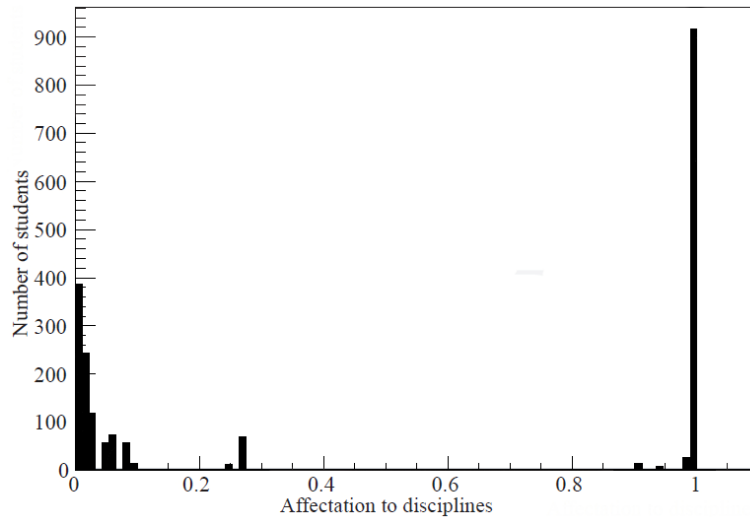
Fig. 12: ANN categorization of 2000 students according to their profiles
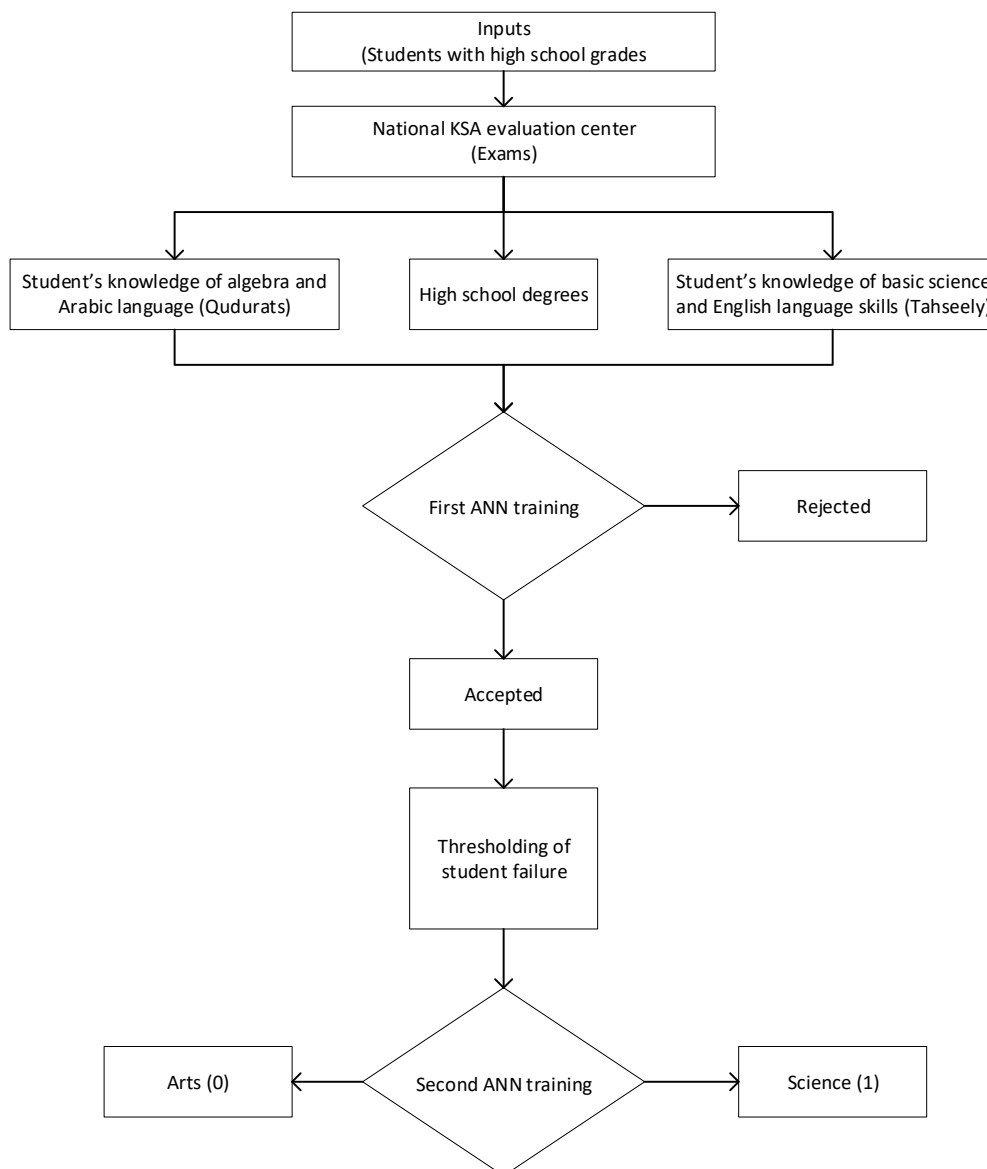

Fig. 13: University orientation procedure

6. Conclusion

This paper contributes to the growing literature on the impact of decision-making and students' choice in a university career. Fully determining the factors that contribute to the success of students in their university studies is still a highly challenging and vague problem. However, it is possible to clarify choice and decision-making by using student profiles. In this paper, we do not try to explain the

factors of choice of a student when they arrive at university; rather, we examine the results of their choice on their university curriculum, using data reflecting the number of failed students in various academic disciplines.

Students at the University of Bisha prefer to enroll and pursue a university degree in Human Sciences and Science than in Islamic Sciences (50.92% in Sciences and 47% in Human sciences). Before entering the university, students arrive at the NKEC with their high school grades (school average) and they pass exams in basic science and English language evaluation (*Tahseely*) as well as in knowledge about algebra and Arabic language skills (*Qudurats*). These three scores help students to be accepted into a discipline of the University of Bisha.

Because ANN was trained on former students, the students' degrees were used as inputs, and the trained ANNs use these degrees to predict the number of failures of these students. Thus, this methodology permits two trained ANNs:

- **The first** ANN predicts the number of failures of a new student when choosing a university discipline using their profile (the *Qudurats*, the *Tahseely*, the high school). It can, therefore, orient the new student by showing the time necessary to have the chosen diploma.
- **The second** ANN categorizes students in one of two ways (as good or bad candidates for a discipline). Using the data from their profile, it can compare their actual choice concerning their competencies and orient the student's new decision between the disciplines.
- **Finally**, the proposed methodology can avoid the inappropriate choices of new students arriving at the university. In economic terms, the poor choice of the student causes several losses such as the loss of time, the high costs of university studies, and the waste of public and private money. These proposed processes are solutions based on scientific standards. They make it possible to find an effective mechanism to support the student's decision making at university orientation that is most appropriate to their competences and to propose an efficient logistics of the university orientation of new students arriving at the public university.

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Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

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