Predicting Students' Final Performance Using Artificial Neural Networks

Tarik Ahajjam*, Mohammed Moutaib, Haidar Aissa, Mourad Azrour, Yousef Farhaoui, and Mohammed Fattah

Abstract: Artificial Intelligence (AI) is based on algorithms that allow machines to make decisions for humans. This technology enhances the users' experience in various ways. Several studies have been conducted in the field of education to solve the problem of student orientation and performance using various Machine Learning (ML) algorithms. The main goal of this article is to predict Moroccan students' performance in the region of Guelmim Oued Noun using an intelligent system based on neural networks, one of the best data mining techniques that provided us with the best results.

Key words: data science; Artificial Intelligence (AI); Machine Learning (ML); neural networks; prediction; recommendation; high school; data analysis

1 Introduction

School guidance is an important component of the education and training system, and because of the nature of its role, which occupies a central place in improving productivity and quality, the National Charter for Education and Training attributed its sixth pillar to educational guidance, disseminating it in five articles (from article 99 to article 103), as a function to monitor and facilitate learners' maturity, inclinations, and educational and professional goals.

The question of educational guidance is rarely raised in our educational contexts, except on circumstantial occasions and from a reduced perspective. The latter is rarely spoken as an essential entry point to remedy the horizontal imbalances ravaging the Moroccan educational organization. This is opposed to what is found in the education systems of states that have made significant strides in improving the performance of their education systems, which has become critical. Many countries' education policymakers have argued for a perceived lack of learners' knowledge, needs, and interests, on the one hand, and knowledge of how to manage professional life, on the other hand, which lead to a lack of capacity to develop an appropriate school and professional project. It exists in a reality that is characterized by rapid changes and transformations in various aspects of life. They use guidance as the foundation for connecting what students learn in school with what they find and will find in life, thereby increasing their motivation to learn.

Today, as is known, education is no longer limited to give young people knowledge skills only, but their importance, because they aim to take charge of various aspects of the human personality, with teachers watching this that the learner is fully integrated into school life before talking about his subsequent integration into professional life. School life is not only the fragmented body of knowledge but the life that learners live at all times and in all school places

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to uplift them through all the religious, educational, and programmed training activities that take into account. It counts the cognitive, emotional, and sensory-motor aspects of their personality that qualify them for later social and professional life. As a result, educational guidance is critical, both in terms of the quality of this school life, and thus of optimal qualification of social, socioeconomic life, or to correct the imbalances of the education system in general, including poor compatibility. School or educational guidance is one of the modern pillars of developed societies, providing psychological, educational, and professional services, which can be individual or collective, the teacher aims to preserve the entity and society of the student, through self-interview, understanding the personality of the learner, and its integration into the academic and professional environment, while reaching out to the community by providing information on existing studies. Contributions to the discovery of educational and professional capacities and trends, in light of scientific and technological advancement, require an appealing education.

The main goal of school counselor is to prepare well for the future, following the course of the students and helping them to develop their energies and their preparations, and to hone their talents and skills. This makes school or educational guidance extremely important in the learner's life and the demands of society, and it is especially important whenever it is necessary to try to satisfy the learner's curiosity. Student in the common core of the baccalaureate is supervised according to her abilities and her interest.

To make this process a success in its educational dimension, the Educational and Vocational Guidance Advisor framework was set up, whose tasks revolve around a program drawn up by the Department of Evaluation, guidance, and communication, which is one of the most important structures of the Ministry of National Education.

Even if there is a good orientation, the decision and choice are difficult; the choice of course or school should be consistent with the student's preferences and hobbies to avoid problems, such as wasting time.

This study is an improvement of Ref. [1]. Here, we used a comparative study of three algorithms, namely linear regression, Decision Tree (DT), and random forest, to predict the performances of the students to make a good orientation, finally we adopted random forest which gave us better scores.

The rest of this paper is organized as follows. Section 2 describes the context of our research, emphasizing the significance of artificial intelligence and Machine Learning (ML) in education. Section 3 includes a list of related works. Section 4 describes our proposed method in detail. Section 5 discusses the obtained results. Finally, Section 6 brings our paper to a close.

2 Research Background

2.1 Impact of artificial intelligence on education

Artificial Intelligence (AI) is based on algorithms that enable machines to make decisions instead of humans. This technology improves users' experiences in a variety of areas.

Schools and students are an excellent source of data because it is possible to design school systems that can simultaneously manage school and student data and store them in the form of huge databases. This big data can be used to train massive neural networks that can predict vulnerability at the individual student level as well as material and human resource shortages at the school and university levels before they occur. Because AI is heavily reliant on data, such algorithms will assist ministries and schools in making informed decisions about their institutions, thereby increasing the quality of academic results and lowering the costs of these institutions. As a simple example, data can be collected to prepare, use and retrieve books based on the number of students in schools in previous years, and then predict the need for books in various schools in the Kingdom during the year. Coming year depending on the expected number of books from students in all schools. This way, the ideal amount of books are sent to schools instead of the increase and decrease that occurs every year, which causes students to delay receiving their books, sometimes until the middle of the semester[2–4].

In the field of education, AI can increase the level of the education system by improving each component of the teaching triangle (teacher, student, and knowledge).

2.1.1 Impact of AI on the teacher

The AI ensures the development of several technologies that are likely to replace predictable and repetitive tasks of teachers like the correction of controls so it also allows recommending books for the improvement of the level of the teacher. It is no secret to us that technology intervenes better than humans in certain contexts, and will inevitably evolve to become more and more present

in our lives in all fields, including education. So can ask ourselves: Will AI replace the teacher?

It is difficult to definitively answer this question at present, but most researchers believe that the role of the teacher will always be present, but it will differ in terms of practical and educational value, become more inclusive so that it is more concerned with the social dimension that the machine cannot and will not be able to compensate for; for many students, the source of perseverance and motivation at school remains human interaction and human contact.

2.1.2 Impact of AI on the student

For several years, Massive Open Online Courses (MOOCs) have been a great success with students who can learn what they want, when they want, and most importantly, at the pace that suits them. However, the freedom of choice and abundance of opportunities can lead to uncertainty about what to learn. AI can assist in preventing this while also providing more relevant exercises or lesson sequences for the student. In addition, intelligent tutors could predict when a student's interest begins to wane and warn their teachers to avoid a potential drop in motivation.

2.1.3 Impact of AI on knowledge

The impact of AI on knowledge appears to be at two levels: first, the training that students should receive to understand and use AI. Second, there is the knowledge that humans should have to live in a world where AI will become increasingly prevalent in an increasingly digitalized world. As a result, curricula must be tailored to meet the needs of students in seeking expertise or critical thinking development.

2.2 Machine learning techniques

ML is an AI technology that gives computers the ability to learn without being explicitly programmed. Unsupervised learning, which does not provide the algorithm with tagged data to enable it to find structure and discover logic in input data, and supervised learning, which forms classification algorithms or regressions based on human-tagged input and output data, are two of the most widely used ML methods[5, 6].

Supervised learning is the most popular learning paradigm in ML and neural networks. As the name suggests, it involves overseeing ML by showing it examples (data) of the task needed to be performed. There are numerous applications: Speech recognition, computer vision, regressions, and classifications are all examples of ML. Supervised learning is used in the

vast majority of ML and neural network problems. It is therefore critical to comprehend how this mechanism operates.

Since we are faced with the problem of predicting the baccalaureate means, we have to work with the regression by the algorithm neural networks.

So for the student to find a branch that is adequate at his level, we propose an intelligent system that meets the needs of the students. To do this, a system will be needed that will predict the average of the student's baccalaureate through his common core grades using the supervised neural networks algorithm presented in Fig. 1.

3   Related Work

Several researches have been carried out in the field of data mining to improve the educational system to ensure the good future of the student. Thus Iatrellis et al.[7] presented two methods of unsupervised (K-means algorithm) and supervised (random forest algorithm) learning techniques to predict student outcomes using. In other words, Fernandes et al.[8] presented a descriptive and preventive statistical study using data mining algorithms to predict the performance of Bronze Capital students via classification by the Gradient Boosting Machine (GBM) algorithm, which showed that the grades and absences attributes are the most relevant for predicting the end-of-year academic results of student performance. Further, Tomasevic et al.[9] compared machine learning algorithms to predict student performance in exams, i.e., finding students with a "high risk" of dropping out of the course. Moreover, Uskov et al.[10] proposed a project that evaluates eight ML algorithms to predict students' academic performance in a course. Furthermore, Abu Saa et al.[11] used DTs, naive Bayes, and artificial neural networks algorithms to predict student academic performance from a new dataset from a private university in the United Arab Emirates (UAE). In contrast, Sekeroglu et al.[12] proposed a system to predict and classify student performance using five ML algorithms, demonstrating
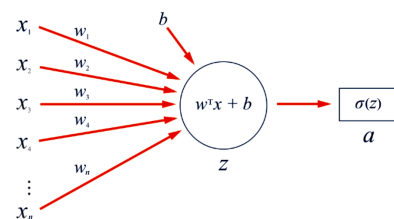

Fig. 1   Representation of a neuron.

that social and family environment has a significant impact on student performance. Abu Saa et al.[13] gave a study that verified the factors that influence student performance, namely previous student grades and class results, student online learning activity, student demographics, and social information of students, using data mining algorithms DTs, naive Bayes classifiers, and artificial neural networks. As a result, Manouselis et al.[14] discussed the value of recommender systems in Technology-Enhanced Learning (TEL) and other application areas. Thai-Nghe et al.[15] proposed a system for predicting student performance, using data mining algorithms such as DT, Bayesian Networks (BN), and Support Vector Machines (SVM) to address the issue of class imbalance. Thai-Nghe et al.[16] also proposed a comparison study of recommendation system techniques with traditional regression methods, such as logistic regression using educational data, with experimental results demonstrating that the proposed approach can improve prediction results. Furthermore Romero et al.[17] compared data mining methods to rank students based on their Moodle usage, they also applied discretization and rebalancing preprocessing techniques on the original digital data to check if better classifier models are obtained. Besides Bekele and Menzel[18] used data mining techniques to predict student performance, indeed it demonstrates an application of the Bayesian approach in education and shows that the BN classifier has the potential to be used as a student performance prediction tool. Hence Nghe et al.[19] used data mining techniques to compare the accuracy of DT and BN algorithms for predicting students' academic performance. Furthermore, Chavarriaga et al.[20] proposed a recommendation system that helps students improve their learning skills and reflects that students' social knowledge and skills are good sources of valuable recommendations for online and blended courses. On the other hand, Tarik and Farhaoui[21] proposed a system of recommendation for the orientation of the students of the high school of the education academy of the region of Guelmim Oued Noun located in the center of Morocco by using the algorithms of data mining. In addition, Sekeroglu et al.[22] proposed six experiments with two domains of ML, namely classification and regression, to determine student performance. This experiment demonstrates that the neural network with radial basis function outperforms the other models considered in this research. In addition, Liao et al.[23] proposed a prediction methodology using

the binary classification of the SVM to identify students at risk at the start of the term to reduce the student failure rate, and Moutaib et al.[24] discussed the importance, concept, and functionality of IoT, as well as a general study on power consumption and data storage with a solution that solves the problems of these two factors.

4　Methodology

To solve the aforementioned problem, our solution should implement an intelligent system that meets the requirements of the students. This requires a system that will predict the student's Baccalaureate average through his or her core grades using ML and data mining techniques.

The goal of this article is to design and implement a system for orienting students from the common core to one of the first baccalaureate's technical, literary, or scientific branches. The goal of this system is to have a good orientation that will allow the student to obtain a good grade based on an existing model that includes all of the students who have already passed their baccalaureate in the region of Guelmim Oued Noun.

As it is illustrated in Fig. 2, our proposed approach is detailed. With the aim to predict the pupils' averages, many steps have to be completed.

SQL table: This is the first phase of our approach with the DBMS Mysql. The DBMS Mysql is a relational SQL database server designed with high read performance in mind, which means it is more suited to serving data that is already in place rather than frequent and secure updates. It has multiple threads and users.

Python script: In this phase, we programmed our source code with Python, which is a programming language developed in 1989 used in various fields of application, particularly in AI. Its main characteristics are open-source, simple, and very readable, with a large basic library, a large number of libraries available, great portability, object-oriented, dynamic typing, and support for the integration of other languages.

Test and score: At this point, we can begin training the neural network's algorithm, but first we must divide the dataset into three parts: the training data will be used to train the algorithm, the test data will be used to check the performance of the result with a score, and the validation data will be used only at the very end of the process.

Fig. 2　Approach of solution.

Predictions: In last step we tested new student predictions by introducing scores to predict baccalaureate averages.

Any project in the field of ML requires a very detailed approach.

4.1 Data search and preprocessing

This is the most critical stage for a data scientist when beginning a ML project. The information comes from the Guelmim Oued Noun region's Regional Academy of Education and Training in central Morocco.

Preprocessing and data cleaning are important tasks that must be done before using a dataset for model training. Raw data are frequently noisy, untrustworthy, and incomplete. When used in modeling, they can produce misleading results.

After the data are processed, a set of cleanups is performed to remove irrelevant elements and correct for missing values.

The Regional Academy of Education and Training initially provided us with the grades of 142 110 students after data filtering (removal of missing values and students who did not have their baccalaureate degrees), but the fact remains that the averages of 72 010 students enrolled between 2000 and 2015.

The main objective of our research is to have an intelligent system that allows us to predict the baccalaureate average from an already existing model.

4.2 Presentation of data

The GestionNotes database contains the grades of students in the high school cycle at three levels: common core, first-year baccalaureate, and second-year baccalaureate.

Table 1 shows the orientation of a student in each branch in different options chosen in the first year of his or her high school career.

4.3 Select model

There are many families of algorithms, variants of algorithms and each may require many parameters. It will therefore be necessary to

• preselect a set of algorithms to be tested corresponding to the type of problem and data available;

• define relevant comparison metrics according to the objective;

• design a method for learning and testing with the dataset, with possible validation;

• on the basis of the defined metrics and test, launch a comparison and selection process which can be manual

Table 1 High school career.

Level	Technical	Scientific	Literature
Level I	Technical core	Core science	Core literature
Level II	MST	MS	LSS
	EST	MS	–
	ESM	–	–
	MS	–	–
Level III	MST	MSA	L
	EST	MSB	SS
	ES	PS	–
	AMS	LES	–
	MSB	–	–

Note: MST: Mechanical Science and Technology; MS: Mathematics Sciences; LSS: Literature and Social Sciences; EST: Electrical Science and Technology; ESM: Economic Science and Management; MSA: Mathematical Science A; L: Literature; MSB: Mathematical Science B; SS: Social Sciences; ES: Economics Sciences; PS: Physical Sciences; AMS: Accounting Management Sciences; LES: Life and Earth Sciences.

or automatic. It is common to begin with manual tests using various graphical visualizations to understand the evolution of the model, followed by an automatic process to search for optimal algorithms and parameters; and

• analyze and possibly create more advanced models, such as combining models or model scenarios according to the available data.

### 4.4 Used algorithm (neural networks)

Neural networks are simple imitations of the functions of a neuron in the human brain to solve ML problems. A neuron is a unit that is generally expressed by a sigmoid in the following:

$$f(x) = \frac{1}{1 + e^x} \tag{1}$$

The simple perceptron is said to be simple because it only has two layers: the input layer and the output layer. The network is activated by the reception of input data. In this network, data are processed between the input and output layers, which are all interconnected. As a result, the entire network has only a weight matrix. The simple perceptron's ability to transform the weighted sum received as input is limited by the fact that it only has a single weight matrix in the case of regression. The activation function is the identity function; it returns what it has received in full like in Fig. 3.

5 Result

At the end of the first year of high school (common core), students are led to choose a course according to their preferences and abilities, considering the studies
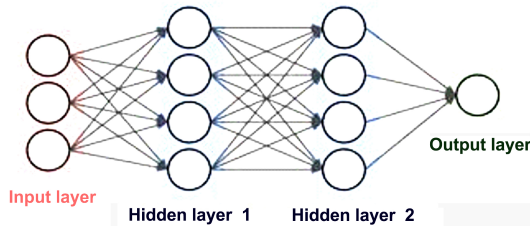
Fig. 3   Architecture of a multilayer perceptron.

envisaged after the baccalaureate.

The goal of this system is to have a good orientation that will allow the student to get a good grade based on an existing model that includes all students who have already passed their baccalaureate in the region of Guelmim Oued Noun.

After testing the neural networks algorithm, we built graphs that illustrate the score of each algorithm for each chosen sector.

5.1   Literature branch

The LSS is one of the branches that a high school student can choose after a common core of LSS. The main objective of the LSS branch is to enable students to deepen a literary culture based on the spirit of analysis and synthesis, as well as to develop their communication skills, both written and oral.
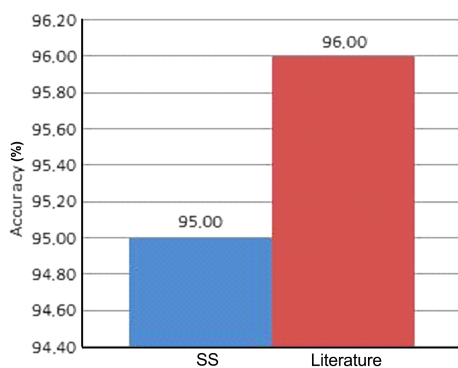
This branch also aims to enable students to acquire a good knowledge of the SS.

Students who chose Literature in the first year (common core) can choose either Literature or SS in the second year. Table 2 presents the statistics for each option.

Figure 4 gives the scores of the program executed on

Python using the Tensorflow library with 95% for the SS option and 96% for the Literature option.

5.2   Science branch

The science branches aim to enable students to acquire solid and coherent training in scientific culture in several disciplines (MS, LES, PS, etc.).

The students in the science common core are encouraged to be fully introduced to scientific subjects because it allows them to integrate better into the school and to choose a branch of study that will allow them to reach the path they have set before arriving at the school.

So to succeed in high school, the student must have the reflex of a scientist who has a critical mind and a way of doing things that is methodical.

For students who have chosen Science in the first year (common core), they have the option of choosing either MSB, MSA, PS, or LES. Table 3 presents the statistics for each option.

Figure 5 gives the scores of the program with a score of 85.42% for the MSB option, a score of 90.29% for the MSA, a score of 89.22% for the PS option, and finally a score of 92.03% for the LES option.

5.3   Technical branch

Technical education is structured around technical and scientific fields to train students with good analytical skills and solid know-how.

For students who have chosen science in the first year (common core), they can choose EST, MST, ES, AMS, and MSB.

Table 4 presents the statistics for each option.

Figure 6 presents the scores of the algorithm tested on

Table 2   Statistics for SS and Literature.

Branch	Number of students
SS	24 290
Literature	28 305
Total students	52 595

Fig. 4   Score of branches SS and Literature.

Table 3   Statistics for branch of science.

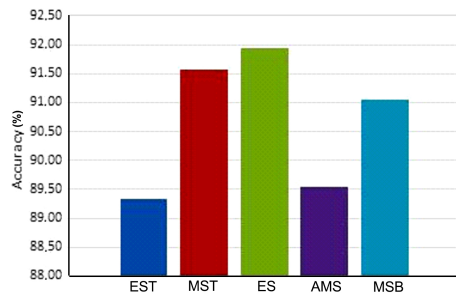| Discipline	Number of students
MSB	241
MSA	721
PS	8792
LES	9255
Total students	19 009
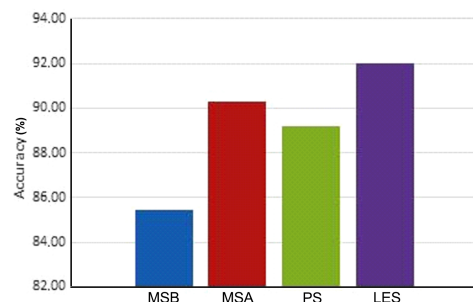
Fig. 5   Score of science branches.

Table 4   Statistics for technical branches.

Discipline	Number of students
EST	140
MST	71
ES	122
AMS	52
MSB	31
Total students	416

Fig. 6   Score of technical branch.

the marks of the students who chose the basic technical option with a score of 91.56% for the MST option, a score of 89.33% for the EST, a score of 91.95% for the ES, a score of 89.53% for the AMS, and finally a score of 91.05% for the MSB option.

6   Conclusion

In this article, we have discussed the problem of school guidance in the Guelmim Oued Noun region and its impact on students' life. We were able to predict the baccalaureate average as a function of several explanatory variables (the grades of the common core courses). To achieve the best possible results for a good academic and professional orientation, we used the neural network algorithm, which provided us with good scores and predictions.

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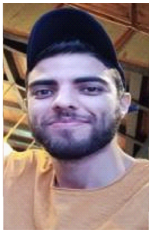
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