An Intelligent Procedure for Dynamic Evaluation in a Scientific Learning Session

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Abstract. In this research, we are interested in the evaluation of scientific subjects’ teaching components such as course questions, examples, application and deepening exercises. Thereby, we have presented a method that allows the teacher to make decisions using a system that implements interpretations based on the decision tree. The proposed system does not only propose assessing students’ learning, but it also offers the teacher intervention phases to reduce the difficulties encountered by students. This evaluation approach offers the opportunity for each student to acquire the necessary skills needed in their learning according to their abilities. In our research, we are interested in an evaluation that is based on an intelligent strategy to adjust the students learning during the classroom session. We present the interaction strategy between the teacher, the intelligent system and the students. Last but not least, we build the decision tree and interpret the results obtained, its use by the teacher for any further improvement. Consequently, this indicates the importance of this evaluation conception through artificial intelligence and its impact on machine learning by offering it an interesting database.

1. Introduction

Several researchers are interested in involving the different aspects of the scientific research development in several fields, notably in education \cite{1}-\cite{5}. Therefore, it allows students to acquire knowledge and skills that improve their performance. They proposed new pedagogical approaches which meet the requirements of existing progress and which provide the learners with motivation. To succeed in any learning operation, Kenn Fisher \cite{6} proposed the methods which allow the insertion of technological means in the students educational environment. The interaction between advanced didactic means (software) and learners is of great importance to achieve the success of an educational objective \cite{5} \cite{7}-\cite{11}. This research focused on the relevant evaluating means for a judicious contribution of technological tools and procedures in the learning operation. Artificial intelligence, like other various fields, has undergone an enormous evolution thanks to its remarkable development in scientific universe and technological research. Thus, different sectors have considerably improved and they offer more efficient services to citizens than before. The research carried out, by using artificial intelligence, in the educational field focuses on the personalized and dynamic learning paths of the learners. The enormous development in the fields of scientific research, computer programming, technological tools, didactic means and pedagogical procedures, allowed the learners to obtain a qualified education which meets the needs of each one \cite{3} \cite{4} \cite{10} \cite{12} \cite{13}. Recent research \cite{13}-\cite{17} has focused on the use of artificial intelligence in the student evaluation operation at the end of learning session.
The dynamic evaluation of the content as the session progresses offers the possibility of reducing the difficulties encountered by the students. This allows equity between learners to acquire knowledge and allow everyone to improve his level according to their abilities. We also cite the research [18] [19] which evoked the importance of the use of the decision tree in teaching and its impact on the operations of analysis, syntheses and data interpretations. It is an interesting tool to improve the learning of the management system so that it can increasingly make precise decisions. We also cite research that involves the application of artificial intelligence in the dynamic assessment of skills for scientific subjects [20]. In our research, we were interested in an evaluation through an intelligent strategy to allow the teacher to make the appropriate decision and to adjust the students learning at the end of session. This paper is organized as follows. In section 2, we present the research method and we describe the interactions between classroom stakeholders in the learning operation. We also provide a theoretical study which highlights the impurity function in a decision tree then we process to a practical application. In section 3, we provide the necessary results and interpretations. At the end, we offer a conclusion.

2. Research method
The method used in this research is based on the following steps. We firstly design the approach for the evaluation of each teaching component of scientific subjects and the procedure for retrieving the results. Besides, we present the interaction strategy between the teacher, the intelligent system and the students. We also offer the importance of data processing tools for making good decisions. Moreover, we highlight the decision method by specifying the importance of the Gini decision index. Then, we study the impact of our intelligent system on the performance of the learning operation through examples. Finally, we show the importance of this evaluation design through artificial intelligence and its impact on machine learning by providing it with an interesting new database.

2.1. Interactions description
We specify the necessary educational tools for the operation of the learning assessment in the stakeholders environment. We present, see figure 1, the existing components and their interpretations for scientific subjects.

- Information: these are the knowledge that the teacher would like to transmit to the learners. It can tackle the different skills that are targeted during a specific session. The teacher must prepare his lesson according to a strategy composed of sequences which will be evaluated as the session progresses. Course questions, examples, application and deepening exercises are prepared in advance by the teacher in order to assess the transitional phase.

- Informatics tools: these are the technological means that will be used during a session, namely computers or tablets for the students, a computer for the teacher, a data show whose projection is in front of the teacher.

- Software and computer programs: these are the procedures and computer programs that allow us to assess the learners performance. These are different computer programs that can display the questions, examples and exercises proposed by the teacher and collect the learners’ answers. Also there are computer programs which process the information obtained and evaluate it by proposing solutions to be adapted by the teacher.

- Visualization of the evaluation: It is the operation of visualizing the students results, it can be instantaneous and recovered by the teacher as the learning session progresses. She can provide us with an evaluation at the end of the learning session for further improvement. Also, it offers interpretations of student results throughout the school year and monitor the level of the class level.
Course questions
Examples
Application exercises
Deepening exercises

System
Assessment
Visualization

Deepening exercises

Figure 1. Teacher interaction with dynamics assessment of different tests

- Methodology: the teacher must prepare the content to be transmitted, specify the questions necessary to assess the understanding of the course, examples, application and deepening exercises. In developing this content, he must also specify the stages of transitions between his assessments. In the moment of a student’s performance evaluation, they respond through their tablets and the computer system processes, analyzes and interprets the results obtained. Then displays conclusions on the data show which is in front of the teacher. The system offers, in the event of insufficiency, solutions to resolve the learning difficulties identified when assessing a type of understanding. An analysis of the progress of the information is presented by the system on the learning content during this session. The system also proposes improvements for possible transmissions of this session content. It is an intelligent evaluation process as the learning session progresses.

2.2. Learning assessment conception

The teacher adopts an educational approach to animate his learning session by transmitting the content through activities that are well suited to the expected skills. The information transmission activities can contain explanatory questions, introductory examples of illustrations and educational exchanges between class members. The teacher proposes the tests as the course of the learning session progresses: course questions, examples, application and deepening exercises. Students respond through technological tools (computers, tablets, etc.), the system automatically collects and processes student responses for each component mentioned above. The course questions are linked to the concept transmitted and which aim at ensuring the understanding of its definition and its properties. The test on the examples involves the direct application of the concept and its properties. The main objective of this phase is to make sure that the students have clearly defined the subject and all the domain of the concept and that step does not present enough difficulties. The application exercises are directly implemented in the content of the session and is more difficult than the examples. The main objective is to ensure that students can apply the concept in direct application situations. The deepening exercises require additional reflections for the learning session content. Their objective is to improve the overall use of the concept among students, and their difficulty is more than the application
exercises. This allows the teacher to have an evaluation on the knowledge transmission in progressive difficulty. The intelligent system makes it possible to provide, at the end of the learning session, the necessary recommendations to reduce the problems encountered by the students. Thus, the artificial intelligence can help the teacher make appropriate decisions at the end of learning session, in order to minimize the difficult situations encountered by the students. The teacher must also plan lesson questions, examples and additional exercises to be satisfied with the student performance. The system can compare the evolution of the learning components mentioned above during a learning session.

2.3. Impurity function in a decision tree
The construction of the decision tree is subject to the rule of splitting the learning sample into more significant parts. Each time, we must decompose the data into two parts with maximum homogeneity. Thus, the Gini index is an important factor which intervenes to show the magnitude of the homogeneity in the distribution of the data. Maximum homogeneity of the resulting nodes is characterized by the so-called impurity function \( i(t) \), where \( t \) denotes the instant \( t \), see [21]. In practice, to define the impurity function, we have interested in the Gini splitting rule which is defined as follows:

\[
i(t) = \sum_{1 \leq k, l \leq K; l \neq k} p(k|t)p(l|t),
\]

where \( K \) is the class number of \( N \) observations and \( p(k|t) \) is the probability of the class \( k \) knowing that we are at the node \( t \). After solving a maximization problem, see [21], the impurity measure \( i(t) \) is given by,

\[
i(t) = 1 - \sum_{k=1}^{K} p^2(k|t)
\]

2.4. Practical application
Let us put the set of all the tests components by \( Test = \{C_1, C_2, C_3, C_4\} \), where \( C_1 \): Course questions , \( C_2 \): Examples, \( C_3 \): Application exercises and \( C_4 \): Deepening exercises. Let \( N \) be the number of all pupils in a class. Each student has the choice between three answers, for each question of a tests component. Consider the following notation: 1 if the answer is correct and 0 if the answer is false or if the student did not answer the question. Each tests component includes a number of questions or educational situations for which the student must answer. Consequently, for each tests component, we calculate the average of the correct answers for each student. Let us note for all integer \( i \) in \([1, N]\) and for all integer \( j \) in \([1, 4]\), \( n_{i,j} \) the average of a student \( i \) in the test component \( C_j \), so,

\[
\forall i \in [1, N], \forall j \in [1, 4] \quad n_{i,j} = \frac{N_{c,i,j}}{N_{i,j}},
\]

where \( N_{c,i,j} \) is the number of correct answers for student \( i \) in the tests component \( C_j \) and \( N_{i,j} \) is the total number of questions in the tests component \( C_j \). For each tests component \( C_j \), let us note \( N_j \) the total number of correct answers of all the pupils, thus,

\[
\forall j \in [1, 4] \quad N_j = \sum_{i=1}^{N} n_{i,j}
\]
To implement the importance of each tests component in the learning operation, we consider a specific weights. Thereby, for each learning session, we put $T$ the total number of all students correct answers in all tests components with its weights. So, we get the following relation,

$$ T = N_1 + 2N_2 + 3N_3 + 4N_4 $$

(5)

Hence, the general average of the four tests components is given by,

$$ M = \frac{1}{10}T $$

(6)

We present in the table 1, the general average of the four tests components, evaluation and recommendations given by the system at the end of learning session.

| Amplitude of the result | Correspondence | Lesson recommendation                  | Assignment |
|-------------------------|----------------|----------------------------------------|------------|
| $M \in \left[ \frac{4}{5}N, N \right]$ | $M++$          | Very successful                         | 4          |
| $M \in \left[ \frac{3}{5}N, \frac{4}{5}N \right]$ | $M+$           | Successful                             | 3          |
| $M \in \left[ \frac{2}{5}N, \frac{3}{5}N \right]$ | $M$            | Acceptable and apply decision 1        | 2          |
| $M \in \left[ \frac{1}{5}N, \frac{2}{5}N \right]$ | $M-$           | Insufficient and apply decision 2       | 1          |
| $M \in \left[ 0, \frac{1}{5}N \right]$ | $M--$          | Very insufficient and apply decision 3  | 0          |

- Decision 1: Suggest other deepening exercises.
- Decision 2: propose other application exercises.
- Decision 3: Provide more course explanations and add extra examples.

3. Results and interpretations

The objective of studying this decision tree is to know the degree of each learning operation success, and the suitable decisions that must be made in case of difficulties faced by the students. Then, we give simulations on the students performance in a class that contains thirty students ($N = 30$). We present in the figure 2, the decision tree relating to the data recovered by the learning phases evaluations mentioned above. The database is populated with 50 results. We first start to interpret the decision tree by looking at its database, see figure 2. We interpret some results obtained by the paths provided in the decision tree, to assess the educational performance of a scientific session, see table 2. The teacher, as the session progresses and through the results obtained from $C_1$, $C_2$, $C_3$ and $C_4$, can predict the final evaluation. Consequently, he can make decisions to remedy the difficulties encountered at the appropriate time. The system collects information on student performances and evaluates the learning operation at the end of session. It also offers recommendations to remedy situations that present difficulties for students. The results expected for the tests are generally defined in the computer program as follows:

[4] correspond to 'M++' : The lesson is very successful and the performance is excellent.

[3] correspond to 'M+' : The lesson is successful and the objective is accomplished.

[2] correspond to 'M' : The performance is acceptable. Suggest other deepening exercises.

[1] correspond to 'M-' : The yield is insufficient. propose other application exercises.

[0] correspond to 'M--' : The performance is very insufficient. Provide more course explanations and add extra examples.
Table 2. Interpretation of the used database in the decision tree.

| Result conditions | Number of samples | Level |
|-------------------|-------------------|-------|
| $N_1 \leq 19$ and $N_2 \leq 6.5$ | 5 | $M$ $-$ |
| $N_1 \leq 19$ and $6.5 < N_2 \leq 13$ | 7 | $M$ $-$ |
| $N_1 \leq 19$, $13 < N_2$ and $N_4 \leq 19.5$ | 15 | $M$ |
| $N_1 \leq 19$, $13 < N_2$ and $19.5 < N_4 \leq 25$ | 1 | $M$ $+$ |
| $N_1 \leq 19$, $13 < N_2$ and $25 < N_4$ | 1 | $M$ $+$ $+$ |
| $19 < N_1 \leq 27.5$ and $N_3 \leq 13.5$ | 1 | $M$ |
| $19 < N_1 \leq 27.5$, $13 < N_3$ and $N_4 \leq 23$ | 13 | $M$ $+$ |
| $19 < N_1 \leq 27.5$, $23 < N_3$ and $23 < N_4$ | 2 | $M$ $+$ $+$ |

The proposed tests are:
Test 1: `print("The level of lesson assessment is", dtree.predict([[26, 25, 28, 25]]))`
The level of lesson assessment is $[4]$
Test 2: print("The level of lesson assessment is", dtree.predict([[12, 10, 8, 7]]))
The level of lesson assessment is [1]
Test 3: print("The level of lesson assessment is", dtree.predict([[10, 5, 4, 4]]))
The level of lesson assessment is [0]
Test 4: print("The level of lesson assessment is", dtree.predict([[22, 20, 20, 19]]))
The level of lesson assessment is [3]
Test 5: print("The level of lesson assessment is", dtree.predict([[16, 15, 15, 13]]))
The level of lesson assessment is [2]

We note that the results of our research are consistent, if we compare them with the data table. Each time a result is known, our database is enriched and becomes more important for decision making.

4. Conclusion
The used approach allows the teacher to ensure students’ acquisitions and to make the appropriate decision during the learning session. Thus the intervention of the teacher in the encountered difficulties case is so precise through the proposals of the intelligent system used. A database is built on the students performance throughout the school year which allows permanent monitoring of the class progress. The collected information can feed the system and consequently the evaluation operation becomes increasingly efficient in decision making. We may be interested locally in evaluating each learning phase thereby the decision making by the system will be more precise and the evaluation will thus be dynamic as the session unfolds. We can focus on a more precise scale by distinguishing between false answers and unanswered questions. We can also give more importance to learning components weighting mentioned above to improve the system decision.

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