Learning Evaluation in Classroom Mediated by Technology Model Using Fuzzy Logic at the University of Amazonas State

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Abstract - This article presents a tool developed to follow up and to evaluate the student learning using Fuzzy model. This tool enable the coordination of Classroom mediated by technology (CMT) courses at University of State of Amazonas to elect the best teaching practices that allow the increasing of student’s performance. The course coordinators will have a tool to support decision-making, assisting professors in the use of new methods. The learning environment is modeled using Fuzzy theory, based on parameters and rules selected by courses coordinators, teachers and pedagogical experts. Analysis of the environment to be modeled and of its requirements shows the parameters to be selected. In the CMT system the teacher has no direct contact with the student in the classroom, to ask direct questions, or even to look facial expressions to detect immediately the doubts of the student. For this reason, the system must monitor the students behavior as they perform different activities, that will be tracked by the system and used in the fuzzy modeling to evaluate individual performance as well as whole learning process. The paper presents the selected parameters, developed rules and the results of the fuzzy model for the evaluation in a real situation.

Index Terms – Learning, Classroom mediated by technology, Fuzzy Logic.

INTRODUCTION

The use of ICT (Information and Communication Technology) has been growing and gaining impulse, with new ways of information transmission emerging in the market and many of them, when applied to education, are key factors in the learning process.

In the state of Amazonas the population is distributed in distant places where navigation in the rivers has been the main transport mean. Education is a necessity to promote the social inclusion of individuals and is a key issue to assure sustainability of the Amazon region but the large geographical distances appears as a major obstacle. Despite the state capital Manaus to be an industrialized city with many universities, the human resources needed for the promotion of training is scarce in remote areas and new ways as been provided to take education at various levels to the population along the rivers of the region.

Classroom mediated by technology (CMT) is the result of the urgent necessity felt in a region where geographical distances are an obstacle to overcome before people can have access to sustainable development. Designing this new hybrid model, that has characteristics of both, classroom and distance education models, has been a challenge in the way of providing education with quality to students in the Amazon state, Brazil. Synchronous distance classes are transmitted via satellite by University of Amazonas State (UEA) and at every place the classes are received, a local teacher gives support to students during and after the class presentation. This scenery is complemented by a LMS (Learning Management Systems) that helps in supporting complementary material, collaboration and interactivity in the proposed classroom mediated by technology model. This approach has the aim of providing higher education to places where the lack of qualified professionals is high, as well as transport and access to technological resources, among others.

The development of the solution presented in this paper will benefit the many kinds of courses of this new model allowing the follow-up of the learning process. As long as new methodological guidance is established, the student learning will be gradually raised. The tool may also support the coordinators of the course to make decision, and even assist teachers in using new methods, according to the school subject that they teach.

In this analysis of the environment in which the model is found, many parameters can be defined, that is, there is a range of possibilities to be analyzed and used. In the system of classroom mediated by technology (CMT) the professor does not have direct contact with the student like happens in the normal classes. In this kind of classes, verbal questions or facial expressions show how students are understanding a concept and the teacher can try different ways to explain the concept to make it clear to all students. The development of activities is a complicated factor, considering that the professor must infer the doubts students may have, based on their previous experiences in the classroom, to avoid to the maximum amount of doubts and questions that may arise. Then, on this stage it is believed that a tool that monitor the student’s actions and analyzes the generated records using a fuzzy algorithm allow assessing the interactions of the students in this new learning environment.
This article presents a fuzzy model processes for monitor and evaluation the student’s participation in the proposed activities to offer a diagnosis of the student learning to the coordinators of the course in TCM model of the UEA in the way to elect the best teaching practices allowing students greater performance.

The structure of the article includes the following topics: section two will present the status of the UEA classroom mediated by technology (CMT) system, in section three, the fuzzy model and, finally, section four presents the final considerations.

**UEA’S CLASSROOM MEDIATED BY TECHNOLOGY**

The CMT courses are offered by University of Amazon State in Brazil and some resources are used according the courses and the subject offered. For each subject there are three main professors that are called Titular Professors. They are responsible for the elaboration of the didactical material, the slides presentations and the evaluations, besides teaching. The classes are live transmitted via satellite from Manaus (Figure 1) to distant communities where they are synchronously assisted (figure 2).

In every locality the class is received there is another kind of professor, the Assistant Professor who is in charge of monitoring the activities of the students concerning the classes ministered by professors at Manaus where they are located in television studios.

In the system there are two types of activities, one is face-to-face that is performed by the professor and monitored by an assistant professor and another activity is in the Virtual Learning Environment called TADS virtual.

As discussed in [1], it is necessary that the professor is familiar with these technologies, their language, the potential uses of convergence of technologies, and the risks of failures, especially how to integrate the teaching process, transforming them in ways to promote learning.

The professor guideline includes adopting methods and techniques suitable for the efficiency of education, trying to improve the student achievement in the subject, encouraging them in exercises and in collaborative work.

This model of education is categorized as a hybrid of models face-to-face and distance education. The name often used is blended learning as discussed in [2].

In those hybrids courses all the activities in the continuous spectra are positioned in space (virtual / real), time (synchronous / asynchronous) and interactivity (passive / interactive).

All this revolution of educational strategies and new models bring a long-standing concern, how to think about evaluation aspects in situations so antagonistic?

According to [3], evaluation mediated by electronic technologies becomes a new extension of memory, with qualitative differences when related to other technologies. It enables that the linearity of reasoning be changed by ways of thinking, based on simulation, experimentation, and a new language that involves written, oral, pictures, and instant communication.

The system being developed is intended to help the teacher to obtain an assessment of student performance.

Pedagogical coordinators of the courses have a necessity to obtain a return on student learning in the subjects, which could bring subsidies to specify working approaches and pedagogical methodologies to the titular professor as far as the assistant professors.

At present the new virtual learning environments (VLE) requires more and more artificial intelligence techniques for supporting staff in carrying out the monitoring of activities, both synchronous as asynchronous.

The work of this paper has focus on formative assessment, to meet the necessity for more effective use of the information about the student and their interactions by monitoring the footprints and actions produced by the
Fuzzy Model

Insofar as the complexity increases, the ability to clarify (make precise and significant) decreases until it reaches a limit where accuracy and relevance become mutually exclusive characteristics.

Reflecting on these questions, L. A. Zadeh in [4] introduced the concepts of Fuzzy Theory as a theory that sought the representation of vagueness and imprecision of human expressions of natural language.

The introduction of fuzzy theory concepts according to [3], offer a basis for thinking about vague concepts using a tool to model the knowledge. This tool considers reasoning that the main concepts of human thought are not numbers but linguistic labels. Linguistic label is a kind of variable having a Fuzzy set as domain. For instance, the performance of students may be represented by a linguistic label “Performance” assuming values “insufficient”, “fair” and “good”, corresponding to a fuzzy set.

Unlike in classical set theory when a membership variable might take only two values 0 or 1, according x belong or not to a set A, in Fuzzy model a continuous grade of membership may vary in the interval [0,1], with the value of the function \( f_A(x) \) representing the degree of membership of \( x \) in A. Such a function is defined as \( \mu_A(x): X \rightarrow [0,1] \) where A is formed by ordered pairs like \( A = \{(\mu_A(x), x) | x \in X\} \). \( \mu_A(x) \) reflects the confidence degree of a given linguistic label applied to a particular element of a fuzzy set.

The fuzzy inference system consists of three stages. In the first stage called fuzzification values of measurements, evaluations, tests, perceptions observed in a dataset are transformed in fuzzy variables. Then and consequently it is a mapping of precise information into combinations that are relevant and nebulous. The second stage is the inference process where a list of if-then-else declarations called rules is used to map a fuzzy entry space into a fuzzy output space. After the inference process, the third stage of defuzzification performs an interpretation of such information. Although there are many methods of defuzzification the most used are the center of the area and the average of the maximum.

The base of rules is supplied by specialists in plain language or through questionnaires. They can also be based on operator control actions, based on the observation of input and output data.

The inference engine is the core of the fuzzy system, and it embodies all the logic of the fuzzy inference system. According to [4], fuzzy inference models are particularly appropriate in cases that require decision making, as these applications depends on the knowledge and experience in the processes involved.

I. Application

Figure 3 shows the system to be modeled, and the tool (fuzzy inference system) proposed to support decision making, helping improving the teaching-learning process.

In this work, data are from two basic sources, the information relating to the virtual learning environment (TADSvirtual) and face-to-face information.

In this system, specific situations and processes are vague, imprecise and uncertain and some of the parameters can be analyzed and defined, but often hard to measure. Figure 3 presents the variables of the tool and its specifications.

From the five input variables is established a single output variable that expresses the level of learning that has been achieved by the student, that is, naprendizagem Fuzzy variable results from the input variables during the inference process.

The model is fuzzy and generates results based on the use of tools of virtual learning environment by students. Once the actual needs are defined by the experts, the parameters or variables necessary to infer potential learning outcomes are obtained, resulting in linguistic input and output variables. There are two types of variables, non-linear variables that depend of judgments relating to interactions in the virtual environment and linear variables that result from assessments made in the form of presence test.

Table I presents the linguistics variables of the system, its meaning and Fuzzy set of its value.

The linguistic terms of input variables, “insufficient”, “good” or “very good”, were defined through knowledge experts, which in this case were the main teachers and coordinators of the course.

In table II it is observed the membership functions of the linguistic variable vlchat.
TABLE I. LINGUISTIC VARIABLES OF FUZZY SYSTEM.

<table>
<thead>
<tr>
<th>LINGUISTIC VARIABLES</th>
<th>FUZZY SETS</th>
<th>UNIVERSE OF DISCOURSE</th>
<th>DEFINITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>vlchat</td>
<td>Insufficient</td>
<td>[0:10]</td>
<td>Variable that measures the student's interactions in virtual chat.</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very Good</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vlforum</td>
<td>Insufficient</td>
<td>[0:10]</td>
<td>Variable that measures the student's interactions in the forum.</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very Good</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vltarefa</td>
<td>Insufficient</td>
<td>[0:10]</td>
<td>Variable that measures the activities and tasks of the student.</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very Good</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vlteste</td>
<td>Insufficient</td>
<td>[0:10]</td>
<td>Variable representing the student's grade on the test partial or final exam.</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very Good</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vlfrequencia</td>
<td>Insufficient</td>
<td>[0:10]</td>
<td>Variable that represents the percentage of student attendance in the evaluation period.</td>
</tr>
<tr>
<td></td>
<td>Good</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very Good</td>
<td></td>
<td></td>
</tr>
<tr>
<td>naprendizagem</td>
<td>Insufficient</td>
<td>[0:10]</td>
<td>Represents the level of learning achieved by fuzzification of input data.</td>
</tr>
</tbody>
</table>

TABLE II - MEMBERSHIP FUNCTIONS OF THE VLCHAT VARIABLE.

Insufficient: \( \mu(x) = \begin{cases} 
0 & \text{for } x < 0 \\
1 & \text{for } 0 \leq x < 1 \\
\frac{5}{4} - \frac{x}{4} & \text{for } 1 \leq x < 5 \\
0 & \text{for } x \geq 5 
\end{cases} \)

Good: \( \mu(x) = \begin{cases} 
0 & \text{for } x < 0 \\
\frac{x}{4} & \text{for } 0 \leq x < 5 \\
\frac{9}{4} - \frac{x}{4} & \text{for } 5 \leq x < 9 \\
0 & \text{for } x \geq 9 
\end{cases} \)

Very good: \( \mu(x) = \begin{cases} 
0 & \text{for } x < 5 \\
\frac{5}{4} & \text{for } 5 \leq x < 9 \\
1 & \text{for } 9 \leq x \leq 10 \\
0 & \text{for } x > 10 
\end{cases} \)

Simulation

It has been used the Fuzzy Logic Toolbox of the MATLAB® 7.4.0 for system simulation. Figure 4 present the summary of system parameters with the use of that tool and figure 5 shows the membership functions of the variable vlchat.

Figure 6 represents the summary of Tool, where crisp values are input of the inference engine which activates certain rules and after defuzzification generates a real value, that is, crisp output representing a fuzzy mean of all activities of the student in the learning environment, both virtual and face-to-face.

The inference rules are those that determine the relationship between the linguistic variables, that are part of the set of inputs, and their direct relationship with the output. These rules are based on expert knowledge and are of the modus ponens, if \( x = A \) then \( Y = B \). Table III, shows a sample set of rules used in this tool.

TABLE III

<table>
<thead>
<tr>
<th>SAMPLE RULE BASE OF THE TOOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. If (vlteste is Insufficient) and (vlchat is Insufficient) and (vlforum is Insufficient) and (vltarefa is Insufficient) then (output1 is Insufficient) (1)</td>
</tr>
<tr>
<td>2. If (vlteste is Insufficient) and (vlchat is Insufficient) and (vlforum is Insufficient) and (vltarefa is Good) then (output1 is Insufficient) (1)</td>
</tr>
<tr>
<td>3. If (vlteste is Insufficient) and (vlchat is Insufficient) and (vlforum is Good) and (vltarefa is Insufficient) then (output1 is Insufficient) (1)</td>
</tr>
<tr>
<td>4. If (vlteste is Insufficient) and (vlchat is Insufficient) and (vlforum is Good) and (vltarefa is Good) then (output1 is Insufficient) (1)</td>
</tr>
<tr>
<td>5. If (vlteste is Insufficient) and (vlchat is Insufficient) and (vlforum is Good) and (vltarefa is Good) then (output1 is Insufficient) (1)</td>
</tr>
</tbody>
</table>
From the five input variables is provided a single output variable that expresses the level of learning that has been achieved by the candidate, that is, through the input variables, is obtained the fuzzy value naprendizagem using the linguistic terms “insufficient”, “good” and “very good”, and a set of rules.

Performed the simulation, it can be noticed that a rule base allows the conformation of the assessment model needs, as can be seen in figure 6.

The difference between the arithmetic average and fuzzy average, as showed in table IV, is the result of the will of the experts that defined the rules in such way to value certain actions of the students that are not considered in arithmetic average.

TABLE IV - COMPARISON OF ARITHMETIC MEAN AND FUZZY

The fuzzy average evaluated by the rules is increased as the student participates in many activities during the lessons. For example, two students may have the same grade equal 6, evaluated by arithmetic average, but using fuzzy average, if one of the students participated in less activity, his fuzzy average will be lower than that of the student who participated in more activities. This happens because the expert rules reward students participation in multiples activities.

According to [6], one reason to develop rigorous educational software evaluation is because our knowledge of learning and teaching is incomplete and fallible. Thus, our software is built with imperfect knowledge. And according [7], what can be measured can be understood, and if the results is not measured it is not possible to determine whether there was success or failure. The failure must be recognized to correct it and the success must be recognized to reward it. If the success is not recognized it is not possible to learn from it.

CONCLUSIONS

Considering this model of education that was described in this work, it was showed the necessity for an assessment of formative character that would provide feedback to the learning process.

The regular monitoring of the evolution of student results is important benefits, especially within the context of the learning environment, where there is no physical contact between course participants and the main teachers.

The proposed fuzzy model has been developed with emphasis on the necessities of the experts involved in the teaching-learning process of technology-mediated courses.

The success of the model is visible as it contributes positively to assist in decision making in an educational institution of prestige, because the tool provided information necessary for the teacher to have success in their discipline.

The tool allows valuing many aspects of student’s participation, not only grades got on exams and tests, in a formative way. Difficulties of some students in the learning or a pedagogical methodology not suited to the course can be put in evidence by the system and countermeasures can be taken to improve the learning process resulting on more motivated students and reducing course evasion.

REFERENCES


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