CURUMIM: A Proposal of an Intelligent Tutor System to Teach Trigonometry

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***Abstract*—This article presents a proposal for an Intelligent Tutoring System (ITS) for teaching Trigonometry in K-12 programs, using the teacher as an active agent in the learning process and employing the assumptions of the Theory of Mediated Learning Experiences (MLE). In the current scenario where Distance Learning (DL) has become a necessity, ITS offer an alternative to individualized study, however, for the construction of knowledge, mediation in learning is often necessary. MLEs offer pedagogical support focused on mediating and addressing learning problems, desirable characteristics for disciplines based on problem solving. Therefore, this research aims to present a proposal for an ITS to support the development of mathematical knowledge in trigonometry problems, inserting the teacher as an active agent in this process, exploring the potential of the MLE for the construction of the ITS. The proposed system, called CURUMIM, also has a Pedagogical Virtual Assistant (PVA) with the function of clearing up doubts arising from the subject, generating a dialogue according to the student's reciprocity index.**

***Index Terms*—Mathematical Education, Trigonometry, Intelligent Tutoring Systems.**

I. Introduction

Currently, the technology is explored in different environments and has been used in different fields of science. It is indisputable that Information Technology takes more and more space in society, most people, regardless of age group, have their own technological resources, such as smartphones, tablets or computers.

Faced with a new world scenario, impacted by the pandemic caused by Covid-19, the role played by technology in providing the creation of important tools to make life easier for the population becomes even more necessary. Technology has been presenting itself as a fundamental piece for people to be able to meet their contact needs with others, both in the personal and professional spheres.

The changes caused by the pandemic provided a period of challenges for Education with a sudden rupture in the educational environment [1]. In this process, many educators sought to adapt their classes to resources that could be used in digital media and, in this aspect, to adopt different strategies in order to be able to teach their classes at a distance. The teaching plans and methods were reformulated and many subjects were affected by this change, such as the Mathematics subject [2].

The teaching of a certain content with the help of computational tools imposes a challenge to any developer, due to the fact that there are variables of difficult computational modeling, such as subjective data about the student's impressions about a content being worked [3]. In addition, it is possible to observe that there are different groups of users with cognitive limitations and their respective characteristics. Therefore, teaching mediated with individual monitoring can be a partner in the construction of knowledge.

In the mathematical scenario, more specifically in the teaching and learning of Trigonometry. This intelligent feature is realized with a system that can solve each step of simplification trigonometric problems, due to the difficulties encountered by students in learning this content [4] [5].

The use of Artificial Intelligence (AI) applied to Education, proposes computational alternatives that can help in teaching, an example is the use of ITS, which offer one-to-one tutoring, which unite AI techniques with pedagogical theories to tutor a student in a given domain [6].

However, ITS are traditionally designed as learning tools, so the presence of the teacher is not necessary. In most cases, the content base of an ITS is composed of activities and problems to be solved by the student with the help of an artificial tutor. From the student, decisions are made about the exercises that should be proposed, with the help of heuristics and rules that allow the construction of a diagnosis about a user.

Based on research and studies, the importance and feasibility of proposing an ITS model was identified to support the educational process in the discipline of mathematics, more specifically in trigonometric problems for high school. The content was chosen based on the difficulties faced when learning Trigonometry, being still a central theme to understand topics in Physics, Architecture and many branches of Engineering [3].

The main objective of this research was to develop and analyze the usability features of the CURUMIM System with the view of the faculty. From the above, the problematic question of the present scientific research arises: Does the

CURUMIM System meet the main usability rules, making it possible to achieve objectives such as ease of learning, efficiency and user satisfaction?

In view of the above scenario, this research proposes to present an ITS as a tool in the conception of knowledge in Trigonometry, inserting the teacher as an active agent in this process. In this way, the research will explore the potential of the MLE Theory [7], for the construction of the ITS as it offers pedagogical support focused on mediation and attendance to learning problems.

II. Background

A. Basics of Trigonometry

The study of Trigonometry was not elaborated or thought of by a single individual, several thinkers at different times were part of the construction of this area [8]. The concept of Trigonometry comprises a branch of Mathematics that covers the relationship between the measures of the sides and angles of a triangle.

The most common applications are: the Law of Cosines, Law of Sines and Trigonometric Relations in the Right Triangle, as shown in Figure 1.

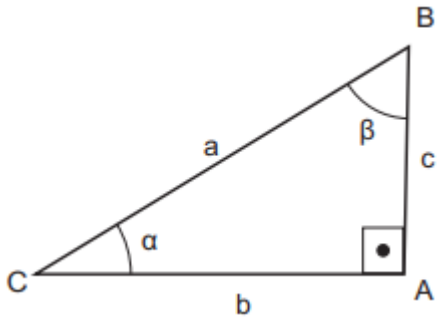

Fig. 1. Right Triangle

In Figure 1, as for the triangle ABC rectangle in A whose line segments $\overline{AB}$ and $\overline{BC}$ are concurrent at points B and $\overline{BC}$ and $\overline{AC}$ concur at point C, thus forming the angles α and β respectively and that the line segments $\overline{AB}$, $\overline{AC}$ and $\overline{BC}$ are the sides of the right triangle and that $\overline{AB}$ and $\overline{AC}$ are called legs ("perpendicular") and are given special names accordingly. with the position of the angle of analysis that we will represent by b and c. The side $\overline{BC}$, opposite the right angle, is called the hypotenuse, which means "what is understood below".

B. Theory of Mediated Learning Experiences

Psychologist Reuven Feuerstein, who studied Vygotsky's socio-constructivist theory in depth, elaborated in his studies the concept of the Theory of Mediated Learning Experiences.

Feuerstein [9] states that human beings can learn in two ways. The first is the direct learning experience, that is, the learner's relationship with the environment, while the other is the MLE, which configures the presence and activity of an individual to organize, interpret and elaborate what has been experienced.

The MLE reports three fundamental concepts that should be the object of deliberate attention on the part of the mediator: Intentionality/Reciprocity, Meaning and Transcendence. Intentionality describes that the mediator deliberately interacts with the subject, selecting and interpreting in the process of knowledge construction. Reciprocity implies exchange, that is, the mediator's opening to the subject's responses, in such a way that the subject can feel that he is cooperating and involved in the learning process.

Meaning refers to the value, the energy attributed to the activity, objects and events, making them relevant to the subject's reality. At this stage, the mediator shows interest and always evidences the reason for carrying out the activity, analyzing whether the stimulus being presented is sensitizing the mediated.

The third criterion is Transcendence, which seeks to promote the acquisition of principles or strategies that can be generalized to other situations. It is the reach for knowledge in other contexts in everyday life, which requires the development of reflective thinking about what underlies the situation.

MLE is a pedagogical approach that can help individuals to become more flexible, so that their ways of reasoning can interact with new information, through new strategies for perceiving this information [9]. In this sense, people become more apt and able to perceive their weaknesses and potential.

C. Intelligent Tutoring Systems in Education

ITS are computer systems developed using AI techniques with the intention of knowing what they teach, to whom and how they do it, with the main aim of providing content and instructional method adapted to the student [10].

An ITS is a computer system for teaching that has some degree of autonomous decision-making regarding its interactions with users (students). This decision process is necessarily done online, during the system's interactions with users, and generally the system needs to access various types of knowledge and reasoning processes to enable such decisions to be made [11].

Within the ITS, AI techniques are applied to decide how to present the content, as well as what content should be presented and how to model the knowledge acquired by the student until the given moment of using the system.

In general, an ITS is software capable of instructing the learner through a curriculum that is usually composed of a series of tasks while monitoring the learner's progress [12]. These systems are capable of making pedagogical decisions in real time (in execution), guiding the student in the learning process and adapting the contents considering each user's profile.

III. Related Papers

MAZK [13] is an intelligent tutor for teaching and learning different topics. In this environment, the identification of the user's knowledge levels, as well as the difficulty criteria of the

exercises, are automatically adjusted according to the student's interaction with the tutor. However, the platform still needs a greater interaction with the user in view of the lack of a conversation agent to assist students in the construction of knowledge.

PAT2Math [14] is a Multi-agent based system that aims to teach 1st and 2nd degree equations with one variable to elementary school students through step-by-step solution. The environment applies motivational instructional techniques to students through an Animated Pedagogical Agent. However, the system does not save errors to show them to students and tutors in the long term.

ITS [15] was developed to support teaching and learning that evolve solutions to first-degree equations. The system provides an environment to follow the equation solving process and step-by-step guidance and identify specific problems and provide feedback at each step supported by a Virtual Assistant who explains basic concepts related to the subject. However, this environment does not present the actions that the teacher can take from the students' difficulties.

Table I summarizes the main features supported by the mentioned ITS.

TABLE I
FEATURES SUPPORTED IN APPLICATIONS

Functionalities	[13]	[14]	[15]	CURUMIM
Teacher Module	X	X		X
Content Consultation	X		X	X
Knowledge Assessment	X	X	X	X
Use of Virtual Assistant		X	X	X
Pedagogical Theory	N/A	Vygostky	Vygostky	Feuerstein

In most of the papers, the difficulty in interacting the system with the user is pointed out, which still requires adaptation of the conversation systems, as well as the human teacher/tutor does not participate in interactions directly in the systems presented.

From Table I, it contributed and motivated the development of this proposal, since the results serve as the basis for the implementation of a system that has sought to meet the needs found by focusing on student engagement in order to support and improve knowledge and skills with a focus on in solving problems involving trigonometry. Furthermore, in this research, we propose the educational construct of Mediated Learning as a learning theory that provides criteria to assess educational potential and to involve the teacher as a fundamental part of the evaluation process.

In the next section, we have a detailed description of the development environment presenting an overview of the platform and its functionalities.

IV. WORK DESCRIPTION

A. System Architecture

The system architecture is composed of three agents, each with its specific function. Table II describes each of the proposed agents and their respective roles.

TABLE II
AGENTS AND THEIR ROLES

Conversation Agent	Interacts with the student by activating the student,answering questions and providing the necessary information for the student.
Mediation Agent	Responsible for the student's communication interface with the environment, sends data and consults information about the student, requestsand sends content and questions to show in the student interface.
Diagnostic Agent	Receiver, updater and issuer of student data, storingthis information in the Apprentice Module databasethat contains all relevant data about the student, in addition to sending student actions to the monitoring module.

The Mediation Agent requests data and receives it from the Diagnostic Agent according to the student's profile. The Diagnostic Agent implements the concept of Meaning and Transcendence, aiming to transform potential skills into real skills and seeking to expand the student's development capacity in the studied topic. In this way, the Mediator Agent will intervene in the interaction between the student with the MLE concepts.

A function also of the Diagnostic Agent is to analyze the behavior and performance of the student regarding the use of the system and send it to the teacher. The Monitoring Module will identify the student's last access to the system and inform about the performance of a specific event (example: there are activities to be corrected).

In Figure 3, the Tutoring Cycle was divided into three layers, presenting an overview of the ITS developed, as well as their interactions:

1) **Student Interface**: The student interacts with the conversation agent whenever there are doubts about the content. The Conversation Agent has a Dialog module that contains all the data referring to the domain base.
2) **Agents That Work in MLE**: The Mediator and Diagnostic Agents are also responsible for observing the real development of the student proposing the concepts based on the MLE.
3) **Teacher Interface**: The teacher will have available the data referring to the behavior and performance of the student in the use of the system.

B. System Overview

The CURUMIM System has been developed in order to assist in the teaching and learning process of Trigonometry, encouraging students to exercise their knowledge even though they are geographically far from the classroom. Therefore, to implement the desired features and resources, PHP and Javascript programming languages, Framework Bootstrap, HTML markup language (Hyper Text Markup Language), CSS (Cascading Style Sheets) and MySQL for data persistence.

The web environment will have two modules, teacher and student. The user needs to register in the system to gain access, after registering he will be able to access the platform using his login and password, as shown in Figure 2.

Fig. 2. Login and Password Screen

When accessing the system for the first time, the teacher will register by choosing the "Register" link, filling in the necessary information and then clicking on the "Save" button.

Once registered on the platform, the teacher will create a class for interaction with the class, being able to create as many as they wish. When choosing the class want to manage, will be presented with a list of all the students enrolled in the class, in addition to graphs with the performance and progress of the class. The teacher will have the option to select each student individually and view their performance, progress and experience level, on this same screen the date of the student's last access to the platform will be shown.

The teacher will have the option to send activities/materials to the class, as well as correct the exercises that were submitted by the students, always being alerted about the receipt for correction and having the option to send it again to the student after the activity is corrected.

The module will also have a direct channel for questions sent by the student, where the teacher can answer and clarify individual questions. Figure 4 shows the initial screen of the teacher module.

In order for the student to access the activities on the platform, he/she must also register in the system. The registration works in the same way as in the teacher's area, however the student registers with the user type "Student". After registering, when accessing the system for the first time in ITS CURUMIM, the student will see the classes created and will have to choose their respective class.

After choosing the class, in the first access, the system will invite him to answer a placement test with 10 random questions, according to Figure 5, on some topics of Trigonometry, so that it can be possible to identify the level of that student in relation to the course, adapting the user's profile to the challenges that will be presented, in such a way as to consider the success and error rates of the proposed questions, the degree of difficulty and knowledge.

After completing the placement test, the system will present a tour guide for the student to understand where to find the main features and how to use the platform in the best possible way.

Course content will be divided into topics that are activated based on student progress and performance. Each topic is divided into: Study Materials, Supplemental Studies, Extra Activities, Topic Review, and Challenge.

- **Study Materials**: Subjects already registered in the system, with texts, images and videos that help students understand the topics. The explanations of the content will be based on the concepts of Meaning and Transcendence [9], thus contextualizing the subject with its reality, making it possible to have meaning in what is being explained, and also, strengthening the autonomy of the student.
- **Complementary Studies**: The teacher will have the option of submitting their own materials.
- **Extra Activities**: The teacher will be able to prepare and send to the students their own activities and assessments.
- **Challenge**: As registered in the database and evaluating the experience level of each student. Each topic will have a challenge with 15 multiple choice questions, which must be answered before the next topic can be activated. In addition to the concepts of Meaning and Transcendence at this stage, Intentionality will also be applied, customizing the tasks according to the profile of each user.

C. Pedagogical Virtual Agent

PVA was implemented, which interacts with the student when he/she requests contact. With courses in progress, sometimes the student has a content-related question and is therefore unable to proceed. It is by working with new concepts and new challenges that the student is able to incorporate them. As shown in Figure 6.

The student module will also have a Pedagogical Virtual Assistant (PVA), as shown in Figure 6, with the aim of interacting with the student, clearing up doubts and queries about the topics covered. If the doubt persists, the student can also contact the teacher by sending their questions and waiting for a response later. Therefore, the concept of Reciprocity will be present, that is, at the disposal of the mediator to place himself on the same level as the student and pay attention to his answers.

The technology adopted in the PVA implementation was Google's Dialogflow, which uses Natural Language Processing (NLP) and Machine Learning to train *intents* [16]. The flow of intents in Dialogflow was mapped with possible questions from students, triggering the necessary responses.

In this study, Dialogflow will do the work of parsing the user's text. In this case, Dialogflow uses machine learning to identify the meaning of what the user is typing, with this, the system can improve the interaction according to the user experience [16]. Based on that, this research uses the tool in order to provide the student with a way to consult basic concepts related to Trigonometry contents, through the conversion interaction.

D. Teaching Strategies

The Teaching Strategies present in ITS CURUMIM are responsible for adjusting the level of the question to the

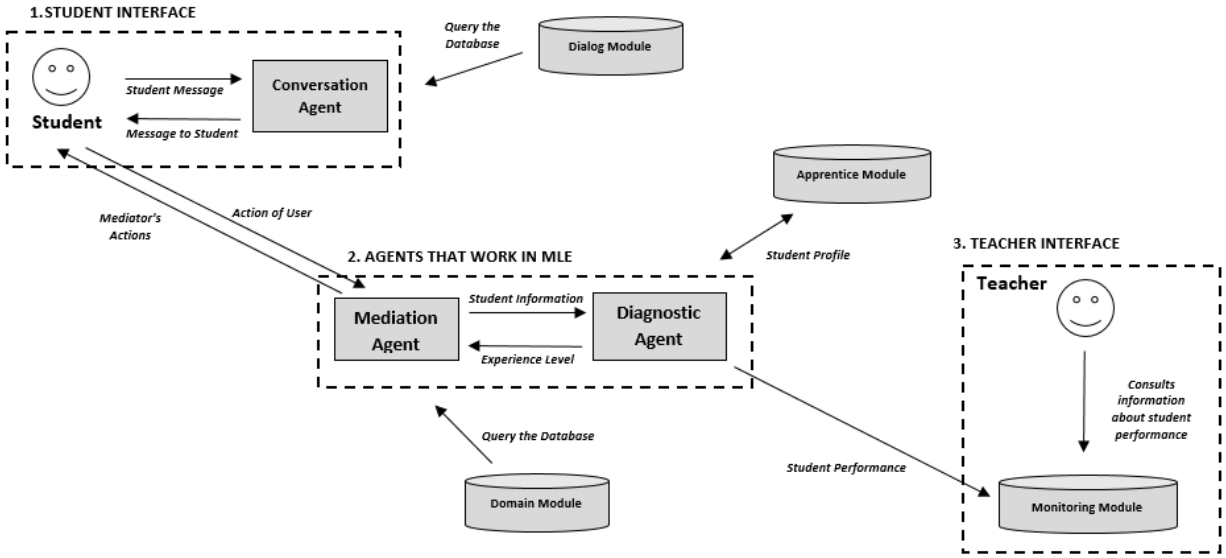

Fig. 3. ITS CURUMIM Architecture

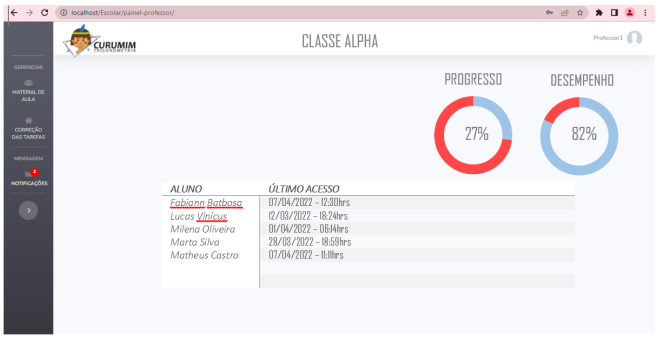

Fig. 4. Teacher Home Screen

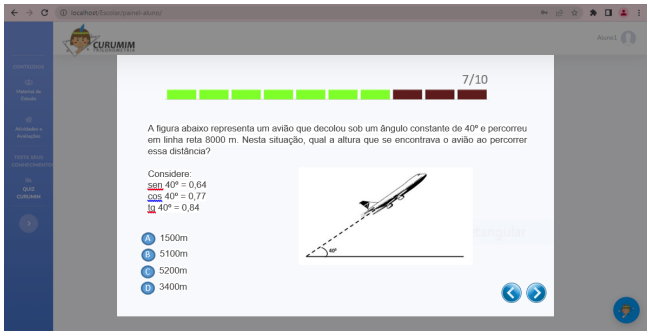

Fig. 5. Assessment Fit Level

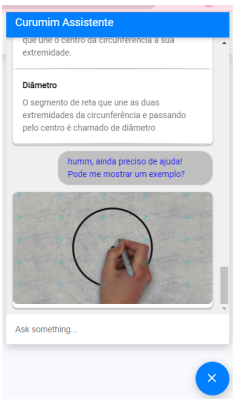

Fig. 6. Pedagogical Virtual Agent

student's level of knowledge, as well as choosing the time to change the level of difficulty. For this, the MLE concepts will be used throughout the process of using the environment.

The concepts of Intentionality/Reciprocity will be applied in the student's interaction with the conversation agent. As for the concepts of Meaning and Transcendence, they will be used in the questions to be solved and will be used to assess the student's level of knowledge.

For each of the questions, a summative assessment will be used, occurring at the end of the teaching process [17]. The student's knowledge level is computationally adjusted by analyzing the number of hits and errors of each student.

The knowledge level is divided into: Beginner, Intermediate and Experienced. For a concept to become learned, the student must get 80% of the questions right and have received some Transcendence and Meaning mediation and, therefore, is approved for the next topic.

E. Knowledge Base

Each of the questions composed in each challenge is offered based on the Teaching Strategies during interaction with the Interface. The database has a total of 30 questions per topic

divided into 10 basic, 10 intermediate and 10 advanced. This base is being fed as the research progresses.

The Knowledge Base is composed of three difficulty levels (Basic, Intermediate and Advanced) and at all levels the MLE concepts will be applied. Also, based on the resolution of each question and the relationship with other contents of Mathematics, the difficulty level of each question is also defined.

In this way, the Basic level relates to three steps to arrive at the answer to the question and addresses only a single content of the subject. Intermediate level requires between 4 to 6 steps to reach resolution and addresses up to 2 issues. And at the Advanced level, it covers more than 6 steps and employs more than 2 themes in the question.

F. System Usability Assessment

There are several questionnaires available for Usability Testing that can help you assess the usability of a product or service. Many of these questionnaires are used to assess specific types of interfaces, while others can be used to assess a wider range of interface types.

The System Usability Scale (SUS) is a test that can be used to assess the usability of a variety of products or services. SUS is one of the most used tools to measure the usability perception of a system or product [18]. The SUS method is quite popular for labs and unmoderated usability testing, as it provides insights into what users think about the usability of the tested product or website [19].

The characteristics of the SUS that make its use attractive [19], are:

- **Comprised of only ten statements:** it is relatively quick and easy for study participants to complete and for administrators to score;
- **Non-proprietary:** profitable to use and can be scored quickly, immediately upon completion
- **Technology independent:** can be used by a wide range of usability professionals to evaluate virtually any type of user interface;

Therefore, for data collection, the SUS questionnaire was used, consisting of 10 items, with 5 response options. The participant, when answering the questionnaire, marks his answer on a Likert scale ranging from 1 (I totally disagree) to 5 (I totally agree) as seen in Figure 7.

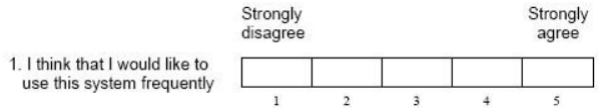

Fig. 7. Example of SUS items

The SUS scale allows a simple subjective assessment of the usability (effectiveness, efficiency and satisfaction) of products, services, software, hardware, websites and interface applications. The statements of the 10 items of the scale seek to map the usability of a system by alternating positive and negative meanings. Table 3 presents the items of the SUS questionnaire.

According to studies by Tullis and Albert [20], to obtain a valid result in usability testing, a sample of between 12 and 14 users is required. Thus, the target audience selected for the statistical data collection in this study included 12 Mathematics teachers, 5 of whom are PhDs, 4 Masters and 3 with specialization. The procedures used for data collection were divided into four stages, all supervised by the researcher. The details of the activities are presented below:

1) Guided by the researcher, the teachers accessed the platform, being able to browse and explain all the access settings to the learning environment.
2) The researcher performed some examples of practical steps and activities that could be used in the system.
3) Theoretical concepts about software usability evaluation were also explained, as well as the purpose and functioning of the System Usability Scale (SUS) tool.
4) Application of the Questionnaire – At this stage, the researcher presented the ten questions of the SUS questionnaire, showing the functioning of the likert scale.

TABLE III
SUS QUESTIONNAIRE

NUMBER	ITEM
1	I think that I would like to use this ballot frequently.
2	I found the ballot unnecessarily complex.
3	I thought the ballot was easy to use.
4	I think that I would need the support of a poll official to be able to use this system.
5	I found the various parts of this ballot were well integrated.
6	I thought there was too much inconsistency in this ballot.
7	I would imagine that learn to use this ballot very quickly.
8	I found the ballot very awkward to use.
9	I felt very confident using the ballot.
10	I needed to learn a lot of things before I could get going with this ballot.

After completing the questionnaire, the selection and tabulation of information was performed according to the methodology of the SUS system. The analysis consists of a scoring system, as shown below.

SUS produces a single number representing a composite measure of the overall usability of the evaluated system called the Score. To calculate the Score, use the following procedure:

- For odd answers (1,3,5,7 and 9), subtract 1 from the score that the user answers;
- For even answers (2,4,6,8) subtract the answer from 5. That is, if the user answers 2, count 3. If the user answers 4, count 1; in this way the values obtained will be from 0 to 4 (four being the most positive answer);
- Multiply the sum of the Scores by 2.5 to obtain the overall SUS value on a scale from 0 to 100;

Once the data has been computed, the result obtained will be the user satisfaction index in relation to the evaluated system. Any Score equal to or above 68 points is considered an adequate product or service, however if the score is lower than

this value, the evaluated system is not satisfactorily meeting the usability requirements.

Bangor et al. [21], suggest in their studies the use of an adjective rating scale instead of a numerical scale as an alternative to understand the absolute meaning of a SUS score. This scale is similar to the traditional school classification, ie: A= 90-100; B=80-89; C= 70-89 and so on until the letter F, each letter related to the degree of usability satisfaction of the evaluated system, as shown in Figure 8.

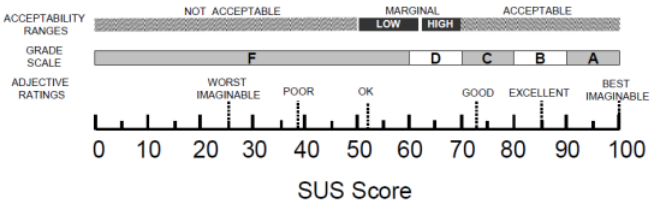

Fig. 8. Adjective Rating Scale

From the perspective of Brook [22], the scores for individual SUS items are not significant on their own, aiming to measure only the global measure of satisfaction with the system. However, recent studies show that the instrument allows the individual assessment of usability items and learning to use [20].

Brook [22] state in their research that the usability attributes defined by Nielsen [23] can be observed in the following items of the SUS questionnaire, as shown in Table 4.

TABLE IV
USABILITY ATTRIBUTES VERSUS ITEMS – SUS

Usability Attributes	Items – SUS
Learning Facility	3, 4, 7 and 10
Efficiency	5, 6 and 8
Ease of Memorization	2
Error minimization	6
Satisfaction	1, 4 and 9

The data obtained were analyzed and presented globally and individually (per item) for a better understanding of the points that stood out, seeking correlations, with the aim of answering the research problem. The analysis of the data collected and the results achieved are presented in the next chapter.

V. ANALYSIS AND PARTIAL RESULTS

The evaluation of Usability of the environment, carried out by the participants using the System Usability Scale, revealed that the global result (Score) is 82.50 points, well above the global average obtained in the studies by Sauro [19], shown in table 5.

As pointed out in the studies by Bangor et al. [21], usability evaluation of the CURUMIM system can be considered excellent, since in its adjective classification, it received a 'B' = between 80 and 89 points. To assess usability attributes such as ease of learning, efficiency and user satisfaction, the individual score index of each SUS question was verified.

TABLE V
EVALUATION OF USABILITY OF THE ENVIRONMENT

SUS: System Usability Score Calculation											
USERS	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	SUS SCORE
U1	4	2	3	2	5	3	5	1	5	1	82,5
U2	4	2	5	2	3	1	5	1	5	2	85,0
U3	4	1	5	2	3	1	5	1	5	1	90,0
U4	3	1	5	1	3	1	5	1	4	2	85,0
U5	3	3	5	1	5	2	5	1	5	1	87,5
U6	5	1	4	1	5	4	5	2	5	2	85,0
U7	5	1	5	3	5	2	5	1	5	2	90,0
U8	3	1	5	1	5	1	5	1	4	1	92,5
U9	5	2	5	3	4	2	4	1	5	2	82,5
U10	4	1	5	1	3	2	5	1	4	1	87,5
	Q - Questions					Average SUS Score:					82,50

- **Ease of Learning:** this criterion can be observed in questions 3, 5, 7 and 10 of the SUS questionnaire. The mean referring to the grouping of these items was 92.00. This average receives an 'A' in the adjective classification, so it is concluded that users were very easy to learn to use the environment.
- **Efficiency:** efficiency is represented in questions 5, 6 and 8, such questions totaled an average of 80.00 points. It can be observed that even though this score is slightly below the other items, it is in accordance with the usability standards referenced in the usability assessment, with 'B' on the adjective scale.
- **User Satisfaction:** the criteria corresponding to user satisfaction in relation to the system are referenced in items: 1, 4 and 9, the average score of such questions was 86.00 points. According to the adjective scale, this score is categorized as 'B'. The average obtained is above the 68 points defined by the SUS Score, therefore, users are satisfied with the usability of the CURUMIM system.

VI. CONCLUSION

The proposed scientific research aims to generate a contribution through an Intelligent Tutor System, to the area of Informatics in Education Trigonometry learning process.

The usability evaluation of the CURUMIM Environment, carried out with the teachers through the SUS, presented a score (Score) of 82.50 and an adjective classification "B". These results demonstrate that the system meets the main usability criteria, such as ease of learning, efficiency and user satisfaction. After the results of these evaluations, there was a need to improve some aspects relevant to the efficiency of the system.

Therefore, for future work, an application will be carried out in the classroom in order to obtain results in relation to the use of the tool and the development of mathematical knowledge in trigonometry problems by the students. Finally, from the previous citations, it was demonstrated that this research fully achieved the proposed objectives, adding values and knowledge in the academic field.

ACKNOWLEDGMENT

We thank for Brazilian Coordination for the Improvement of Higher Education Personnel (CAPES) and thanks for the support the Postgraduate Support Program - POSGRAD (UFAM) and Federal Institute of Amazonas (IFAM).

REFERENCES

[1] Lichand, G. and Christen, J., "Using Nudges to Prevent Student Dropouts in the Pandemic". University of Zurich, Department of Economics, Working Paper No. 363, 2020, Available at SSRN: https://ssrn.com/abstract=3724386 or http://dx.doi.org/https://doi.org/10.2139/ssrn.372 4386.

[2] Anggraini, T. W. and Mahmudi, A., "Exploring The Students' Adversity Quotient in Online Mathematics Learning During The Covid-19 Pandemic". JRAMathEdu (Journal of Research and Advances in Mathematics Education), 6rd ed., vol. 2, 2020, pp. 221–238.

[3] Weber, K., "Students' understanding of trigonometric functions". Mathematics Education Research Journal, 2005, v. 17, pp. 91–112.

[4] Orhun, N., "Students' mistakes and misconceptions on teaching of trigonometry". Journal of Curriculum Studies, 2004, v. 32, pp. 797–820.

[5] Chigonga, B., "Learners' errors when solving trigonometric equations and suggested interventions from grade 12 mathematics teachers". Unisa Press, 2016.

[6] Woolf, B. P, "Building intelligent interactive tutors: student-centered strategies for revolutionizing e-learning". Burlington, MA: Morgan Kaufman, 2009.

[7] Feuerstein, R., "Instrumental enrichment: an intervention program for cognitive". Secretariat of Middle and Technological Education. Illinois: Glenview, Scott: Foresman and Company, 1980.

[8] E. Tatar, "The effect of dynamic mathematics software on achievement in mathematics: The case of trigonometry". Energy Education Science and Technology Part B: Social and Educational Studies., 4 (1), 2012, pp. 459-468.

[9] Feuerstein, R., "The ontogeny of cognitve modificability – applied aspects of mediated learning experience and instrumental enrichment, Jerusalém: ICELP HWCRI, 1997.

[10] S. Yu, X. Tianwei and L. Zhiping, "Intelligent Search Agents for Web-Based Intelligent Tutoring Systems," 2008 International Conference on Computer Science and Software Engineering, 2008, pp. 1148-1151, doi: 10.1109/CSSE.2008.19.

[11] G. Santos and J. Jorge, "Atomic and Molecular Intelligent Tutoring Systems - A New Architecture for Interoperable Tutors as Open Educational Resources," 2013 IEEE 13th International Conference on Advanced Learning Technologies, 2013, pp. 138-140, doi: 10.1109/ICALT.2013.44.

[12] L. M. M. Giraffa and R. M. Viccari, "The use of agents techniques on intelligent tutoring systems," Proceedings SCCC'98. 18th International Conference of the Chilean Society of Computer Science (Cat. No.98EX212), 1998, pp. 76-83, doi: 10.1109/SCCC.1998.730785.

[13] M. H. Coelho, V. F. Pereira, E. Valeriano, L. B. Frigo and E. Pozzebon, "Application of Fuzzy Control in Embedded Sensing Systems for Beekeeping Monitoring," 2018 XLIV Latin American Computer Conference (CLEI), 2018, pp. 207-214, doi: 10.1109/CLEI.2018.00033.

[14] P. A. Jaques, H. Seffrin, G. Rubi, F. Morais, G. Cássio, I. I. Bittencourt and I. Seiji. "Rule-based expert systems to support step-by-step guidance in algebraic problem solving: The case of the tutor PAT2Math". Expert Syst. Appl., vol. 40, no. 14, pp. 5456–5465, 2013.

[15] A. M. M. Lopes, J. F. d. M. Netto, R. A. L. de Souza, A. B. Mourão, T. O. Almeida and D. P. R. de Lima, "Improving Students Skills to Solve Elementary Equations in K-12 Programs Using an Intelligent Tutoring System," 2019 IEEE Frontiers in Education Conference (FIE), 2019, pp. 1-9, doi: 10.1109/FIE43999.2019.9028363..

[16] Renz, A., Krishnaraja, S. "Toward responsible, human-centered ai in edtech". In: .[S.l.: s.n.], 2020.

[17] Ford, L. "Teaching strategies and tactics in intelligent computer aided instruction artificial intelligence review" Springer, p. 201–215, 1987.

[18] Finstad, K. "The usability metric for user experience" Intel Corporation, 2010.

[19] Sauro, J., Lewis, J. "Quantifying the user experience practical statistics foruser research, 2012.

[20] Tullis,T., ALbert,W. "Measuring the user experience." Amsterdam, 2008.

[21] Bangor, A., Kortun, P. T., MILLER, J. T. "The System Usability Scale(SUS): an Empirical evaluation."International Journal of Human-Computer Interaction, 2008.

[22] Brook, J. "A "quick and dirty" usability scale. Usability Evaluation in Industry."pages 189 – 194, 1996.

[23] Nielsen, J."Usability engineering." MA: Academic Press. Boston, 1993.