Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467

https://doi.org/10.23913/ride.v11i22.848

Artículos científicos

Sistemas de tutoría inteligente y su aplicación en la educación superior

Intelligent Tutoring Systems and their application in higher education

Sistemas de tutoria inteligentes e sua aplicação no ensino superior

Mario Humberto Rodríguez Chávez
Universidad Politécnica de Victoria, México
mrodriguezc@upv.edu.mx
https://orcid.org/0000-0002-5421-427X

Resumen

El sector educativo está cambiando con la evolución e implantación de nuevas tecnologías. Hasta hace poco, las plataformas virtuales para el desarrollo de actividades educativas, el *software* colaborativo de *e-learning* e incluso los dispositivos móviles como las tabletas electrónicas eran recursos impensables en un aula. Sin embargo, debido a la evolución de la tecnología, se han venido desarrollando nuevas herramientas didácticas para fortalecer la educación, entre estas tenemos sistemas tutores inteligentes (ITS), los cuales están diseñados para fortalecer el aprendizaje dentro y fuera del aula. Por eso, el objetivo principal de este trabajo es el análisis del uso y características de los sistemas de tutoría inteligente como programas de enseñanza asistida por computadora, los cuales utilizan técnicas de inteligencia artificial para la representación del conocimiento y así proponer/dirigir una enseñanza preparada para comportase como un experto capaz de realizar un diagnóstico situacional del alumno y, en relación con ello, ofrecer una solución o acción. Para cumplir este objetivo se estudiaron los diferentes componentes de un sistema de tutoría inteligente y su implementación en diferentes áreas de conocimiento de las ciencias.

Palabras clave: educación, inteligencia artificial, programación, tutor inteligente.

Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467

Abstract

The education sector is changing with the evolution and implementation of new technologies. Until recently, virtual platforms for the development of educational activities, collaborative e-learning software and even mobile devices such as electronic tablets were unthinkable resources in a classroom. Due to the evolution of technology, new teaching tools have been developed to strengthen education, among these we have Intelligent Tutor Systems (ITS) which are designed to strengthen learning inside and outside the classroom.

The main objective of this work is the analysis of the use and characteristics of Intelligent Tutoring Systems as computer-assisted teaching programs, which use Artificial Intelligence techniques for the representation of knowledge and propose / direct a teaching prepared to behave as an expert, being able to make a situational diagnosis of the student and, in relation to it, offer a solution or action. In order to achieve the objective, the different components of an Intelligent Tutoring System and their implementation in different areas of science knowledge were studied.

Keywords: education, artificial intelligence, programming, intelligent tutor.

Resumo

O setor de educação está mudando com a evolução e implementação de novas tecnologias. Até recentemente, as plataformas virtuais para o desenvolvimento de atividades educacionais, softwares colaborativos de e-learning e até dispositivos móveis como tablets eletrônicos eram recursos impensáveis em uma sala de aula. Porém, devido à evolução da tecnologia, novas ferramentas didáticas têm sido desenvolvidas para fortalecer a educação, entre elas temos os sistemas tutores inteligentes (STI), que têm como objetivo potencializar a aprendizagem dentro e fora da sala de aula. Portanto, o objetivo principal deste trabalho é a análise da utilização e das características de sistemas tutoriais inteligentes como programas de ensino assistido por computador, que utilizam técnicas de inteligência artificial para a representação do conhecimento e, assim, propor / direcionar um ensino preparado para se comportar como um especialista capaz de realizar um diagnóstico situacional do aluno e, em relação a ele, propor uma solução ou ação. Para cumprir este objetivo, foram estudados os diferentes componentes de um sistema de tutoria inteligente e a sua implementação em diferentes áreas do conhecimento científico.

Palavras-chave: educação, inteligência artificial, programação, tutor inteligente.

Revista Iberoamericana para la Investigación y el Desarrollo Educativo
ISSN 2007 - 7467

Fecha Recepción: Agosto 2020 **Fecha Aceptación:** Febrero 2021

Introduction

In recent years, with the proliferation of information and communication technologies, the term innovation has become almost synonymous with technological innovation in education. The new culture of total quality that is being implemented in education from the business world makes "innovation" subordinate to continuous "improvement" (Barraza, 2005). In this way, the incorporation of technological elements - such as intelligent tutoring systems (ITS), which are systems designed to replicate the effectiveness of human tutoring in digital tools - help students to understand the characteristics of specific programming languages. and develop their general problem-solving skills.

Computer-assisted teaching through ITS was born in the 1960s, after being investigated and developed in centers and universities, taking on a greater boom after the appearance of microcomputers. ITS are programs that approach a teaching session as a cooperative process between the tutor and the student with the objective of teaching and learning certain concepts; Its design and construction is the basis of cognitive psychology, educational research and artificial intelligence (Quispe, 2014). Regarding the development of ITS, this is a topic related to the birth of artificial intelligence (AI) and the documentation of the use of algorithms such as Bayesian networks, neural networks or fuzzy logic, which are alternatives for the construction of a tool increasingly intelligent and empathetic to support learning software development.

ITS began to be developed in the 80s and were designed with the idea of imparting knowledge based on some form of intelligence to guide the student in the learning process (Urretavizcaya, 2001). Its purpose is to exhibit a behavior similar to that of a human tutor, which adapts to the behavior of the student, identifying the way in which he solves a problem himself to help him when he makes mistakes. An intelligent tutor, therefore, "is a software system that uses artificial intelligence (AI) techniques to represent knowledge and interacts with students to teach it to them" (VanLehn, 1988, p. 55).

Wolf (1984) defines ITS as systems that model teaching, learning, communication and the domain of the specialist's knowledge and the student's understanding of that domain. Likewise, Giraffa, Nunes and Viccari (1997) in their research define ITS as systems that incorporate AI techniques (artificial intelligence) in order to create an environment that

considers the diverse cognitive styles of the students who use the program. Among the ITS developed following the ideas of Carbonell (1970) and based on conventional programming paradigms (not through the paradigm of intelligent agents) the following can be highlighted: Scholar (Carbonell, 1970), Why (Stevens and Collins, 1977), Sophie (Brown et al., 1989), Guidon (Clancey et al., 1991), West (Burton et al., 1981), Buggy (Brown and Burton, 1978), Debuggy (Brown et al., 1989) , Steamer (Stevens and Collins, 1977), Meno (Wolf, 1984), Proust (Johnson, 1986), Sierra (VanLehn, 1988). Then the Andes emerge (Gertner, Conati, and VanLehn, 1998; Gertner and Van Lehn et al., 2000) in the Pittsburgh Science of Learning Center's LearnLab, which its consortium with members from Carnegie Mellon University, University of Pittsburgh and Carnegie Learning. Metutor is a means-ends tutor at the Department of Computer Science, U. S. Naval Postgraduate School, Monterey (Galvin, 1994; Rowe, 1998).

A new student who takes a first course in algorithms and computational programming is unaware of several topics related to understanding a text, analyzing and solving a mathematical problem or proposing a solution strategy to carry out the implementation of an algorithm to a problem presented. The success of overcoming these obstacles is related to two main elements in the teaching-learning process: the student and the teacher. The first by having tenacity and initiative to learn, understanding the value of learning for the success of being employed as an expert in the software industry and the second by identifying the strengths and weaknesses of the student to propose an action plan that allows self-realization of the student, and that the tolerance to the frustration of this increases.

The key element in the aforementioned dynamic is to know what is the usability of ITS in education. To answer the research question, it is necessary to identify the strengths and weaknesses of the student, as well as the need for reinforcement of topics related to computer programming and problem solving. In this way, intelligent tutoring systems help students in the classroom and outside of it to learn different topics, since the ITS acts as the teacher to offer an alternative to study and learn different topics.

In short, the research proposes to analyze the different ITS used at the higher level to support learning in different educational areas, as well as the AI techniques used for their development and implementation.

Conceptual framework

Rodríguez (2019) states that today traditional computer-based learning systems need improvements, which are more evident with the increase in exposure to the Internet and the growth of systems known as virtual education. Ovalle and Jiménez (2006) detail that the difficulty of providing individualized teaching adapted to the specific needs and characteristics of the student requires a paradigm shift in the learning process through the computer.

Within this framework, Rodríguez (2019) explains that there are various computerized educational systems that use artificial intelligence (AI) techniques, which - according to Ovalle and Jiménez (2006) - seek to apply them to the development of teaching systems. computer-assisted learning with the aim of creating smarter systems.

Ovalle and Jiménez (2006) point out that "some of the artificial intelligence techniques are Instructional Planning, Case-Based Reasoning (CBR), ITS, Collaborative Learning Environments (CSCL) and Multi-agent Systems (MAS), among others" (p. 99).

Teachers and tutors -according to Morales (2007) - play a crucial role in the teaching-learning process, as they provide the student with feedback on what has been studied and guidance on the route to follow, thereby achieving a certain degree of personalization of the educational process to the specific needs and abilities of each student.

Ovalle and Jiménez (2006) refer that research in this field is very ambitious, since this type of systems propose the development of tools that intelligently monitor and analyze the degree of attention and the level of productivity of students in any area of knowledge. In Rodríguez's research (2019), reference is made to the design of ITS, which use AI techniques, a discipline that studies the creation and design of entities capable of reasoning for themselves (Cataldi and Lage, 2009), vision for generating forms that imitate the behavior of human intelligence and the growing demand of the educational system to measure student performance. In this context, AI together with ICTs created computer-assisted instruction (CAI), a computer instruction system that has two important characteristics: the student and the computer, which serves as a vehicle for instructions, hence it is not a teaching method (Huapaya, 2009).

An intelligent tutorial system (ITS) is defined as computer systems designed to provide instruction and intelligently support the teaching-learning processes through interaction with the student (Arias, Jiménez & Ovalle, 2009). From this perspective, an ITS

is a type of interactive environment that is designed for individual learning and is distinguished from other types by its ability to model the cognitive state of the user, allowing context-sensitive advice and feedback on all steps of a learning process (Graesser, Chipman, Haynes & Olney, 2005). Its main objective, in addition to mastering a specific area of knowledge, is to develop a methodology that adapts to the student and interacts dynamically with him (Hernández and Rengifo, 2015).

It is assumed that when learning to program computers, the student develops certain skills, but teachers state that not all students develop them with the same efficiency as they have deficiencies in aptitude and attitude (Quiroga, 2016).

The teaching of programming within the Polytechnic University of Victoria (UPV) takes the group of students as a dynamic entity, that is, it passes from one topic after another, but it is in this path where the student does not reach the domain of the topic, which lacks sufficient tools to tackle the following. This causes the student to progressively be overcome by the activities of the subject and end up giving up and moving away from the programming. For this reason, the lack of mastery of the topics when developing software produces a lack of interest in the students, which represents a problem in academic results causing high rates of failure and school dropout within the UPV.

In the area of computer programming, the student must develop emotional intelligence skills and problem-solving strategies. The skills that you can highlight within a student are:

- Establish a detailed plan to solve the problem.
- Mastery of a programming language.
- Test and debug code.

Specifically, the software development subjects within the UPV seek for the student to be able to abstract from reality the elements of a problem that imply the automation of the tasks for the management of information, analyze, mold and describe necessary components for troubleshooting computer problems.

To support learning within the classroom on issues related to software development, there are ITS that —through AI— help to detect student learning in a timely manner and provide an alternative of knowledge.

ITS are systems designed to replicate the effectiveness of human mentoring in digital tools. The effectiveness of individual tutoring in large group instruction has been established through experiments with human tutors. Tutoring is a form of educational attention where

the teacher supports a student or a group of students in a systematic way through the structuring of objectives, programs, organization by areas, appropriate teaching techniques and integration of groups according to certain criteria and monitoring and control mechanisms, among others (Crow, Luxton-Reilly y Wünsche, 2018).

Methodologies for the development of ITS

According to Rodríguez (2019), there are several architectures to develop an intelligent tutor system, so there are also multiple methodologies that are used with the same objective; one of them is elaborated by Salgueiro, Costa, Cataldi, Lage, García-Martínez (2005), in which they propose a new approach, without moving away from the classical structure, which emphasizes above all the tutor module. This is based on the idea that the more instructional knowledge is possessed, the better the content and activities will be explained, which will translate into more knowledge for the student.

Cataldi and Lage (2009), in turn, propose a methodology focused on the student's module. The authors indicate that an STI that has a very detailed student module guarantees the intelligence of the system, since it adapts to the needs of the students.

Rodríguez (2019) explains that there are methodologies that pursue the integration of a learning management system (LMS) with an STI (Tarongí, 2010), thus providing the latter with a Web-based approach. In the integration of the ITS components, relationships are established indicating the equivalence between the data in the different tables of the database.

The first relationship found in the student module is the learning style, which determines the pedagogical method of the tutor module. Based on the different types of pedagogical methods, equivalences with the different dimensions of learning styles have been established. In this way, the style that predominates in each method is marked, according to the characteristics of the student and according to their deficiencies; These are taken into account in order to instruct you in the best possible way.

Other relationships that exist between the student module and the tutor module are the basis for defining the activities that the student will carry out, which are conditioned by the learning style component, and are marked by the level of knowledge component. The learning style component determines the format in which the objects will be presented, while the level of knowledge determines their complexity.

On the other hand, the interface is modeled by the learning style, although this relationship is not very binding, since the student is free to modify and adapt it to their liking; Likewise, the changes you make are saved and kept for subsequent work sessions that you establish.

As an initialization of the ITS application, the established guidelines can be taken into consideration, where the characteristics presented by the different types of tools and their relationship with the dimensions of the learning style have been analyzed.

The main objective of the intelligent tutoring system is to identify the level of learning about the area of software development through an artificial intelligence algorithm, which will allow an early detection of the level of mastery of topics related to computer programming for offer an alternative solution in the form of exercises to strengthen meaningful learning. The system will allow the student to offer solutions to learn to develop software and thus strengthen the knowledge about computer programming.

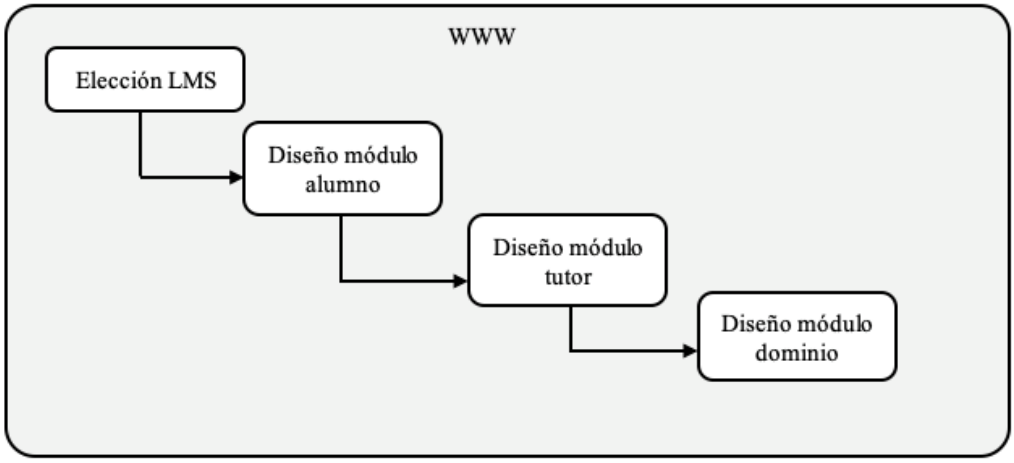
There are different artificial intelligence libraries that allow the development of algorithms for the creation of intelligent tutor systems. For example, Tensorflow is an open source library for machine learning across a range of tasks, developed by Google to meet its needs for systems capable of building and training neural networks to detect and decipher patterns and correlations, analogous to learning and learning. reasoning used by humans (Tensorflow, 2019).

The use of artificial intelligence tools —as is the case of Tensorflow for the construction of intelligent tutoring systems— allows generating teachings in real time that favor free discussion between the technological tools and the student.

Figure 1 graphically presents the methodology followed as the development of a Web-based ITS; This consists of 4 stages:

a) Selection of the learning manager platform (LMS).
b) Design of the student's module.
c) Design of tutor module.
d) Domain module design.

Figura 1. Metodología para la construcción de un ITS basado en la Web



Nota: El diagrama muestra los módulos y la interconexión entre ellos para la construcción de un ITS basado en la Web.

Fuente: Elaboración propia

Selection of the learning manager platform (LMS)

There are different SGA platforms that support the teaching-learning process. In the development of this research, for the construction of an ITS applied in the teaching of computational algorithms at the undergraduate level, the Moodle platform was chosen because it is open source and completely modifiable. It is an option to integrate the ITS due to its modular structure, which offers the option of adding or removing code without affecting the operation of the learning management system (LMS); likewise, it integrates various database managers, such as PostgreSQL and MySQL, which are easy to install.

This section establishes the relationships between the main components that are part of the ITS; The first relationship found in the student module is the learning style, which determines the pedagogical method of the tutor module. Starting from the different types of pedagogical methods, the equivalences with the different dimensions of the learning styles have been established, the style that predominates in each method is marked, according to the characteristics of the student and according to their deficiencies; These are taken into account in order to instruct you in the best possible way (Suárez, Arencibia Rodríguez y Pérez Fernández, 2016).

Student module design

The design of the student module happens when the student's strengths and weaknesses are analyzed at the time of assimilating the contents of a subject. It provides information that can be fed back through the ITS and is closely linked to the contents and the pedagogical method of the tutor's module, with which the student is instructed, as well as the user interface in which the contents are presented by the domain module (Suárez et al., 2016).

To get an idea of the level of knowledge that the student possesses prior to the interaction with the ITS, a data mining is performed on the average of the marks of the subject Introduction to Computer Programming, which are currently taken at the Polytechnic University of Victoria . Using a deep training neural network built with artificial intelligence tools, the student is classified, according to the set of linguistic terms, as competent, basic advanced, basic and not competent.

Tutor module design

The tutor module is the execution engine of the adaptive system, coding the teaching methods that are appropriate for the target domain and the student. This selects the most appropriate educational intervention based on the students' knowledge and learning styles (Suárez et al., 2016).

The design of the tutor module consists of coding the teaching methods that are appropriate for the objective domain of the students, selecting the appropriate educational intervention based on the knowledge and learning styles of the students. The characteristics of the student determine the format in which they want the materials to be presented, along with the complexity of the content to be learned; This allows planning a learning path through a neural network so that a work proposal is offered in the student module.

Domain module design

Finally, the domain module consists of integrating a deep learning neural network through artificial intelligence libraries that will allow the student's actions and choices to be compared in an expert system with the aim of evaluating what the user knows and does not know.

The domain module is made up of the learning path that is defined by the tutor's module. This learning path contains the sequencing to be applied to define and structure the

topic, which must be materialized in a series of activities (tasks, questionnaires, surveys, etc.) that are designed and conditioned by the course and that are offered to the student at through a user interface, adapted to the characteristics of the student (Suárez et al., 2016).

The student's interaction with the activities in the interface produces a series of reports that are stored in a database to verify the student's progress. Said analysis is obtained from the average of the grades obtained as a result of the student's interaction with the ITS on the Moodle platform; With this, through a neural network, it is possible to classify the student's learning in a certain topic.

Methodology

Based on the research question, what are the uses of intelligent tutoring systems in education? An exploratory quantitative methodology is presented to show the results of the use of a Web-based ITS that helps in the learning of computational algorithms. and to identify the causes that affect the academic performance of students.

This section explores the use of ITS in higher education through the analysis of the literature; Likewise, a description is made of the methodology used for its development and the characteristics of computer-assisted teaching programs that use AI as a basis for the representation of knowledge to direct a teaching strategy prepared to behave like an expert.

In the first phase of the methodology, an investigation was carried out that is divided into two aspects: the investigation of the literature and the applied investigation. The first involved the analysis of the ITS used to support teaching and the testing of theories to satisfy intellectual interests, while in applied research knowledge was used to solve practical problems.

The literature review made it possible to outline the available studies in the implementation of ITS, which provided a field of action for the realization of new research that highlights the progress of the implementations, generating each time tutor systems with a high sense of intelligence using new techniques of cognitive analysis.

Likewise, an exploratory analysis of the various ITS implemented in the different sciences of higher education was made; Based on this, the models for the construction of the Web-based ITS are presented, which will provide support in the learning of computational algorithms within the subjects related to the development of software and computational algorithms.

As it is an innovative subject of study for the investigation of the different STIs in higher education, a specific range of dates for the publication of research was not considered, so that all the findings were focused on results.

For the selection of the initial set of the exploratory analysis, the title intelligent tutoring systems in education was consulted. The initial set was refined by reading each publication in full.

Models of smart tutoring systems

Arias *et al.* (2009) propose an instructional planning model in intelligent tutorial systems that is based on the level of knowledge of students, on the theory of AI planning and on the course structure applied in the intelligent tutorial system (adaptive intelligent courses). This model allows generating activity plans adapted to the characteristics of the students; In addition, as students progress through a course, they acquire new knowledge that allows them in turn to enable new topics. In this way, instructional planning based on the sequencing of the curriculum can be achieved (Sánchez, Cabrera & Martínez, 2015).

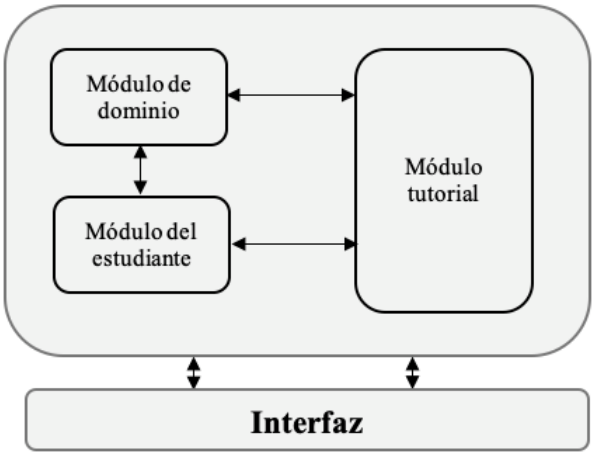
In the work of Ovalle and Jiménez (2006) an intelligent distributed learning environment is evidenced where ITS and collaborative learning environments are integrated, AI techniques are implemented specifically in the area of machine learning, known as reasoning based on cases, with which an individualized and collaborative education is achieved (Sánchez et al., 2015).

In Cataldi and Lage (2009) a basic architecture for ITS is exposed, where the tutor module is shown. This architecture presents a more effective form of communication between the user and the system, since it considers the student's learning style and proposes integrating intelligent agents for the development of intelligent tutor systems.

Figure 2 shows the architecture of an ITS, in which each of its component parts are observed: 1) the domain or expert module represents knowledge; here AI methodologies such as neural networks for classification and deep learning intervene through the use of tools such as Tensorflow, 2) the student module where its main function is to capture learning from the domain module; 3) The tutorial module contains the strategies, methodologies and instructions that are adjusted to the needs of the student without the intervention of the human being. The objective of this element is to minimize the difference in knowledge between the expert and the student (Sánchez et al., 2015). The last module of the ITS is called 4)

environment module, which is the interaction manager between all the system components and controls the user interface between the computer and the human being, showing usability tools and user experience for employment appropriate ITS.

Figura 2. Arquitectura de un ITS



Fuente: Salgueiro *et al*. (2005)

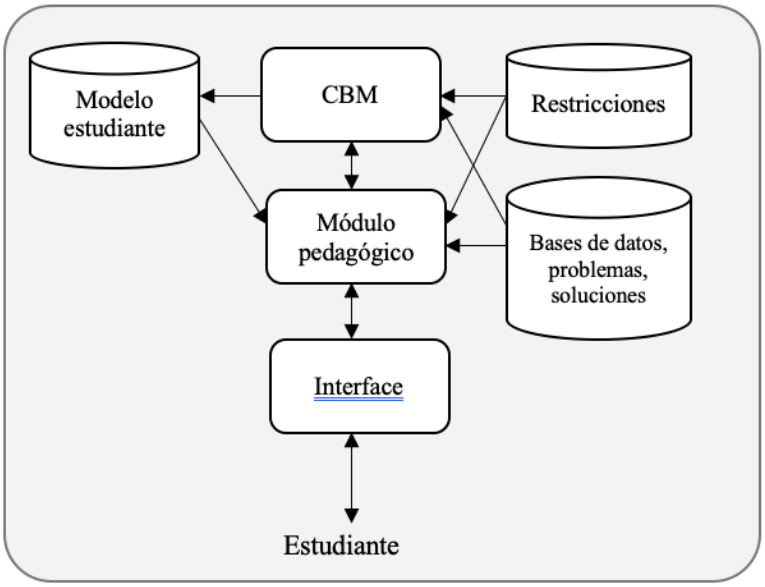
Another prominent ITS model is the one exposed by Guzmán and Conejo (2005), in which a cognitive evaluation model is disclosed to be applied to an ITS as a diagnostic module of student knowledge. This integrates computerized adaptive tests and a response model based on the item response theory, this in order to estimate the student's knowledge to decide which questions will be shown in the test (Sánchez et al., 2015). This model can be used to learn any type of subject in different areas, such as mathematics and computer programming.

Regarding smart tutoring systems in higher education, there is a relationship between projects and documents that apply ITS in the educational field, identifying their application in different areas of knowledge. The research by Rodríguez, Castillo and Lira (2013) shows the development of an ITS with reactive characteristics and the interactive communication component for learning mathematics; This system was called Malvi and the researchers used it to identify the learning level of some undergraduate students. After doing this study, it was identified that the students of the degree in Health Education and the degree in International Trade showed a very low general knowledge of basic mathematics, which were surpassed by the engineering students with 13% of their performance (Sánchez et al., 2015).

Likewise, Mitrovic, Olhsson and Barrow (2013) present an ITS called SQL-tutor, which serves as a guide in making queries to students, which helps them improve

performance in the database area. The system offers the student a problem that must be solved so that it can later be sent for analysis; Once analyzed, the ITS provides a response indicating whether the query was successful or not. Figure 3 shows the architecture of the SQL-tutor.

Figura 3. Arquitectura SQL-tutor



Fuente: Mitrovic y Ohlsson (1999)

The SQL-tutor system consists of an interface for interaction with the student, a knowledge base for the expert and a student model that determines the content of the pedagogical actions (Mitrovic and Ohlsson, 1999).

On the other hand, Arevalillo-Herráez, Arnau and Marco-Giménez (2013) describe an intelligent tutorial system that focuses on the stage of translation of word problems in symbolic notation, since one of the most difficult steps to learn algebra is translation from a word problem to algebraic notation. The ITS is based on a hypergraph description language capable of simultaneously representing algebraic solutions to a given problem, it tracks each of the student's actions and in turn builds a student model. It is a system that contains a user interface capable of following the sequence of steps that the Cartesian method describes. The system has been evaluated in an experimental environment to which several algebraic exercises were assigned to solve. The group of students, with the help of the ITS, managed after several sessions of use to finish the exercises correctly, since the system allows the student to take a valid route to produce a correct solution. The experimentation of the ITS based on hypergraphs yields the improvement of the student's skills in problem solving (Sánchez *et al*., 2015).

Another important work on the use of ITS is that of Cabada, Barrón and Olivares (2014), who present an ITS for the teaching-learning of mathematics, this in order to identify the emotional state of the student. The software carries out an emotional analysis through an artificial neural network, which takes into account the time and errors within a mathematical problem, as well as the facial recognition images of the student. In this work it is shown that the recognition of students' emotions plays an important role in the learning process.

In the research by Oulhaci, Tranvouez, Espinasse and Fournier (2013) an ITS called Simfor is proposed, which through gamification trains non-professionals on risk management. The game consists of modules for creating scenarios that simulate an event with a risk factor for user interaction. It is in this training process where the user acquires knowledge about risk and how to face it.

Results

Once the literature has been reviewed, Table 1 lists the chronologically ordered publications that meet the previously defined criteria of interest and exclusion:

Tabla 1. Usabilidad por áreas de especialización de los sistemas de tutoría inteligente

Autores	**Nombre**	**Área**
Rodríguez *et al*. (2013)	Malvi	Matemáticas
Mitrovic *et al.* (2013)	SQL-tutor	Base de datos
Arevalillo-Herráez *et al*. (2013)	Traductor verbal algebraico	Álgebra
Cabada *et al*. (2014)	Aprendizaje matemático	Matemáticas
Oulhaci *et al*. (2013)	Simfor	Factor de riesgos

Fuente: Elaboración propia

In the different areas of knowledge that ITS have been implemented, the approach towards mathematical and computational sciences can be observed, which helps to identify their characteristics and serve as a basis in the construction of a new ITS model to support learning of computational algorithms.

In the construction of a new ITS model as support in the teaching process of the coding of computer programs through algorithms, the different techniques that have been

implemented in its development must be analyzed to generate a new paradigm through a strategy make use of AI techniques that will support the construction of a new ITS.

Therefore, table 2 shows the research work of Sánchez et al. (2015), where the techniques and trends of AI used as technology in the development of ITS are analyzed from the research done on the use and development of intelligent tutors.

Tabla 2. Técnicas de inteligencia artificial implementadas por los respectivos autores

Técnicas de IA	Autores que la utilizan
Lógica difusa	Peña, C., Marzo, J., De la Rosa, J., Fabregat, R.
Razonamiento basado en casos	Peña, C., Marzo, J., De la Rosa, J., Fabregat, R; Ovalle, D. y Jiménez, J.
Agentes inteligentes	Cataldi, Z., Salgueiro, F., Costa, G., Calvo, P., Méndez, P., Rendón, J., Lage, F.
Red neuronal artificial	Salgueiro, F., Cataldi, Z., Lage, F., García-Martínez, R; Arnau, D. Arevalillo-Herráez, M., Puig, L., González-Calero, J.; Sánchez, R., Bartel, Ch., Brown, E., DeRosier, M.; Oulhaci, M. A., Tranvouez, E., Espinasse, B., Fournier, S.; Zhiping, L., Tianwei, X., Yu, S; Cabada, R. Barrón, M. y Olivares, J. M. J.
Redes bayesianas	Cataldi, Z., Salgueiro, F., Lage, F., García-Martínez, R.
Lingüística difusa	Badaracco, M., Martínez, L; Azoulay-Schwartz, R., Hani, Z.
Representación de conocimiento	Arevalillo-Herráez, M., Arnau, D., Marco-Giménez, L.
Lingüística computacional	Xuechen, He; Ferreira, A., Kotz, G.
Procesamiento del lenguaje natural	Latham, A., Crockett, K., McLean, D.; Gorrostieta, J., González, S., López, A.; Jackson, T., Graesser, A.
Visión artificial	Sathyanarayana, S., Littlewort, G., Bartlett, M.; Qui-rong, Chen.

Fuente: Elaboración propia con base en Sánchez *et al*. (2015)

Discussion

Analyzing the literature on the different types of ITS existing in various disciplines, it is observed that for their development the authors use AI techniques implementing neural networks and educational theories, such as cognitive psychology. In this sense, Mitrovic and Ohlsson (1999) show in their system a student model that determines pedagogical actions; likewise, Arevalillo-Herráez et al. (2013) describe an intelligent tutorial system that focuses on the stage of translation of word problems in symbolic notation, which allows learning to

solve algebraic problems verbally. On the other hand, the work of Cabada et al. (2014), where they develop an ITS to learn mathematics, taking as an outstanding variable the emotional state of the student; For this work they make use of an artificial neural network that takes into account the problem solving time and the number of errors that occurs when solving mathematical problems. Finally, the ITS Simfor, a system developed by Oulhaci et al. (2013) through which, through gamification with students, they train on the identification and management of physical risks.

As future work - based on the findings of the literature on the ITS developed and the methodologies implemented - the bases are taken for the construction of an ITS to support the teaching of the area of computational algorithms. For this, the implementation of an ITS is considered essential for the development of reasoning, analytical and logical thinking in students of the Engineering degree in Information Technologies of the Polytechnic University of Victoria (UPV), since the subjects related to software development are the ones with a high failure rate. Table 3 shows the behavior of failure of subjects per semester within the period January 2019-August 2020. It is important to note that the identified subjects are those that are related to software development and that in turn they have been taught one or more occasions within the indicated period.

Tabla 3. Comportamiento de reprobación de materias por cuatrimestre: periodo enero 2019-agosto 2020 del programa académico (PE) de ITI de la UPV

Materia	***Enero-abril 2019***	***Mayo-agosto 2019***	***Septiembre-diciembre 2019***	***Enero-abril 2020***	***Mayo-agosto 2020***
Programación orientada a objetos					83 %
Graficación por computadora avanzada				71 %	
Fundamentos de programación orientada a objetos				67 %	
Minería de datos aplicada	62 %				
Cómputo en dispositivos móviles		44 %			43 %
Introducción a la graficación por computadora	25 %		59 %	35 %	
Estructura de datos	42 %	27 %	39 %		
Tecnología y aplicaciones web		36 %	49 %		32 %
Matemáticas básicas para computación	33 %	34 %		44 %	
Probabilidad y estadística		34 %	24 %		
Introducción a la programación			36 %	21 %	
Negocios electrónicos	39 %			20 %	32 %
Introducción a las tecnologías de información	29 %				
Programación		32 %	24 %		
Base de datos					28 %
Programación web	27 %	28 %			
Integración de tecnologías de la información		25 %			
Introducción a las bases de datos	20 %				

Nota: Esta tabla representa los resultados de reprobación de las materias relacionadas al desarrollo de *software* en el periodo comprendido entre enero 2019 y agosto 2020. En ella se aprecian los cuatrimestres donde las asignaturas se impartieron y el nivel de reprobación que arrojaron los resultados en cada uno de ellos, según el Sistema Integral de Información de la UPV (SIIUPV 2020).

The implementation of this tool is chosen, since it is considered efficient in the teaching-learning process. In addition, it has been shown in the literature to take into account the cognitive abilities of each student and adapt to their learning abilities.

Conclusions

Based on the exploration of the literature on the use of ITS in higher education and assuming that the main objective of ITS is the identification of the level of learning about an area of science to offer support in the teaching process- learning for the stimulation of students, some systems make use of gamification so as not to generate disinterest and boredom. Therefore, based on the exploratory analysis of ITS used in higher education as a support in learning in different areas of science, it is observed that the incorporation of ITS in education helps to solve the teaching problem. to consider that all students have the same learning needs and the same way of learning. In relation to this, ITS play a very important role, since they have been created to identify individual weaknesses and learning needs and thus establish an appropriate teaching methodology according to each case.

The goal of ITS is not to replace the human tutor, but to reinforce teaching inside and outside the classroom. In the implementation of the ITS, the human tutor makes her activities more efficient, taking charge in a personalized way of the tasks that the ITS cannot perform. Under this panorama of teaching, the student is considered as the main center in the educational process, since it is he who regulates her learning. In this way, it is possible to create a teaching vision where the student is the protagonist of the model and his needs are the priority.

As future work, the findings found in the literature are considered to serve as a basis for the construction and implementation of an ITS in the ITI career of the UPV to improve the academic performance of students in the areas of software development.

Future lines of research

The line of research to work for the development of an ITS at a higher level is intelligent systems applied to education. With this, the bases for the construction, implementation and experimentation of a tutor system in the support of computational algorithms in the ITI educational program of the UPV will be established, where through the use of the educational theory of cognitive psychology it is intended create a level of motivation in students to generate an interest in learning to build software. In this sense, AI will be used to implement a deep learning neural network and create intelligent nodes to establish a tool capable of simulating the human brain implemented in a computer system and provide support and advice to students in the creation of computational algorithms.

References

Arevalillo-Herráez, M., Arnau, D. and Marco-Giménez, L. (2013). Domain-specific knowledge represen- tation and inference engine for an intelligent tutoring system. *Knowledge-Based Systems*, *49*, 97-105.

Arias, F., Jiménez, J. y Ovalle, D. (2009). Modelo de planificación instruccional en sistemas tutoriales inteligentes. *Revista Avances en Sistemas e Informática*, *6*(1), 155-164. Recuperado de: https://www.researchgate.net/publication/220136853_Modelo_de_planificacion_instruccional_en_sistemas_tutoriales_inteligentes

Barraza, A. (2005). Una conceptualización comprehensiva de la innovación educativa. Innovación Educativa, 5(28),19-31. Recuperado de: https://www.redalyc.org/articulo.oa?id=1794/179421470003

Brown, J. and Burton, R. (1978). Diagnostic Models for Procedural Bugs in Mathematical Skills. *Cognitive Science*, *2*(2), 155-192.

Brown, E.; Palincsar, B. (1989) Guided, Cooperative learning and the individual knowledge acquisition. En Resnick B. (comp.) Knowing, learning, and instruction. Hillsdale. N.J.

Burton, R. R.; Brown, J. S. (1981). An investigation of computer coaching for informal learning activities. In: Sleeman, D., Brown, J. (eds.): Intelligent Tutoring Systems, Capítulo 4, p. 79-98, London: Academic Press.

Cabada, R., Barrón, M. y Olivares, J. M. (2014). Reconocimiento automático y aspectos éticos de emociones para aplicaciones educativas. *Komputer Sapiens*, 27-33.

Carbonell, J. R. (1970). AI in CAI: An artificial intelligence approach to computer assisted instruction. *IEEE transaction on Man Machine System, 11*(4), 190-202.

Cataldi, Z. y Lage, F. (2009). Sistemas tutores inteligentes orientados a la enseñanza para la comprensión. *Edutec*, (28). Recuperado de http://www.edutec.es/revista/index.php/edutec-e/article/view/456

Clancey, W. J. (1991). Intelligent tutoring systems: A tutorial survey, en App. Artificial Intelligence: A Sourcebook. McGraw-Hill.

Crow, T., Luxton-Reilly, A. and Wünsche, B. (2018). Intelligent tutoring systems for programming education: a systematic review. *20th Australasian Computing Education Conference*, 53-62. Doi: https://doi.org/10.1145/3160489.3160492

Galvin, T. (1994). *Mebuilder: An Object-Oriented Lesson Authoring System for Procedural Skills (9/94)* (tesis doctoral). Retrieved from https://calhoun.nps.edu/handle/10945/30938

Gertner, A. S., Conati, C. and VanLehn, K. (1998). Learning Procedural help in Andes: Generating hints using a Bayesian network student model. *Research & Development. American Association for Artificial Intelligence*. Retrieved from https://asu.pure.elsevier.com/en/publications/procedural-help-in-andes-generating-hints-using-a-bayesian-networ

Gertner, A.S. y VanLehn, K. (2000). Andes: A Coached Problem Solving Environment for Physics. Lecture Notes In Computer Science; Vol. 1839 Proceedings of the 5th International Conference on Intelligent Tutoring Systems. Pages: 133 - 142

Giraffa, L., Nunes, M. A. and Viccari, R. M. (1997). Multi-Ecological: A Learning Environment using Multi-Agent architecture. MASTA'97: Multi-Agent System: Theory and Applications. Proceedings. Coimbra: DE-Universidade de Coimbra.

Graesser, A. C., Chipman, P., Haynes, B. and Olney, A. (2005). AutoTutor: an intelligent tutoring system with mixed - iniciative dialogue. *IEEE Transactions on Education, 48(*4). Retrieved from https://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1532370

Guzmán, E., y Conejo, R. (2005). Un modelo de evaluación cognitiva basado en Tests Adaptativos Informatizados para el diagnóstico en Sistemas Tutores Inteligentes. (tesis de pregrado). Universidad de Málaga. Recuperado de: http://www.lcc.uma.es/repository/fileDownloader?rfname=LCC1406.pdf

Hernández, J. y Rengifo, Y. (2015) Los sistemas tutores inteligentes y su aplicabilidad en la educación. *Horizontes Pedagógicos, 17*(2), 104-115. Recuperado de https://revistas.iberoamericana.edu.co/index.php/rhpedagogicos/article/view/17209

Huapaya, C. (2009). *Sistemas tutoriales inteligentes. Un análisis crítico*. Facultad de informática. Universidad Nacional de la Plata. Recuperado de https://postgrado.info.unlp.edu.ar/wp-content/uploads/2014/07/Huapaya.pdf

Johnson, W. L. (1986). *Intention-based diagnosis of novice programming errors*. Morgan-Kauffman.

Mitrovic, A. and Ohlsson, S. (1999). Evaluation of a constraintbased tutor for a database language. *International Journal of Artificial Intelligence in Education*, *10*(3-4), 238–256.

Mitrovic, A., Olhsson, S. and Barrow, D. (2013). The effect of positive feedback in a constraint-based intelligent tutoring system. *Computers & Education*, *60*(1).

Morales, R. (2007). Modelado del estudiante para ambientes virtuales de aprendizaje en Web. *Apertura: Revista de Innovación Educativa*, *7*(7), 21–35. Recuperado de http://search.ebscohost.com/login.aspx?direct=true&db=zbh&AN=28627025&site=ehost-live

Oulhaci, M. A., Tranvouez, E., Espinasse, B. and Fournier, S. (2013). Intelligent Tutoring Systems and Serious Game for Crisis Management: a Multi- Agents Integration Architecture. *2013 Workshops on Enabling Technologies: Infrastructure for Collaborative Enterprises.*

Ovalle, D. y Jiménez, J. (2006). Ambiente inteligente distribuido de aprendizaje: integración de ITS y CSCL por medio de agentes pedagógicos. *Revista EIA*, (6), 89-104.

Quiroga, L. (2016). *Prototipo de tutor inteligente para el aprendizaje de la programación de computadores* (tesis de pregrado). Universidad Católica de Colombia, Bogotá, Colombia. Recuperado de https://repository.ucatolica.edu.co/bitstream/10983/14968/1/PROTOTIPO%20DE%20UN%20SISTEMA%20TUTOR%20INTELIGENTE.pdf

Quispe, R. (2014) Tutor inteligente para fortalecer el aprendizaje de la estructura morfosintáctica a nivel primero de primaria (Tesis de pregrado). Universidad Mayor de San Andrés, La Paz, Bolivia.

Rodríguez, A., Castillo, J. y Lira, A. (2013). Diseño de un sistema tutorial inteligente. Apertura, *5*(1), 36-47.

Rodríguez, M. (2019). Sistema de tutoría inteligente aplicado a la enseñanza de programación de computadoras a nivel licenciatura. En Borrego Gómez, D., Cantú Cervantes, D. y Molina Montalvo, H. *Educación y tecnologías* (pp. 179-189). Editorial Palibrio.

Recuperado de https://www.amazon.com.mx/Educaci%C3%B3n-Tecnolog%C3%ADas-Daniel-Desiderio-Borrego/dp/1506530214

Rowe N. C. y T. P. Galvin, (1998) "An authoring system for intelligent procedural-skill tutors," en IEEE Intelligent Systems and their Applications, vol. 13, no. 3, pp. 61-69, May-Jun 1998, doi: 10.1109/5254.683211.

Salgueiro, F., Costa, G., Cataldi, Z., Lage,F. y García-Martínez, R. (2005). Nuevo enfoque metodológico para el diseño de los sistemas tutores inteligentes a partir de un acercamiento distribuido. *Revista de Informática Educativa y Medios Audiovisuales*, *2*(4), 25-32. Recuperado de http://laboratorios.fi.uba.ar/lie/Revista/Articulos/020205/A3ago2005.pdf

Sánchez, I. I., Cabrera, J. M. y Martínez, J. E. (2015). Ayudas virtuales como apoyo al aprendizaje inclusivo en la ingeniería. *Revista Horizontes Pedagógicos*, *17*(2), 104-116.

Stevens, A. and Collins, A. (1977). *The goal structure of a Socratic tutor*. Proc.s of the National ACM Conference. New York: ACM.

Suárez, J. J., Arencibia Rodríguez, Y. y Pérez Fernández, A. C. (2016). Metodología para desarrollar un sistema tutor inteligente basado en la Web para estudiantes de ingeniería. *Universidad y Sociedad*, *8*(4), 108-115.

Tarongí, V. A. (2010). *Sistema tutor inteligente adaptativo para laboratorios virtuales y remotos* (tesis de master). Valencia: Universidad Politécnica de Valencia.

Tensorflow Core https://www.tensorflow.org/ Consultado el 24-07-2019.

Urretavizcaya, M. (2001). Sistemas inteligentes en el ámbito de la educación. *Inteligencia Artificial. Revista Iberoamericana de Inteligencia Artificial*, *5*(2), 5-12.

VanLehn, K (1988). Student Modelling. M. Polson. *Foundations of Intelligent Tutoring systems*. Hillsdale. N.J. Lawrence Erlbaum Associates, 55-78.

Wolf, B. (1984). *Context Dependent Planning in a Machine* (Ph. D. dissertation). University of Massachusetts, Amherst, Massachusetts.