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Intelligent Interfaces: Pedagogical Agents and Virtual Humans

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Abstract

Little by little, we are entering the new era, intelligent interfaces are absorbing us more and more every day, and artificial intelligence makes its presence in a stealthy way. Virtual humans that represent an evolution of autonomous virtual agents; they are computer programs and in the future capable of carrying out different activities in certain environments. They will give the illusion of being human; they will have a body, and they will be immersed in an environment. They will have a set of senses that will allow them: 1) Sensations and therefore associated expressions; 2) Communication; 3) Learning; 4) Remembering events, among others. By integrating the above, they will have a personality and autonomy, so they will be able to plan with respect to objectives; allowing them to decide and take actions with their body, in other words, they will count on awareness. The applications will be focused on environments that they will inhabit, or as interfaces that will interact with other systems. The application domains will be multiple; one of them being education. This article shows the design of OANNA like an avatar with the role of pedagogical agent. It was modeled as an affective-cognitive structure related to the teaching-learning process linked to a pedagogical agent that represents the interface of an artilect. OANNA, has the necessary animations for intervention within the teaching-learning process.

Keywords

Intelligent Interfaces, Expert Systems Applied to Education, Autonomous Virtual Agents, Pedagogical Agents, Avatar, Virtual Humans, Operational Strategies, Cognitive Strategies, Affective-Cognitive Structure

1. Introduction

Intelligent education systems (IES) belong to the class of expert systems; in which the representation of knowledge is articulated in more detail. The above given that they simulate and make explicit an important class of human intelligence; this being the teaching-learning process at the highest level of abstraction. They can be seen as active agents adapting their teaching strategies; based on the changes perceived by the user, when the latter is within said process. The articulation of teaching strategies, as well as the control of learning, are aspects that play an important role in their construction. The first teaching systems that made their appearance were called computer aided instruction (CAI). The latter have evolved from their beginnings to date; using different techniques that facilitate their use and make them more attractive.

The incorporation of artificial intelligence (AI) techniques began in the 70s, which gave rise to intelligent teaching systems (ITS), or intelligent learning systems (ILS). The term intelligence is associated with the ability to adapt to different types of users. They achieve this by incorporating the aforementioned techniques in: 1) The knowledge that the system has of the domain; 2) The principles of the tutorial process and the methods under which they are applied; 3) The representation of the user's knowledge; 4) Currently developing intelligent interfaces that incorporate the emotional aspect. When we refer to ITS, it is implied that the design of the teaching-learning strategy is centered on the tutor module, and when we refer to ILS, we are focusing the design on the user experience. As the latter can often be lost in the process, a combination is proposed. Given the previous explanation, from this point on, we will refer to both ITSs and ILSs as artilects.

The artilect approaches the teaching-learning process as a cooperation between the tutor and the user. Based on the perception of the user's performance, the tutor decides at all times which strategy is appropriate. These strategies will be chosen based on the measurement of a series of parameters such as: mistakes made, learning style, mastered knowledge, etc. The above is in order to decide which strategy to use; based on the following questions: 1) What to explain; 2) With what level of detail; 3) When and how to interrupt the student. They are also directly related to the perception of the following variables: 1) Interest and desire to continue; 2) Help; explicitly requested or offered by the artilect; 3) Strategies; actions carried out by the artilect; 4) Interruption; on the part of the artilect; 5) Possibility of resignation; by the user; 6) Performance; regarding the evolution of the task; 7) Latency; referring to the appropriate time to respond to different situations during the teaching-learning process. All of them are considered in the representation of knowledge and in the inference engine [1] [2]. The above will be limited to a domain, the latter being the reason for teaching.

Research in the area of these artilects has been focused on different aspects, since the inspection of each of its constituent modules [3] [4] [5] [6] [7], the form interacting with the user: reactive [8] [9], by dynamic or static planning,

among others, elaboration of generic architectures [7], machine learning. As well as the construction of design aids for these artilects [10]. A field that has gained a lot of interest is the development of intelligent interfaces that involve the use of emotions as part of the new technologies [11] [12] [13] [14] [15]. Shu-Hsien [16] reviews the different methodologies applied to expert systems in a decade from 1995-2004; where they include ITS/ILS.

The domain of artilect development is at the intersection of three different areas: 1) Computer science (artificial intelligence); 2) Pedagogy (educational resources); 3) Cognitive psychology (methods of analysis of the different processes cognitive). In addition, there is the area of knowledge that is intended to be taught through the system (**Figure 1**).

In the case of educational resources, the contribution refers to the learning techniques that support the problem-solving process and thus be able to diagnose student errors. The diagnosis of errors, allows us to know according to the errors that you make that you have or have not understood and thus create remedial strategies and tactics. In the case of learning techniques, it allows us to implement instructional strategies and tactics based on different learning styles, and according to different types of diagnosis; taking into consideration the type of knowledge: declarative, procedural, factual; reason for teaching [17].

In the case of **computer science**, the contribution is basically focused on **artificial intelligence techniques** which can be included in: 1) The knowledge that the system has of the domain (reason for teaching); 2) The principles of the process tutorial, and the methods under which these principles are applied; 3) The design of intelligent interfaces in order to enhance interaction. However, it is important to mention that the implementation of sophisticated systems such as systems involving **artificial intelligence** are highly beneficial with the use of formalization techniques, and analysis and design belonging to **software engineering**, due to the fact that complex behaviors are being modeled. Therefore, it is considered that there is also an important contribution in this regard.

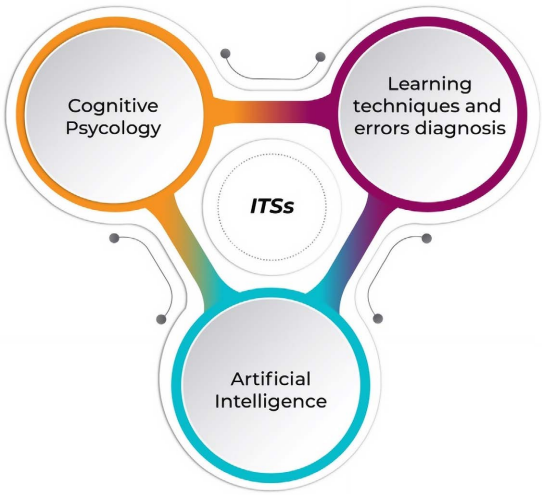


Figure 1. Artilect domain.

In the case of the contribution of **cognitive psychology**, it is increasingly valued; here is the study and clarification of cognitive processes. Studies with invaluable results when it comes to *emulating human behaviors in systems with artificial intelligence techniques*.

The structure of this article is as follows. In *section two*, an introduction is given in which the characteristics of the components of the: intelligent teaching systems and intelligent learning systems that we call artilects are exposed; emphasizing the intelligent interface design, which is where this research is focused. In *section three*, the term autonomous virtual agent and its different roles are defined, as is the case of a pedagogical agent represented by an avatar and the advantage of including it within a teaching-learning process where the importance of emotions as part of new technologies during user interaction. There is also a vision of virtual humans as an evolution that will be enriched in appearance and behavior. In *section four*, a perspective of the future capabilities of a virtual human-avatar and its impact on education is given. The above will be a journey through technology related to the teaching-learning process, and the possible pedagogical practices of virtual humans. Emphasizing that they can also be applied to pedagogical agents; represented by an avatar. In *section five*, the appearance and behavior that a virtual human-avatar can have are explained according to the characteristics of the intelligent-teaching process. The above is analyzed from three points of view: focus, keywords and learning challenges. In *section six*, a reflection is made regarding the user-learner and his relationship with: 1) his motivation (intrinsic and extrinsic), and 2) the Pre-conditions necessary for appropriate learning. And how to introduce new technologies into the teaching-learning process can improve motivation, because emotions are a fundamental part of it. In *section seven*, we reflect on the design of an avatar, where the behavior and appearance will be made taking into consideration: 1) the *Turing test* and 2) the *disturbing valley of Mori*. The above is related to the subdisciplines of artificial intelligence. In *section eight*, an avatar named OANNA is introduced; this being a pedagogical agent, with the behavior of an autonomous virtual agent within a specific domain, object of teaching. To achieve this, an *affective-cognitive structure* was integrated, where emotions are included in the general didactic model. An explanation of the cognitive and operational strategies and their relationship with the sentences and animated expressions of the avatar is given. In *section nine*, an explanation of the ProgEst device is given; emphasizing some results with the use of the avatar, and its relationship with motivation. Finally, we come to the *conclusions section*, where a reflection is made on the use of an avatar as a coach, tutor or mentor; within the teaching-learning process and the possible advantages that its inclusion may have. The above focused on an interaction enriched by appearance and behavior. The premise is to avoid frustration and a possible resignation from the course.

2. Components of an Artilect (ITS/ILS)

The following briefly describes the characteristics of the components of an arti-

lect (Figure 2).

The expert module: it is the place where the knowledge that the system tries to teach the user is articulated. The implementation of this component is closely linked to the tutor module. Because the tutor will teach the domain with emphasis on the organization of the expert module. Hence, it is interesting that this module is organized in a pedagogical way based on the type of diagnosis and type of knowledge [17].

The student model: it is a database that contains user information that allows the development of the following functions: 1) Adaptation of the system based on the competence that the student has of a certain material (object of teaching); 2) Make a report of the material covered according to the curriculum; 3) Select the appropriate level of intervention and explanation; 4) Facilitate user feedback.

The tutor module: has the responsibility of deciding what actions to take to teach or correct a certain domain based on the information in the curriculum and the objectives that the planner has; with respect to one or more specific topics to be taught. This module selects the problems, analyzes the answers, presents the solution of certain problems or decides to show some examples. Manages the didactic material and is in charge of selecting the most appropriate material based on the reported performance. This performance is mainly determined by the demands of the scheduler and user behavior perceived through the interface. Planner is understood as the place where the control methods for the selection and sequencing of teaching strategies are implemented.

The interface: it can be considered as a simulation environment in the sense that it is the place where the outputs and inputs of the system are represented. Its basic responsibility *is the communication between the system and the user*, although as it is the means of exit for the actions of the artilect, it also has a didactic responsibility. Our work focuses on the design of the interface. The latter has evolved so much that currently its design is between appearance and behavior; as explained in *section seven*, belonging to the research area known as *intelligent interfaces.*

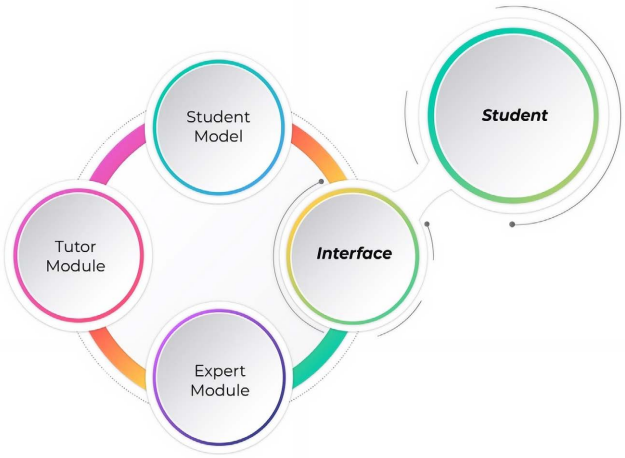


Figure 2. Elements of the artilect.

Although there are various definitions and characterizations of *intelligent interfaces*, it is observed that their fundamental objectives are: to improve communication between the user and the machine, personalization of the interaction and flexibility in the use of the interface [18]. In turn, there is a strong link between these objectives; when a specific proposal seeks to improve communication with the user, this proposal must consider that users have different needs and therefore a personalized and flexible interaction with the user is required. In the same way, it is expected that the customization of an interface will provide greater flexibility in its use and it is expected that there will be better communication. Finally, the flexibility of an interface will allow the user to personalize their experience with it and thereby improve their communication. Smart interfaces are a must; a smart interface implies a user-based cognitive design. This means getting into the user's shoes in order to be able, through empathy, to understand the problems they are facing.

3. Pedagogical Agent: An Intelligent Interface

The autonomous virtual agents with whom these systems are designed can be of various types: collaborative, interface, mobile, informational, reactive, and cognitive, hybrid, or autonomous [2] [11] [19] [20]. This research focuses on the design of an interface agent with emphasis on the teaching-learning process, which is why it is known as a *pedagogical agent.*

These autonomous virtual agents can be represented by an avatar, which is a graphic representation that represents an autonomous virtual agent, or a user in digital environments. These representations can be: photographs, drawings, or three-dimensional representations with facial and body expressions. As already mentioned, the interface is of the utmost importance as it is the means through which the system communicates with the environment. In this work, we use a pedagogical agent whose reactive behavior depends on the aspect of the environment [8] [9]. The latter is represented by the agent receiving the information; this is a communication process between two agents.

There are studies that show that the use of devices with emotions in different contexts helps the individual to regulate their emotions in a positive way. On the other hand, Reeves and Nass agree, as mentioned in Klein, Moon, Picard [21]; people have a propensity to interact with machines as if they were other people. The above shows the importance of emotions during an interaction [22]. One of the emotions that most damages a teaching-learning process is frustration, which depends on the temperament, the situation and the user's emotional intelligence capacity to handle and control the situation. This can bring: low productivity, inability to pay attention, stress and depression [21].

The benefits that are reported when using these pedagogical agents within an educational environment are: 1) They take care of the progress of the user and convince him that they are in it together; 2) They are sensitive to the progress of the user so they are able to intervene when he loses interest or is frustrated; 3)

They can be emotional and excite the user with different emotional levels similar to the human; 4) An agent with a rich and interesting personality can simply make learning more fun. In order to achieve the above it is important that the user's emotions are recognized; the latter being a social competence. This implies developing methodologies that allow the recognition of emotions as part of the new technologies and consequently equip the systems with the necessary skills that allow them to be recognized [2] [15] [23] [24].

Intuition and emotions play a significant role as part of the skills that allow for making rational and intelligent decisions. This has been demonstrated by the experiments developed by Damasio and his colleagues. With them it was concluded that emotions are part of a non-conscious mechanism that directs the decision-making process towards the most appropriate one. Damasio named this mechanism *the somatic marker hypothesis*. The latter is related to the possible consequences after a decision, which can be very: 1) good, or 2) painful. This will create an incentive or an alarm respectively [25].

It is considered that the benefit of having a pedagogical agent implies complicity, because the user will feel less intimidated, or ashamed for constantly asking; And as already mentioned, it is about creating a complicity in which it is presumed that the two are involved in the teaching-learning process, in addition to showing empathy during the interaction. According to the OCC theory [24]; one of the ways of seeing the world is with the perspective of objects, which are often anthropoformed by people. Being these objects with which you have a daily deal such as the car, some kitchen utensil and in this case the interface, hence the pedagogical agent is part of this process of anthropoformization [13] [14] [15] [22].

Learning techniques are constantly evolving and new models involve theories related to: virtual environments, avatars, autonomous virtual agents, and virtual humans [5] [27]. The case study refers to an evolution that has its origin in a pedagogical agent, with a direction towards a virtual human where the responsibility will be the same. Emphasizing that it will: 1) enrich the appearance with facial and body expressions, and 2) the interaction by incorporating emotions, creativity and motivation, among others. In **Figure 3**, the elements that a virtual human will have been shown. Where *six areas* are distinguished that integrate the virtual human; related to the *eight areas of research in artificial intelligence* (see section seven). They are described below.

1) The ***red*** *and* ***orange*** areas represent: sensors and actuators; related to the areas of research in artificial intelligence: *computer vision and robotics*.

2) The ***pink*** area is related to the areas of research in artificial intelligence: *emotions and artificial consciousness*.

3) The ***green*** area is related to the areas of research in artificial intelligence: *natural language processing*, *knowledge representation*, *automated reasoning and machine learning*.

4) The ***turquoise blue*** area is related to the research areas in *avatar design and animation*.

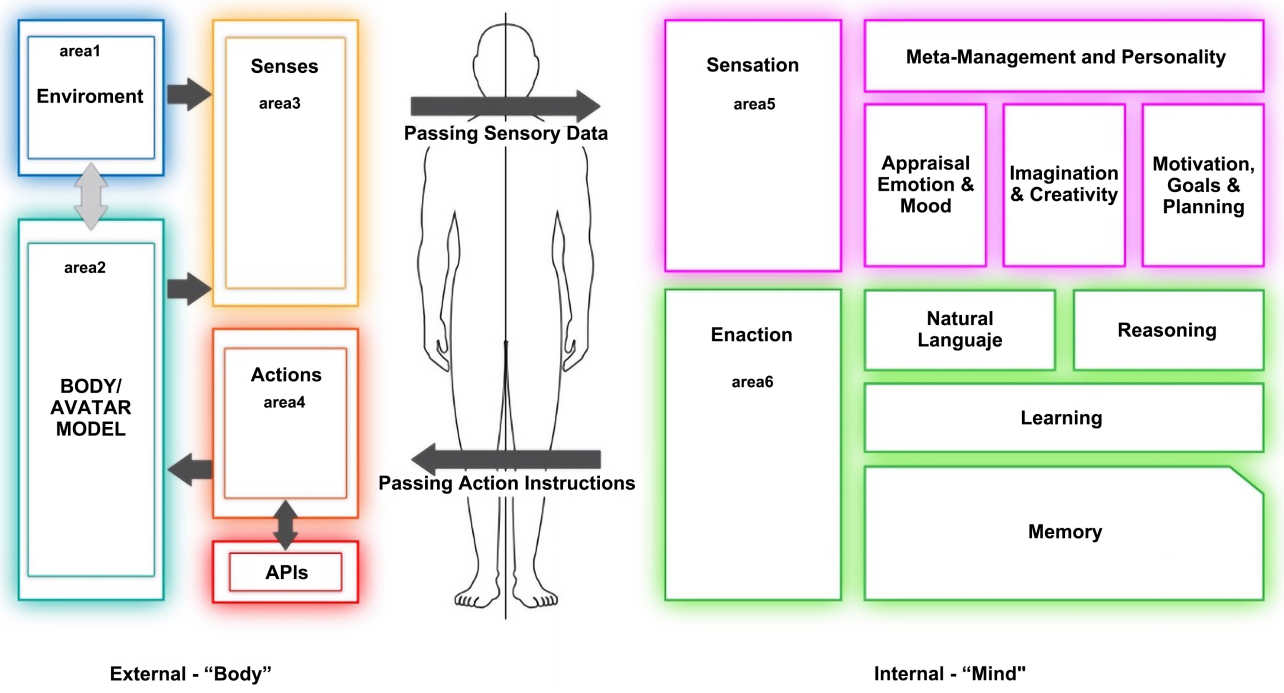


Figure 3. Elements of a virtual human. Taken from: Burden and Savin-Baden [26].

5) The ***cobalt blue*** area is related to the research areas in: *artificial intelligence*, *avatar design and animation*. Depending on the latter, the domain to which the avatar will be limited.

The virtual humans in education, as well as the pedagogical agents, will be in charge of supporting the human-apprentice in a lesson, course or even in an entire career program. They move between the following roles: *teacher*, *coach*, *and mentor*. With direct help and motivation, being able to identify the gaps in the knowledge of the human-learner, and consequently what underlies the teaching-learning process. This allows you to find the best way to apply the teaching-learning process. Emphasizing that its inference engine is represented by an *autonomous agent*.

To achieve this, they require the characteristics mentioned in *section three*. In addition to a design of environments, as well as appearance, and behavior. The development of these avatar invites different areas of research in order to achieve it in a trans-disciplinary way; among which is: *artificial intelligence*, *intelligent interface design*, *behavioral design that involves emotions*, among other characteristics. Emphasizing that they are limited to a domain represented by the object of teaching.

4. Virtual Human-Avatar

A virtual human-avatar has a behavior represented by an autonomous agent; having an evolution enriched by appearance and a more sophisticated behavior. An autonomous agent is something that acts. The word agent comes from Latin and means *agere* willing to do. These agents have other attributes that distin-

guish them from just programs. The characteristics of an autonomous agent are: 1) Operate an autonomous control; 2) Perceive its environment; 3) Persistence (large periods of time interacting with the environment); 4) Adaptation to changes; 5) Be able to modify its objectives. They have a degree of rationality in it that they will be able to take an action considering the best; by involving reasoning with uncertainty.

According to Burden, *et al.* [26], the appearance of a virtual human-avatar will be like a character, and will be represented by expressed behaviors, through: computer screens, embedded in some habitat, or they will only use speech as a communication resource; taking into consideration the above, they will use some or all of the following characteristics: speeches, emotions, translations, and corporal and facial expressions.

They can be defined under different roles: 1) Virtual assistants such as: Siri, Alexa, Cortana, among others; 2) Chatbot, included in the applications of different APIs; 3) Others can be more sophisticated as virtual autonomous agents, among which are those represented by an avatar.

The main elements of a virtual human-avatar consist of: 1) A body, which can be a: microphone or a text interface. 2) A set of sensors that allow you to perceive. 3) The ability to: a) assess events as positive or negative and through assessment, change mood and show emotions; b) plan through objectives and internal motivations; c) reason and solve problems; d) show imagination and creativity; e) communication through natural language; f) machine learning; g) remembering and having access to their memories; h) managing the aforementioned and seeing it reflected in a personality; i) defining their actions and carrying them out with your body (actuators). 4) Communication with other interfaces (APIs). 5) an environment in which one can exist and interact.

Possible traits of a virtual human-avatar

Different traits can be used to differentiate a virtual human-avatar from simple programs. These can show intelligence based on some of their characteristics. These characteristics are related to the elements that define them. In some cases, it is holistic, and in others it is determined by related characteristics, that is, dichotomous. The characteristics can be: any of the following: 1) Physical, digital, or visual; 2) Speaking or textual; 3) Immersed or not in the environment; 4) Humanoid or not; 5) Uses: commands, or natural language; 6) Autonomous or controlled; 7) With or without emotions; 8) With/without personality; 9) With/without ability to reason; 10) With/without learning ability; 11) With/without imagination; 12) With/without consciousness.

5. The Teaching-Learning Process

The teaching-learning processes have always been in constant dynamics. Trying to understand the cognitive process, together with pedagogical strategies. Learning environments have been created to ensure relative learning. And thus, new learning theories have emerged [5] [21] [27] [28]. Below are the different learning approaches related to the design of a possible virtual human-avatar dedicat-

ed to education [26]. The approaches are analyzed from three points of view: 1) Focus; 2) Keywords; 3) Learning challenges. Based on the latter, the behavior and appearance of an appropriate virtual human-avatar are chosen.

First Approach

1) *Focus*: behavioral behavior.

2) *Keywords*: specific goals, related to clear objectives; essential for learning.

3) *Challenges in learning*: it focuses on incentives, which does not necessarily incentivize everyone.

An *appropriate virtual human-avatar*: would be represented by a type of behavior that focuses on covering the curriculum and verifying that the learning objectives are met.

Second Approach

1) *Focus*: human aspect.

2) *Keywords*: it focuses on the users' freedom to access the learning topic and must be controlled by the users and not by the tutor.

3) *Challenges in learning*: too much freedom can be disappointing. The above refers to that; because they are not experts in the field, it can lead them down tired and wrong paths. Users don't always know what they need to learn.

An appropriate virtual human-avatar: it is represented by the behavior of a virtual mentor and a life coach; his approach is towards personalized learning.

Third Approach

1) *Focus*: cognitive aspect.

2) *Keywords*: each person has a unique cognitive structure (such as a fingerprint), hence new information can only be acquired based on previously acquired knowledge.

3) *Challenges in learning*: emphasis is placed on learning styles, in order to appropriately put the content of learning.

An *appropriate virtual human-avatar*: is represented by an expert in the domain of knowledge that allows adjusting the learning and motivations of the different learners.

Fourth Approach

Focus: development coupled with a punctual and detailed monitoring of the teaching-learning process.

Keywords: emphasis is placed on the PRE-conditions, that is, the prior knowledge necessary to be able to access the new knowledge, which will allow the user to advance in a timely manner.

Challenges in learning: a very formal monitoring of the effectiveness of learning is carried out through a monitoring of criteria vs. reagents. The above is to check that the concept has been understood. The importance lies in making mistakes clear, rather than advancing the content.

An appropriate virtual human-avatar: it is represented by a mixture of the behavior of a tutor and a coach, whose intervention is adapted to the personal needs of each individual.

Fifth Approach

Focus: a critical consciousness.

Keywords: each person has a profile of personal values, including tutors. And learning is not exempt from this intrinsic value. Learning always takes place in a socio-cultural context.

Challenges in Learning: there is a difficulty in managing the learner vs. tutor, who ensures a balance, and is not seen too politicized.

An appropriate virtual human-avatar: in this case the behavior of a virtual mentor who is able to focus on: 1) Exploring assumptions; 2) Hidden agendas; 3) Political contexts is implied.

6. Intelligent Interfaces and Motivation

One of the challenges to overcome when introducing these avatars, in their different versions, is the fear of losing jobs.

There is a fallacy, which refers to the fact that the more teachers there are in the classrooms, a more efficient teaching-learning process will be provoked, which is not true. The foregoing is that it is forgotten to involve two very important variables and these refer to: 1) the *intrinsic motivation* of each student, and 2) the *PRE-conditions* referring to the *necessary prior knowledge*. In Figure 4, the mental model of the learner is shown, highlighting how important *motivation*

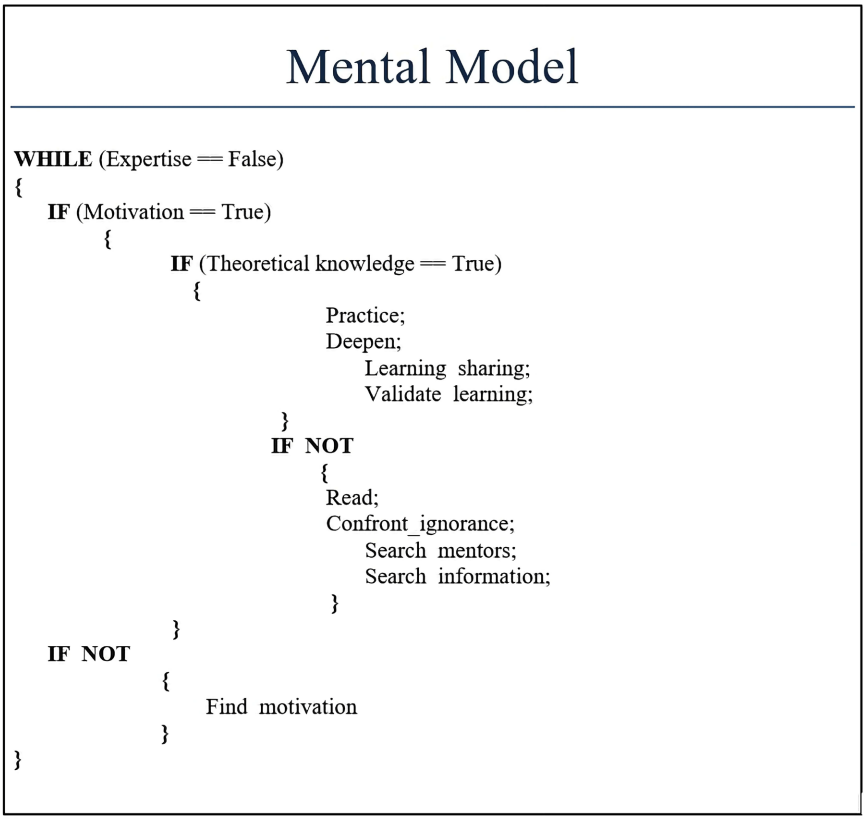


Figure 4. Mental model of the learner and the importance of motivation and prior knowledge.

can be. In this case, it has been shown that students with *intrinsic motivation* outperform those with *extrinsic motivation* [29] [30] [31] [32] [33]. However, it is possible to construct a directed behavior taking into account the emotions. The latter are part of i*nternal motivation* [34].

7. Behavior and Appearance

From the perspective of artificial intelligence, the evolution and design of an avatar will take place in two directions. 1) making these virtual human-avatar look more and more like us physically, or 2) creating more complex, sophisticated and intelligent behaviors.

Two indicators that allow us to measure these characteristics are: the *Turing test* [35], and the *disturbing valley* of Mori, MacDorman, Kageki [36].

The Turing test [35] was developed in order to provide an operational definition of intelligence. Basically, an intelligent system passes the test if after a series of questions from a human being, he cannot distinguish if the answers come from a system, or a human being.

In conclusion, the system that passes the test must have the following capabilities:

1) *Natural language processing*: being capable of successful communication.

2) *Knowledge representation*: store what you know and hear.

3) *Automated reasoning*: use the information to answer questions and obtain new conclusions.

4) *Machine learning*: adapting to new circumstances, as well as detecting and extrapolating learning patterns.

The Turing test [35] deliberately avoids physical interaction between the interrogator and the system, since the physical simulation of a person does not require intelligence. The Turing [35] total test includes a video signal, so the questioner can test perceptual skills in addition to being able to analyze physical objects.

Therefore, the system will also need:

5) *Computer vision*: to perceive objects.

6) *Robotics*: to manipulate objects and move.

7) *Emotions*: as motivation for actions; and for the purpose of a friendlier interface vs. user by perceiving his emotional state; that is, it will have synthetic emotions.

8) *Artificial consciousness*. Which will allow planning according to motivations and objectives, as well as a meta knowledge of their actions and personality.

These *eight disciplines* comprise most of what is called *artificial intelligence*.

By adding these last features, we are creating more complex behaviors. Any interface capable of understanding a dialogue and understanding the emotions of its interlocutor is of immense importance, since it can perform any task that is communicated to it and can be sensitive to the emotional state of the interlocutor.

As for the second indicator, it is based on the *disturbing valley* theory; proposed by Mori *et al.* [36]. It identifies that humans tolerate industrial robots, and the latter does not provoke any emotional response. As for human-like robots, the situation changes because toy robots and good-quality human-like toys do elicit affinity and empathy. This is due to the fact that objects are being anthropoformed [14] [22] [24].

However, the virtual human-avatar, who looks a lot like humans, is considered to *create discomfort*, *during the interaction.*

Therefore, it is important to consider these *two criteria* at the design stage in order not to create such discomfort.

8. OANNA: An Avatar with the Role of Pedagogical Agent

It was modeled an affective-cognitive structure related to the teaching-learning process linked to a pedagogical agent that represents the interface of an artilect. The above allows you to choose the appropriate strategies to enhance the teaching-learning process. This cognitive-affective structure feeds the avatar's inference engine and is specific for teaching undergraduate students.

It was sought to enrich the general didactic model, including the emotional behavior of the user during the teaching-learning process. It was necessary to design a cognitive model that represents said cognitive-affective structure [2] [37] [38] [39]. According to Ortony, *et al.* [24] an affective-cognitive structure (**Figure 5**), is represented by a general structure in which it is specified that there

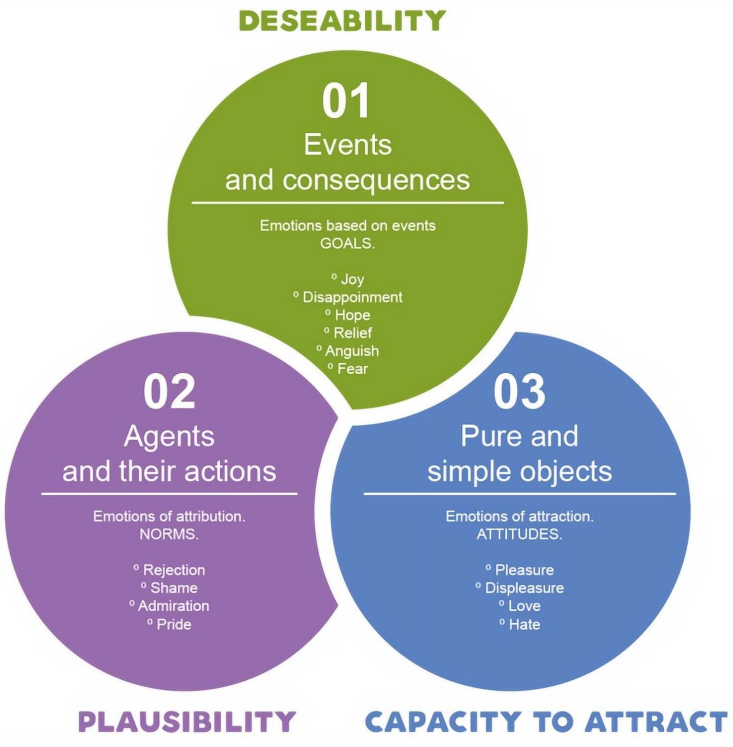


Figure 5. Emotions according to OCC-Theory. Taken from: Ramírez-Laureano, *et al.* [15].

are three large classes of emotions, each of which part of the three highlights of the world: events and their consequences; agents and their actions; and pure and simple objects; taking as evaluation criteria: goals to evaluate the events; norms to evaluate the action of the agents; and attitudes to evaluate objects [37].

Based on this research, an avatar was designed whose role is that of a pedagogical agent, who interacts with the students immersed in an artilect called ProgEst. The latter is a system developed to learn the basic concepts of Structured Programming. The latter is a compulsory subject of the Common Core of Engineering careers at the Autonomous Metropolitan University-Azcapotzalco [29] [30] [31] [32] [33] [40] [41] [42]. The expressions that OANNA uses when the student needs feedback are related to the following characteristics (**Figure 6**): 1) Interest and desire to continue; 2) Help (explicitly requested or offered by the pedagogical agent); 3) Strategies (actions developed by the pedagogical agent in order to make interaction with the user more efficient and comfortable); 4) Interruption (by the pedagogical agent); 5) Resignation (by the user); 6) Performance (with respect to the evolution of the task); 7) Latency (referring to the appropriate time to respond to different situations during the teaching-learning process). All of them are related to the possible emotions of the user and are considered in the affective-cognitive structure [2] [43].

OANNA, has the necessary animations for intervention within the teaching-learning process. **Table 1**, shows a relationship between the inferred strategies,

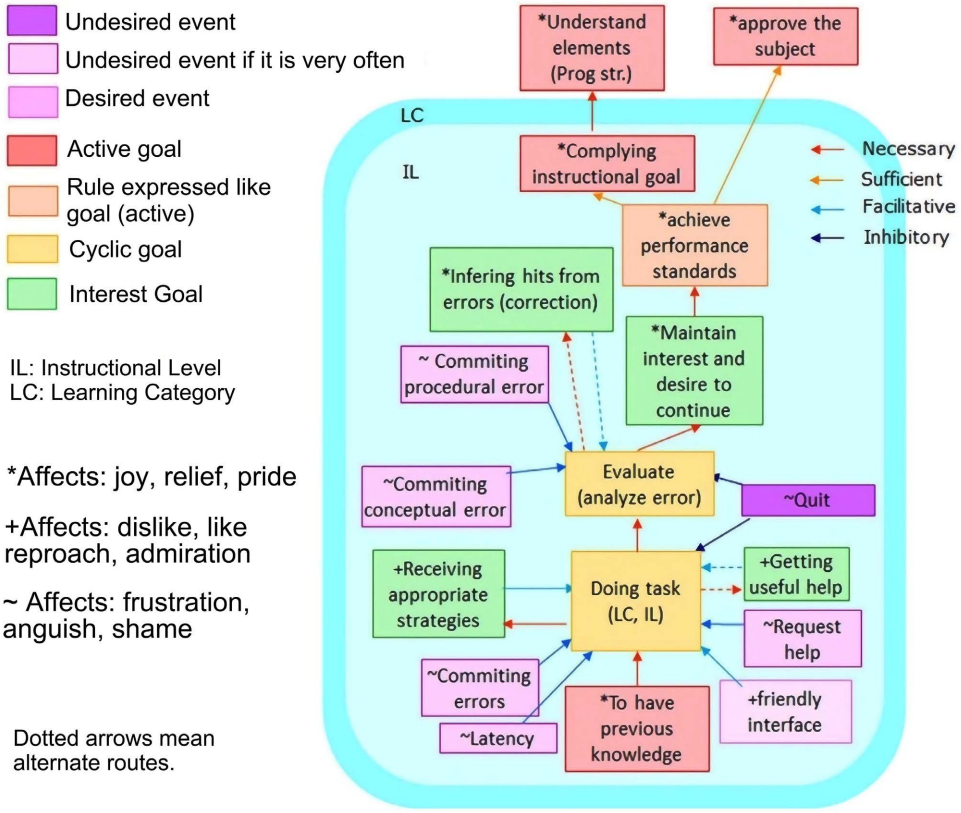
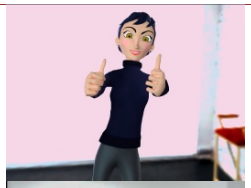
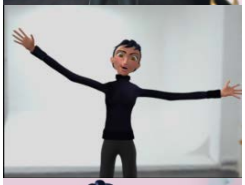
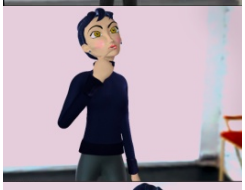
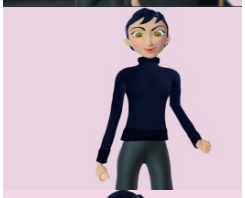
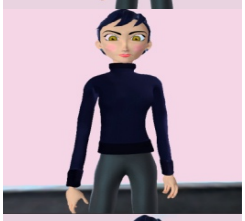
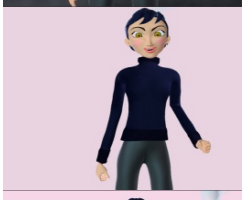
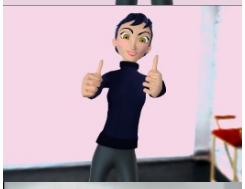
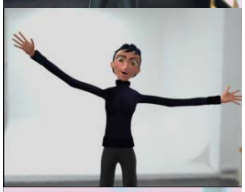


Figure 6. Affective-cognitve structure. Taken from Mora-Torres *et al.* [2].

Table 1. Strategies Inferred by the artilect, related sentences and expressions of OANNA.

Strategies	Sentences	Oanna's expressions
Recognition of effort Operational	Congratulations, keep going.	
Admire achievements Operational	You are making very good progress on this task!	
To relieve tension; when help is requested Cognitive	Good time to express doubts; this subject is not entirely simple!	
To like Cognitive	Would you like to know more about this?	
To like Cognitive	Do you want more tips?	
Admire achievements Operational	Keep trying! Success is on the way!	
Admire achievements Operational	You are a winner! Remember all your achievements!	
Admire achievements Operational	Success in performing this task shows the new skills acquired.	
To relieve tension; when several mistakes are made in a row Operational	Wrong answer! Together we can achieve it, it is important to keep trying!	

the sentences and the related expressions of OANNA. Where the emotions and the capacity of attraction of the pedagogical agent are considered, in the sense of its relevance and aspect [14] [38]. It has been shown in experiments carried out on purpose that it is more interesting to have a presence within a specific task than not to have it, in addition to being able to know their opinion [28]. The strategies are actions performed by the pedagogical agent. A classification of the different types of strategies that can be used is detailed, to enrich and make interaction with users more efficient and comfortable [43] [44].

Strategies in the Teaching-Learning Process

The strategies are classified as cognitive and operational [43].

Cognitive strategies refer to actions that belong to the student's cognitive diagnosis:

- *Strategies for the presentation of instructional material*: 1) Give an explanation of a concept: a) general, b) brief, c) detailed (step by step). 2) Show examples of expert operation. 3) Propose a practical exercise: a) operation of a procedure, b) analysis of a failure.
- *Strategies to evaluate the knowledge and skills acquired by the user*: 1) evaluate through a test, 2) evaluate through a practical exercise.
- *Strategies for the treatment of errors*: 1) strategies for the description of errors, 2) explanation of the error: at a superficial level, at a detailed level.
- *Strategies for correcting errors*: 1) inform: explanation of knowledge, 2) consolidate: explanation of behavior.
- *Strategies to remedy errors*: 1) Redo a practical exercise; 2) Show a remedy; 3) Propose a similar exercise.

Operational strategies: are the actions that belong to the student's affective-motivational diagnosis:

- *Strategies to situate (contextualize the user)*: 1) Present the session to the user. 2) End the session. 3) Inform the user: a) next action (s) to take; b) action that is being carried out; c) last (s) action (s) carried out. 4) Review: a) a concept; b) the previous session; c) the PRE-requisites of a given concept.
- *Strategies to motivate the user*: 1) congratulate the user, 2) encourage the user.
- *Strategies to guide the actions of a user*: 1) Advise; 2) Prevent; 3) Ask an indirect question; 4) Help.
- *Strategies to capture the user's attention*: capture the user's attention, through: 1) Text; 2) Body and facial expressions; 3) Vocalization.

9. Progest: Some Results with the Avatar

At this time, we have found that there is a substantial difference between the groups that have used ProgEst and those that have not. The above according to the statistics mentioned in Sánchez-Guerrero, *et al.* [29] [30] [31] [32] [33].

The ProgEst system has the purpose of supporting learning in the Structured

Programming (SP) course that is imparted to engineering students at the Universidad Autónoma Metropolitana Campus Azcapotzalco (UAM-A). The school cycles at UAM-A are quarterly, with three quarters per year (Winter (W), Spring (S) and Autumn (A)), and the nomenclature is the year and its distinctive W, S and A, each quarter with an equivalent to 40 hours per course.

The ProgEst was implemented in the SP courses in person in the quarters from 1st to 20th. As can be seen in Table 2, the performance of the students enrolled in the course and the percentage of approval by course-quarter. In this case, the percentage of approved is greater than 70%. Among the students approved in the quarters from 18-W to 20-W there is a higher average number of students who used the ProgEst system to support SP learning. Students who passed the subject in the 2018-W to 2020-W quarters were asked their opinion of their experience with the ProgEst avatar (see Table 3). Figure 7 shows that the largest number of respondents, which is equivalent to 75.2% of the sample of users from quarters 18-W to quarters 19-S, 75% mentioned that they were positively encouraged by the avatar interventions.

It could be inferred that according to the results obtained in the sample (Table 2 and Table 3), the highest percentage of students who approved the courses used the ProgEst (Figure 7).

Table 2. SP courses where the ProgEst system was used.

Trimester	Users registered in the course	Approval percentage (%)
18-W	29	82.8
18-A	34	82.4
19-S	30	86.7
19-S	30	76.7
19-A	27	88.9
20-W	39	71.8

Table 3. Percentage of users registered in the course who mentioned that they were positively encouraged by the avatar interventions.

Trimester	Percentage of users registered in the course who selected the avatar (%)	Percentage of users registered in the course who no selected the avatar (%)
18-I	71	29
18-O	73	27
19-P	86	14
19-P	90	10
19-O	80	20
20-I	73.1	26.9

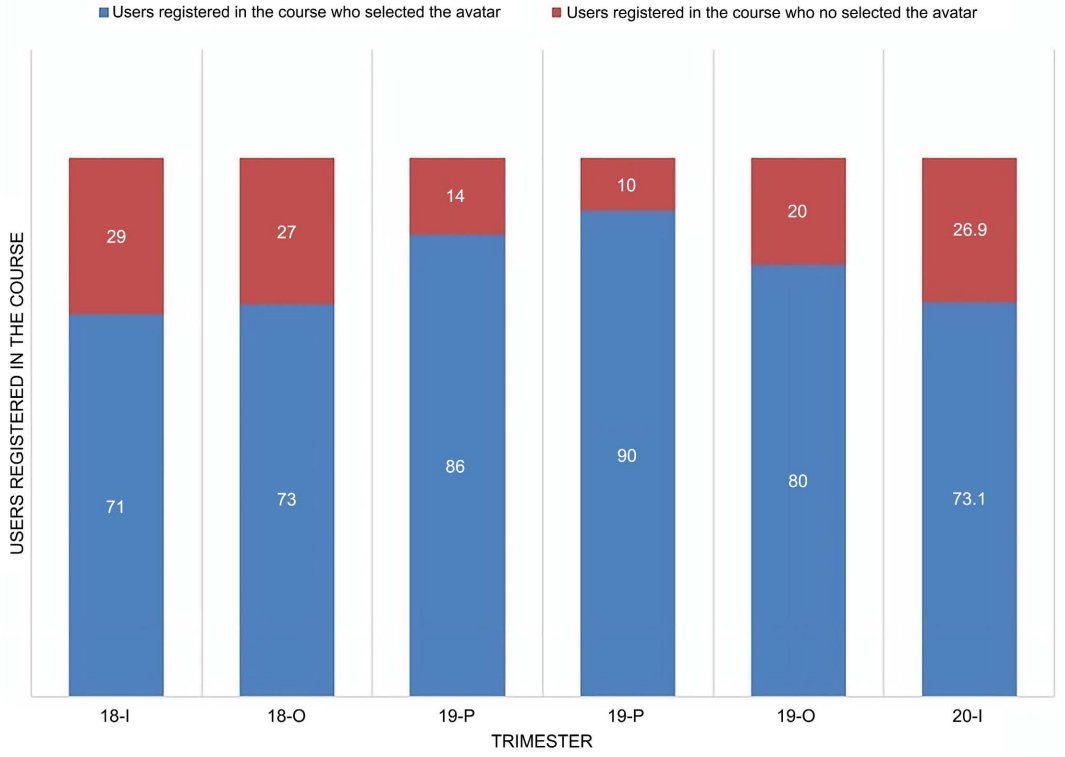


Figure 7. Comparison of users registered in the course who mentioned that they were positively encouraged by the avatar interventions vs users registered in the course who mentioned that not use the avatar.

10. Conclusions

Virtual humans/pedagogical agents are a promise in their various roles: coach, tutor and mentor. The above can be an important point to consider in motivation. The personality of these and the relevance of their appearance have been investigated, the animation of the avatar helps to interest students, as well as to thread their learning by relating the student's model and the curriculum to be covered. Knowledge is a very serious thing. Therefore, the use of these avatars should not be used only as information or entertainment providers.

In the aspect of the teaching-learning process; It is important to mention that most of these focus artilects are on critical aspects within a domain that is the object of teaching. This implies considering the representation of knowledge in more detail in order to help users understand it.

Our future work is to refine the design of OANNA, both in appearance and behavior by including more detailed and sophisticated expressions according to the different strategies mentioned, in addition to vocalizing them. It is intended to incorporate cameras that allow us a feedback, through body and facial expressions; and thus, strengthen and enhance the interaction of the avatar, in addition to enriching the affective-cognitive structure. The premises of this project are to find the students who are about to quit and not complete the course. By having an avatar that constantly accompanies them on the journey; evidence may be obtained, which will serve to demonstrate that through interaction with the user it is possible to avoid frustration or resignation [45].

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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