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The Ways of Thinking in a Sample of the Student Community of the Subjects of Structured Programming and Numerical Methods in Engineering of the UAM-Azcapotzalco within the Emerging Remote Teaching Project (PEER)

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Abstract

Due to the pandemic that is currently being experienced worldwide, educational institutions (HEIs) have had to reinvent and innovate the mode of teaching, in order to continue the process of training students at all educational levels. Higher education has not been immune to this situation, the institutions of this educational level face various challenges in remote teaching: one of them, perhaps the most important, was to answer the question: How to get the student to continue their undergraduate studies remotely? In this sense, it was necessary, on the part of the students and the teachers, a preparation to go from the face-to-face to the virtual mode. This paper addresses the specific case of the analysis of the teaching-learning process of the Teaching-Learning Unit (UEA for its acronym in Spanish) of Structured Programming and Numerical Methods for Engineering at the undergraduate level, at the Universidad Autónoma Metropolitana, Unidad Azcapotzalco (UAM-A) and its relation to the student's way of thinking. Likewise, the analysis will be carried out if the way of thinking of the students of the sample influences their academic performance when studying the subject of Structured Programming and Numerical Methods for Engineering.

Keywords

Intelligent Teaching Systems, Emerging Remote Teaching Project (PEER),

Way of Thinking, Cognition, Motivation and the Locus of Control

1. Introduction

At the Universidad Autónoma Metropolitana (UAM), to face the challenge posed by the pandemic, the Emerging Remote Teaching Project (PEER for its acronym in Spanish) was developed and implemented. The PEER is applied to the various courses that in the UAM are called Teaching-Learning Units (UEA) and whose teaching could be done remotely. Each teacher was given the task of developing materials for their subjects, using different technological platforms as tools; some also implemented them in systems called LMS (Learning Management System). These content management systems support the production of content for the design of the subjects, such as MOODLE, used in the tool called Azcapotzalco Virtual Campus (CAMVIA for its acronym in Spanish), tailored to the institution. For decades, advances in techniques and software development in education have produced applications with more sophisticated techniques, which include artificial intelligence to support the instrumentation of the teaching-learning process. This is how Intelligent Teaching Systems (ITS) emerged.

As part of a research project at the UAM, the Intelligent Teaching System with Learning Objects "ProgEst" was developed, and this development focused on the subject of Structured Programming (SP) and Numerical Methods in Engineering (NM). This article will focus mainly on observing one of the characteristics of the student that are directly involved in the teaching-learning process; we refer to the student's way of thinking.

The student's way of thinking was identified in the Structured Programming and Numerical Methods courses in trimesters 21-I and 20-O, within the PEER modality, in order to observe the impact of this characteristic on student performance in the course of SP and NM. The results obtained and shown in this work will allow making the necessary adjustments in the strategies applied during the courses in the context of PEER; in order to answer the question posed at the beginning: How to get the student to continue their undergraduate studies remotely? And in this way, to reduce the dropout rate whose levels increased significantly in this pandemic. The following sections of this work briefly explain what Intelligent Teaching Systems (ITS) are, particularly the ProgEst system to finally address the student's mindset, the different test scenarios, the results obtained and the conclusions.

2. Intelligent Teaching Systems

Intelligent Teaching Systems (ITS) are the result of the development and evolution of the so-called computer-assisted instruction systems (CAIs). These systems did not include artificial intelligence (AI) techniques in their inference mechanisms, so they did not adapt to interaction with the user, they only showed the material, and asked a series of questions whose answers were evaluated [1].

On the other hand, ITSs adapt their teaching strategies based on interaction with the user during the learning process [2] [3].

ITSs have been developed for different learning domains and with different artificial intelligence techniques according to the type of knowledge to be represented. They have been used from bayesian networks based on probability theory for the representation of knowledge of the application domain of the system [4]; as well as the technique of beliefs, desires and intentions (BDI for its acronym: Belief, Desire, Intentions), to make decisions about system interventions with information from the environment, motivations and instructional objectives [5]; multi-agent systems that perceive the environment through autonomous agents specialized in one aspect of the domain and resolve system decisions among themselves to adapt to changes in the environment [2] [6], cognitive maps [3] that model the intelligent teaching process through a network of causality between the elements involved in said process.

3. ProgEst (Intelligent Teaching Systems)

ProgEst is an Intelligent Teaching System (ITS) that combines Information Technologies (IT), e-learning and Learning Objects (LO) and ITS [7] [8]. The ITS includes Artificial Intelligence (AI) techniques that support the instrumentation of the teaching-learning process. The process is based on a genetic graph where the instructional objectives are represented. Following the architecture proposed by Laureano-Cruces [2], and Laureano-Cruces and De Arriaga [6], the ProgEst system uses this architecture; but it also includes an inference engine based on a general didactic tutor Laureano-Cruces [6], linked to the tutor module of the case study and to the behavior of the student represented through the student model [9]. This relationship between the tutor module and the student model allows the development of teaching strategies. To represent the general didactic model, nine elements proposed in Laureano-Cruces, [6] are considered, these are represented by the Artificial Intelligence (AI) technique for the representation of knowledge, called Fuzzy Cognitive Maps (FCM) related through causalities; what constitutes the aforementioned inference engine [10].

4. Student's Way of Thinking

The *mode of thinking* is related to the form of motivation and the locus of control.

From the point of view of cognitive psychology, the study of motivation is related to processes that provide energy and direction to behavior, the concept of energy being an indicator of the intensity and persistence of motivation; just as the concept of direction indicates the purpose (goals) of the behavior. This energy of motivation comes from the individual (internal motivation) and the environment (external motivation) [11]; therefore, motivation can be of two types: 1) Intrinsic, integrated with emotions of physiological and cognitive origin, and cognition itself, related to objectives, expectations and psychological elements; 2) Extrinsic, within which are the climatic aspects, as well as those related to a particular state of the personal environment, such as incentives. According to Atkinson and Birch (1970 and 1978); Bolles (1975) and Ekman & Friesen (1975) all cited in Reeve [11], a motivated behavior can be inferred from the observation of seven aspects of behavior that reveal the presence and intensity of motivation and They are: effort, latency, persistence, choice, response probability, facial expressions and body expression, all of which are present in the teaching-learning process. The locus of control, for its part, is defined as the ability of the human being to dominate an event according to the perception that control is inside or outside of it [12]. According to this definition, two types of locus of control are identified: 1) Internal, when the individual perceives that he can control the situation; 2) External, when he perceives that, despite his efforts, control does not depend on him but on chance or the power of others. Each individual has a particular and characteristic style of perceiving and making sense of the environment, that is, they develop a way of thinking (**Table 1**).

The teaching-learning process that includes the student's way of thinking is represented by a causal matrix, where the elements that intervene are: Interest and Desire (ID), Help (He), Cognitive-operative strategies (St), Renunciation (R), Performance (Pr), Latency (Lt), Errors (Er), Joy-Pride (JP), Admiration-Like-Love (A3), Relief (A1), Dislike-Hate-Rejection (Re), Frustration-Fear (Fc), Shame (Sh), Proximity (Pr), Internal Locus (IL), Intrinsic Motivation (IM, External Locus (EL) and External Motivation (EM) [8] [13].

These elements make up the concepts involved in student behavior during the teaching-learning process. The causal matrix [14] [15] [16] [17] represents the causal relationships between the concepts, in order to relate the causalities between the components that make up a cognitive system. The causal relationships are diffuse, and it is possible to encode them with values within the range [0, 1], the 0 represents that there is no causality relationship, in the case of the value 1 it represents maximum causality. The causal relationships between the elements can be positive or negative, it is positive when it is a directly proportional relationship between the elements, in other words, if the causality of one increases, then the causality of the other increases and vice versa; and it is negative when the relationship is inversely proportional, that is, as the causality of one element increases, the causality of the other decreases and vice versa. In our case, the relationships between the elements are represented by an incidence matrix $M(n \times n)$. $V(t)$ is a vector that symbolizes the force of the concept at a given time t and $V(t+1) = S[V(t) \times M(n \times n)]$ represents the subsequent state that is equivalent to a prediction [16]-[27]; where S is a non-linear function [28]-[34] applied individually to the elements of the matrix M multiplied by the vector $V(t)$ at a given time t. The congruence that the vector $V(t+1)$ has in relation to the vector $V(t)$ indicates the performance of the reasoning [12] [35] (**Tables 2-5**).

Table 1. Student's way of thinking according to their type of locus and motivation.

Locus value	Motivation Value	Student's way of thinking
External Locus	Intrinsic motivation	Environment-guided learning
Internal Locus	Extrinsic Motivation	Learning by commitment
Internal Locus	Intrinsic motivation	Principle-guided learning
External Locus	Extrinsic Motivation	Fear-guided learning

Table 2. Causal matrix of the mode of thinking by principles.

	ID	Ay	Es	R	Rd	Lt	Er	AO	A3	Al	Do	Fc	V	Pr	LI	MI
ID	0	0	0	−1	1	0	−1	1	1	0	−1	0	0	0	0	0
Ay	0	0	1	0	0	1	−1	0	0	1	0	0	0	0	0	0
Es	1	0	0	−1	1	0	−1	0	1	0	−1	0	0	0	0	0
R	−1	0	−1	0	−1	0	1	−1	−1	−1	0	1	1	0	0	0
Rd	1	0	1	−1	0	−1	−1	1	1	1	−1	−1	−1	0	1	1
Lt	0	0	1	0	−1	0	0	0	0	−1	0	0	0	0	0	0
Er	−1	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0
AO	1	0	0	0	1	−1	−1	0	1	0	−1	0	0	0	1	1
A3	1	0	1	−1	0	−1	0	0	0	0	−1	0	0	0	1	1
Al	0	0	1	−1	1	0	0	0	0	0	0	−1	0	1	0	0
Do	−1	0	1	1	−1	1	1	0	−1	−1	0	1	1	0	0	0
Fc	0	0	0	1	−1	1	1	−1	−1	−1	1	0	1	1	0	0
V	−1	0	1	1	−1	0	1	−1	−1	0	1	1	0	0	0	0
Pr	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
LI	1	0.5	0	−1	0.5	0	0	1	1	0	−1	−1	−1	0	0	1
MI	1	0.5	0	−1	0.5	0	0	1	1	0	−1	−1	−1	0	1	0

Table 3. Causal matrix of the mode of thinking by fear.

	ID	Ay	Es	R	Rd	Lt	Er	AO	A3	Al	Do	Fc	V	Pr	LE	ME
ID	0	0	0	−1	1	0	−1	1	1	0	−1	0	0	0	0	0
Ay	0	0	1	0	0	1	−1	0	0	1	0	0	0	0	1	1
Es	1	0	0	−1	1	0	−1	0	1	0	−1	0	0	0	0	0
R	−1	0	−1	0	−1	0	1	−1	−1	−1	0	1	1	0	1	1
Rd	1	0	1	−1	0	−1	−1	1	1	1	−1	−1	−1	0	1	1
Lt	0	0	1	0	−1	0	0	0	0	−1	0	0	0	0	0.5	.5
Er	−1	0	1	1	0	0	0	0	0	0	0	1	1	0	1	1
AO	1	0	0	0	1	−1	−1	0	1	0	−1	0	0	0	0	0
A3	1	0	1	−1	0	−1	0	0	0	0	−1	0	0	0	0	0
Al	0	0	1	−1	1	0	0	0	0	0	0	−1	0	1	0	0
Do	−1	0	1	1	−1	1	1	0	−1	−1	0	1	1	0	1	1
Fc	0	0	0	1	−1	1	1	−1	−1	−1	1	0	1	1	1	1
V	−1	0	1	1	−1	0	1	−1	−1	0	1	1	0	0	1	1

Continued

Pr	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
LE	0	0	1	0.5	0	0	0	0	−0.5	−1	0.5	0.5	0.5	0	0	1
ME	0	0	1	0.5	0	0	0	0	−0.5	−1	0.5	0.5	0.5	0	1	0

Table 4. Causal matrix for the mode of thinking by commitment.

	ID	Ay	Es	R	Rd	Lt	Er	AO	A3	Al	Do	Fc	V	Pr	LI	ME
ID	0	0	0	−1	1	0	−1	1	1	0	−1	0	0	0	0	0
Ay	0	0	1	0	0	1	−1	0	0	1	0	0	0	0	0	1
Es	1	0	0	−1	1	0	−1	0	1	0	−1	0	0	0	0	0
R	−1	0	−1	0	−1	0	1	−1	−1	−1	0	1	1	0	1	1
Rd	1	0	1	−1	0	−1	−1	1	1	1	−1	−1	−1	0	1	1
Lt	0	0	1	0	−1	0	0	0	0	−1	0	0	0	0	0	0
Er	−1	0	1	1	0	0	0	0	0	0	0	1	1	0	0	0
AO	1	0	0	0	1	−1	−1	0	1	0	−1	0	0	0	1	0
A3	1	0	1	−1	0	−1	0	0	0	0	−1	0	0	0	1	0
Al	0	0	1	−1	1	0	0	0	0	0	0	−1	0	1	0	0
Do	−1	0	1	1	−1	1	1	0	−1	−1	0	1	1	0	0	1
Fc	0	0	0	1	−1	1	1	−1	−1	−1	1	0	1	1	0	1
V	−1	0	1	1	−1	0	1	−1	−1	0	1	1	0	0	0	1
Pr	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
LI	1	1	0	−1	0.5	0	0	1	1	0	−1	−1	−1	0	0	1
ME	0.5	0.5	0	0.5	0	0	0	0	−0.5	0	0.5	0.5	0.5	0	1	0

Table 5. Causal matrix of the mode of thinking guided by the environment.

	ID	Ay	Es	R	Rd	Lt	Er	AO	A3	Al	Do	Fc	V	Pr	LE	MI
ID	0	0	0	−1	1	0	−1	1	1	0	−1	0	0	0	0	0
Ay	0	0	1	0	0	1	−1	0	0	1	0	0	0	0	1	0
Es	1	0	0	−1	1	0	−1	0	1	0	−1	0	0	0	0	0
R	−1	0	−1	0	−1	0	1	−1	−1	−1	0	1	1	0	1	0
Rd	1	0	1	−1	0	−1	−1	1	1	1	−1	−1	−1	0	1	1
Lt	0	0	1	0	−1	0	0	0	0	−1	0	0	0	0	0.5	0
Er	−1	0	1	1	0	0	0	0	0	0	0	1	1	0	1	0
AO	1	0	0	0	1	−1	−1	0	1	0	−1	0	0	0	0	1
A3	1	0	1	−1	0	−1	0	0	0	0	−1	0	0	0	0	1
Al	0	0	1	−1	1	0	0	0	0	0	0	−1	0	1	0	0
Do	−1	0	1	1	−1	1	1	0	−1	−1	0	1	1	0	1	0
Fc	0	0	0	1	−1	1	1	−1	−1	−1	1	0	1	1	1	0
V	−1	0	1	1	−1	0	1	−1	−1	0	1	1	0	0	1	0
Pr	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
LE	0	0.5	0	0.5	0	0	0	0	−0.5	0	0.5	0.5	0.5	0	0	1
MI	1	1	0	−1	0.5	0	0	1	1	0	−1	−1	−1	0	1	0

Test Scenarios

Several scenarios were proposed and tested, where an entry scenario is a current state of the student at that instant, on the other hand, an exit scenario is a probable subsequent state. This exit scenario is interpreted for a possible action according to the evaluated events [17] [18].

The elements ID, Es, Rd, AO, A3, Al, Do, Fc and V are not directly measurable, therefore they are indicated in the proposed scenarios with a value of zero, to indicate that there is no information. These values are inferred from the vector of the proposed scenario and the effect of the causal matrix, according to the *Mode of Thinking*. The values of the elements Ay, R, Lt, Er, and Pr can vary between zero and one and are directly measurable; therefore, 2^5 possible combinations would be obtained, that is, 32 scenarios.

However, the 8 scenarios where Ay and R were indicated with values one and one respectively were eliminated, because there would be a contradiction in asking for help (Ay) and at the same time giving up (R); Therefore, the possible scenarios would be 24.

Next, the 24 possible scenarios considered for *Principle Thinking Mode* are shown, where the elements *locus* (LI) and *motivation* (MI) are *internal and intrinsic*, respectively (**Table 6**).

The 24 possible scenarios considered by the *Fear Mode of Thinking* are practically the same, only the locus (LE) and motivation (ME) change, where the first is *external* and the second is *extrinsic* (**Table 7**).

The 24 possible scenarios considered for the *Commitment Mode of Thinking* are practically the same, only that the *locus is internal* (LI) and the *motivation* is *extrinsic* (ME) (**Table 8**).

Table 6. Proposed scenarios of the mode of thinking by principles.

No.	ID	Ay	Es	R	Rd	Lt	Er	AO	A3	Al	Do	Fc	V	Pr	LI	MI
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**
2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**	**1**
3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**	**1**
4	0	0	0	0	0	0	1	0	0	0	0	0	0	1	**1**	**1**
5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**	**1**
6	0	0	0	0	0	1	0	0	0	0	0	0	0	1	**1**	**1**
7	0	0	0	0	0	1	1	0	0	0	0	0	0	0	**1**	**1**
8	0	0	0	0	0	1	1	0	0	0	0	0	0	1	**1**	**1**
9	0	0	0	1	0	0	0	0	0	0	0	0	0	0	**1**	**1**
10	0	0	0	1	0	0	0	0	0	0	0	0	0	1	**1**	**1**
11	0	0	0	1	0	0	1	0	0	0	0	0	0	0	**1**	**1**
12	0	0	0	1	0	0	1	0	0	0	0	0	0	1	**1**	**1**
13	0	0	0	1	0	1	0	0	0	0	0	0	0	0	**1**	**1**

Continued

14	0	0	0	1	0	1	0	0	0	0	0	0	0	1	**1**	**1**
15	0	0	0	1	0	1	1	0	0	0	0	0	0	0	**1**	**1**
16	0	0	0	1	0	1	1	0	0	0	0	0	0	1	**1**	**1**
17	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**
18	0	1	0	0	0	0	0	0	0	0	0	0	0	1	**1**	**1**
19	0	1	0	0	0	0	1	0	0	0	0	0	0	0	**1**	**1**
20	0	1	0	0	0	0	1	0	0	0	0	0	0	1	**1**	**1**
21	0	1	0	0	0	1	0	0	0	0	0	0	0	0	**1**	**1**
22	0	1	0	0	0	1	0	0	0	0	0	0	0	1	**1**	**1**
23	0	1	0	0	0	1	1	0	0	0	0	0	0	0	**1**	**1**
24	0	1	0	0	0	1	1	0	0	0	0	0	0	1	**1**	**1**

Table 7. Proposed scenarios of the mode of thinking by fear.

No.	ID	Ay	Es	R	Rd	Lt	Er	AO	A3	Al	Do	Fc	V	Pr	LE	ME
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**
2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**	**1**
3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**	**1**
4	0	0	0	0	0	0	1	0	0	0	0	0	0	1	**1**	**1**
5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**	**1**
6	0	0	0	0	0	1	0	0	0	0	0	0	0	1	**1**	**1**
7	0	0	0	0	0	1	1	0	0	0	0	0	0	0	**1**	**1**
8	0	0	0	0	0	1	1	0	0	0	0	0	0	1	**1**	**1**
9	0	0	0	1	0	0	0	0	0	0	0	0	0	0	**1**	**1**
10	0	0	0	1	0	0	0	0	0	0	0	0	0	1	**1**	**1**
11	0	0	0	1	0	0	1	0	0	0	0	0	0	0	**1**	**1**
12	0	0	0	1	0	0	1	0	0	0	0	0	0	1	**1**	**1**
13	0	0	0	1	0	1	0	0	0	0	0	0	0	0	**1**	**1**
14	0	0	0	1	0	1	0	0	0	0	0	0	0	1	**1**	**1**
15	0	0	0	1	0	1	1	0	0	0	0	0	0	0	**1**	**1**
16	0	0	0	1	0	1	1	0	0	0	0	0	0	1	**1**	**1**
17	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**
18	0	1	0	0	0	0	0	0	0	0	0	0	0	1	**1**	**1**
19	0	1	0	0	0	0	1	0	0	0	0	0	0	0	**1**	**1**
20	0	1	0	0	0	0	1	0	0	0	0	0	0	1	**1**	**1**
21	0	1	0	0	0	1	0	0	0	0	0	0	0	0	**1**	**1**
22	0	1	0	0	0	1	0	0	0	0	0	0	0	1	**1**	**1**
23	0	1	0	0	0	1	1	0	0	0	0	0	0	0	**1**	**1**
24	0	1	0	0	0	1	1	0	0	0	0	0	0	1	**1**	**1**

Table 8. Scenarios proposed for the mode of thinking by commitment.

No.	ID	Ay	Es	R	Rd	Lt	Er	AO	A3	Al	Do	Fc	V	Pr	LI	ME
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**
2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**	**1**
3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**	**1**
4	0	0	0	0	0	0	1	0	0	0	0	0	0	1	**1**	**1**
5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**	**1**
6	0	0	0	0	0	1	0	0	0	0	0	0	0	1	**1**	**1**
7	0	0	0	0	0	1	1	0	0	0	0	0	0	0	**1**	**1**
8	0	0	0	0	0	1	1	0	0	0	0	0	0	1	**1**	**1**
9	0	0	0	1	0	0	0	0	0	0	0	0	0	0	**1**	**1**
10	0	0	0	1	0	0	0	0	0	0	0	0	0	1	**1**	**1**
11	0	0	0	1	0	0	1	0	0	0	0	0	0	0	**1**	**1**
12	0	0	0	1	0	0	1	0	0	0	0	0	0	1	**1**	**1**
13	0	0	0	1	0	1	0	0	0	0	0	0	0	0	**1**	**1**
14	0	0	0	1	0	1	0	0	0	0	0	0	0	1	**1**	**1**
15	0	0	0	1	0	1	1	0	0	0	0	0	0	0	**1**	**1**
16	0	0	0	1	0	1	1	0	0	0	0	0	0	1	**1**	**1**
17	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**
18	0	1	0	0	0	0	0	0	0	0	0	0	0	1	**1**	**1**
19	0	1	0	0	0	0	1	0	0	0	0	0	0	0	**1**	**1**
20	0	1	0	0	0	0	1	0	0	0	0	0	0	1	**1**	**1**
21	0	1	0	0	0	1	0	0	0	0	0	0	0	0	**1**	**1**
22	0	1	0	0	0	1	0	0	0	0	0	0	0	1	**1**	**1**
23	0	1	0	0	0	1	1	0	0	0	0	0	0	0	**1**	**1**
24	0	1	0	0	0	1	1	0	0	0	0	0	0	1	**1**	**1**

The 24 possible scenarios considered for the *Environment Guided Mode of Thinking* are practically the same, only that the *locus* is *external* (LE) and the *motivation* is *intrinsic* (MI) (**Table 9**).

5. Results

In the *Principles of Thinking mode*, no matter what happens in the environment, remain with the same way of thinking. This way of thinking is explained in an individual capable of taking responsibility for their own learning.

In *Fear Thinking mode*, no matter what happens in the environment, stay with the same mindset. The challenge in this mode of thinking will be what strategies to apply to move from this mode of thinking to an intermediate one such as *guided by commitment* or *guided by the environment*, where will have the opportunity to move to a mode of thinking such as *guided by principles*.

In the case of the *Commitment Mode of Thinking*, the determining factor to change the behavior from the way of thinking *guided by commitment* to a way

Table 9. Proposed scenarios for the environment guided mode of thinking.

No.	ID	Ay	Es	R	Rd	Lt	Er	AO	A3	Al	Do	Fc	V	Pr	LE	MI
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**
2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	**1**	**1**
3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**	**1**
4	0	0	0	0	0	0	1	0	0	0	0	0	0	1	**1**	**1**
5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	**1**	**1**
6	0	0	0	0	0	1	0	0	0	0	0	0	0	1	**1**	**1**
7	0	0	0	0	0	1	1	0	0	0	0	0	0	0	**1**	**1**
8	0	0	0	0	0	1	1	0	0	0	0	0	0	1	**1**	**1**
9	0	0	0	1	0	0	0	0	0	0	0	0	0	0	**1**	**1**
10	0	0	0	1	0	0	0	0	0	0	0	0	0	1	**1**	**1**
11	0	0	0	1	0	0	1	0	0	0	0	0	0	0	**1**	**1**
12	0	0	0	1	0	0	1	0	0	0	0	0	0	1	**1**	**1**
13	0	0	0	1	0	1	0	0	0	0	0	0	0	0	**1**	**1**
14	0	0	0	1	0	1	0	0	0	0	0	0	0	1	**1**	**1**
15	0	0	0	1	0	1	1	0	0	0	0	0	0	0	**1**	**1**
16	0	0	0	1	0	1	1	0	0	0	0	0	0	1	**1**	**1**
17	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**	**1**
18	0	1	0	0	0	0	0	0	0	0	0	0	0	1	**1**	**1**
19	0	1	0	0	0	0	1	0	0	0	0	0	0	0	**1**	**1**
20	0	1	0	0	0	0	1	0	0	0	0	0	0	1	**1**	**1**
21	0	1	0	0	0	1	0	0	0	0	0	0	0	0	**1**	**1**
22	0	1	0	0	0	1	0	0	0	0	0	0	0	1	**1**	**1**
23	0	1	0	0	0	1	1	0	0	0	0	0	0	0	**1**	**1**
24	0	1	0	0	0	1	1	0	0	0	0	0	0	1	**1**	**1**

of thinking *guided by fear* were, on the one hand, *resignation* and on the other hand, the combination of *latency* and *error*.

In the case of the *Environment guided May of Thinking*, the determining factor to modify the behavior from the mode of thinking *guided by the environment* to a mode of thinking *guided by fear* were, on the one hand, *resignation* and the other side, the combination of *latency* and error. As long as don't need the *help*, even when go wrong and make *mistakes*, will continue to shift the mind to being *guided by principles*. However, as soon as requires help, the perception of the teaching-learning process changes and with it the mode of thinking to *guide by fear*. The modes of thinking were compared with the performance of the students in the subjects of Structured Programming and Numerical Methods in Engineering in trimesters 21-I and 20-O [21] [22] [23] [24].

5.1. Modes of Thinking and Their Performance in the UEA Structured Programming

The way of thinking of the student that was identified in the Structured Programming courses of trimesters 21-I and 20-O, within the PEER modality, were the following (Figures 1-6):

Trimester 21-I

Mode of Thinking	Percentage
Mode of Thinking guided by fear	41%
Mode of Thinking guided by the environment	47%
Mode of Thinking guided of principles	6%
Mode of Thinking guided of commitment	6%

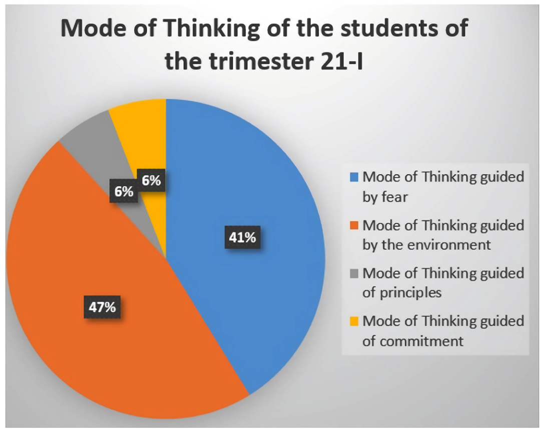

Figure 1. Mode of thinking of the students of the trimester 21-I of the subject of structured programming.

Trimester 20-O

Mode of Thinking	Percentage
Mode of Thinking guided by the environment	54
Mode of Thinking guided of commitment	30
Mode of Thinking guided of principles	16

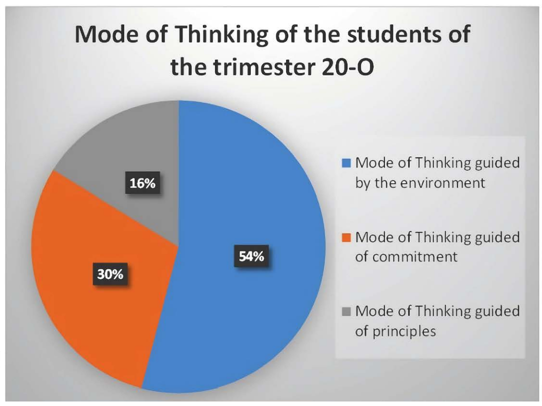

Figure 2. Mode of thinking of the students of the 20-O trimester of the structured programming subject.

The impact of this on student performance in the SP course was the following:

Trimester 21-I

Mode of Thinking	Percentage
Mode of Thinking guided by the environment	50%
Mode of Thinking guided by fear	43%
Mode of Thinking guided of principles	7%

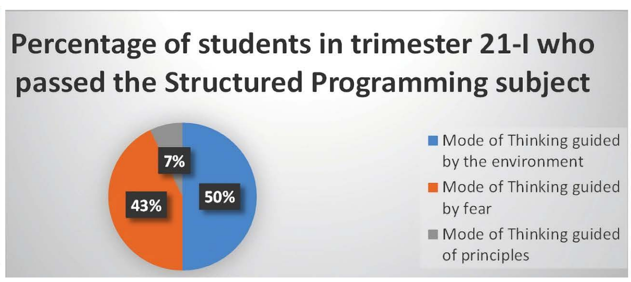

Figure 3. Percentage of students in trimester 21-I who passed the structured programming subject.

Mode of Thinking	Percentage
Mode of Thinking guided by fear	35%
Mode of Thinking guided by the environment	50%
Mode of Thinking guided of commitment	10%
Mode of Thinking guided of principles	5%

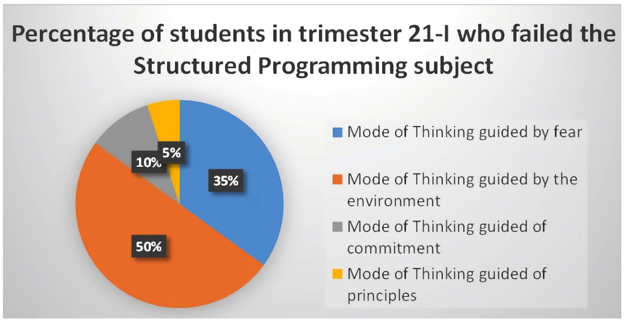

Figure 4. Percentage of students in trimester 21-I who failed the structured programming subject.

Trimester 20-O

Mode of Thinking	Percentage
Mode of Thinking guided of commitment	58
Mode of Thinking guided by the environment	10
Mode of Thinking guided of principles	32

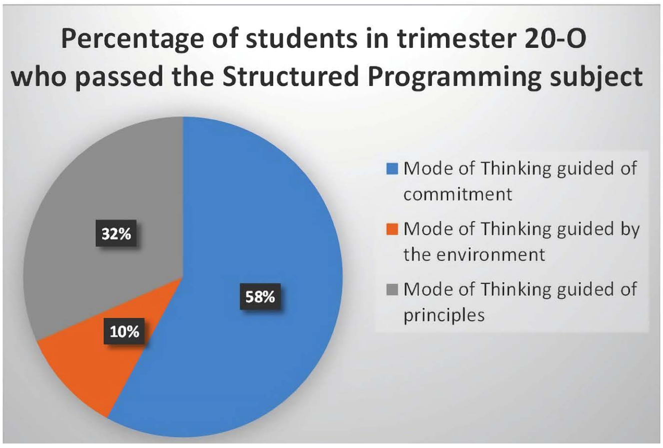

Figure 5. Percentage of students in trimester 20-O who passed the structured programming subject.

Mode of Thinking	Percentage
Mode of Thinking guided by the environment	100

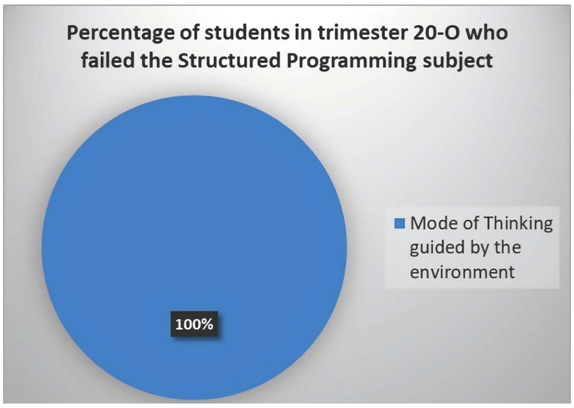

Figure 6. Percentage of students from trimester 20-O who failed the structured programming subject.

5.2. Student's Mode of Thinking and Their Performance in the UEA Numerical Methods in Engineering

The mode of thinking of the student that was identified in the courses of Numerical Methods in Engineering of trimesters 21-I and 20-O, within the PEER modality, were the following:

Trimester 21-I

Mode of Thinking	Percentage
Mode of Thinking guided by fear	45%
Mode of Thinking guided by the environment	41%
Mode of Thinking guided of principles	7%
Mode of Thinking guided of commitment	7%

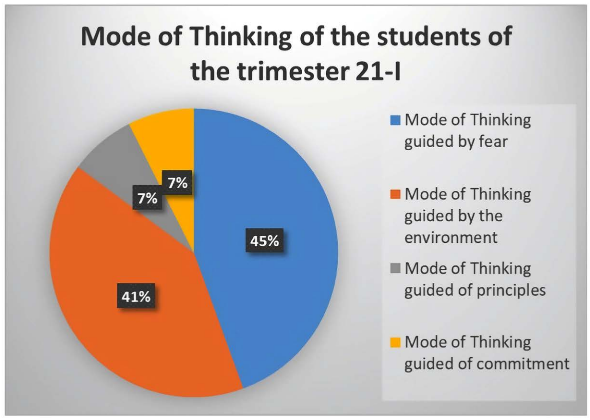

Figure 7. Mode of thinking of the students of the trimester 21-I of the subject of numerical methods in engineering.

Trimester 20-O

Mode of Thinking	Percentage
Mode of Thinking guided of commitment	45%
Mode of Thinking guided of principles	33%
Mode of Thinking guided by the environment	22%

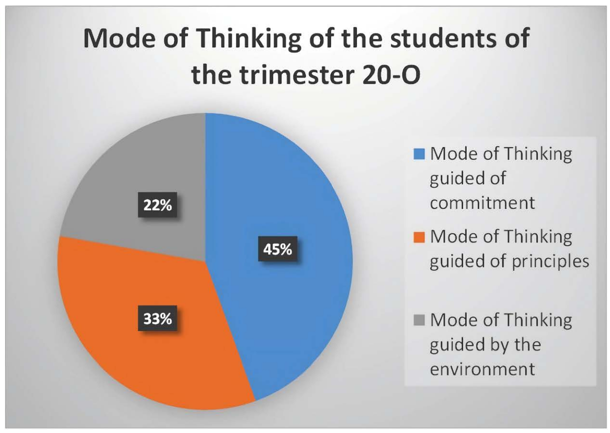

Figure 8. Mode of thinking of the students of the trimester 20-O of the subject of numerical methods in engineering.

The impact of this profile on the student's performance in the NM course were the following (Figures 7-12):

Trimester 21-I

Mode of Thinking	Percentage
Mode of Thinking guided by the environment	44%
Mode of Thinking guided by fear	39%
Mode of Thinking guided of principles	6%
Mode of Thinking guided of commitment	11%

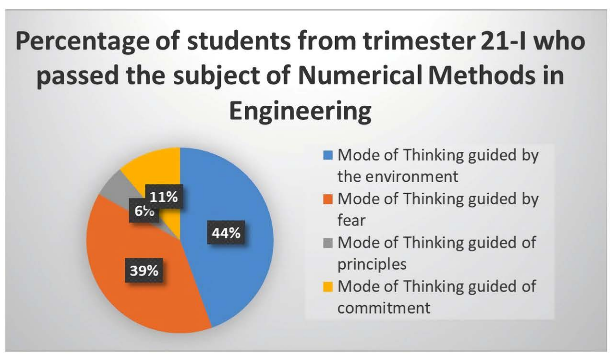

Figure 9. Percentage of students from trimester 21-I who passed the subject of numerical methods in engineering.

Mode of Thinking	Percentage
Mode of Thinking guided by fear	56%
Mode of Thinking guided by the environment	33%
Mode of Thinking guided of principles	11%

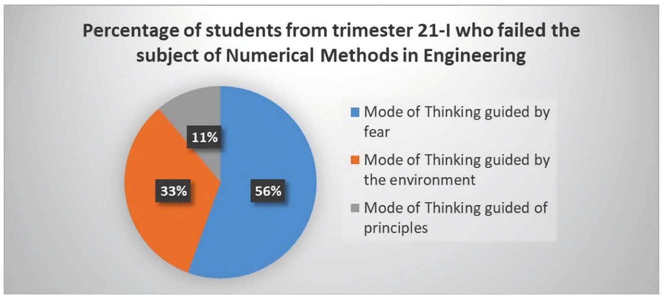

Figure 10. Percentage of students from trimester 21-I who failed the subject of numerical methods in engineering.

Trimester 20-O

Mode of Thinking	Percentage
Mode of Thinking guided of commitment	57%
Mode of Thinking guided of principles	43%

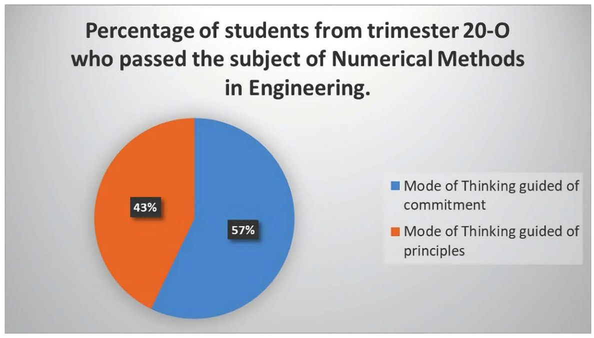

Figure 11. Percentage of students from trimester 20-O who passed the subject of numerical methods in engineering.

Mode of Thinking	Percentage
Mode of Thinking guided by the environment	100%

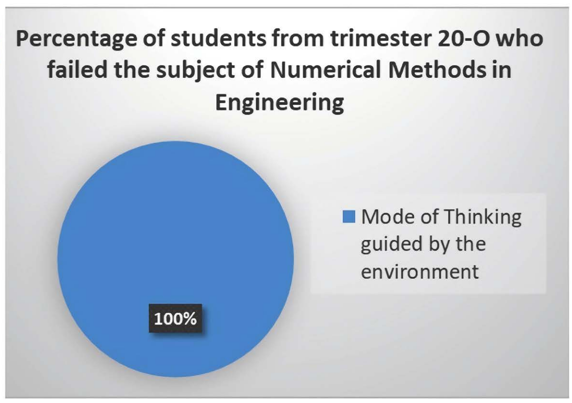

Figure 12. Percentage of students from trimester 20-O who failed the subject of numerical methods in engineering.

6. Analysis of Results

According to the data obtained in trimesters 21-I and 20-O, it can be inferred that it is necessary to dedicate more personal time to the study of UEA (Structured Programming and Numerical Methods in Engineering); in addition to the time that the UAM trimester system dedicates to each UEA.

Likewise, based on the ways of thinking of the students who passed the Structured Programming UEA from trimester 20-O to trimester 21-I, it is observed that there is a change from a way of Thinking by Commitment to a way of Thinking Guided by Fear.

In the case of the UEA of Numerical Methods in Engineering, it is observed that in addition to the modes of Thinking of the trimester 20-O that are by Commitment and by Principles, the modes of Thinking guided by the Environment and by Fear appear.

Another aspect that is important to mention is that the student would be expected to be able to get into the PEER system in trimester 21-I, to achieve the performance objectives; but contrary to expectations, this did not happen and instead performance worsened [19] [20].

7. Conclusions

As part of the conclusions of this work, it is important to comment that the use of these modes of thinking of the student provides information that can be used to include cognitive-operational strategies that support the teaching-learning process [3] [32]-[37].

As can be seen in the subject of Structured Programming and Numerical Methods for Engineering, most of the students had a mode of thinking out of fear, this could be derived from the environment in which they are at the time of taking the classes.

One aspect that is important to highlight is that the number of students who did not obtain a passing grade for both subjects corresponds to students who dropped out of the subjects from the beginning or did not attend the course. It can be inferred that these students do not have the appropriate conditions in the infrastructure necessary to connect or, where appropriate, have two subjects or have a job whose schedules overlap; another case could be that the number of subjects exceeds the limit of the number of subjects they can attend.

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Conflicts of Interest

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

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