Modeling a Virtual Learning Environment as States of a Touring Machine

Loyola Y Blanco, José
CCH Vallejo, Department of Mathematics
UNAM, Mexic
joseloyola@computer.org

Abstract

The Modelling of a Virtual Learning Environment can be accomplished through the modelling of states of a Turing Machine, where learning takes place through the transition of states in which knowledge products are built.
In one state, a Turing Machine reads and as a result of this action may or may not write, and may or may not make a state transition.
In the learning process modelled by states of a Turing Machine, the student reads, processes the information, builds a product of knowledge through actions and finally changes his state or remains in the same one.
The knowledge products, the operations performed in the actions, and the type of contents read are determined by the abilities of the Structure of Intellect Model (SOI) ensuring in this manner that learning takes place.
The modelling of states is the key to displaying and summarizing the curriculum designed by an UML object-oriented modelling, where a Use Case represents a unit of cognitive resources that is developed by the student.
Each use case is developed through an UML state diagram, and then is validated by a Turing Machine modelling state.
It is expected that, in a virtual learning environment, a student should be able to open his own threads of learning with different contents, conduct state transitions determined by his own learning process and produce his knowledge products, which become a case of non-deterministic automata, showing the benefits of adopting the modelling of states of a Turing Machine as a learning model..
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1. Introduction

One of the main characteristics of the Digital Technology is its evolution; due to this characteristic it seems almost impossible to have a standard learning processing in a virtual environment and it is less attainable if for a virtual environment it's just considered the technological aspect.

That´s why computer sciences are introduced along with other references such as psychology, philosophy, neuroscience. Learning is a complex phenomenon largely studied and applied in the Artificial Intelligence and other Computer Sciences. That's why one of the main sources to model this standard process will be found on the Computer Sciences and Software Engineering.

The first principle to consider is that the student that uses technological tools to learn will construct a knowledge system, a system that can be modelled using UML.

So, this research is one of the contributions to develop this model of the standard learning process, which can be applied to every knowledge area.

In order to succeed in their application it has to be presented in such a way that represents every kind of knowledge, so in this case, it will be shown with logic-mathematical contents.

2. Primary references

A Turing Machine is an abstract machine that allows thinking on how a machine can process the information introduced to it. The definition of a Turing Machine (Alfonseca Cubero, Alfonseca Moreno, & Moriyón Solomon, 2007) includes as the main component, the function that determines the behaviour of the automata as it reads the information introduced. The function determines the actions performed depending on the machine's state and the characters read.

We can think about the student's learning process as one that proceeds in the same manner, that is, he or she reads information and depending on his or her cognitive operational schemes he or she will act accordingly. The function that determines his or her behaviour afterwards is a black box.

In a case where the visibility of the knowledge in a studied phenomenon is poor one can use a model that represents the event and depending on the output's reality the model will be adjusted. In this case, the model that serves for this purpose is the Guilford's SOI (Structure of Intellect) Model (Guilford, 1959), where he defines the intellectual abilities that determine our capacities and abilities.

If we converge on both models, the automata and the SOI, we can visualize what might be the learning process that a student can follow to assimilate/accommodate the cognitive operational schemes planned.

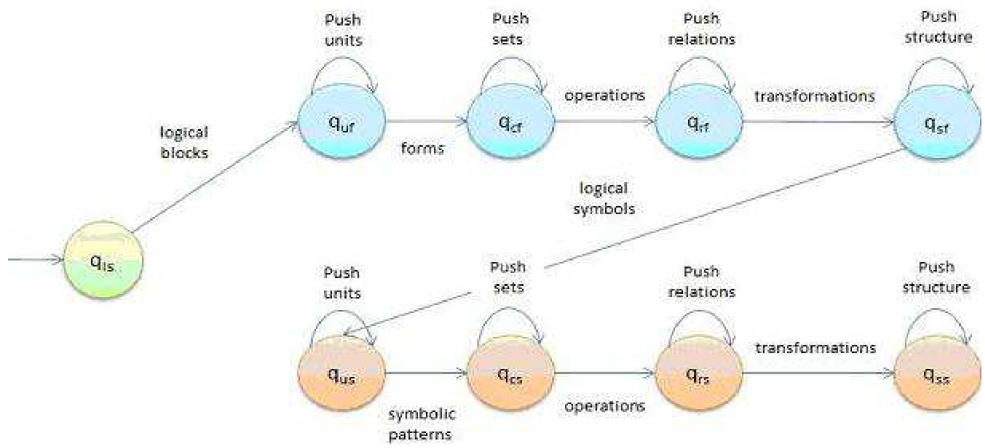

Figure 1: A Turing Machine's diagram of state representing initial mathematical-logical learning

3. The learning process at a glance

In the above figure two types of contents in the virtual mathematical learning are shown, the first one at the top displays the processing with figural contents and the one at the bottom the symbolic content. As can be seen, it is practically the same processing pattern.

We can see an initial state named q_{ls} which establishes the current schemes of the student in the mathematical-logical thinking system. From there, the process transitions to the first learning state established by the SOI Model, the one that constructs figural units.

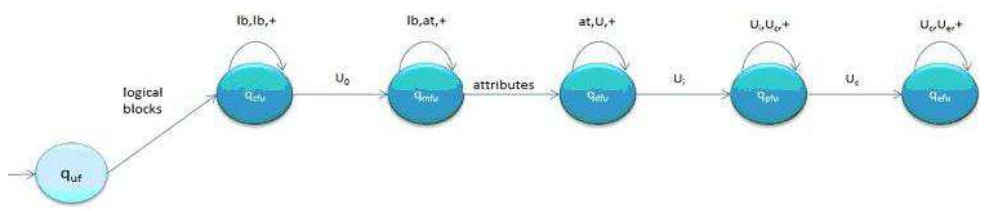

Figure 2: The state where figural units are constructed is divided into sub-states.

The figural units in the mathematical-logical system are constructed through 5 operations.

In the first operation some logical blocks are shown to the student, and the student has to construct an extension of the presented set, the operation that corroborates that the student cognizes mathematical-logical figural units. The construction process is developed using Visio, the technological tool chosen to do the task.

From that knowledge state, a first Universal set is created by the student. In order to test if the student has stored the significant information about the set of objects constructed, he is asked to write down in a spread sheet the meta-cognition information that describes the created set. Excel is used using a spread sheet designed with a structure of cognitive scaffolding. It is expected that the student will create an extension of the given set. However, there are various possibilities for doing this, one student might abstract: 4 geometric shapes, 4 colours and 2 sizes; while another might abstract: 4 geometric shapes, 2 colours and 4 sizes; and yet another: 2 geometric shapes, 4 colours and 4 sizes.

This situation can produce a non-deterministic Turing Machine.

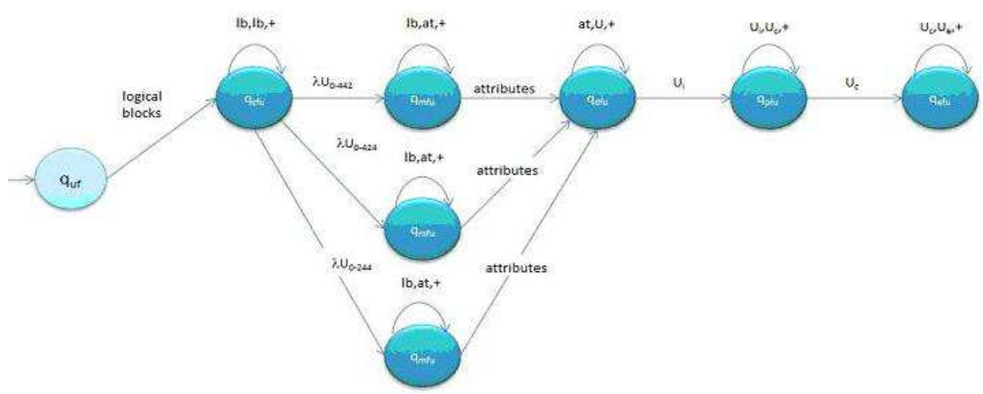

Figure 3: A non-deterministic transition from the state of cognition of figural units.

3.1. A non-deterministic behaviour

This exemplifies that a digital virtual environment allows each student to follow his or her own perceptions, if the necessary resources are built in by the teacher to enable this possibility.

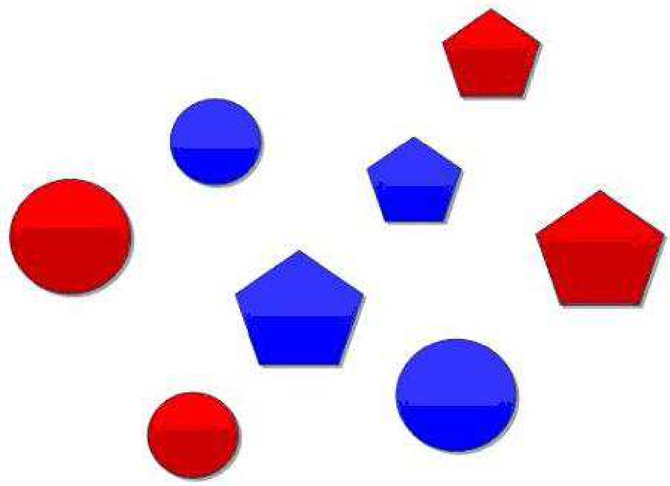

Figure 4: A set of logical blocks given to construct a Universal set.

Once the figural units are constructed by the student, he or she can transition to the next state, the construction of figural classes, which constitutes the first step in developing mathematical-logical abstraction.

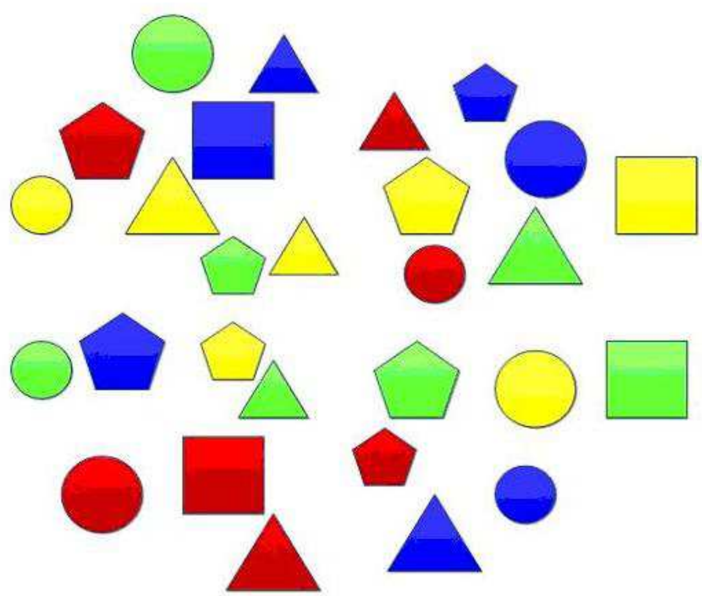

Figure 5: Within the figural relations, some of them are difficult to identify.

At the end of this first level of mathematical-logical figural unit's logical blocks, the student has to end up with in a structure that allows him or her to identify difficult relations.

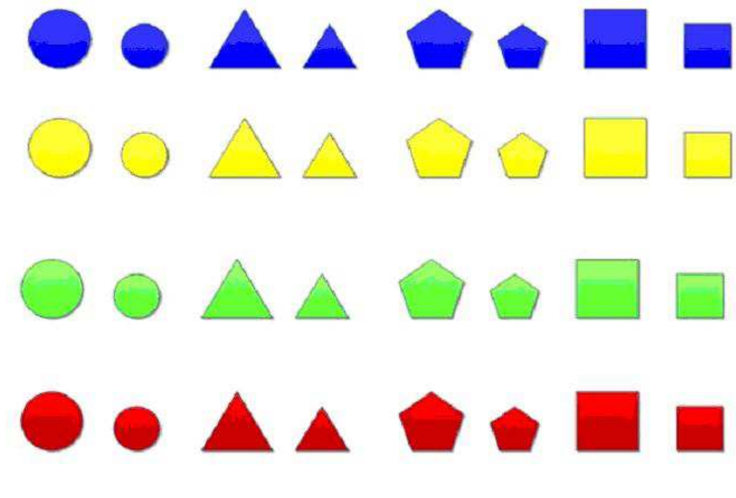

Figure 6: The cognitive operational scheme for the figural contents of the mathematical-logical system.

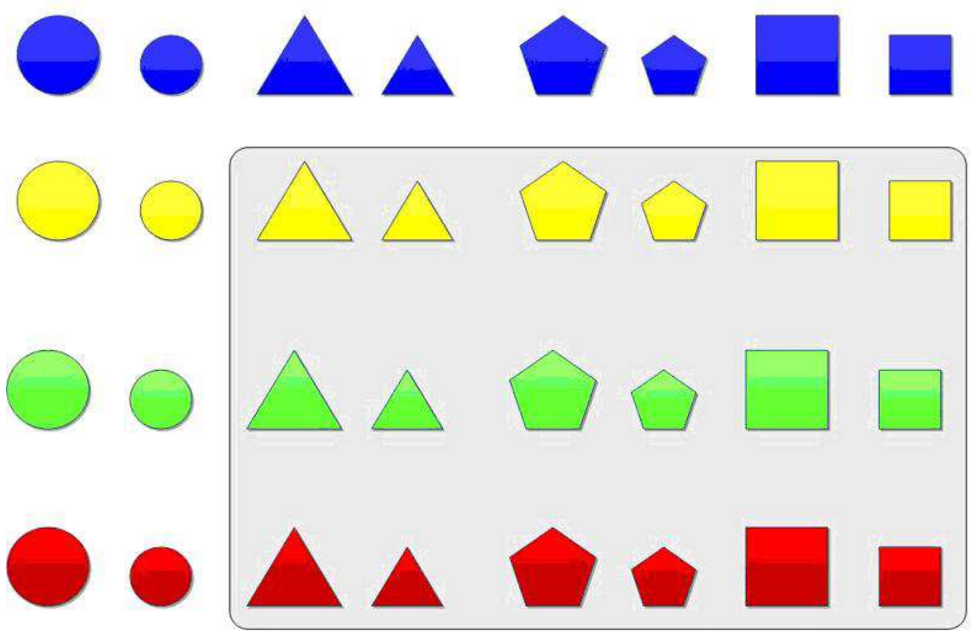

Figure 7: With the cognitive operational scheme the student can define this set as non-blue and non-circle.

With the cognitive operational schema constructed the student redefines the relations given with the logical blocks not structured (see fig. 5). This experience gives the student the ability to make synthetic judgments, transferring him or her from the Transcendental Aesthetic to the Transcendental Analytic in the Kant knowledge system (Kant, 2006) and in the SOI sequence to the symbolic contents.

3.2. The symbolic content

When the processing with the figural contents has reached its goal, which is the cognitive operational schema displayed in figs. 6 and 7, there has to be a transition towards to the symbolic content, which is the following knowledge products construction.

The sequence of operations is the same with the symbolic content as it was with the figural content; that redundancy creates a trace of operational capacity and develops the intellectual abilities used. It also creates the foundation from which to start at this second level of construction.

As this is a transition (Hopcroft, Motwani, & Ullman, 2008) of contents, it has to be started using the student's own symbols. That is why with regard to the ability to cognize symbolic units; first the student creates a set of symbols whose sole restriction is the size of the symbol, and then he or she is asked to create another set using more specific characteristics: a lower case letter and one digit. Afterwards a set of symbols is given with a different intent; in this case, he or she must figure out the meaning of the symbols.

In this moment another class of symbols (Piaget, 1973) is introduced, the symbols of sets, which has to be different, but related:

Create for every set of elements their correspondent symbol

$= \{\ a_0\ a_1\ a_3\ a_6\ a_4\ a_8\ a_5\ a_9\ \}$

$= \{\ r_0\ r_1\ r_3\ r_6\ r_4\ r_8\ r_5\ r_9\ \}$

$= \{\ v_0\ v_1\ v_3\ v_6\ v_4\ v_8\ v_5\ v_9\ \}$

$= \{\ y_0\ y_1\ y_3\ y_6\ y_4\ y_8\ y_5\ y_9\ \}$

Define the elements for every set

C = {

O = {

P = {

T = {

S = {

G = {

Table 1: Cognition of symbolic classes

With these classes of symbols the students has to process different relations.

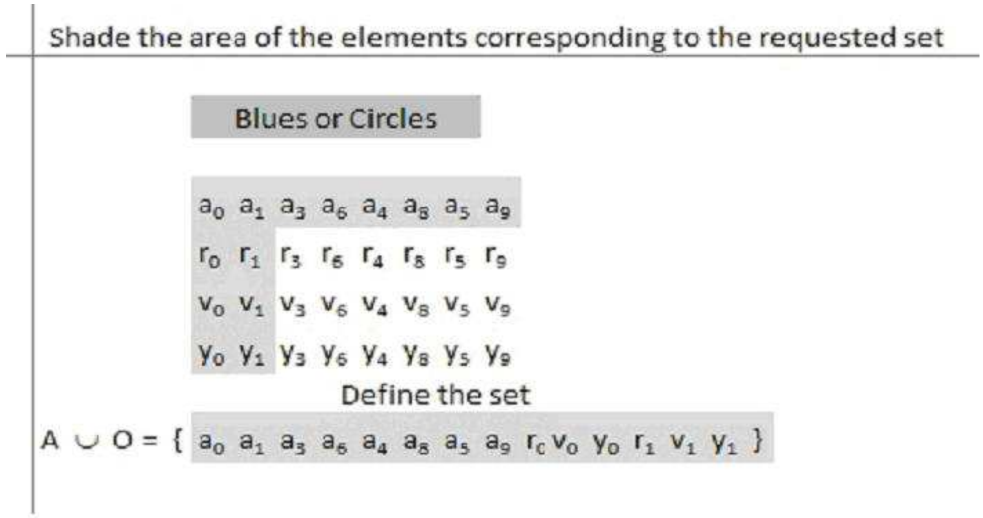

Table 2: Cognition of symbolic relations

At the symbolic relations level, another class of symbols is introduced, and before entering into the symbolic structure it is important to make the student gain awareness of all the different classes of symbols that are being managed.

4. Conclusion

By using the SOI Model structure, the modeling of a virtual learning environment as states of a Turing Machine provides teachers with the opportunity to focus on the selection of content and how to interpret the implementation of intellectual abilities, which is the first purpose of this standard learning process.

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