An environment for constructing and exploring visual models of logic propositions by young students

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Abstract. This paper presents Logic Model Creator's (LMC) main characteristics, architecture and functionalities as well. LMC is a new educational environment that permits young students to build and explore logic models. LMC allows logic models' visual representation using supposition, conclusion and/or decision constructs. In the rest of this paper we also describe an example of use of LMC by groups of young students and discuss the implications of this environment in current teaching practice. As we present, LMC users can have full communication and task evaluation during exploration of decision making problems.

1 Introduction

Modelling is a procedure of describing physical or simulated systems that provides an important means for individuals to examine and understand all the aspects, constraints, characteristics, entities, relations and processes that support the behaviour of every such system. Thus, modelling can be a very strong tool in order to help young students to appreciate the world and to discover new forms of expression [1]. During the last years, new software tools, mostly concerning mathematical models of physical phenomena [2], have been developed in order to support learning through modeling. Other modeling activities have also been proposed by scientists from science education and psychology fields [3]. Their purpose is to support children's reasoning and help them have access to decision making reasoning in a progressive way [4].

Based on an earlier qualitative and semi-quantitative modeling environment, ModelsCreator version 2.0 (MCv2), [5], Logic Models Creator (LMC) offers support to students of 11 to 16 years old in order to be able to construct logic models and to explore logic modeling activities. LMC provides generic techniques for models' validation in order to successfully assist students discover mistaken features in their models and attain an accord with the instructor. The models meet the requirements of many curriculum subject matters, permitting interdisciplinary use of the modelling process. Logic Models Creator puts great emphasis on visualization of the modelling entities, their properties and their relations. Visualization is crucial in supporting the reasoning development of young students and favours the transition from reasoning over objects to reasoning with abstract concepts [5]. This feature is extended also to

the simulation of executable models allowing their validation through representation of the phenomenon itself in a visual way and not in an abstract one, as it is usually the case. The original Decision Support component of ModelsCreator included a validation and model diagnosis module described in [6].

2 LMC architecture

If M is a model then it can be represent verbal as follow:

M= { Ei, i=1, …, k, Rj, j=1,…, l, Am, m=1, …, n }

Where E represents the node entities of the solution, R the relationships connecting them and A the attributes of the entities that participate in the solution.

The decision making models consist basically of entities and relations which connects their attributes. Seven supported types of relations make the environment a very powerful tool for creating and testing decision models. The supported types of relations are the AND, THEN, OR, AND, ELSE and NOT types whereas two types of object notes are supported. Through the above mentioned relations, users can build logical constructs. Using such an environment, one may construct expressions which equivalent logical expression is:

Proposition = *IF* Construct *THEN* Construct
| *IF* Construct *THEN* Construct *ELSE* Construct
Construct = (Construct *AND* Construct)
| (Construct *OR* Construct)
| *NOT*(Construct)
| Attribute=Value

The system considers two basic user categories a) the students and b) the teachers who interact with the visual environment in order to accomplish specific tasks. While the main task of the students is to build and check the correctness of their logical models the main task of the teachers is to create new logical domains and define the reference models.

Testing a model means to find out its correctness. But some times a solution to a decision making problem might not be totally true or false. Furthermore there are alternative correct solutions to a decision problem. The model-checking mechanism of the decision-making module aims to facilitate the cooperative process between students and instructors to make an agreement about the situations in which a decision is valid. In order to overcome this problem a reference model has been specified for each logical domain (any curriculum subject). This way exist for each logical a reference model which consist of a number of alternative right models which have been specified by the domain owner. In this way a better evaluation can be achieved while testing the correctness of the user model. In order to evaluate his model the user has to specify first the logical domain. The logical domain module informs the translation module in order to set the right reference model. Then the model module informs the translation module which starts preparing the interface for the prolog module. This interface consists of the reference model and the user model in ASCII format. The prolog module checks the reference with the user's model and provides to the user the appropriate feedback.

3 Case study of use of LMC

In a recent case study, that involved use of LMC, a pair of two 11-year old students (a boy and a girl) of the final year of a primary school of the city of Volos, in Greece was asked to explore a logical model under the supervision of their teacher. The instructive-training activity with the students kept about 50 up to 60 minutes. They were informed about the environment and they used LMC tools before the instructive activity. This training process kept roughly 10 with 15 minutes. The model is based on a scenario of a dog that is in conduct with a live wire and received an electric shock. The children were asked to investigate the conditions under which they could safely rescue the dog. The mode includes attributes like Material of the *stick* to touch the dog, Material of the *shoes* of the child, Material and condition of the *floor*. The teacher asked the students to investigate various alternatives and to check the validity of the model. The session that lasted one hour was recorded and subsequently analyzed using a dialogue annotation scheme. We mention a part of a dialogue which took place during the students' effort to accomplish the right material for the stick.

Instructor: Let's see. What about the material of the stick? What do you think? Do you have any idea? Which is the best choice among the three available?

Student A: Iron. The iron rod is…

Instructor: Well, let's try the iron value.

Student A: OK, I select iron.

Student B: The iron is the worst choice!

Student A: Hmm, you are right; the iron is the worst...

Instructor: You think that iron is the worst choice, do you? What else you can propose? Which material is suitable? Maybe the wood?

Student A: Wood is not suitable enough…

Student B: Non. Wood is like plastic, but plastic is less safe than wood.

Student A: Yes, wood is mediocre…

Instructor: Wood is modest. And iron is the worst? This is what you believe?

Student B: That's right.

Student A: Yes, …

Instructor: So, which is the best choice for the stick's material?

Student B: Plastic.

4 Discussion-Conclusions

An interesting finding of the study was that the two children were engaged in dialogue with the LMC environment and discussed their own experiences related to the subject domain. They investigated for instance the conducting capability of materials like plastic and rubber in relation to the shoes and inferred that plastic is insulating material, as in cables of household electric appliances. One of the children recalled that her grandmother received a strong shock when she touched a bare live cable. The messages received by LMC were considered relevant and supported the specific task.

As resulted from the total educational dialogue analysis, the training activity total followed the structure Initiation – Response -teacher-led discussion – Initiation - Response (IRtlDIR). We consider that this structure was initially and fundamentally shaped by the "open" type educational environment we used, as well as from the objectives that we had placed for the activity in question. The environment is characterized as "open" with the significance that it has the role to convert the students' proposals and not to guide them by prompting or making indications. That "open" educational modelling environment created a context in which the element "Follow-up" of the communication structure (Initiation-Response-Follow-up) [7] breaks down as "teacher-led discussion" and new informed "Initiation" and "Response".

From the analysis that proceeded, it results that LMC and the activity's objectives placed by the instructor as well, shape the educational workgroup's communication structure. During the dialogue process supported by the instructor, it appears that mutual understanding is constructed between him and the students, having as a mental context their common knowledge. It was found that the environment, which is based on direct manipulation interaction mode, was intuitive to use and explore, while the messages received by the environment were considered useful in the specific domain.

Finally it should be mentioned that the LMC environment, is useful in addition to exploring models in various subject matters, for introducing young students in concepts of logic, like Boolean operators and IF-THEN-ELSE constructs [8].

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