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Modeling Web-based Educational Systems: Process Design Teaching Model

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Abstract

Using modeling languages is essential to the construction of educational systems based on software engineering principles and methods. Furthermore, the instructional design is undoubtedly the cornerstone of the design and development of educational systems. Although several methodologies and languages have been proposed for the specification of isolated educational multimedia systems, none has optimum results for the description of these systems and, especially, for their pedagogical aspect. Of course this is due primarily to how these systems function and are applied; it is not due to the language itself, although its special characteristics contribute substantially to the development of these systems sometimes positively and sometimes negatively. In this paper, we briefly describe the introduction of stereotypes to the pedagogical design of educational systems and appropriate modifications of the existing package diagrams of UML (Unified Modeling Language). The main objective of these new stereotypes is to describe sufficiently the mechanisms of generation, monitoring and re-adapting of teaching and student's models which can be used in the educational applications.

Keywords

eLearning, Web-based Educational systems, UML, educational model, teaching model, instructional design

Introduction

Education is undoubtedly the cornerstone of every society. Thus, in every developed society the achievement of optimal education and the provision of all needed means to every individual to be educated is fundamental. For many years now, major emphasis has been given on the development of educational systems that would be based on or supported by intelligent technologies and the World Wide Web. Usually, we distinguish two basic categories of educational applications: those that complement and support the tasks of the traditional teacher-based classroom, and those that function independently, providing self-learning environment. In both cases, the role of the Internet is very important because it provides easy flow of communication and contains a large amount of information. The target in most cases is to release and free educational process from time and place constraints and to optimize the performance of participants through an individualized education.

In every web-based application we distinguish three basic levels: the web character of the program, the pedagogical background and the personalized management of the learning material.

The term 'web-based program' carries several different meanings in the scientific community. Some scientists believe that it refers to those applications that make use of Java, others think that it is anything that uses a web server, while a view that is between the aforementioned seems to have prevailed.

In this article, we define 'web-based program' as information system that contains a web server, a network, an HTTP and a browser in which data supplied by users act on the system's status and cause changes (Conallen, 1999). When we refer to the pedagogical background, we mean the educational model that will be used in combination with pedagogical goals that are set by the educator every time. More specifically, we refer to methodologies that will be used to making the trainees acquire knowledge and will lead them to develop particular skills (Lionarakis & Rokou, 2000). For that purpose this educational model uses patterns and processes of the physiology of human mind, ways of conceptualization and comprehension of pedagogical strategies as well as learning and teaching theories (Rokou, 2002). When we refer to personalized management of the learning material, we mean the set of rules and mechanisms that we use to select the learning material based on the student's characteristics, the educational objectives, the teaching model and the available media.

Framework

From the above, it is conspicuous that the development of web-based educational systems is much more different from the developing process of software in a variety of ways. Firstly, there are many people from different backgrounds and skills -such as educators, authors, layout designers, programmers and multimedia experts- involved in this process. Secondly, the role of the user becomes stronger and, eventually, makes difficult to determine the functional and non-functional requirements of the system. Thirdly, the non-linear structure of this kind of applications combined with importance of interactivity, increases the complexity of the design process and, of course, the fault rate. Finally, this sort of applications must take into account factors like aesthetics that have no relevance to any traditional kinds of software (Nanard & Nanard, 1995).

At this point, we should note that by saying "traditional software" we mean those programs which are computer applications to office management rather than to special domains an disciplines such as Medicine or Education. It is well known that in the case of "traditional software", the development process of software is quite common in all applications which are produced and must be more analytical, starkly scalable and recurrent than that of traditional systems. Moreover, the maintenance and the frequent renewal of the material of this software are basic requirements, whereas in traditional systems, they do not need to be so frequent and their lack does not make the software useless. Furthermore, all those people who participate in the production team and the structure of the program, based on links, nodes and continual readjustments make demands on modeling procedures and stereotypes used (Hennicker & Koch, 2002).

Furthermore, there is an emerging need to combine and integrate different kinds of learning systems that has led to several standardization projects. These projects focus on determining standard architectures and formats for learning environments, such as Learning Technology Systems Architecture or Instructional Management Systems Project (EDUCAUSE, 1999). Their main issue is the standardization of learning and teaching methods (Adelsberger et al., 2000).

IMS defines and delivers interoperable, XML-based specifications to exchange learning content and information about learners among learning systems. Their aim is the modelling of how the systems manage, transfer and distribute data relevant to the educational process.

For our project, we could have used a sophisticated educational modeling language from those available, like OUNL-EML or its descendant IMS (IMS Learning Design, 2003). Of course, the primary objective of IMS project is to provide:

- standards in order to locate and operate and interactive platform-independent materials;
- support for a collaborative and dynamic nature of learning; and
- incentives and a structure to develop and share content.

More specifically, in order to attain this goal, the teams of IMS have been developing specifications for the following areas:

- Metadata, the labeling of educational materials;
- Content, the actions and responses that IMS-compliant content may perform;
- Management functions, such as access control, session management, tracking students' progress through learning processes, control over the virtual learning environment, and security (Naeve A., 1999).

Thus, definitions like learning sequences and their attributes (which characterize the content) learning objectives and learning materials are being standardized in the Learning Object Metadata Model by the Learning Technology Standards Committee of IEEE (LTSC) and the Instructional Management Systems Project (EDUCAUSE, 1999). The goal of this standardization is to develop a format for interchange, reuse, and combination of learning contents. However, a very important criterion to choose an alternative from a variety of learning sequences is the teaching method which is used for specific learning contents. The above-mentioned standard approaches do not cover a detailed description of teaching methods. Usually, only information is added, which does not cover all aspects of a method and its usability for certain contents (Adelsberger et al., 2000).

Furthermore, if these standards are used, there will be no common ground of understanding between computer scientists and educators. This occurs because the main emphasis is aid on pedagogical and educational aspects without providing clear and easy to use correspondence between the pedagogical, educational and technical aspects of the under construction system.

Furthermore, the specific modeling languages require background knowledge of both Education and Computer Science if they are to be used effectively. So, due to the fact that it is very difficult to find people quite familiar with both fields at the same time, both the modeling and the design of educational software requires the use of a modeling language which can be a common ground for and understood by all people involved.

From the above, it is obvious that the very nature of the educational software and the complexity of the exhisting educational modeling languages makes the use of object-oriented (OO) methods an essential prerequisite for the planning and modeling of developing procedures, and this the UML (Unified Modeling Language) seems to be the most appropriate for the notational description (Berner et al., 1999). Undoubtedly, up to now most efforts to use UML in such specialized categories of software have shown that the specialization of the offered models and procedures for the best performance and the fastest designing is necessary (France et al., 1997).

In this article, we focus on the introduction of stereotypes to the pedagogical design of educational systems and of appropriate modifications of the existing package diagrams of UML (Booch et al., 1999), so that these stereotypes describe sufficiently the mechanisms of generation, monitoring and re-adapting the teaching and student's models that pedagogical applications have been using. However, we are still working on modeling patterns the whole process of educational software production and the expansion of stereotypes, which are based on these patterns.

The presentation in this paper is structured in the following way: We started with an Introduction and a Framework. In Section 3, we make an overview of the educational model and its components (student's model, educational goals and pedagogical strategies). In Section 4, we define and describe semantically those components required for the design of collaboration diagrams, while providing extension for more use. In Section 5, we use the newly added stereotypes to describe the development process of a teaching model. In Section 6, we show how the application of the new stereotypes can be used in the production of a simplified teaching model. Finally, we summarize what we have achieved and outline future prospectives.

The educational model-Expansion of stereotypes

The educational model is the description of theories, principles and processes that aim at standardizing teaching processes and regrouping methods. The process of definition of an educational model (Rokou, 2002) is illustrated in Figure 1.

As we see, the process of defining an educational model includes 3 stages:

1. The definition of the student's features;
2. The definition of educational goals; and
3. The definition of pedagogical strategies.

The definition of student's features aims at the configuration of a model for each student, that is, for each student data –such as his/her learning styles, his/her knowledge and skills -are collected (Rokou, 2002). The reason why this process must take place is relatively simple. We assume that the selection of a suitable educational model requires the particular characteristics of each student, so that individualized learning is implemented. In fact, extracting the student's model simulates the process made by a traditional teacher, who asks his/her student and makes assumptions based on the way that the latter responds to the former's stimuli during the first few lessons.

Then, the definitions of educational goals take place simultaneously. They depend mainly on the kind and the subject of learning material and on the abilities and the skills we want students to acquire and enhance (Pantano Rokou, 2002).

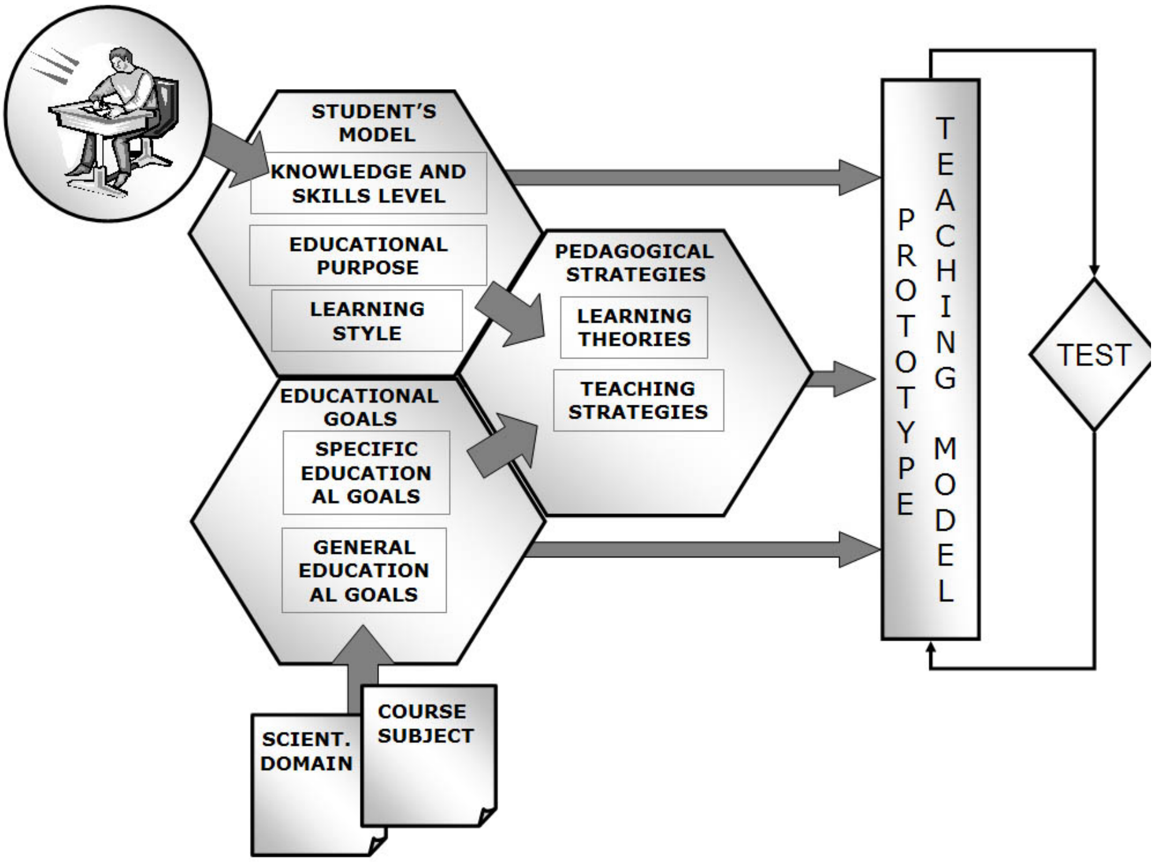


Figure 1. The processes of definition of an educational model

The educational goals are:

- specific, that is the teaching subject (i.e. the scientific domain), the thematic unit and the specificities of the teaching material; and
- general, that is the type of skills that we want the students to acquire; for example, problem solving, etc.

Finally, after having determined the student's model and delineated the educational goals, we select the most appropriate pedagogical strategy (Pantano Rokou, 2002). In order to achieve the most efficient educational model, we select teaching theories compatible with each student's model. Based on this educational model, the course is implemented.

To sum up, we take the process that we have followed for the production of an educational model based on the production of training units. Our objective in this section has been to describe this process in a nutshell in order to make clear the particular character of this model and the need of specialized modeling using suitable stereotypes in this particular case.

Notation

The first and most basic action is the creation of appropriate symbols for the description of the used pedagogical and learning models. In this article, we will concentrate on the definition and the semantic description of the components required for the design of the collaboration diagrams, while we provide extension for more use.

Initially, we have located the primitive components which take part in every teaching model and their basic characteristics. Depending on the teaching model of Figure 1 and on all those referred to Section 3, we can easily deduce that the main components are:

- Student's model;
- Pedagogical strategies; and
- Educational goals

Each of these components requires a set of data for their configuration, while their suitable combination using an intelligent machine produces a final outcome that is the teaching model.

In the Table 1 we see the components of the teaching model properly combined with their features.

Components	**Features**
Student's model	Knowledge and skills level
	Student's needs and motivation
	Personal Learning Styles
Pedagogical strategies	Learning Theories
	Teaching strategies
Educational goals	Specific Educational goals
	General Educational goals

Table 1. The components of the teaching model

At the next stage, we import new stereotypes along with the semantics and the modalities of their use (Tables 2, 3, 4). Furthermore, we assign preconditions and post conditions so that it is clear how and when these components are used.

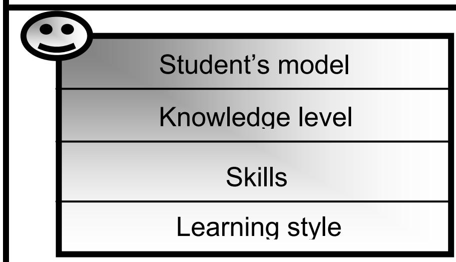
Name	**Student's model**
Preconditions	Profiling mechanism – Rule-based extraction of features
	Describe how the student learns optimally and what his/her strengths and weaknesses are.
Post conditions	Personal learning profile

Table 2. The Stereotype of the student's model

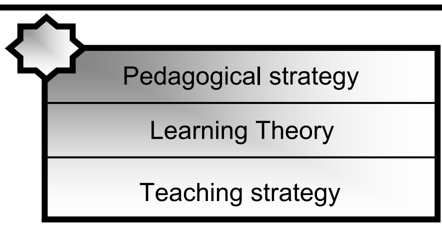
Name	**Pedagogical strategies**
Preconditions	Knowledge-based pedagogical theories and rule-based extraction mechanism
	Combine learning theories with teaching strategies and the data extracted from the repository.
Post conditions	Pedagogical strategies adapted to a specific student and a specific learning subject

Table 3. The Stereotype of Pedagogical strategies

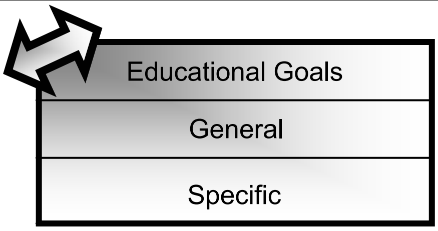
Name	Educational goals
Preconditions	Course subject, scientific domain
	Describe educational goals determined by the educator based on the precondition (i.e. Course subject, scientific domain)
Post conditions	Set of educational goals for a specific course

Table 4. The Stereotype of Educational goals

Using the newly added stereotypes

Most problems during the application of the use of UML (located) are in the correct use of symbols and the adequate determination of the way of the symbols are combined, their position in the proper, for each case, type of diagram and, generally, their utilization in the process of modeling specialized systems.

On the one hand, Figure 2 based on the teaching model of Figure 1 is the collaborative/package diagram of the proposed system which is deduced when we use general forms of UML. On the other hand, Figure 3 is the collaborative/package diagram of the system we are proposing and is based on the new stereotypes we added.

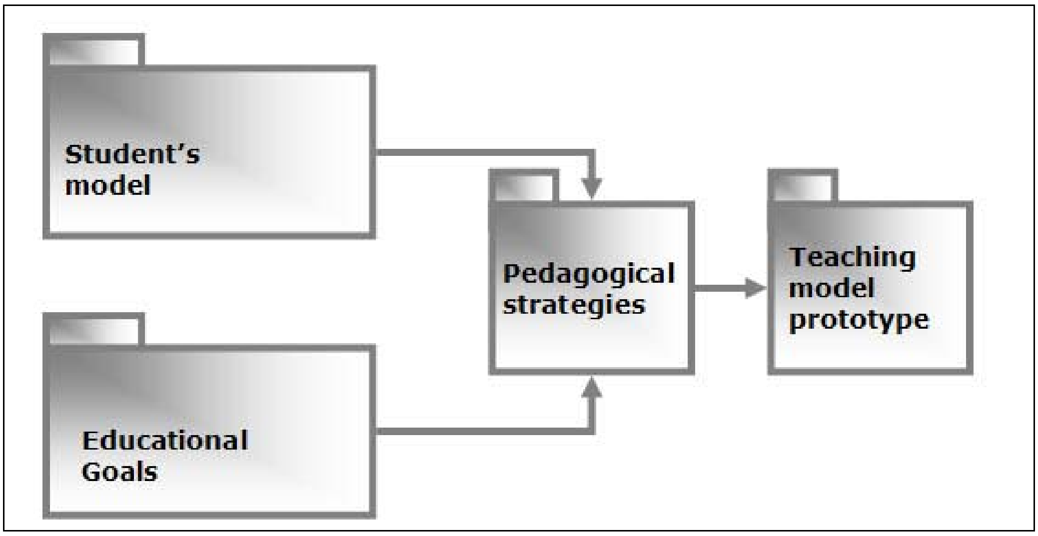


Figure 2. Collaboration diagram with UML

As we see, Figure 2 depicts the general concept of the process but does not provide all the information required. Of course, this is just a package diagram, and we will generate a class and an activity diagram to have the desired output. But why should we do so many diagrams if we can have all the information in one diagram simple and clear but more case specific? Following this train of reasoning, we keep the same diagram using the newly added stereotypes.

In our preceding proposed diagram (Figure 3), the difference may not be huge but it is essential. On the one hand, it gives the opportunity to the developer to combine the components of the system, after having comprehended the why and the how of the process designed by educators and software engineers. On the other hand, the same diagram facilitates educators and software engineers in communicating their concepts and wishes to the developer. Overall, the diagram we are proposing helps developers, educators and software engineers have some common ground of communication and collaborate with each other.

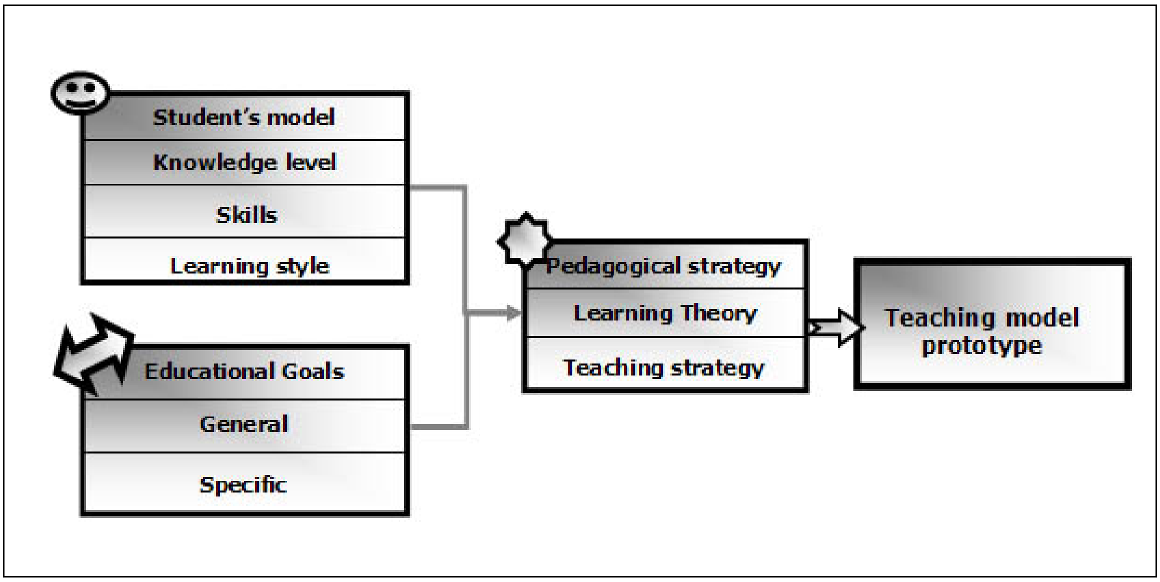


Figure 3. Collaboration diagram with new stereotypes

Case Study

In the following case study we are presenting an example of new stereotypes of the design of the teaching model for the specific purpose, as describe above.

The scientific domain is Mathematics and addresses students of the 2nd level in Junior High School. The general educational goal is the comprehension of the theorem of Pythagoras and the assimilation of the knowledge acquired.

Educational Scenario- Specific Teaching Model

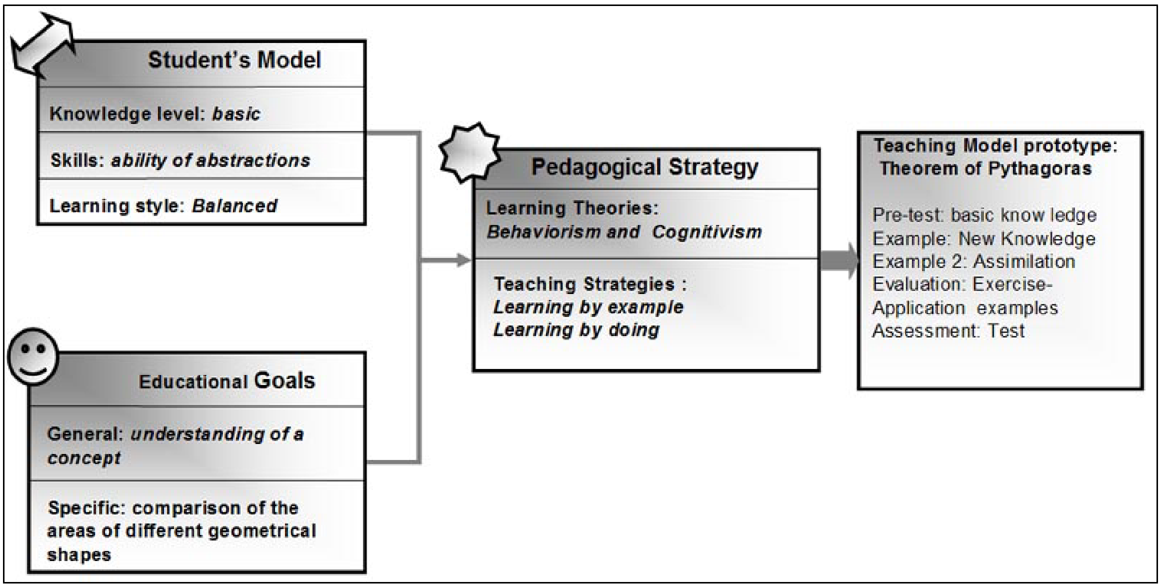


Figure 4. Collaboration diagram with new stereotypes: Specific teaching model

Preconditions

- Discipline: Mathematics
- Course subject: Theorem of Pythagoras
- Target group: Students of the 2nd level in Junior High School
- Level: A (acquisition of basic knowledge)

- Prerequisites: basic knowledge (i.e. what a triangle is, kinds of a triangle, area of a rectangle)
- Learning style: Student type A (the individual learning style has come out of previous special tests of skills and preferences during which there have been determined 4 basic student types. Student type A: a balanced way of learning).

Conclusion

The model proposed in this paper identifies the problems of web learning and intends to explore practical solutions. Whether our solutions are as effective as we designed then to be will become clear when we evaluate the first real web courses, which we will have developed while using the model.

To sum up, from our presentation we can deduce that by expanding UML towards the design of educational modeling we fill in an existing gap in the modeling of such specialized software. Of course, we could have used only IMS specifications, but then we could have solved the problem partly. So, we have been making an effort to combine UML-which is the best know modeling language in Software Engineering- with IMS specifications-which are widely accepted by specialists in Education and Instructional Design. In this way, the proposed solution comes to complete and support the advantages that the use of IMS standards, aiming to provide a complete solution in the design and the development of educational software. Thus, on the hand, we have the standards of the description of how to manage and transfer the educational material and, on the other hand, we know how to formulate their use in the technical part.

More specifically, as shown in Section 4, we have presented a new set of components which can facilitate the design of educational software. The newly added stereotypes offer a specialized view of the prospective software from an educational stand, while rendering the modules that software engineers must develop understandable.
The main aim of our research is to provide educators, specialists in every field and computer scientists with a systems that gives them a common ground of understanding so that all these specialists can communicate their ideas in spoke and written form and understand each other.

Thus, we can claim that there are two primary advantages of the system we are proposing in this paper. First, it gives the opportunity to the developer to combine the components of the system after having comprehended the why and the how of the process designed by educators and software engineers. Second, the same diagram enables educators and software engineers to communicate their concepts and wishes to the developer. Overall, the diagram facilitates the collaboration and understanding of developers, educators and software engineers.

Concluding, we are still working on modeling patterns of the whole process of educational software production and the expansion of stereotypes, which are based on these patterns.

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