Construction of Educative Micro-Worlds to Build Students' Creativity in Terms of Their Own Self-Learning

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Abstract. In this paper, based on Seymour Papert's learning theory, logo creator, we create a theory based on the knowledge of learning objects, which allows teachers and students a dynamic development of content and allows continuous assessment of the student. In this way, we use the cloud system and educational systems, which enables the development of learning objects as independent and modifiable elements from any location and makes it easy to integrate with other systems.

Keywords: Educative systems · Cloud computing · Web services · Systems architecture · Student curriculum · Educative curricula

1 Introduction

In his book "…Mind Challenge: Children, computers, and powerful ideas…" Seymour Papert analyzes the concept of the relationship between children and computers. In his theory, he conceives of the computer as the seed of cognitive products that transcends the presence of concrete materials [1]: "Working with computers can have a powerful influence on how people think. I directed my attention to explore how to guide this influence in positive directions". Papert bases his methodology on constructionism, where children take an active role and are constructors of their own learning, where knowledge will be the fruit of their own work and the result of all the experiences of the individual since their birth. This starting point is a good approach in the present day, primarily due to:

- Increased use of ICT in the classroom.
- Increased media use with regard to learning content developed by teachers as part of the curriculum.
- Lower economic costs.

This is possible due to the technological increase in schools and in the lives of citizens, as the school is a reflection of the social and technological situations of countries. Methodological trends are always a basis for our work, to give a theoretical basis for the creation of these methodological platforms that go beyond the content, and adapt them

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to the higher educational levels that we are dealing with, to be used through the platforms and software applications we are developing. For the development of methodologies using ICTs in the classroom, we must consider the curricular structure and lesson planning of the teacher in the classroom. In addition, we must bear in mind the level of achievement of objectives in terms of evaluation leading to the student's grade. From the technical point of view, we will use cloud systems as the place of location and interaction with regard to these applications. This will allow different platforms and management resources to be integrated easily with existing applications, and with the current available educational management platforms in schools.

The aim of this paper is to develop a new theory of knowledge based on Papert's methodology. This will also be supported by an application that allows the performance of these characteristics in the classroom. Another objective is to develop a system that considers the educational curricula and teachers' lesson planning with regard to the subjects, which allows the creation and construction of knowledge by students. This in turn ensures that the teacher can engage in monitoring and evaluation.

2 State of the Art

Accommodation or adjustment is a psychological concept introduced by Jean Piaget which, along with assimilation, is one of two basic processes introduced by this author as part of the process of cognitive development. Piaget's theory was that knowledge is focused on [2]:

- The construction of knowledge, not its repetition.
- Knowledge is constructed based on people's own experiences, mindsets and beliefs that are then used to interpret objects and events.
- The mind is instrumental and essential when it comes to interpreting events, objects and perspectives on a personal and individual basis.
- Our view of the outside world is different from person to person because every human being has a different set of experiences.

In his theory, Papert gives students an active role in their learning, placing them as designers of their own projects and builders of their own learning. It is within the process of learning that there are the different parts of knowledge. These affect both the process of assimilation of content and the process of reflection of that content. In turn, knowledge construction comprises two types of knowledge: (1) the construction of a public type of knowledge which can be displayed, discussed, examined and tested; (2) a natural ability that occurs when people learn through experience and create mental structures that organize and synthesize information and experiences that take in their everyday lives [3].

There are two aspects of knowledge that can be distinguished: on the one hand, mathematical knowledge that allows the resolution of a problem. On the other hand, the mathematic knowledge that is needed to solve a particular problem. This is done by the student looking for some similar mathematical construct, which he already understands, and then applying what he finds to the new problem in order to resolve it. Once some knowledge has been learned, the student can use this prior knowledge to resolve a current

conflict and in this way he can construct new. Papert mentions that the difference between what is "may" and what "cannot" learn. It depends on the subject's relationship with the three concepts that we consider to be instrumental in providing students with the best opportunities for construction: objects with which to think, public entities and micro-worlds [4, 5].

The hypothesis is "objects to think", once an interaction between students and computers is complete, these objects of thought are objects that can be used by the student to think about other things. Using its own construction of the object under appropriate conditions, can allow the student to develop intellectual skills such as the acquisition of search capabilities and the problem solving skills of reasoning and formal representation, model development knowledge, thinking and learning skills, and improving cognitive, social and emotional aspects [6].

On the other hand we find public entities that allow the visual or audible representation of ideas and concepts to allow the student to experiment with them. The object once created and shared with others, a publically shared entity through which constructionist learning is powerfully reinforced [7].

Then we have micro-worlds that construct by themselves a public entity, and use it as a tool to build objects for the student to think about [8]:

"…A learning environment in which students manipulate and control various parameters to explore their relationships. The more complex micro-worlds are expandable, enabling students to use their creativity to customize and extend the micro-world environment."

The construction of micro-worlds must involve the following objectives:

- To encourage meaningful learning of content.
- To exercise skills related to the topic.
- To exercise the use of principles on which logical thinking is based.
- To develop creativity through building applications.
- To implement social methodologies.

3 Application and Adaptation of Teaching Methods

We have to establish the starting point for the implementation of a teaching methodology depending on the educational curriculum and the way in which the teacher plans to teach Currently curricula follow assumptions that are dictated by education legislation and by the different levels of specification of the curriculum. In terms of curricular programming, the teacher plans the process of teaching whereby learning is the central element of the teaching-learning process. It involves a way of planning the daily work of the classroom where the various elements of the process (level of student development, social origin, family, curriculum, resources) are contextualized. One of its most important functions is to organize the practice of the learning content, select the basic objectives, adhere to the methodological guidelines they work to, and finally to determine the teaching methods needed to improve the learning process. In this research, a system that allows the organization of a set of teaching and learning activities, presents all the

elements of curriculum planning: setting goals and content, designing the lesson, the development and evaluation of the activities, the organization of space and time, and the provision of the necessary resources [9].

We must also mention that technology supports learning, and must remember that there are conceptual designs which aim to support the administration of the educational process, this can be done by applying Distributed User Interfaces (DUIs) to cloud services. CSchool [10] encourages students, teachers and parents to use new technologies in the classroom. This implementation is available across the entire proposed education sector, taking advantage of user-friendly interfaces, distributed in such a way as to facilitate learning-oriented interaction and collaboration between users [10].

In the preceding paragraphs, we have summarized previous publications regarding teaching methods and school organization. These assumptions must be taken into account when applying a particular teaching methodology in the classroom, or performing applications for differing educational environments. It is with regard to those aspects that power is given to the system, and in terms of which curricula are the basis of the daily work of the teacher. The accessibility and management of the system comes from the inclusion of these platforms in educational ERPs (Enterprise Resource Planning) and the use of these applications in the classroom is given by the DUI.

Figure 1 captures the different parts of the methodology that we are applying. These objects need feedback from different parts of the system and from outside the classroom. In addition we may modified the methodology so that an interaction occurs with the objects of knowledge. The schema of the methodology shows that its different parts, at the conceptual level, are perfectly transposable elements in the development process. Taking these elements as objectives, and seeing that they must perform specific maintenance operations for each object according to specific patterns, these objects are as described below:

- **Objects to Think:** The teacher creates an object in order to begin the task given to the students. This object is defined according to a content as defined by the teacher. These contents are introduced to the student who begins the process of building his thoughts as part of an interactive system. It should also allow pattern searching, editing, and completing the objects in terms of more specific patterns. This allows the students to complete the statement of the problem, to solve it, and to help the student build his knowledge from the questions asked.
- **Public Entities:** The teaching process is completed in this section in the discussion of the results obtained. This allows a feedback process with regard to their research, which enable them to create collaborative patterns from the proposed improvement exercise.
- **Micro-worlds:** All these learning objectives can be collected in a set of objects that define a more complex problem. Then, a system for indexing objects is created to achieve more complex objects, where students can solve complete problems by linking objects. Also the teacher can increase the level by dividing complex problems in the micro world by performing activities involving collaborative work, by creating indexed objects from the beginning.
- **Interaction Space:** The system must allow for interaction between the individuals that make up the micro-worlds, in order to allow for collaborative work. It is at this

point that the DUI are used between objects in order to perform collaborative educational patterns.

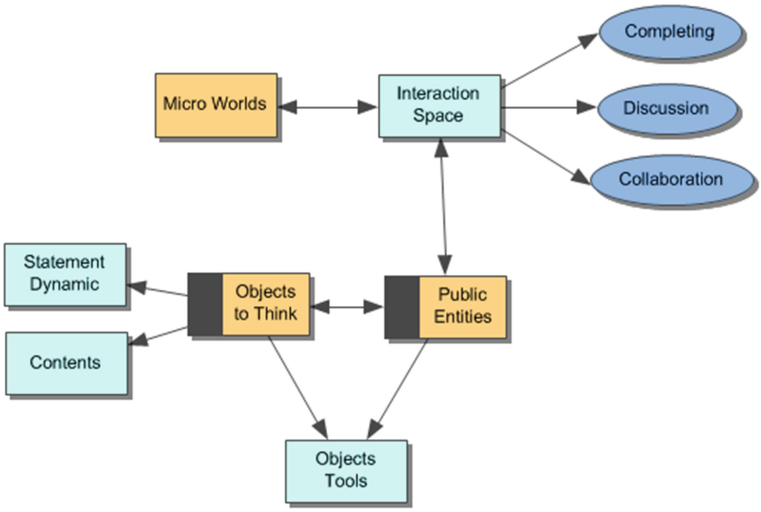

Fig. 1. Schema of the proposed methodology

The development of the methodology in the classroom should also allow the development of subject content. This is a development that enables teachers to track the achievement of the objectives of the students through the content developed by them after being mentored by the teacher. This is part of the development of the daily activities of the students. These activities can be developed over time in several working sessions. This should be taken into account in the development of this platform in order to perform the required monitoring in order to allow the evaluation and quantification of the learning associated with the subject.

In the teaching methodologies that make use of information technologies, by providing activities by which students can perform exercises with a computer or mobile device, we think that the starting point for the development of an activity must involve teacher planning as a result of which the student must complete the proposed activities. Figure 2 emphasizes the tasks that the teacher must undertake in generating objects involving thinking. These must take into account the starting point in the generation of these objects:

The different parts in this methodology are highlighted in color, in order to ensure a design that does not forget the location or the destination application, by applying concepts such as design for educational applications [11]:

- The color purple indicates the parts needed for evaluation, and represents the evaluation process. For this we need to apply the definition of educational evaluation provided by the Joint Committee on Standards for Educational Evaluation (http://www.jcsee.org/) which notes that "Evaluation is the systematic prosecution of the validity or merit of an object", so that in a study, it is important that both good

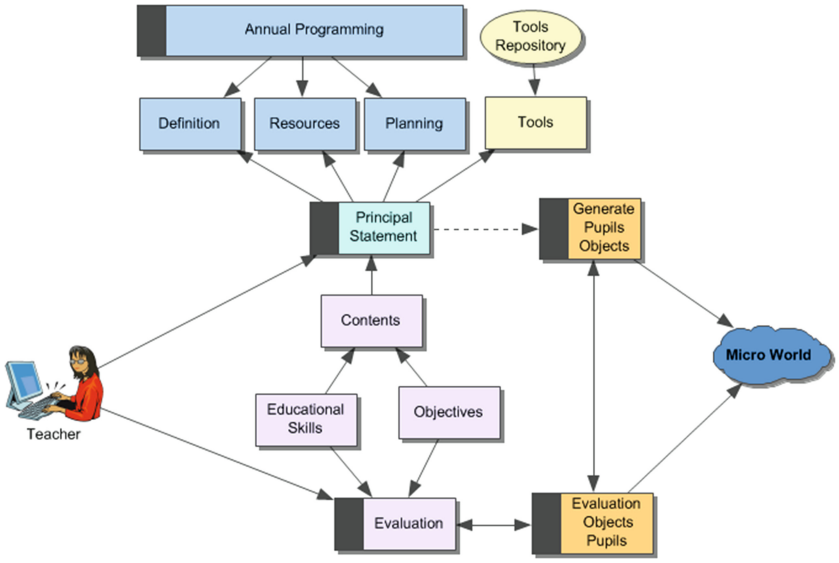

Fig. 2. Tasks of the Teacher

and bad results of an assessed situation are identified. Otherwise, it is not an assessment. From this we can see that evaluation is a complex process but also an essential one. It provides positive reinforcement which "…serves to progress and is used to identify strengths and weaknesses, and to move towards an improvement" [12]. Hence within the statements, we need, in addition to grouping them into contents, the objectives and basic educational skills that are achieved with that object. It is essential that the teacher prepare them for the students.

- The blue color highlights where to encompassed the statements that are predetermined by the annual program, which the teacher has designed for a particular subject with regard to a particular group. Here we have the planning, the precise definition of the objectives, the content and the resources needed for that academic year and for that particular group of students.
- In terms of the color yellow, the teacher has access to tools that enable the creation of the statement. Since the work is done with the computer, these tools can range from the use of text editors to educational standards, to be included in the objects that the students have to think about. This tool completes the object and allows students to perform predefined actions with this object.
- The color orange indicates generated objects as objects related to thinking. The teacher could develop a system that serves all students and allows progress for such students working at different levels. It can also be developed for collaborative work activity, in which students support each other.

When the work object is generated, we must generate an object that allows the monitoring of the work of the student. In this way we keep tabs on the steps performed during the execution of the lesson and its results. These are stored as an object that can be

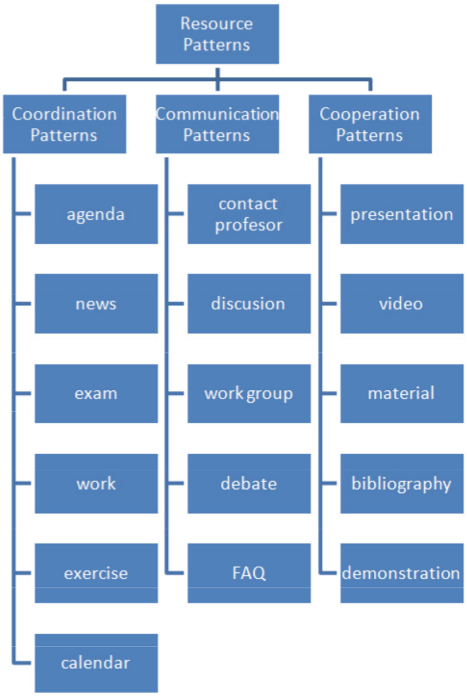

Fig. 3. Design patterns

evaluated by the teacher. The teacher may follow the progress of students throughout the teaching-learning process. In this way, the teacher can make an ongoing assessment and determine the qualifications available at the end of the course.

4 Design Patterns

Patterns are needed to develop an application of this nature and to move to a context-face work on classroom education. They can emerge from patterns of objects in e-learning [13]. See Fig. 3.

Next we describe the design patterns by adding the necessary changes in the concept in terms of its interaction. This can be done to indicate where each pattern works according to the objects of our methodology:

- Coordination Patterns:
  - Agenda: This pattern works in the micro-world as it takes the form of a school diary which the student keeps. At this point the activities undertaken in this pattern may include other coordination patterns in order to group them into objects to which the system itself can add new events.
  - Calendar: This pattern is a summary of the agenda and also indicates the level of achievement of the activities and themes undertaken. There are two types of

calendar. On one side we find the timetable of the student and the teacher. The difference between these is clear in that the student's one is not editable, and that of the teacher is linked with the educational programming in the classroom, in order to access the contents through the calendar.
  - News: This pattern serves students with information internally to objects, i.e. it notifies internal reviews conducted by the teacher and any modifications. It can also be used for coordination between groups of different students when objects are treated collaboratively.
  - Exam: It's a pattern that determines what is the subject of an examination. Student learning can be evaluated with this pattern.
  - Exercise: This can determine whether or not the student has solved the object of an exercise.
  - Work: This pattern is a homework assignment that the student must perform.
- Communication Patterns:
  - Contact teacher: It is important to facilitate communication between the teacher and the students. We must remember that we are in a classroom situation and such communication should be very fluid. ICTs in this area can facilitate communication by passing information objects that students are working on.
  - Discussion: In collaborative work is necessary for the students and the teacher to discuss the aspects that they are working on to get feedback on the teaching-learning process.
  - Work group: This pattern defines groups of objects for collaborative work and teamwork. In this way, in addition to defining teamwork, objects between them are defined.
  - Debate: You can create objects for discussion to allow discussion in the classroom with regard to these objects. Consequently, students can exchange information when the debate occurs.
  - FAQs: In our case, the FAQs is a repository of student questions. The system picks up on the contents and the teacher reviews and modifies it so that the students can have validated information on the system itself.
- Cooperation Patterns:
  - Presentation: The application allows the teacher to upload presentation material. It allows students to view content that the teacher has prepared.
  - Video: This pattern groups the multimedia content that the teacher uploads so that the students can develop the content.
  - Bibliography: This section adds the teacher's bibliographic content that may be further books, where information about the contents that they are working on can be found.
  - Demonstration: This section allows the teacher to add similar exercises in order to clarify the exercise under consideration and to allow students to see practical examples of exercises; this pattern may terminate as an object of thought developed by the teacher for part of the object.

Next we present the patterns of the editing objects of the platform where students develop the content of the exercise:

- Add: This pattern allows adding elements that allow the students to complete the activity. It is possible to add editable objects like text boxes, pictures and files.
- Delete: This pattern allows the deletion of items which the student has added.
- Check: This pattern provides access to online questions or information, which can then be added. This pattern allows the teacher to know what has been consulted so that he can add information.
- Edit: Allows the user to modify the objects added in order to correct or practice the exercise being performed.
- Question: This pattern poses a question to be solved later by the teacher or by the student group. It can also take the form of personal notes allowing the student to continue his work. This is important in collaborative work and in the methodology we are developing, since it allows feedback with regard to the problem and the mathematical solution can act as an extension of student knowledge.
- Communicate: Sometimes students need to communicate their progress to the group of students to allow feedback in terms of student knowledge, and to allow them to enter into discussion or debate. It can be used to extend the student's mathematical knowledge and improve the teaching-learning process.
- Share: Students can share the object being viewed on the screen in order to ask for help or to share their information with any of their companions.

Evaluation patterns include student assessment and the preparation processes of the activities that will subsequently be evaluated. We have determined the following patterns:

- Time distribution: This pattern makes it easier for teachers to keep to time in terms of the distribution of school activities to the students. This entails planning on the part of the teacher or an indication of the time available to the student for each activity within the overall planning for practice studies. This time distribution must include control of any lost time (idle time) and breaks allowed for the students to avoid saturation.
- Monitoring: monitoring of objects and modifications that students perform on objects are considered as part of this process. These patterns also store the goals that have been achieved.
- Correction: This pattern provides correction and scores for each of the objects.
- Rating: The rating process involves not only the final score in terms of the exercise performed by the student. It also marks the level of achievement in terms of each of the objectives and of the educational skills attained in this activity.

5 System Architecture

The system architecture is composed of a set of models, each in a different cloud, and which use Web Services to communicate between them.

Figure 4 offers a conceptual description of the system. We have discarded the operation of objects to think and public entities. Instead, we deal with this in the next section.

The process begins with the creation of objects of thought by the teacher. As we see, it has access to the patterns that will be selected, depending on the specification prepared for each of the activities. The creation of this "needs to think" object by the teacher is related to the students' curricular programs, and therefore removes the different parts of educational management (contents, objectives, powers), to extend the application to the teacher educational programming [9].

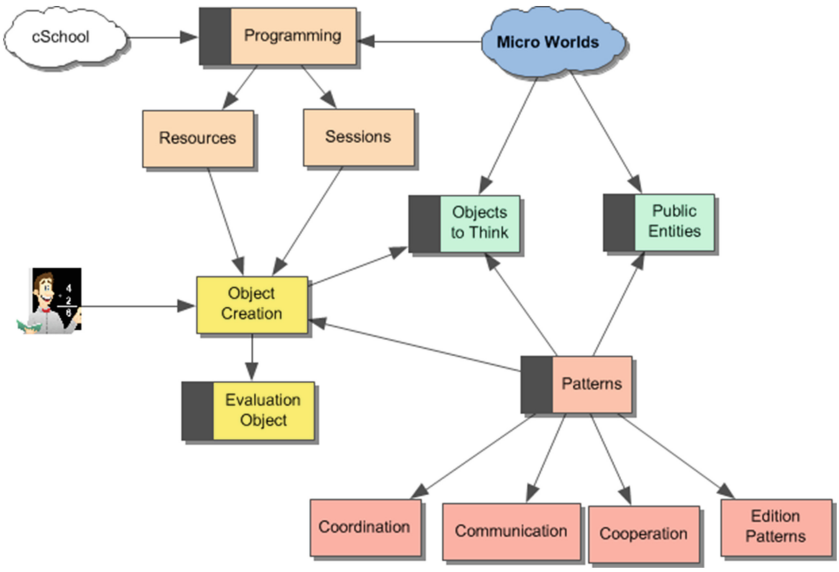

Fig. 4. Conceptual design of the system

In the process of creating the object for students, it in turn creates a system that monitors the student objects in order to perform the evaluation of such objects. Also, with regard to objects and from public entities, students have access to patterns that will work with the various objects.

Figure 5 defines a workspace [14] by DUI. This guarantees the collaboration in real time among team members or in a class [10]. Once the object changes its state, it mutates to a different status as a public entity, where students can decide to publish that part of the object outward, using Web Services posted outward from the class itself. The evaluation of the object is monitored by a system of intelligent agents with regard to the object of each student. This will continuously record student progress and allow the teacher's assessment of that particular object. It will save the result of object programming on the part of the teacher for each student.

This system facilitates the storage of information, since the objects are defined using XML language or other markup language. This will allow storage in a virtual notebook for each student. By linking these objects to each student, we can obtain an ordered list of jobs, ordered by student, with relevant information about their assessment. This can be used in the future as part of curriculum evaluation and the monitoring of the students. Such programs have been designed in previous research [15].

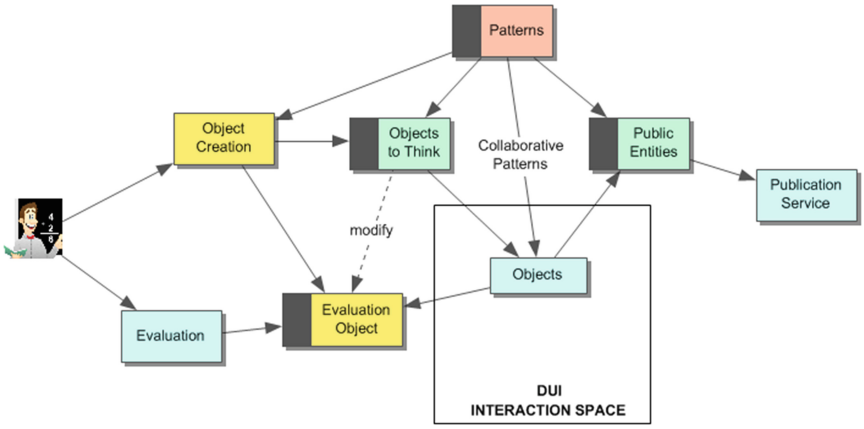

Fig. 5. List of objects to think

6 Conclusions and Future Work

This paper is the continuation of previous research in which we have presented our ideas about curricular organization and collaborative approaches in the classroom. These areas for further research have adapted teaching methods in the classroom. In this way, we have linked the curriculum methodologies. This paper differs from the others in the initial planning of a methodology that follows the ICT premises and terminology, in order to secure an ICT methodology in the field of education.

The rating system allows the control all objects made by the students by creating linked lists of objects in the database system. We believe that, over time, we can create systems that allows the monitoring of students virtually in the classroom. The system could enable new functionalities if we incorporate the process of evaluation and assessment of students in classroom using ICTs from a curricular standpoint.

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