Proceedings of the 2014 Federated Conference on Computer Science and Information Systems pp. 809–814
DOI: 10.15439/2014F397
ACSIS, Vol. 2

New Teaching Techniques of Mathematics Subjects by means of Artificial Genesis

Habib M. Fardoun,
Daniyal M. Alghazzawi
Information Systems Department
King Abdulaziz University (KAU)
Jeddah, Saudi Arabia
Email: {hfardoun, dghazzawi}@kau.edu.sa

Antonio Paules Ciprés
European University of Madrid,
Madrid, Spain
Email: apcipres@gmail.com

***Abstract*—This paper presents an adaptation of the Brousseau method. The concepts of didactic variations and interactions are introduced by using didactic and a-didactic situations. With the main aim of guaranteeing alumni improvement and evaluation processes, a case study application was development founded on a cloud architecture, which is also based in previous research, curricular organization and interaction processes within the class.**

I. Introduction

GUY Brousseau introduced theory of situations, didactic contracts and didactic and a-didactic situations in 1998. This is a teaching theory seeking the conditions for artificial genesis of mathematical knowledge. Brousseau says that "knowing mathematics" is not only about knowing definitions and theorems to recognize the opportunity to use and apply them, but also about "dealing with problems" in a broad sense, which means finding good questions and solutions.

Computer science professors and researchers play an important role at first stages of the computer science teaching process and should be able to start asking questions about the process of teaching and learning that is used with their students in their daily work.

Curriculum development in university subjects lacks structure focused on the student evaluation process. Evaluation and assessment is an inexistent process, since in most cases it consists of an evaluation of the practical part of the subject, accompanied by a short presentation by the student, and a final exam to asses theoretical contents.

This teaching and learning process does not apply any clear pedagogical basis, with the exception of objectives achievement and is often subject to the teacher's decision. For example, in a Master thesis, the final evaluation is done in a presentation where the student talks about her work during a fixed time.

Sometimes, didactic methods are not used due to either ignorance or lack of transversality among subjects. However, there exists a wide use of teamwork [1] or project work [2], mainly because these methodologies adapt perfectly to work that students will perform in their professional future.

Didactic adaptation of subjects at the university level is likely to grow over time. One of the goals of educational outreach is the university of education, which will lead to an increment of the population percentage with higher education. Universities will need to include teaching methods that allow curricular adaptations, significant [3] and not significant [4].

Furthermore, the enhancement of students creative thinking from the Brousseau perspective can lead to the creation of new products and creative solutions to solve complex problems. In this way, students of Computer Science can improve their abilities to solve problems with training and adaptation methods. On the other hand, university teachers could use these methods autonomously and adapt their needs over time.

II. State of the art

During our research work, we have carried out the adaptation of the Montessori method [5] and the leverage of social networks in educative environments [6]. This paper presents an adaptation of the Brousseau method.

Brousseau developed the "Situation Theory", in which he searches conditions for an artificial genesis of mathematic knowledge. Under the assumption that they are not built spontaneously, it is based on the constructive conception of thought.

Pedagogic constructivism is to equip students with the necessary tools, allowing them to create their own procedures to solve problems.

There are four essential features of a constructivist action [7]:

1) It is based on the conceptual structure of each student: part of the ideas and preconceptions that students bring to the classic topic.
2) Anticipates conceptual change is expected from the active construction of the new concept and its impact on mental structure.
3) Confront the ideas and preconceptions related topic of education, with the new scientific concept being taught.
4) Applies the new concept to concrete situations and relates to other concepts of cognitive structure in order to expand its transfer.

Necessary conditions to boost constructivist teaching are the following:

978-83-60810-58-3/$25.00

1) Generate dissatisfaction with prejudices and preconceptions, allowing students to identify their mistakes.
2) The new concept begins to be clear and distinct to the previous.
3) The new concept shows its applicability to real situations.
4) The new concept generates new questions and expectations.
5) The students observe and understand the causes of their prejudices and misconceptions.
6) Create a climate for free expression of student, without coercion or fear of making mistakes.
7) Foster the conditions for the student as a participant in the teaching-learning process: planning, selection of activities, sources of information queries, etc.

In the Brousseau theory of constructivism, students learn to adapt to an environment that is a factor of contradictions, difficulties and new knowledge is acquired through responses that are evidence of learning. This is achieved with didactic and a-didactic situations.

A didactic situation is a set of relations explicitly and / or implicitly established between a student or group of students in an environment, including, eventually, instruments and objects, and an educational system (teacher). Student work should, at least in part, reproduce the characteristics of scientific work itself, to guarantee an effective construction of relevant knowledge. Each didactic situation is governed by a certain type of training contract, i.e. a set of implicit and explicit obligations, namely an action between teacher and students.

An a-didactic situation is essentially characterized by the fact of representing certain learning moments in which the student works independently, not subject to any direct control of the teacher. In this situation, the student becomes able to reuse the knowledge that he is acquiring, in a situation not covered in any teaching context and in the absence of any teacher.

Summing up, a didactic situation is one that inherently contains the intention of someone to learn something. This intention does not disappear in a-didactic situation, where the lack of intention means that the student must address the problem by replying to it based on his knowledge, motivated by the problem, not by the desire to please the teacher [10].

Brousseau establishes a didactic contract. The didactic contract was defined by Rousseau [11] and there are several functions performed:

1) Promotes student autonomy and responsibility.
2) Attends to the particularities of the student.
3) Facilitates the interest and motivation of students in their own learning process.
4) Academically guides student work.
5) Democratizes the education to take into account instances of negotiation in setting learning objectives, course content and assessment process.
6) Stimulates the ability of self-reflection on the student's own learning enhancing critical thinking.

Brousseau also adds that the training contract refers to the actions established between teacher and student, thus comprising the set of behaviors that the teacher expects from the student and the set of that the student expects from the teacher.

The didactic contract, along with educational and a-didactic situations, can be modified by the didactic situations are theoretical objects whose purpose is to study the set of conditions and own a well-defined relations knowledge. The contract can use values that enable students to understand and resolve the situation with their prior knowledge, and then make them face the acquisition of new knowledge by setting a new value of a variable.

The contract has a structure similar to a teaching unit that we developed in prior research. In this previous research we also included a study on how to evaluate and assess students in conventional curricular situations [12] and in social networks [13]. Also, we studied the necessity of curricular organization in rural environments [14]. The outcome from this research showed that evaluation and assessment should be done by taking into account the whole teaching and learning process. Student evolution should be registered and logged during the process.

III. Definition and objectives

This article shows an adaptation of the Brousseau method, developed in order to improve the learning of Computer Science and change the approach of subject from a raw contents perspective. The starting point is to be able to address problems from the computer science point of view. These capabilities involve the use of techniques and technologies designed for problem resolution. Furthermore, this approach can improve students' creativity in the development of new products and particular solutions to problems.

IV. Didactic methodology

Teaching methods drawn from this technique are a part of a master class [15], where the teacher presents concepts and takes the approach to solving problems in addition to the qualification criteria (training contract). At this point, students should start having doubts regarding these content. These doubts or questions are contract breakers. To avoid, the contract breaking, the teacher interferes with the development of problem proposing new situations for the student to solve. At this point project work, collaborative work, or individual work can be used.

The introduction of educational variables in this methodology complements a problem during the teaching-learning process, creating milestones in the teaching methodology and turning points that allow students to obtain new solutions from these variables.

These variables can be adapted by the teacher for students with learning and teaching needs with significant or not significant curricular adaptations, thus adapting the activity of students to the specific needs of these or group level students each time.

These educational variables are milestones, which must be solved by the students. These new standards raise new

questions for students to be overcome and entail the creation of new solutions to the problem proposed completing its complexity or making new methods to its solution.

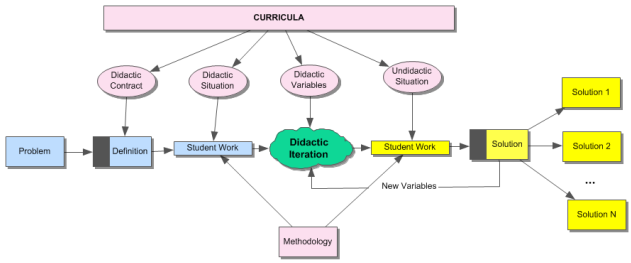

Fig. 1 Didactic Methodology

The above diagram depicts the operation of this methodology. The methodology starts with a problems and ends with a solution. This solution is not unique because during that modify variables included.

• Blue boxes represent the beginning of the process. The teacher defines the problem and the students begin working on its definition. During this process, students adapt the problem to their academic interests, mainly based on the knowledge acquired in previous experience of other activities.

• Didactic Iteration is in green. The teacher introduces variables that cause the a-didactic situation in students and create confusion enabling them to continue the development of the solution. This a-didactic situation can cause various solutions the problem.

• Yellow boxes highlight the iterating process where the teacher introduces new and triggers a process where different teaching methodologies are applied.

• Purple boxes represent the curricular part of the technique described above. This requires access to information in the official curriculums, which are created on the teacher's teaching schedule.

Summing up, the teacher develops a problem statement, which is completed by the students in the teaching-learning process. Then, by creating the conflict, students learn and develop complex problems, from their own knowledge, while teacher supervises the development of the activity and the achievement of objectives.

V. Models and States

The design of models for a solution to this teaching methodology is defined by the following:

• Problem: The problem statement must be constructed from the knowledge gathered from the student group considering transversality and curriculum contents. The process must take into account the objectives and core competencies the activity will be based on.

• Definition: In this model, the teacher helps students continue with the development and realization of the problem statement, using knowledge acquired in other subjects (transversality of education).

• Student Work: The "individual student" work, influenced by the different teaching methods that teachers adopt. These methodologies entail personal, individual work and collaboration, and should be applied after periods of discussion that generate ideas, thus achieving greater articulation of such proposals or solutions as appropriate.

• Didactic Variable: Within the process of learning the teacher can add new challenges to the student. These challenges are raised by questions, which are asked in order to break the didactical contract and sow doubt in the chosen solution, allowing the student progress in this process.

• Teaching Iteration: Starting from the doubt created by the a-didactic, the teacher introduces didactic variables so that students can continue their work. These didactic iterations can last until the teacher considers the objectives are met.

These models must be accompanied by states, which are changes produced by the introduction of a model. In this way, the teaching-learning process is configured and can modify the behavior of the model itself. It is a way to introduce a change in the model by autonomic self-employment in a situation that produces a change in both solution and in the definition.

• Didactic Situation: Not a model itself, but a state in the process where the teacher creates the curricula through the objectives of the practice or problem statement. In this state, the student collects information about what to do and how to do it. The end of the situation is the acquisition of a training contract containing the work to be performed, which may be modified posterity.

• A-didactic situation: This situation is a state of reflection on the proposed problem in which students develop their cognitive elements of an evolution problem. More restrictions to the problem are raised, thanks to the introduction of didactic variables added before.

For the development of this methodology, we consider the situation of the student group and the level of achievement of the objectives. Therefore there is a direct relationship with the official curriculum [12] and in teaching methodology used the classroom [15] [16] hence the need for data collection of the teaching-learning process.

VI. Method Application

The structure we have for the development of the subject of IT projects is a matter that also needs the support of other subjects in the field of software engineering, database management systems and data programming.

From the learning outcomes and assessment criteria the teacher proposes the problem:

Problem: short form corresponds to the problem statement. "...Create a management application that allows professionals to manage their company store..."

Definition: Students begin to define the problem and begin to questions arise that will lead to the creation of the didactic contract. This methodology can be accomplished by collaborative work and well predefined roles.

Didactic contract made by the students and the teacher, which is the result of acquired learning and assessment crite-

ria (goals to achieve). The contract provides students with the ability to get that learning outcome, according to the curriculum of the course:

1. **Identify needs of the productive sector, relating them to projects that can satisfy these needs.** The following results are obtained:

a) Related companies were classified according to their organizational characteristics and the type of product or service they offer.

b) Firms were characterized indicating the organizational structure and functions of each department.

c) Most demanding business needs were identified.

d) Predictable business opportunities in the sector were assessed.

e) Type of project was identified in order to meet the anticipated demands.

f) Specific characteristics of the project were specified as required.

g) Tax, labor and risk prevention and implementation conditions of obligations were determined.

h) Potential aid or subsidies for the incorporation of new production technologies were identified.

i) A roadmap was developed for the project.

2. **Design projects related to the competences described in the statement, explicitly developing the phases that compose it.** The following results are obtained:

a) Information was compiled on the aspects that will be addressed in the project.

b) Technical feasibility study of the project was done.

c) Project stages were defined, specifying its content and deadlines.

d) Targets by scope were set.

e) Development supporting activities were determined.

f) Necessary resources and personnel to complete the project were predicted.

g) Funding needs were identified.

h) Project documentation was defined and created.

i) Aspects that must be controlled to ensure project quality were identified.

3. **Schedule the execution of the project, determining the intervention plan and associated documentation**, The following results are obtained:

a) Tasks were scheduled according to implementation needs.

b) Logistics and resources required for each task were determined.

c) Roles and permissions to carry out each tasks were identified.

d) Procedures have been identified for implementation of tasks.

e) Risks were defined, defining the risk prevention plan and means.

f) Allocation of material and human resources were planned.

g) Economic assessment that responds to the conditions of the project implementation was carried out.

h) Documentation necessary for project implementation was defined and developed.

Once the teacher has presented learning results, objectives and assessment criteria, students define the problem they want to solve, through collaborative work or moderated discussion. The definition of the problem is done following these points

• Conduct a marketing job.
• Conduct a study of economic feasibility.
• Create a project plan.
• Create an implementation plan for the company.
• Specify a requirements document.
• Study legal legislation in the creation of a software project
• Balance project risks
• Perform an economic assessment of the project.
• Characterize the productive sector. Students decided that it would be garage to and a car parts store.
• Establish the garage modules: warehouse management, repair management, billing and online sales.
• Establish phases of application design and make the application requirements in order to ensure the success of it.
• Create a testing phase.
• Tighten the planning of project duration and resources required for its development.
• Perform a marketing study of the developed product.
• Teamwork: Create teams in the initial phase to enable the design, analysis and implementation of the project, also defining the role of each team:

- Design team: system design, databases design, UML and database management systems.

- Analysis Team: conduct the analysis of the final creation of a requirements document, also will perform market research and project feasibility.

- Implementation Team: initially undertake technological evidence necessary for the implementation of the subject and phase necessary to select databases and programming languages needed to implement tests.

Once the didactic contract with students is done, we can see the challenge that students have been established, as there is a considerable lack of order and some aspects remain undefined. At this point, the teacher plays an important role as a project leader, providing the students a pseudo-real situation as close as possible to a corporate project, without forgetting the academic taking into account that the a-didactic situation should let students progress on their own.

A. Introduction to syntactic variables and interaction production

Students showed their findings in a presentation to the group. During the questions and answers time, the teacher asked questions to the group of students from each team. These questions should make students question their own activities and complete their work.

For example, the following are questions made to the different teams. This was asked to the analysis team was: “Is all your work aimed to find the customer's needs, divided into different types of requirements, as you specified in the anal-

ysis phase?" The following comment was made to the design team: "You have decided which technology to use, I see you chose a language taught in other subjects (Java), but I do not see how the analysis team could use that work, you must design thinking to support the analysis team. Should the customer to see something during the requirements phase?" The implementation team was asked the following: "You carried out stress testing, you designed a database cluster and client-server communication, but what if I have to offer an external service such as sending data to a central provider or upgrade fees from the central shopping?"

At the end of the class, a student from the analysis team points out the following: "How should we organize the staff? This is a mess; it took us a week and we have nothing, we can not offer a joint solution for business… in software engineering classes the teacher told us about CASE tools, should we use them?"

A member of the design team questioned this decision and indicated they already had the Rational Rose tool at their disposal, which could be integrated with Requisite Pro tool, a specific tool for requirements definition, also saying that they could create database table in the design stage.

A member of the implementation team showed the possibility of defining a logical structured to develop a modular application. Another member said that they could create the accounting module with an ERP and save time.

The teacher finally decided to step in this chaos, with the sole purpose of moderating, and also indicating that he wanted to see them at his office the next morning. Next morning, only one member of each team showed up. Groups had just defined the team leader role without the teacher intervention.

During this mentoring sessions, issues discussed the day before are solved. Students established a modular structure and decided to continue using Rational Rose and Requisite Pro, as their combination is a way of linking design and analysis phases, finishing up with the definition of use cases. Regarding requirements definition, students decide to start developing IGU prototypes in order to achieve a better definition of requirements and ease the creation of a database. The also decided to do a reverse engineering process on industry applications, to includes industry data in the analysis, which is a good way to make an analysis and design when software teams do not have own data.

In this interaction, with the introduction of variables, the progress was considerable in terms of project organization. Students made decisions based on prior knowledge and sought appropriate solutions to problems, creating a project development methodology.

VII. Architecture

We need to create architecture for incorporating the method of Brousseau. This architecture is focused on the cloud to ensure the possibility of growth and integration of services built on previous research. It is essential to consider the organization the teacher does in the academic environment, the documentation of teaching the set of objectives that the student has reached. Also, the teacher has to conduct the evaluation and monitoring of the goals of the students. This requires the creation of a workspace.

Figure 2 depicts the cloud architecture that enables this work, as we will now need a part that facilitates interaction and creation of workspaces based on the teaching methods and other assessment and preparation activities for the teacher.

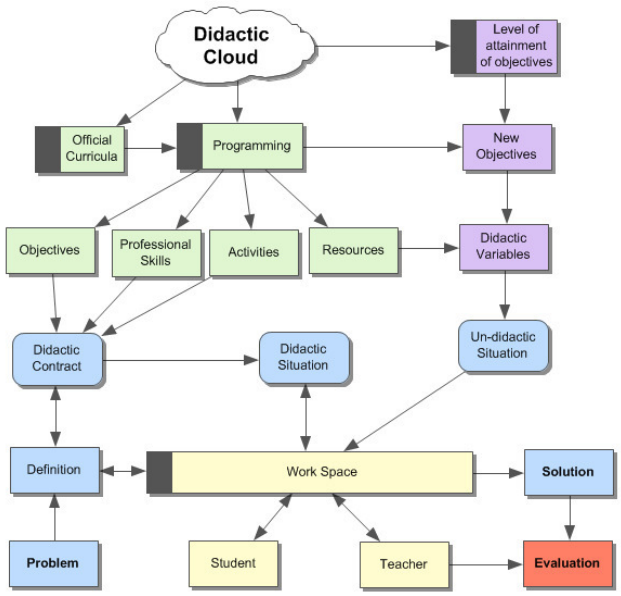

Fig. 2 Architecture in the cloud

We set a conceptual level architecture in the cloud, as we can see there are several parts.

Green modules represent the organization that the teacher created for the subject. Data is gathered from the subject curricula, divided into objectives, skills, activities and resources. The curricular organization that the teacher has developed for a subject must be adapted to the Brousseau methodology, thus conducting a curricular inclusion in the method we are developing.

Parts of the method are depicted in blue. They are some of the patterns and conditions described in the previous section. Data is collected both from the didactic plan and transversality necessary for the advancement of the data. The method begins by defining the problem and creating a learning contract that allows the teacher to start the process. Once the student work and under a teaching situation, the a-didactic situation comes into play, which should finish with the solution of the problem.

In purple, we highlight didactic variables selection that create the a-didactic situation and break the didactic contract. These educational variables are defined by the teacher based on the objectives of the students obtained in other subjects and also new goals. In both cases, the student level of objectives achievement is taken into account, thus guaranteeing transversality and the fact that students will be able to come up with an overall solution.

For the evaluation, the teacher needs objectives developed by each student and the student group as a whole in order to ensure a quantitative assessment of the objectives developed in the problem statement. At this point the teacher needs to

change the perspective to see entire process. This means that activities performed by the students must be complete and must be exported to the teacher assessment notebook.

The workspace or interaction space for students and teachers is where they perform the work. The workspace must conform to the methodology that the teacher has selected and also have access to resources, this can be achieved with the CSchool Interactive Design tool [17] and use a cloud application environment [18].

VIII. Conclusion

The method of Brousseau, raises the goal that students should learn to solve problems. We use this method for computer courses. A case study was presented in which students develop the problem by introducing variables. Teacher's work in such situations is to guide students through the educational variables and produce iterations in each stage of the process. On the other hand, it is important to set limits to ensure the achievement of the objectives of the course and also control the development of the sessions. Course planning comes from the subject curriculum and, in this case in particular, needs other subjects to achieve the same goals. Currently the problem is the inhibition for students to enroll in certain courses if they have not passed previous more basic courses. This is not a problem with our approach, as there is a possibility that students review the lessons learnt in other subjects. This suggests that future work on this methodology should be directed towards improving students' curriculum and promotes the objectives of subjects from others that require such knowledge. For example, if a student does not have the minimum knowledge to pass the programming databases course, he could be placed in a team with another student who masters this subject, supporting the other student. Activities like this one would need to know what to do with interdisciplinary work between subjects, how to evaluate it and how allow academics the student profile improvement.

References

[1] Hernández, F., & Oller, M. V. (1992). La organización del currículum por proyectos de trabajo. Graó.

[2] Ander-Egg, E. (2001). El trabajo en equipo. Editorial Progreso.

[3] Ballester Vallori, A. (2005). El aprendizaje significativo en la práctica. In V Congreso Internacional Virtual de Educación.

[4] Stainback, S., & Stainback, W. (Eds.). (1999). Aulas inclusivas: un nuevo modo de enfocar y vivir el currículo (Vol. 79). Narcea Ediciones.

[5] Habib M. Fardoun, Abdullah Saad AL-Malaise Al-Ghamdi, Antonio Paules Cipres, Creating new Teaching Techniques with ITCs Following the Montessori Method for Uneducable Young Students, 15th International Conference on Enterprise Information Systems (ICEIS-2013), ESEO, Angers Loire Valley, France-2013.

[6] H. M. Fardoun, B. Zafar y A. Paules, "Using Facebook for collaborative academic activities in education," Springer Online Communities and Social Computing, vol 8029, 2013, pp. 137-146.

[7] i Gallart, I. S., & Font, C. M. (1996). Asesoramiento psicopedagógico: una perspectiva profesional y constructivista. Alianza Editorial.

[8] De Zubiría Samper, J. (2006). Los modelos pedagógicos. Hacía una pedagogía dialogante. COOP. EDITORIAL MAGISTERIO.

[9] D'Amore, B., & Brousseau, G. (2005). Bases filosóficas, pedagógicas, epistemológicas y conceptuales de la Didáctica de la Matemática. Reverté.

[10] Johsua S. Et Dupin J. J. (1993) Introduction à la didactique des sciences et des mathématiques, Paris, PUF

[11] D'Amore, B. (2002). Influencias del contrato didáctico y de sus cláusolas en las actividades matemáticas en la escuela primaria.

[12] A. Paules, H. M. Fardoun y A. Mashat, "Cataloging teaching units: Resources, evaluation and collaboration," Proc Federated Conference on Computer Science and Information Systems, 2012, pp. 825-830

[13] H. M. Fardoun, A. H. Altalhi y A. Paules, "Improvement of students curricula in educational environments by means of online communities and social networks," Springer Online Communities and Social Computing, vol 8029, 2013, pp. 147-155.

[14] H. M. Fardoun, A. Paules y K. M. Jambi, "Educational Currículum Management on rural environment," Elsevier Procedia - Social and Behavioral Sciences, vol 122, 2014, pp. 421-427.

[15] H. M. Fardoun, A. Paules Ciprés y D. M. Alghazzawi, "Distributed User Interfaces to Enrich Collaborative Teaching Methods," Proc. of the 3nd Workshop on Distributed User Interfaces: Collaboration and Usability, 2013, pp. 37-41. DBLP. SPRINGER

[16] H. M. Fardoun, A. Paules Cipres, D. M. Alghazzawi, "Distributed User Interfaces in a Cloud Educational System," Distributed User Interfaces: Usability and Collaboration, M.D. Lozano, J.A. Gallud, R. Tesoriero y V. Penichet eds.,Srpinger, 2013, pp. 151-163.

[17] Habib M. Fardoun, Bassam Zafar, Abdulrahman H. Altalhi, Antonio Paules Ciprés: Interactive Design System for Schools using Cloud Computing. J. UCS 19(7): 950-964 (2013)

[18] H. M. Fardoun, B. Zafar, A. H. Altalhi y A. Paules, "Interactive Design System for Schools using Cloud," Journal of Universal Computer Science, vol. 19, no. 17, 2014, pp. 950-964. JCR, IF=0.762. SCOPUS. Thomson Reuters. DBLP.