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LISP(P) : a New Pedagogical Approach for Learning Mathematics in Colleges

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***Abstract*—The education level of any given nation is a major indicator of its progress and well-being. Developed countries are always elaborating new curricula and integrating them into modern technological forms in order to make the learning process much more easier. Following these countries footsteps, underdeveloped countries are trying to do the same and Algeria is one of them.**

In Algeria, and according to statistics published by the Ministry of National Education regarding the level of students in term of languages and mathematics, results are not very cheerful. Lot of reasons can be behind these results, some of them are of pedagogical nature such as teaching techniques, others can be technical like the teacher's training.

The aim of our work is to provide teachers and students with more modern tools that can make the learning process a much more pleasant experience for both of them, and this can be achieved by taking advantage of the rapid and progressive development of information and communication technologies (ICT).

Our proposed educational approach is called LISPP (Learn, Imagine, Select, Practice, Play). This approach has been implemented in a platform called M2M (Mathematics for 2nd year Middle), a straightforward interface, that attracts students to learn mathematics in a funny and non-intimidating way.

In order to assess the students progress, the system make them passe collaborative as well as individual tests before letting them reach the final level.

***Index Terms*—collaborative learning, self-assessment, collaborative assessment, mathematics learning, serious game, e-learning, distance education, middle school, Algeria, ICT**

I. Introduction

Basic mathematics are among the most important skills that a person must possess and master; not only for his academic success, but also for the success of management of his daily living and economic activities [1]–[4]. Mathematics research is about learners' ability to analyze, reason and communicate effectively as they pose, solve and interpret mathematical problems in a variety of situations [5].

In all over the world, mathematics should be learned from the earliest ages and continued up to university, where it is fundamental to other disciplines such as computer science, electronics, physics, chemistry, finance, etc.. Therefore, it is a highly required part of the curriculum of any student at any university.

Unfortunately, learning mathematics doesn't seem to be an easy task for many learners [6].

According to Chiappini [7], one of the reasons that makes the learning of mathematical concepts difficult is that some of these concepts like numbers or functions are not intuitive and not practicable through everyday experiences.

Our field study revealed other reasons for having low or unacceptable results in mathematics.

- Failure to manage several pieces of information at the same time.
- Failure to remember relationships.
- Inability to apply mathematical rules and standards.
- Lack of organization.
- Failure to follow instructions.
- Failure to understand what is required of them when solving problems and exercises.
- Confusion in their thoughts

For all the above reasons, we had the idea to contribute to national efforts to improve the level of mathematics among Algerian students and thus positively change their vision on this subject by taking advantage of the many benefits of information and communication technologies on the one hand, and the passion of these students towards Smartphones and tablets on the other one.

We first began our work by conducting a field study so that

we can figure out for ourselves what are the problems faced by that students of middle school regarding mathematics learning. This study made it possible for us to come up with a new approach that would make it easier to learn mathematics.

This approach has been embodied through the development of an online mathematics learning system called M2M (Mathematics for 2nd year Middle). Developed system is not intended to replace the classroom teacher, on the contrary, it provides a tool that allows the teacher to do a more effective job and also gives more in-depth support for students who are experiencing difficulties. Therefore, the proposed system needs to be equipped with all the features seen in face-to-face environments empowered by other tools that are based on information and communication technologies.

The rest of the paper is organized as follow. In section II we will present related works. In section III we will outline our proposed approach. Then in section IV we present the different components of the implemented system. Section V is the conclusion.

II. Related works

There is a growing demand on good skills and knowledge in mathematics and foreign languages [8]. Several scientists have adopted the use of ICTs in their own ways. In this section we will mention some studies that have proposed using new technologies for learning mathematics.

Munoz-Arteaga and his co-authors proposed an architectural model for the implementation of a graphical user interface for mobile applications, particularly for basic mathematics. It focuses on students aged 6 and 12 who generally have difficulties in learning mathematics [6].

Another research has proposed the use of collaboration among students in both learning and assessment process. In fact, many researchers have suggested the use of a collaborative problem-solving solution to improve student success rates. Among these studies, Huang [9] proposed the use of a digital pen-based learning system (DPLS) with collaborative problem solving to improve the learning outcomes in a conventional mathematics course . A quasi-experimental model was adopted to implement all teaching activities.

For the same purpose which is improving learners' level of mathematical knowledge, other studies have used serious games. These are long recommended to allow students to develop a meaningful understanding of mathematical ideas before they move on to abstractions [10]. Ernest suggested several reasons for including games in the mathematics classroom [11], for example, they generate enthusiasm, they are motivating, they improve students' attitudes, they cannot be played passively, they involve students' dialogue and cooperation, and they contribute to the development of problem solving and superior thinking skills; he justified the inclusion of games in the mathematics classroom supported by further research.

Other researchers have proposed different strategies and methods like Satpute [12], who proposed the RTL (Read, Think and Learn) technique for mathematics learning. "Reading, thinking and learning" is the main curriculum for students. As a matter of fact, at least once a week, students should choose a subject of interest that is at a level higher than their grade. Then, they must read (Read) and think (Think) on the same subject so that they learn it (Learn) at the right time.

In the literature We also found systems that have been implemented to make online mathematics learning easier and more effective. MathCityMap, is a system that focuses on the mathematics curriculum through the use of a mobile phone application [13], [14]. This system was not only designed to build and use mathematical learning objects, but it includes also the whole process: preparation (how to design the program), implementation (how the program works) and evaluation (the impact of the program on students to do mathematics as well as its impact the mathematical beliefs of the teaching staff). A mobile phone application was also developed as a support tool, that was created and used during this project [15].

Another system for learning mathematics is the MoMAMath system [16]. It is an interactive online mathematics learning application based on Mathematica and WebMathematica. The system was developed by the authors and tested to support classical basic mathematics courses for first year engineering students at the University of Salerno. MoMAMath is completely interactive and based on the "learning by doing" approach. The particularity of MoMAMath is the ability to perform interactive online exercise sessions, in addition to other traditional services such as theoretical sessions, asynchronous communication with teachers, etc. [16].

Intelligent Web Teacher (IWT) is another platform for learning mathematics. It is a distance learning platform, developed at the Italian Pole of Excellence on Learning and Knowledge, equipped with the functionalities of content management systems, an adaptive learning system and allowing the definition of personalised and collaborative teaching and learning experiences through the explicit representation of knowledge and the use of Web 2.0 techniques and tools [5]. Because of the presence of a learner model with its different components, the inland navigation system allows the student to achieve the defined learning objectives by delivering a personalized course that takes into account his or her specific needs, knowledge, preferred learning styles, didactic model more adapted to the learner's knowledge and mental model (and then engagement) [5].

The use of mobile technologies (such as smartphones and tablets) in the teaching and learning of mathematics is generating growing interest among researchers and educational practitioners. The characteristics of mobile devices such as portability, availability, Internet access, and its wide acceptance among young people and others have made mobile devices an emerging agent capable of expanding the boundaries of mathematics education and learning beyond the classroom

walls [17].

Another hypermedia-based mathematical learning system is PCMAT, a system that allows the adaptation of the application and that is based on a progressive self-assessment (exercises, tasks, etc.) and applies constructivist learning theories and learning style theories. The objective is to create a better, more appropriate adaptation model that takes into account the complexity of the different users [18].

3D representation was used to present concepts requiring schematics and graphics. Mithalal and Balacheff [19] presented a theoretical framework, in relation to an experiment based on a dynamic 3D geometric environment. Based on a case study, the researchers showed that construction tasks with specific representations do the work required and play a key role in learning geometry.

Lastly, we would like to mention the CBR-PROMATH system, which is a case-based mathematics learning system. This system is adaptive and has the ability to suggest appropriate learning content using previous learner cases that are based on the individual learning profiles and styles of all learners [20].

III. Proposed approach

The main objective of this work is to provide a solution capable of making the learning process much more easier for students of middle school to learn mathematics while respecting all different steps already involved in conventional classrooms. That means that all the teaching stages presented in the classic classroom and in front of a real teacher can be experienced remotely via our solution without the need for any teacher to be present.

As a second objective, we intend to help new teachers or candidates who haven't yet found an effective way to teach students to find out how the mathematics teaching process could be carried out.

That is why we have proposed a new approach that eases and supports the learning of mathematics in the middle school years. This approach allows the students to:

- learn by reading the content of a set of concepts (Learn),
- by linking them with his imagination to the real world (Imagine),
- which allows him to identify and select what he needs to learn and share with his peers or with the teacher so that he can develop his knowledge through (Select),
- the application of concepts learned through the resolution of exercises (Practice),
- and finally (if possible) create a competitive and recreational challenge by playing a series of educational games between students or online in order to master the concepts learned (Play).

We have named this approach LISPP (Learn, Imagine, Select, Practice, Play).

The figure (Fig. 1) shows the different stages of the proposed approach.

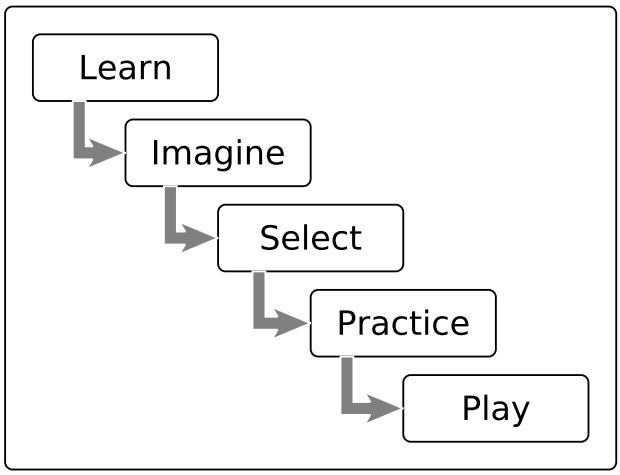

Fig. 1. LISPP approach

A. Learn

The student must learn the concepts presented by the teacher who chooses the content of the concepts associated with a knowledge (chapter or pair in the case of the middle school). Before the beginning of learning, the teacher who designed the lesson must meet the following conditions: relevance, realism and simplicity. In other words, he begins with an example that is related to the lesson to be presented and then he represents a real problem that contributes directly to the transformation of mathematics from the abstract to a practical mathematics.

B. Imagine

Students practice two kinds of imagination: the first is the scattered imagination that leads the student to daydreaming and the second is the creative imagination that leads the student to draw a painting, compose a poem or solve a problem. What is needed in the school is the product of creative imagination. Teacher himself must use a lot of imagination to give creative imagination to his students. Imagination is therefore strategic in creative teaching

In order to develop the students' imagination, we can mention a few points.

- Use real-world experiences, and let him process them and interact with them.
- Give the learner's experiences a solid reality that is adapted to his cognitive abilities so that he can use the environment.In this type of learning, real experiences that are related to the learner's senses are used.
- The use of physical images and media such as models, samples, maps, drawings, slides, films and others.
- Train learners to visualize and represent things through words, letters or symbols, and to train individuals to contemplate, conceptualize and improve ideas that help them develop their scientific concepts.

C. Select

After the journey of imagination, the student is offered a range of options that can be optional questions, graphics or geometric shapes, or puzzles to solve and pick what is appropriate for his imagination. After translating reality into mathematical equations, methods and symbols, the student will be able to generalize the rule. The student will also share his opinions, present his ideas and discuss them whith his peers as well as with his teacher. At this stage, the student uses his memory to remember rules, formulas, theorems and other mathematical notions to choose from among several possible ones.

D. Practice

It is the act of applying the concepts that have been acquired during each phase. It can be done in two steps, the first one is the direct application. It may be a simple exercise or a direct application of the lesson depending on those exercises requiring the direct use of the topic to be solved, without any difficulty or thinking. The aim is to strengthen the use of the topic.

In the second phase, a set of more complex exercises is presented. Which requires the resort for the formulation of the question in such a way that it can be applied directly in everyday life. A common example of these exercises is complex mathematical problems.

E. Play

Educational games are designed to help students to gain certain skills and develop their communicative skills as well as to increase their interaction with the environment through the game as well.

As a third objective, the proposed system may be able to face some classic difficulties already encountered by students and teachers in conventional classroom. To do so, we must first find what are the major reasons that led to the emergence of these difficulties in the first place. Our field study has revealed two main reasons:

1) the overcrowding of students in the classrooms.
2) the teacher is time-bounded and limited by the program.

Overcrowding in the classroom (sometimes 45 students in the classroom) is a real nightmare because with this kind of situation the teacher finds it difficult to ensure that information is properly received by all elements in the classroom. To avoid this problem lot of teachers uses the technique of working in groups, by dividing the students of the class into equal groups. This is why we proposed to apply a technique based on collective and collaborative work when learning mathematics.

It is imperative to mention that despite the fact that this technique is often successful, some teachers consider that working with groups creates chaos in the classroom and can waste learning time.

And since the assessment of students' knowledge is an essential element in any human learning system that can reflect the success or failure of the system, we have chosen to use a semi-collaborative assessment. This means that students have the ability to do an assessment that is done in two stages:

1) Resolution of the exercises collectively, where students are grouped into small groups to learn and self-assess themselves. Meaning, they solve the exercises together.
2) By the end of the collaborative problem-solving period, another assessment is offered to the students, but this time it is individual. Therefore, each student is asked to solve an exercise on his own.

IV. System Architecture

While designing this system we aim to have a system that combine excitement with simplicity. This system includes a set of tutorials in both text and in video formats, with series and exercises that can be with or without solutions. It offers options that allow the student to study mathematics in a fun and not boring way by including educational games within it.

Fig. 2. M2M based on LISPP

The proposed system, called M2M (Mathematics for 2nd year Middle), supports mathematics learning by adopting the LISPP approach.

The system is composed of :

1) three interfaces associated with its three main actors,
2) a web server
3) and a database that contains all the related data like :
   - The human actors of the system like teachers who are in charge of managing the subject's concepts, students or the administrators who manages teachers' and students' accounts.
   - The interactions between the different human actors of the system already mentioned.
   - All the actions performed by the students during the realization of the various pedagogical activities.

A. Domain model

It takes care of the structure of the course to be taught (Mathematics in our case). We have retained the same structure

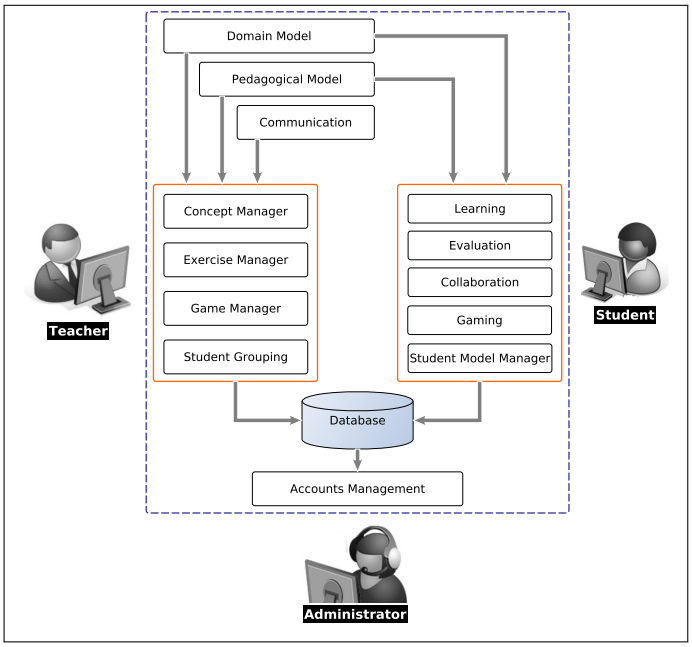

Fig. 3. M2M Architecture

proposed in the school textbook.

We were able to establish its structure in collaboration with a teacher who has been teaching this course in an intermediate school in the wilaya of Guelma.

The mathematics curriculum for the second year of the middle school is divided into three pairs: "numerical activity - data organizing and regulating - geometric activity". Each pair is organized in the form of gates (lessons).

Fig. 4. First pair lessons (gates)

The academic year has 3 pairs. The teacher proposes a set of lessons (syllabus) to vary them during the class. For example, lesson 1 of the Digital Activities pair and the second lesson of the Geometric Activities pair.

B. Concept Manager

It is a module that manages the pedagogical content to be transmitted to students. These concepts are structured according to lessons and associated pairs.

C. Exercise Manager

The evaluation stage is necessary in any training session. It allows students to be offered a set of exercises of different types. These exercises are taken into account by an exercise manager.

D. Game Manager

In order to motivate students during their learning process, we propose to add some simple educational games. These games enhance students' mathematical knowledge.

E. Pedagogical module

It takes care of the sequencing of the concepts to be presented to the students by applying the same rules applied by the teachers in face-to-face classes. In other words, we should begin by applying the LISP method steps step by step. In addition, this module can deliver these concepts in a weekly way as it is done in a real-world classroom.

F. Educational Activity Managers

: Learning, Evaluation and Collaboration A set of modules have been reserved for the different pedagogical activities carried out by the students such as: learning, self-assessment and collaboration.

G. Student Model Manager

All information about the student are represented by a model. This model includes static data such as last name, first name, etc. as well as dynamic data that provides information on the student's cognitive level, evaluation scores obtained, etc.

H. Communication Manager

It offers students a set of tools to facilitate communication between students and each other or with their teachers. These tools are email and chat.

I. Grouping module

Since students can perform educational activities in groups, they are grouped into groups of 4 students each. The method of grouping is random.

V. Conclusion and Future Works

Over the past decade, several sectors have benefited from the advantages of information and communication technologies (ICTs). Indeed, with the evolution and popularity of social networks, many actors wanted to take advantage of this opportunity to offer services that could be adapted to their users. National education is one of these sectors that has undergone several developments.

Our work consisted of designing and implementing an online mathematics learning system for students in the second year of middle school. This system is intended to be a support tool and not a substitute for the classroom teacher. In other words, we plan to use this system as a tool to support and strengthen students' knowledge.

Our system embraces the same structure of the course material as well as the type of activities available in the classroom. This choice was made in order to keep the same circumstances of the students lived in the classroom. Our system is called (M2M: Mathematics for 2nd year Middle), adopts a new technique designed for this purpose that includes several educational and recreational activities (such as educational games). The new proposed method LISPP is made of a set of steps covering all the learning phases of a pair in a subject. During the implementation of the system, we also associated a different color for each phase, this makes it easier to adapt the method.

We must mention that the game stage was optional because we have noticed that some students are not very interested in this type of game although our opinion was the opposite.

The system developed has several advantages, some of which are listed below:

- supports the language of instruction which is Arabic.
- It offers a range of educational and recreational activities that allow students to increase their levels of mathematical knowledge.
- It offers a set of exercises to facilitate the acquisition of the different concepts related to the content of the material.
- It supports collaboration between students organized in small groups.

In order to validate the advantages of the proposed approach, we have programmed a test phase (experimentation) of the system with real students. However, and since the students in middle school took their holidays in mid-May, we were unable to do this test.

The results obtained from this work are encouraging. They make it possible to open up new avenues of research in this area. As a perspective to this work we must test this system with real samples of students. Furthermore, we want to add a module that manages students' collaborative projects by taking into account the different submission and response times. Finally, we plan to add a module to recommend recreational activities to students.

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