

ONLINE GAMES FOR THE TEACHING OF MATHEMATICS

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Abstract

In this article we present a didactic experience developed by the GIE (Group of Educational Innovation) "Pensamiento Matemático" of the Polytechnics University of Madrid (UPM), in order to bring secondary students and university students closer to Mathematics. It deals with the development of a virtual board game called Mate-trivial.

The mechanics of the game is to win points by going around the board which consists of four types of squares identified by colours: "Statistics and Probability", "Calculus and Analysis", "Algebra and Geometry" and "Arithmetic and Number Theory".

When landing on a square, a question of its category is set out: a correct answer wins 200 points, if wrong it loses 100 points, and not answering causes no effect on the points, but all the same, two minutes out of the 20 minutes that each game lasts are lost.

For the game to be over it is necessary, before those 20 minutes run out, to reach the central square and succeed in the final task: four chained questions, one of each type, which must be all answered correctly.

It is possible to choose between two levels to play: Level 1, for pre-university students and Level 2 for university students.

A prototype of the game is available at the website "Aula de Pensamiento Matemático" developed by the GIE: <http://innovacioneducativa.upm.es/pensamientomatematico/>.

This activity lies within a set of didactic actions which the GIE is developing in the framework of the project "Collaborative Strategies between University and Secondary School Education for the teaching and learning of Mathematics: An Application to solve problems while playing", a transversal project financed by the UPM.

Keywords: Mathematical Games, Serious Games, Didactics of the Mathematics, Technology in Education, Innovations in Education.

1 INTRODUCTION

The GIE "Pensamiento Matemático" has for long collaborated with the Project which the UPM has been developing for the last years in connection with the start-up of activities intended to create a collaborative bond between the university and both schools and institutes.

Among the activities developed by the GIE there stands out the "Aula de Pensamiento Matemático" which is at present operating and whose contents can be consulted at:

<http://innovacioneducativa.upm.es/pensamientomatematico/>

By using the experience acquired in this kind of projects, the GIE has continued working on the creation of new collaboration spaces in mathematics alongside with the Secondary Teaching sector. To this purpose they applied for and were granted the transversal project of educational innovation: "Collaborative Strategies between University and Secondary School Education for the teaching and learning of Mathematics: An Application to solve problems while playing", within the "La Convocatoria de Ayudas a la Innovación Educativa y a la Mejora de la Calidad de la Enseñanza 2011 de la UPM".

On the one hand, the project focuses on the necessity to collaborate with pre-university teachers of mathematics with the intention to bring bachillerato students close to the university, while, on the other hand, trying to find both university and pre-university students' motivation towards the contents of mathematics.

The GIE's work in this line have always aimed at the proposal of recreational activities which can bring students to Mathematics and its applications. In this new project the principal idea is to develop an on-line laboratory of games, where students can acquire, reinforce and put into practice theoretical knowledge of mathematics from a recreational point of view.

In this article we present one of the proposed games in the laboratory: The Mate-Trivial, a board game to play individually, although competitions can also be established through a ranking. In it, students have the same capacity to move across and about the board with the object of reaching its centre, at which point the game is considered to be over. In order to achieve this end they will have to face up to a series of mathematical questions, as a test, which will allow them to achieve their ultimate objective.

Why have these games been chosen? The game has the nature of a pastime and entertainment which, although at first sight is opposed to the idea of study, can also be used in its benefit. In fact, the idea of entertainment and the possibility of going into action quickly which underlies all games, can be used to initiate students into mathematics. The game can be an attractive and motivating element which turns the task into a much more pleasant and stimulating one.

1.1 Objectives

The didactic objective intended with the game is that students, in an enjoyable way, get in contact with aspects of mathematics that they must know and will be using in their studies. On this regard, there are several proposals of various authors in which a student is presented with mathematical challenges at an informative level (see, for example, [1], [2], [4]). Our proposal is to set it out in a more attractive way for young people, as it can be the case through a computer game, which would eventually be an interesting contribution of the project that is here presented.

The particular objectives which are pursued in this work are:

- Bring students closer to Mathematics.
- Reinforce the mathematical knowledge in four basic areas: "Statistic and Probability", "Calculus and Analysis", "Algebra and Geometry" and "Arithmetic and Number Theory".
- Promote competitiveness with learning purposes.
- Facilitate secondary students' transition to university.
- Complete the theoretical education of university students.
- Strengthen the collaboration between university and secondary teachers.

2 DESCRIPTION OF THE GAME

In order that participants are familiarized with the proposed game and do not find it difficult to deal with, a model like the Trivial-Pursuit has been developed with certain changes and adaptations to mathematical contents. The board game can be seen in Fig. 1.

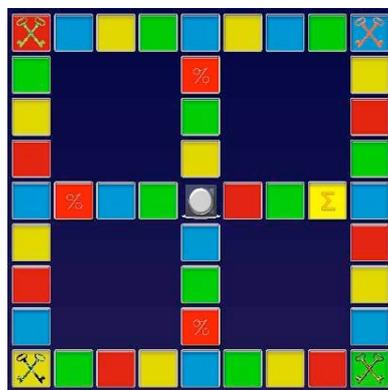


Fig. 1: Board game

There follows a specification of the game's instructions:

2.1 Instructions

The game “Mate-Trivial” is played in the following way:

Before starting the game the player must choose between two levels: Level 1 for the pre-university student and Level 2 for the university student. (See Fig 2).

Each turn the dice is thrown so that the counter is moved forward to a further square. There are four types of squares identified by colours: “Statistic and Probability”, “Calculus and Analysis”, “Algebra and Geometry” and “Arithmetic and Number Theory”.

When landing on a square, there is a question of its category set out, and a countdown of two minutes starts: a correct answer and within the time limits wins 200 points, a wrong answer causes a loss of 100 points, not answering at all does not affect the score, but, mind you!, on doing it two minutes, out of the 20 that each match lasts, can be lost.

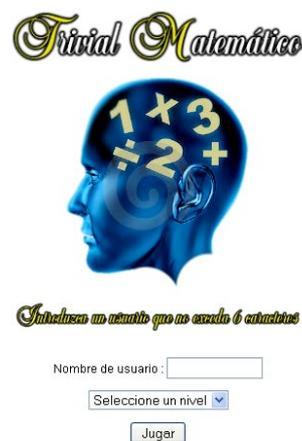


Fig. 2: Logon screen

To finish the match, before those 20 minutes run out, the player must reach the central square and succeed in the final test: 4 chained questions, one of each type, which must be all answered correctly. On succeeding this, the player will win 500 extra points, which will not be given to the player that does not manage to do it before the time runs out.

Does this test look difficult? There is something that can help. Scattered all about the setting there are four keys in different colours: each key obtained allows the player to skip one of the four questions of the final test, that of the same colour. For instance, with the green and blue keys, the final test narrows down to questions yellow and red, and with the four keys... Instant victory! Mind you, to obtain each key, the player must land on its square and answer the question correctly. (See Fig.3).

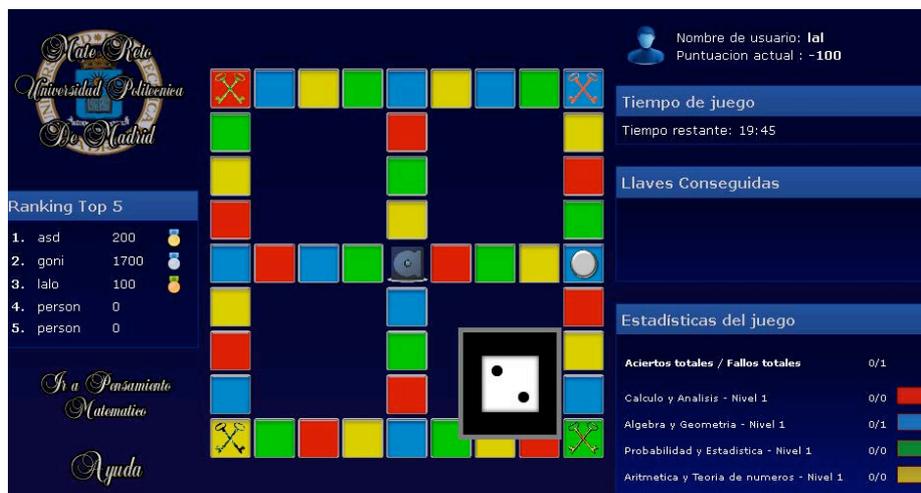


Fig. 3. Game screen

2.2 Contents of the game

As it has been commented in chapter 2.1., the game is intended to reinforce four basic pillars of mathematics in students' education, which are represented within its four categories. There are four types of squares, identified by colours which correspond to each of the categories: "Statistics and Probability", "Calculus and Analysis", "Algebra and Geometry" and "Arithmetic and Number Theory".

The questions which are set out are basic questions about those matters which must be answered by choosing one of the three options that have been offered alongside with the heading. (See Fig. 4).

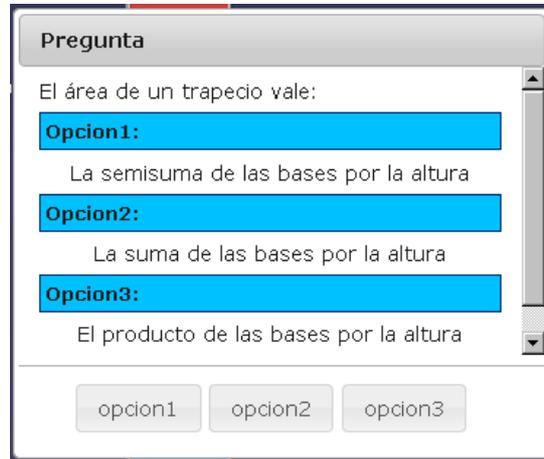


Fig. 4: Panel of questions and answers

These are simple questions which are set out to prove the agility in theoretical knowledge of the subjects. So as to make the game both dynamic and enjoyable, the questions are thought to be answered quickly and without the necessity of using any tools like calculators or even a pencil and paper.

As an example of this we will find below several questions of each category and level:

a) Questions corresponding to level 1 (pre-university)

- "Calculus and Analysis " category

The area delimited by $y = x^2$, $x=0$, $x=1$ and the axis OX is:

Answer options:

- 1: 2/3 units
- 2: 1 units
- 3: 1/3 units

- "Algebra and Geometry" category

Given two similar triangles T and T':

- 1: T and T' have proportional angles
- 2: T and T' are equal
- 3: T and T' have proportional sides

- "Arithmetic and Number Theory" category

The correct identity is:

- 1: $\log 10 = \log 2 + \log 5$
- 2: $\log 10 = \log 2 \cdot \log 5$
- 3: None of the previous ones

- " Statistics and Probability " category

The chances that a card, drawn at random from a Spanish deck, can be a face card or cups are:

- 1: 10/40
- 2: 12/40
- 3: 19/40

b) Questions corresponding to level 2 (university)

- “Calculus and Analysis” category

The Taylor polynomial of order 3 of the function f in $x=0$ is $p(x)=1-x^2+5x^3$. It can be stated as follows:

- 1: f reaches a relative máximo at $x=0$
- 2: f reaches a relative mínimo at $x=0$
- 3: f reaches a point of inflection at $x=0$

- “Algebra and Geometry” category

Let C be a hyperbola:

- 1: The asymptotes of C are parallel to the axes of C
- 2: The asymptotes of C cross the centre of C
- 3: The asymptotes of C are polar straight lines of points belonging to C

- " Arithmetic and Number Theory" category.

The golden ratio is:

- 1: A rational number
- 2: A relation between the rational length of two segments
- 3: An irrational number

- “Statistic and Probabilty” category

Let X and Y be statistical variables such that $\bar{X} = 4$, $\sigma_x = 2$, $\bar{Y} = 6$, $\sigma_y^2 = 9$. Then:

- 1: Variable X shows a larger dispersion than variable Y .
- 2: Variable Y shows a larger dispersion than variable X .
- 3: X and Y are equally dispersed.

2.3 Implementation of the game

The game itself is written in JavaScript, json for “talk” with database using php, relying on the canvas element of HTML5. While the game elements and changes are drawn, the game script “talks” with the web page, updating scores and times, and connecting to the game’s database. The database holds all the game’s questions about mathematics, composed of plain text of the questions and the answers, possibly an image, and LaTeX code. This LaTeX code is interpreted by the page and shown within the question as mathematical formulas, expressions or whatever the question needs about complex representation.

3 FUTURE ACTIONS: PRODUCTION

In order to assess and study the motivating capacity towards learning and the possibilities of the application of the developed resource, there are two kinds of experience proposed to be performed during the next academic year 2012-2013.

- In the sphere of the university: Encourage incoming students to log in the website of the "Aula de Pensamiento Matemático" to play Mate-Trivial. In order to motivate the participation there will be a competition during the first month of the academic year, consequently awarding the student who obtains a high score. This competition will be played at level 1 so that students can review mathematical concepts acquired in bachillerato, which are necessary for the first academic year of university. Such competition will be repeated at the end of the academic year, this time at level 2 of the game. This way the student will be able to weigh up the mathematical capacity acquired during the academic year.

There will be satisfaction surveys at the end of both competitions with the purpose of introducing improvements in the new versions of the game.

- In the sphere of the secondary teaching: The teachers of the GIE who work in secondary teaching will carry out a similar experience to that introduced in the sphere of the university for students of second year of bachillerato. This will show the motivating capacity towards learning and the possibilities of applying the game to the sphere of the institutes.

4 CONCLUSIONS

The papers related to how to bring students to mathematics are always of great interest due to the fact that many students show their reluctance to it. This article presents the work that the GIE "Pensamiento Matemático" has been developing during the academic year 2011-2012 to make the review of mathematical concepts enjoyable and attractive. For this we have chosen on-line games as a tool, which we believe to be an original and updated means of committing this purpose.

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