# Gami-Math: Educational Escape Rooms as learning environments, an optimal tool for horizontal mathematization and curricular integration

**José Carlos Piñero Charlo**
Department of Didactics, Section of Mathematics
Faculty of Educational Sciences
University of Cadiz, Spain.
660584895
josecarlos.pinero@gm.uca.es

**María del Carmen Canto López, Malena Manchado Porras**
Department of Psychology, Section of evolutionary and educational psychology
Faculty of Educational Sciences
University of Cadiz, Spain.
mari.cantolopez@uca.es, malena.manchado@uca.es

**Rocío Noriega Bustelo**
Department of Didactics, Section of Mathematics
Faculty of Educational Sciences
University of Cadiz, Spain.
rocio.nb.1986@hotmail.com

## ABSTRACT
Because of the worrisome performance of Spanish students (PISA tests) and mathematics teachers (TEDS-M report), the authors proposed specific didactic-mathematic teacher formation based on a Game-Based Learning approach. This contribution delivers summary and a report of the performance of the 4 years-history of the formative program in terms of: (i) connectivity and re-contextualization of mathematic knowledge; (ii) Improvement of the didactic-mathematic knowledge and related professional mathematic teacher's skills, and (iii) Reduction of the math anxiety

## Keywords
Math anxiety, curricular integration, didactic knowledge, mathematic knowledge, teacher instruction

## INTRODUCTION
School's curriculum may appear unrelated, fragmented or somewhat disjointed due to the lack of communication and connection among topics and subjects. This fragmentation often affects students' performance inducing lack of interest and confusion; thus, perceiving some knowledge as useless and affecting the experience being delivered to them in school (Beane, 1991). Indeed, some core curricular subjects seem to be clearly affected by these issues, particularly scientific and mathematical knowledge. For the particular case of Spain, schoolchildren show their worst results in scientific knowledge in PISA tests (scoring below OECD average). PISA 2018 report

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indicates that such a result might be due to students' lack of capacity to formulate, manage and interpret mathematics in a variety of contexts (Education GPS, 2018). This bad performance might be related to the lack of connections of scientific/mathematical knowledge to other curricular topics but might also be related to their teachers' specific lack of knowledge. Indeed, for sake of comparison, PISA statistic data can be compared to that of the TEDS-M report (Instituto Nacional de Evaluación Educativa, 2013); thus giving information about the teachers' specific lack of mathematical knowledge. In doing so, worrisome data regarding the mathematical and didactic knowledge of on-service teachers are revealed (see Figure 1). These results reveal the key importance of specific "mathematical training programs" for teachers' education, being Spain teachers lightly below the mean score for both didactic and mathematic knowledges.

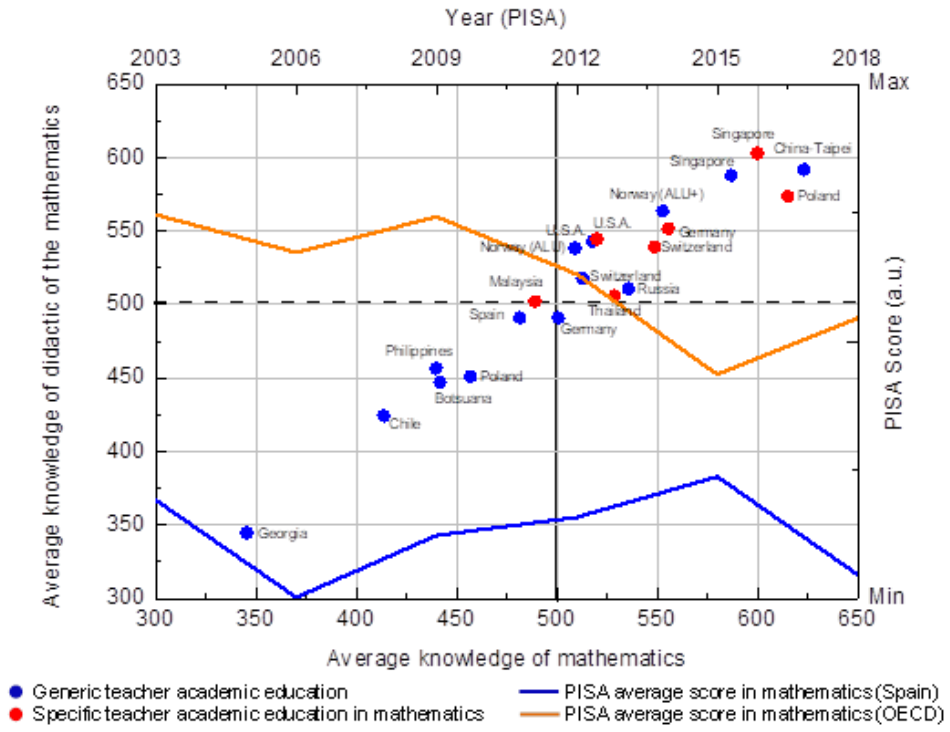


**Figure 1:** Teachers' didactic-mathematical knowledge by country (blue and red dots) and average performance of Spanish students in PISA tests (thick orange line). Adapted and translated from: Ministerio de Educación, Cultura y Deporte TEDS-M database. Retrieved from: TEDS-M report, 2012 and PISA reports.

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In conclusion, three main challenges should be attended:

- To solve the "curricular isolation" of the mathematics discipline, promoting the ability to establish connections.
- Designing specific teacher academic education in mathematics to improve didactic-mathematical knowledge.
- Reduce the mathematical anxiety of students and teachers in training.

## A FORMATIVE PROPOSAL USING GAME-BASED LEARNING

Considering how games can be used to overcome math anxiety (The learning counsel, 2022), as well as to learn and to evaluate mathematics (Piñero Charlo, 2020; 2021), the authors -researchers and teachers at the University of Cadiz- have created a mentoring program formalized as two academic year's student/teacher cooperation. The goal of the mentoring program was to improve didactic-mathematical knowledge of participant students (trainee teachers). This goal should be achieved in two stages (each one, corresponding with a different academic year). Both years would be dedicated to solve specific mathematical difficulties reported by on-service teachers in cooperating schools. Difficulties would be treated by designing gamified environments (educational escape rooms), specifically developed to mobilize mathematical competencies in a curricular integration approach. It is: students should design an educational escape room which shall mobilize curricular knowledge as a way to promote connections and relations among the different curricular subjects. In doing so, some research questions should be answered by students: can an educational escape room be used to promote a curricular integration approach?, how to analyze didactic situations?, how to analyze the performance of the methodology (in terms of promotion of the knowledge, skills and reduction of the math anxiety)?

The project started with a small group of 5 cooperating students (which has been increased in the incoming years), creating a team able to design, implement, evaluate and re-design such educational escape rooms in close relation to cooperating primary education schools (CEIPs). This procedure allows students (future teachers) to enjoy a "specific mathematic education", in close relation with their own interests while providing valuable support to the CEIPs. Students should have accomplished the core mathematic education of the "Primary Education Degree" of the University career, so the two-year cooperation was designed to go beyond the core instruction. In this project, the authors' starting hypothesis considers that an escape room-based activity might be a powerful educational resource not only to create learning opportunities for primary-school children; but also, to promote professional skills on trainee teachers by designing EERs. Furthermore, the implementation of this formative proposal is unique and engaging because it empowers students and invite them to re-invest their skills, deepen them and developing new ones.

In this contribution, we present a summary and a report of the performance of the 4 years Gami-Math mentoring program in terms of:

- Connectivity and re-contextualization of mathematic knowledge
- Improvement of the didactic-mathematic knowledge and related professional mathematic teacher's skills
- Reduction of the math anxiety

## BIBLIOGRAPHY

Beane, J., The Middle School: The Natural Home, *Educational Leadership*, vol. **49**, no. 2, pp. 9–13, 1991.

Dowker, A., Sarkar, A., and Looi, C. Y., Mathematics Anxiety: What Have We Learned in 60 Years?, *Frontiers in Psychology*, 2016.

Education GPS - Spain - Student Performance (PISA 2018).

Instituto Nacional de Evaluación Educativa, TEDS-M. Informe Español. Estudio Internacional Sobre La Formación Inicial En Matemáticas de Los Maestros. Análisis Secundario, Madrid, 2013.

The learning counsel, Overcoming Math Anxiety Through Games | the Learning Counsel, 2022.

Piñero Charlo, J. C., Educational Escape Rooms as a Tool for Horizontal Mathematization: Learning Process Evidence, *Education Sciences*, vol. **10**, no. 9, p. 213, accessed August 22, 2020, from https://www.mdpi.com/2227-7102/10/9/213, August 20, 2020. DOI: 10.3390/educsci10090213

Piñero Charlo, J. C., Ortega García, P. and Román García, S., Formative Potential of the Development and Assessment of an Educational Escape Room Designed to Integrate, *Education Sciences*, vol. **11**, no. 3, p. 131, from https://www.mdpi.com/2227-7102/11/3/131, 2021. DOI: https://doi.org/10.3390/educsci11030131