



**HAL**  
open science

## Kinesthetic Promotion of Function Graph Recognition at University Level

Mohamed El-Demerdash, Pedro Filho Lealdino, Christian Mercat

► **To cite this version:**

Mohamed El-Demerdash, Pedro Filho Lealdino, Christian Mercat. Kinesthetic Promotion of Function Graph Recognition at University Level. International Congress on Mathematical Education (ICME-13), Jul 2016, Hambourg, Germany. pp.24 - 31, 10.13140/rg.2.1.1696.1527 . hal-01546444

**HAL Id: hal-01546444**

**<https://hal.science/hal-01546444>**

Submitted on 23 Jun 2017

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

## **KINESTHETIC PROMOTION OF FUNCTION GRAPH RECOGNITION AT UNIVERSITY LEVEL**

Mohamed El-Demerdash<sup>1,2</sup>, Pedro Lealdino Filho<sup>1</sup>, Christian Mercat<sup>1</sup>

<sup>1</sup>Claude Bernard University, Lyon 1 (France), <sup>2</sup>Menoufia University (Egypt)

*The research work presented in this paper is driven by a unique goal which is promoting students' recognitions and understanding of mathematical function graphs. Given that some students need to use other senses as a preparation for abstract and symbolic thinking, we developed Augmented Reality kinesthetic digital resources around standard mathematical functions. Aiming at verifying the resources effectiveness in promoting recognition and understanding of mathematical function graphs, an experimental approach with pretest and posttest is considered here. The experiment with freshmen students is going to be implemented at the beginning of winter semester 2015-2016 at UCBLI.*

### **INTRODUCTION**

The emergence of motion-controlled technologies within the increasing usage of embodied cognition and augmented reality environments opens new doors for students to use their different senses into the learning process (Mercat, 2015). The goal besides making them more motivated to pay attention to the information presented and better retain the information (Tsai & Yen, 2013) is to let students experience an alternative way to build concepts.

The concept of function is unifying idea in mathematics. It plays an important role throughout mathematics curriculum (NCTM, 2000). Like many concepts in mathematics, developing a thorough understanding of mathematical functions is challenging for many students (Clement, 2001). Students have learning difficulties with mathematical functions include operations with functions, recognizing functions in different context.

Tall and Viner (1981) identified some difficulties that students faced while using graphical methods on functions. Aspinwall, Shaw and Presmeg (1997) asserted that in many cases the graphical representations can cause cognitive difficulties, because the perceptual analysis and synthesis of mathematical information presented implicitly in a diagram often makes greater demands on a student than any other aspect of a problem. For students to develop a holistic understanding of the concept of mathematical functions, they have to be able to identify the connection elements of a functional dependency and to combine these (Nitsch et al., 2014). The ability to translate between various functional representations is essential for this purpose (Ainsworth, Bibby & Wood, 2002; Seufert, 2003).

Smith, King & Hoyte (2014) found that students who focused on static representations of angles experienced less learning gains than those who participated in the movement-based lessons.

In order to provide different ways to perceive mathematical functions, we developed a game which is the subject of this research, using embodied motion as a fundamental strategy.

The contents of the kinesthetic digital materials include a wide range of mathematical functions aimed at freshmen students: Constant function, linear function, quadratic function, cubic function, absolute value function, fractional function, trigonometric functions, exponential function, logarithm function.

An achievement test is developed to assess the impact of this experiment in enhancing students' recognition and understanding of mathematical function graphs.

## **METHODOLOGY**

### **The Development of Kinesthetic Digital Resources**

In order to get kinesthetic feedback from the students, we used the Microsoft Kinect sensor and some programming, using Unity 3D Development Kit, Microsoft Kinect (SDK) - Software Development Kit - and CindyScript the programming language associated with Cinderella - Dynamic Geometry Software, linked through a UDP (User Datagram Protocol) connection. The software recognizes students' body gestures as input representations for mathematical function graphs.

As shown in the figure below, Cinderella software plots two function graphs, the red one corresponds to body gestures, and the green one corresponds to the goal graph which the student should perform to obtain the positive score during the game.

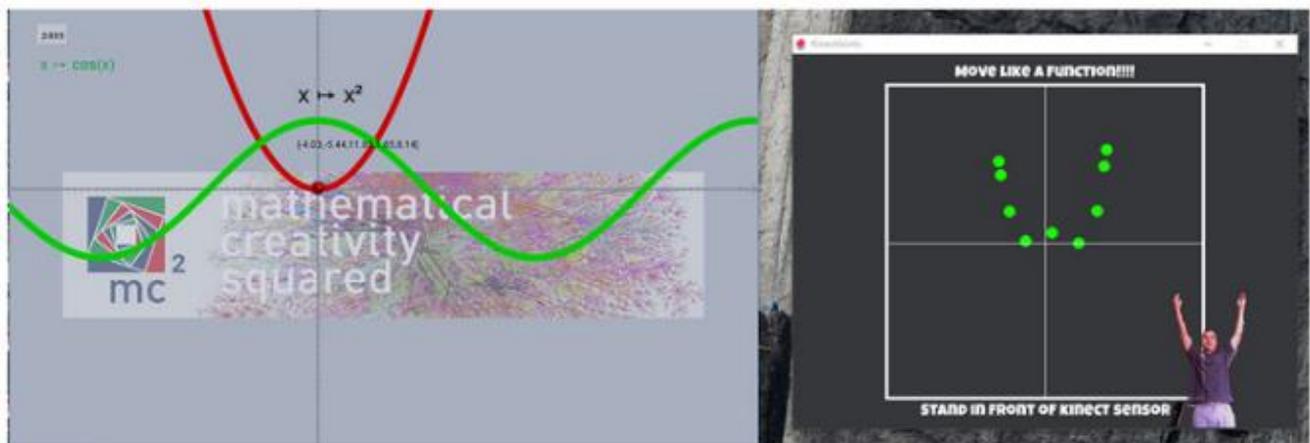


Figure 1: Cinderella plots the function graph in accordance to body gesture detected by the Kinect sensor.

On the left side of the figure above we show Cinderella plotting the functions in accordance with what the player (right side) is performing in front of Kinect sensor.

### **The Development of Achievement Test**

Since the purpose of the present study is to promote students' recognition and understanding of mathematical functions, we designed an achievement test (It is available as a download from: <https://dl.dropboxusercontent.com/u/5761672/AchievementTest.pdf>), that can be used in assessing students' performances before and after administering the prepared kinesthetics digital resources.

The following table shows the test specification in terms of mathematical function types that have been covered in the digital resources with respect to recognition and understanding levels of

mathematical achievement. The test consists of 40 items that are equally distributed among the two levels of achievement: recognition and understanding. 20 items are designed at each level in isomorphic pairs that will be administered randomly as whether pretest or posttest.

The items type for the test are multi-choice questions of 4 choices to eliminate the guessing issues from the students' side. The test items were written in verbal and nonverbal, symbolic and graphical ways.

The total score of this test is set to be (40) marks. One-point mark is given to each correct item response.

Table 1: Specification of the Achievement Test

Achievement Level	Recognition		Understanding		Sum	%
	No. of Items	Items Numbers	No. of Items	Items Numbers		
Constant function	2	11, 12	2	23, 30	4	10%
Linear function	2	9, 10	2	21, 24	4	10%
Quadratic function	2	1, 15	2	27, 37	4	10%
Cubic function	2	2, 16	2	28, 38	4	10%
Square root function	2	3, 6	2	32, 36	4	10%
Absolute value function	2	17, 18	2	29, 35	4	10%
Fractional function	2	7, 8	2	22, 31	4	10%
Trigonometric function	2	19, 20	2	39, 40	4	10%
Exponential function	2	4, 13	2	25, 34	4	10%
Logarithm function	2	5, 14	2	26, 33	4	10%
<b>Sum</b>	<b>20</b>		<b>20</b>		<b>40</b>	
<b>%</b>	<b>50%</b>		<b>50%</b>			<b>100%</b>

### Procedure of Experimental Study

We are going to set up a challenge where volunteer teams of freshmen students will have to compete by achieving highest scores and be rewarded by some goodies (T-shirts, caps...). The learning gain is going to be computed and correlated with the scores in performing the kinesthetic game in order to look for evidence of a relation between their engagement and achievements.

### ACKNOWLEDGEMENTS

This study was carried out in the framework of the MC Squared project (<http://mc2-project.eu/>) funded by the European Commission, under the 7th Framework Programme for Research, Technological Development and Demonstration (ICT-2013.8.1 "Technologies and scientific foundations in the field of creativity", Project 610467).

CAPES - Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Bolsa de Doutorado Pleno no Exterior - Processo: 0791-14-08 - Pedro Lealdino Filho

## **REFERENCES**

- Ainsworth, S., Bibby, P., & Wood, D. (2002). Examining the effects of different multiple representational systems in learning primary mathematics. *The Journal of the Learning Sciences*, 11(1), 25-61.
- Aspinwall, L., Shaw, K. L., & Presmeg, N. C. (1997). Uncontrollable mental imagery: Graphical connections between a function and its derivative. *Educational Studies in Mathematics*, 33(3), 301-317.
- Clement, L. (2001). What do students really know about functions. *Mathematics teacher*, 94(9), 745-748.
- Mercat, C. (2015). La diffusion: un lieu pour une mathématique plus humaine? Paper presented at EMF (Espace Mathématique Francophone), 10-14 October, 2015, Alger, Algeria.
- NCTM, P. (2000). Standards for school Mathematics. National Council of Teachers of Mathematics, Restin, VA.
- Nitsch, R., Fredebohm, A., Bruder, R., Kelava, A., Naccarella, D., Leuders, T., & Wirtz, M. (2014). Students' competencies in working with functions in secondary mathematics education – empirical examination of a competence structure model. *International Journal of Science and Mathematics Education*, 13(3), 657-682.
- Seufert, T. (2003). Supporting coherence formation in learning from multiple representations. *Learning and instruction*, 13(2), 227-237.
- Smith, C. P., King, B., & Hoyte, J. (2014). Learning angles through movement: Critical actions for developing understanding in an embodied activity. *The Journal of Mathematical Behavior*, 36, 95-108.
- Tall, D., & Vinner, S. (1981). Concept image and concept definition in mathematics with particular reference to limits and continuity. *Educational studies in mathematics*, 12(2), 151-169.
- Tsai, C. H., & Yen, J. C. (2013). The Development and Evaluation of a Kinect Sensor Assisted Learning System on the Spatial Visualization Skills. *Procedia-Social and Behavioral Sciences*, 103, 991-998.