GEOMETRIC FIGURES AND MOBILE TECHNOLOGY FOR NUMERICAL RELATIONS AS A WAY TO TEACH AND LEARN IN THE XXI CENTURY

A mobile way to teach students as well as people with numerical disabilities

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1. RESUMEN:

Les relacions numèriques actuals, com a part de les matemàtiques, utilitzen dibuixos, signes i codis, així com mètodes manuals que no han variat gaire durant centenars d'anys. Avui en dia, la irrupció dels dispositius mòbils ho desafia. Aquest nou enfocament capacita tant als estudiants com a

persones amb discapacitat numèrica per aprendre relacions numèriques. S'obre un munt de noves possibilitats perquè la comprensió és més ràpida, la desconnexió cerebral és més curta .... La tecnologia MNT (Mobile Numbers Technology) amb figures geomètriques amplia la base de l'usuari.

2. ABSTRACT:

Present numerical relations, as a component of Math, is using drawings, signs and codes as well as manual methods with hundreds of years. Nowadays, the irruption of mobile devices challenges it. This new approach empowers students as well as people with numerical disabilities in order to learn numerical relations. A bunch of new possibilities opens up because comprehension is faster, brain disconnection is shorter…; mobile math technology (MNT) with geometric figures widens user's base.

3. PALABRAS CLAVE: 4-6

Tecnologia mòbil, geometria, discapacitat matemàtica, matemàtiques

4. KEYWORDS: 4-6

Mobile Technology, geometry, mathematical disabilities, math

5. DESARROLLO:

1. Introduction

It is kwown that mobile learning is a challenge for learners, teachers and institutions (Cobcroft et el. 2006). Smartphones and tablets have great computational power and extraordinary graphic screen: showing and dealing with geometric figures (polygons, polytopes, and fractals) is affordable in order to deal numerical relations with them. Whenever we do so, we use our visual-spatial intelligence in addition to the logical -mathematical that is just used in classical methods (text based). In order to show the numerical relations, we create a new family of polygons: the polynaris. For example: binary formula a + b = c is a trinary. Each of the elements a, b and c is a trinus. The trinus is the basic element of any binary formula.

From a completed research, the communication shows, for instance, an application that simplifies complicated math formulas with brackets using the graphical representation of Sierpinski fractal and gives directions about other developments using geometric figures, see figure 1. This is a disruptive way: from present devices (paper, pen…) to XXI century mobile devices in order to deal with numerical relations with our visual spatial intelligence rather than logic mathematic intelligence. On the other hand, different people can have disability with numbers. A significant percentage of ordinary people have difficulties with numbers. Most of the intellectually disabled people with its diverse degrees has also troubles with numbers. We show a solution that comes from a proven mobile number technology that uses graphical context and multi touch screen features of smartphones and tablets (mobile devices) in order to deal with number. Our approach is an alternative to other carried out in the field of mobile technologies (Chen et al. 2008) (Martínez and Garaizar, 2014). It is mobile way to teach students as well as people with numerical disabilities.

2. Mobile Numbers Technology

Mobile Numbers Technology (MNT) is an original and emerging tool to manage mathematical formulas by means of a graphical context based on the combination of geometry and multi touch features of a mobile environment. In this tool, graphical representations and relational maps are efficiently combined to help the visualization, understanding and better comprehension of classical concepts. In previous works we have presented the basis of MNT methodology (Suñol et al. 2016 and references therein). MNT has been used to interpret scientific business and technological magnitudes and equations, and a full compendium of geometries, colors and icons

have been created for this purpose. MNT is not just a set of applications for new tools and communication devices based on graphic environments, but a new (more intuitive) approach to addressing and solving practical problems that support a mathematical formulation.

The development of mobile learning systems provides the learner the possibility to test its knowledge inside or outside the classroom. MNT allows students to work in a visual and tactile manner the mathematical equations used habitually. MNT can play with the variables of the equations to help students reaching the final result. Thus, students are not passive subjects, now they are part of the process. This is a new experience for them, a role that motivates. Likewise, graphic representations must be easy to understand for the end users because that they should be able to understand the physical phenomena associated to the relations between the physical quantities and to play with these variables to get the full potential of the developed applications.

Thus, one way to represent scientific or business equations is based on triangles. From the graphical context, one or more variables should be fixed, at least one variable should be an input and the calculated variables are the outputs. It is possible to play by exchanging input, fix and output variables. In our MNT approach these modifications can be obtained by touch or by displacement with fingers. Fig. 2 shows a sum, a and b can be one physical variable as the angular momentum of two objects (A and B) and c the total angular momentum of the system formed by A, B.

Nevertheless, this graphical context is not very attractive for new learners because for more complex equations to build all with triangles can difficult understanding the concepts that these equations represent. One option is the use of arrows and to generate graphs with the combination of arrows. It is to apply positional status with a vectorial shape. We should remark the selection of colours and symbols.

- Green square means input
- Yellow within a circle means fixed value.
- Green eight-pointed star means input.

3. Development

The technology here applied can be developed in learning STEM (Science, Technology, Engineering and Mathematics). The selection of the related parameters determines the field of application because is based in their mathematical relationships. Furthermore, this technology can be also applied in game environments.

3.1. Mathematics

MNT has a graphic context where you can represent in a visual way any mathematic relation. The addition-subtraction and multiplication-division operations achieve a nice visual look that the typical mathematical expressions don't have and are more intuitive. Besides of the originality (which makes it a more intuitive to represent and understand the nowadays mathematic operations) the practice applications of the MNT are relevant because you can see intuitively its multiple applications for the new communications devices (mobiles, tablets, etc… all them multi-touch screens) in a very different fields (engineering, chemistry, medicine, physics, economy, education...).

It is important to develop a graphical context. Classical way to express mathematical equations as: ((a+b)/c)=d should be substituted by graphs representations. There are different options. In Mathematics, triangles are a good option to generate a graphical context in simple equations.

One application is the DUAL CALCULATOR (BDC) a pilot that allows you to build and interact with a pyramid scheme's associated structure, without pressing any button! With mobile technology, the app interaction is only based on the touch and move of the finger on the screen (see figure 3).

BDC is an arithmetic calculator that uses with geometric shapes and fractals in a graphical context, which is handled in an intuitive way to perform arithmetic operations easily understand. This methodology fits with the current platforms of tablets and smartphones trends. It can also be used in a traditional way (dual calculator).

The purpose of this application is to show the synergy between touch screen and MNT. So it's possible to check comprehension and use ease of several MNT technology aspects when applied to the type of devices it's created for. It allows simplifying the difficulty of understanding the textually expressed mathematical forms and a full and direct interaction with the structure, the values of the variables and the precision shown on screen. This enables a dynamic environment where adding or erasing a function block is as easy as moving a finger. It can be also modified to be used for young learners as a game. There are other applications as Dimensional Analysis (Vivas 2016).

3.2. Business

There are some applications of MNT developed in business and financial areas:

A) Discount Formula:

Discount formula is designed to find any of the parameters involved in the formula. The key of this application is the fact the graphic representation of the formula is unalterable. Whatever the parameter you want to calculate, the visual structure does not change and ensures that the user does not have to constantly adapt to any introduced changes, as shown in figure 4.

The parameter you want to calculate is marked out with an eight pointed star, while the other two are marked with a green square (input) and a yellow circle (fixed).

Internally, the program inverts the calculation formula depending on whether you want to find the final price of an item, its base price or the applied discount.

Discount Formula application is a *first-to-market* product, so that it is a very innovative product with a big applicability potential. Also, there is no similar product so it is considered a pioneer project.

Discount Formula allows selecting the value you want to calculate and display the results updated at any variation of input and / or fixed values.

The purpose of this application is to show simple application of the vectorial representation. Using Mobile Math Technology, the user will not have to strive to understand the discount function structure, which is quite complex for most users.

B) The Mobile Dupont Formula:

The Dupont formula is well known in the financial field. A graphical formula that breaks ROE (Return On Equity) into three parts (as shown in Figure 5). There are 3 financial figures and 3 financial ratios. They are related between them. So, you just need the numeric information of 3 of them in order to get the whole network. Just, drag it!

Furthermore, it can be expanded to other financial ratios.

3.3. Science and Technology

Our MNT graphical context was also applied some applications on Physics and Engineering (Suñol et al. 2015):

Physics: to the second law of Newton, the relation between Force, Power and work (see figure 6) and to the law of conservation of the mechanic energy. Learning Physics with MNT has to be a complementary way for understanding physical relationships between physical magnitudes.

Engineering: to the Kinetics of the polymerization reaction. It has been applied the existing graphical context of this MNT to the kinetics of the step polymerization reaction. The analytical representation and the irregular tetranary has been created for this purpose, and the main kinetic mechanisms of the step polymerization reaction (self-catalyzed and with external catalyst) have been expressed in this MNT language. As a result, a first attempt of the use of this platform for the polymerization reaction is accomplished and the basis to further explore this possibility is established.

3.4 Perceptions

The paper shows the perception of experiences from users and experts related to the teaching of mathematical formulas with mobile technology (graphic and multi touch features multi touch with mobile devices) of the R & D of Mobile Numbers Technology (MNT) on dissemination phase. It encloses experiences in creation (realization of computer programs), implementation (user experience) and monitoring (learned lessons). The pilots made to date show that learning MNT is fast, intuitive ... and is more efficient when applied.

Some opinions:

A) The application running on the tablet enabled the mobile users to instinctively calculate or use mathematical equations. The application made use of the touching capabilities of mobile devices to improve usability and the overall experience of the user, especially for users with difficulties using traditional mathematical representations (equalition, inequations, multi-variable systems, etc.).
B) These applications were interesting, but in mour opinion, the real innovation comes from the new learning paradigms to teach mathematics. The idea is that instead of using traditional representations for mathematics (which takes a long time to interpret), mathematical objects or variables would have geometric representation, various color schemes, etc. that are instinctively identifiable, and as a results nearly instantaneous to the student. Thus, making the students and users grasp complicated interactions between mathematical variable in a very short time.

Regarding the specific product Dual calculator:.-“In my opinion, dual calculator can ease the comprehension of abstract algebraic expressions as they become 2 dimensional”. Professor, Barcelona University.-“Dual calculator is well done and very intuitive. The aggregated sum has an accurate graphical representation.” Xavier Espinach, Universitat de Girona.-“[Dual calculator]

usability has been tested and well accepted among young groups as they are accustomed to mobile devices". Oriol Janés, computer engineer. Other opinions about it:-"Certainly appears to be an innovative approach to display (using the fractal layout)". Kevin Hogan, MS (Applied Mathematics), Austin TX.-"Really looks interesting. I think numbers and their (size) relations can become much clearer when entering them graphically." Dr. Andreas Loos, Institut für Mathematik, Berlin.-"There is applicability, especially in didactics implemented with mobile devices." Pere Garcia, The Artificial Intelligence Research Institute (IIIA), Barcelona.-"iSchool Initiative, a nonprofit dedicated to reforming education through technology […] if it were fully developed as commercialized product, we would be very interested in researching, testing, and spreading the word of this new product". Travis Allen, iSchool Initiative.

In summary, a disruptive way: from present devices (paper, pen…) to XXI century mobile devices. Numerical relations with our visual spatial intelligence rather than logic mathematic intelligence. Any contribution to disabled people has social impact. The final social impact would be from improvement of particular numeric disabilities to specific disabilities. In a global scale, a solid impact.

We also show here comments performed by potential users, developers and experts on new technologies in Education: -"We think the apps related with the concept `math without numbers' can do well at appstore." Managing director, Educational app development companies.-"The overall approach running away from math formula textuality is great. No doubt about it!". Lourdes Tavira, The Artificial Intelligence Research Institute (IIIA), Barcelona.

Conclusions

We generate a graphical context of geometric figures to be applied in STEM and Business. There are several innovations to be taken into account. MNT is a well-developed graphical context and original methodology based on colours, icons, symmetries providing STEM and Business information in an intuitive and coherent way. Our approach is also of interest in other scientific and technological fields.

ACKNOWLEDGEMENTS

Design, graphs and works are based on research and technological development of J. Tarrés, whereas graphical icons are designed by T. Vinyes. We also acknowledge not only the works of 27 students from University of Girona as company internships bust also the final engineering degree

works of different students from University of Girona and University of Barcelona.

The present communication reflects the deployment of MNT Edu (Mobile Numbers Technology) by a team of university professors, high school teachers, university students and professionals in order to be implemented in education on edu free licensing basis. The mission is to facilitate a new way of teaching in order to extend the knowledge and use of the STEM disciplines to students of all social and intellectual conditions that will help them to face the challenges of the 21st century.

At this time, the core MNT Edu deployment team is formed by Fabiola Vilaseca, Joan Josep Sunyol, University of Girona; Manuel Moreno, Universitat Politècnica de Catalunya; Timo Tiihonen, Jyvaskyla University; Arcadi Juncosa, IES Llança; Alex Espigol, junior researcher UdG; and Josep Tarrés. Different companies and organizations are also related.

5.1. FIGURA O IMAGEN 1

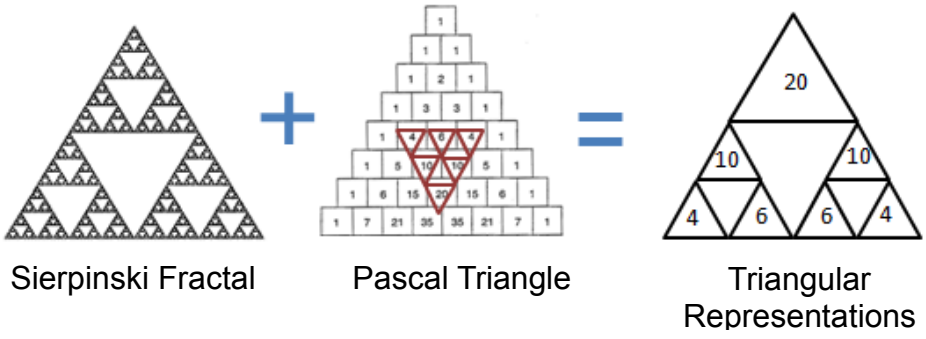

Figure 1: Triangular representations based on Sierpinski fractal and Pascal triangle.

5.2. FIGURA O IMAGEN 2

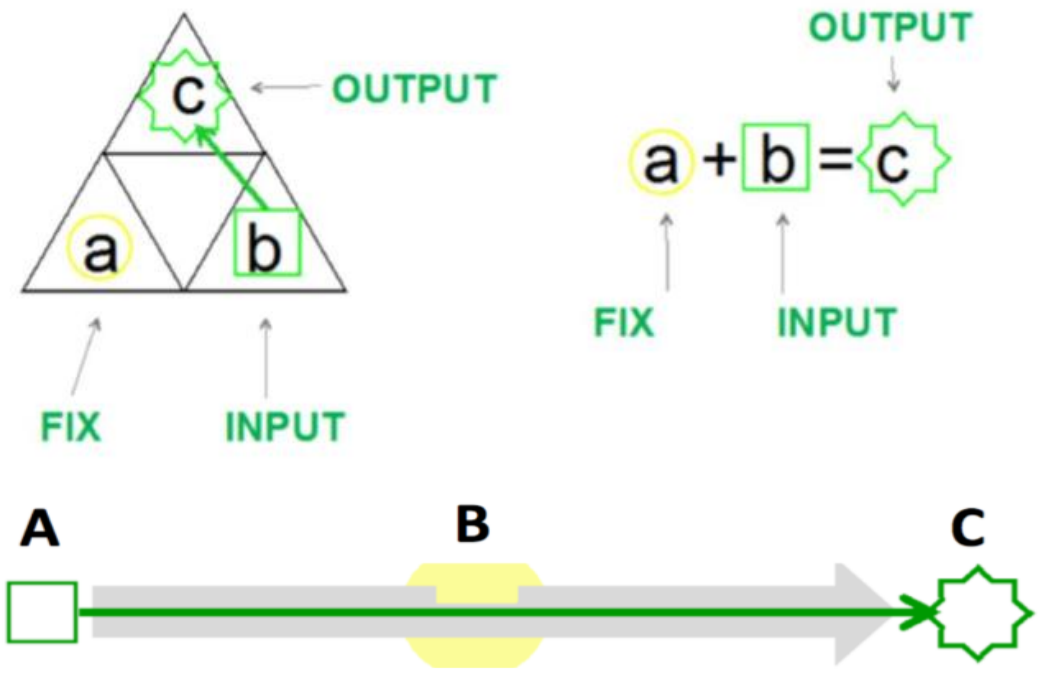

Figure 2. Triangle graph with input, fix and output parameters.

5.3. FIGURA O IMAGEN 3

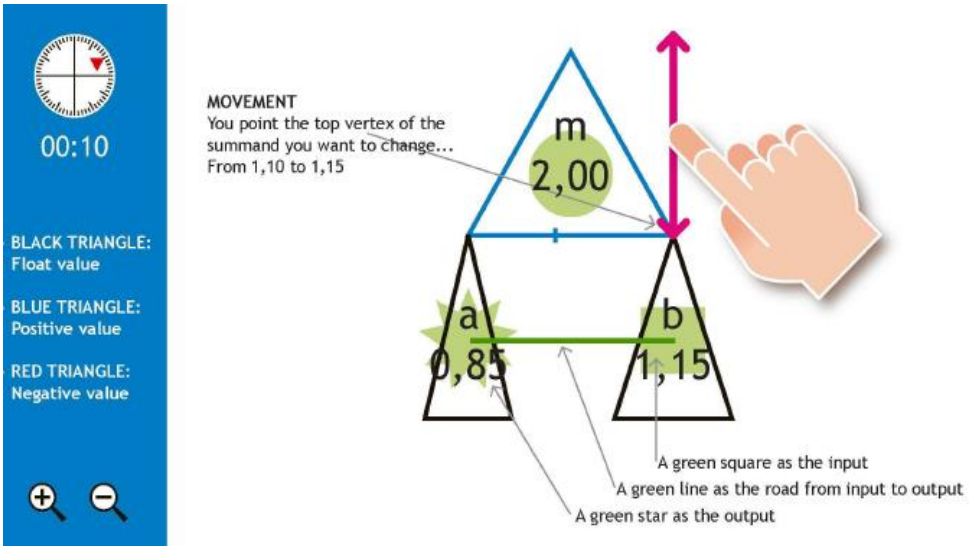

Figure 3. BDC Calculator.

5.4. FIGURA O IMAGEN 4

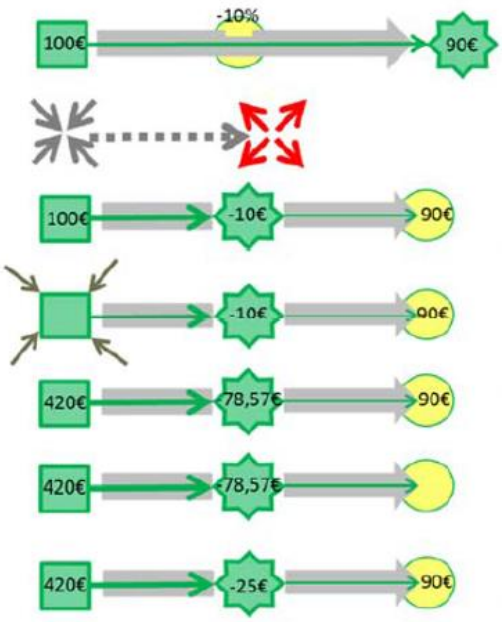

Figure 4: Discount formula.

5.5. FIGURA O IMAGEN 5

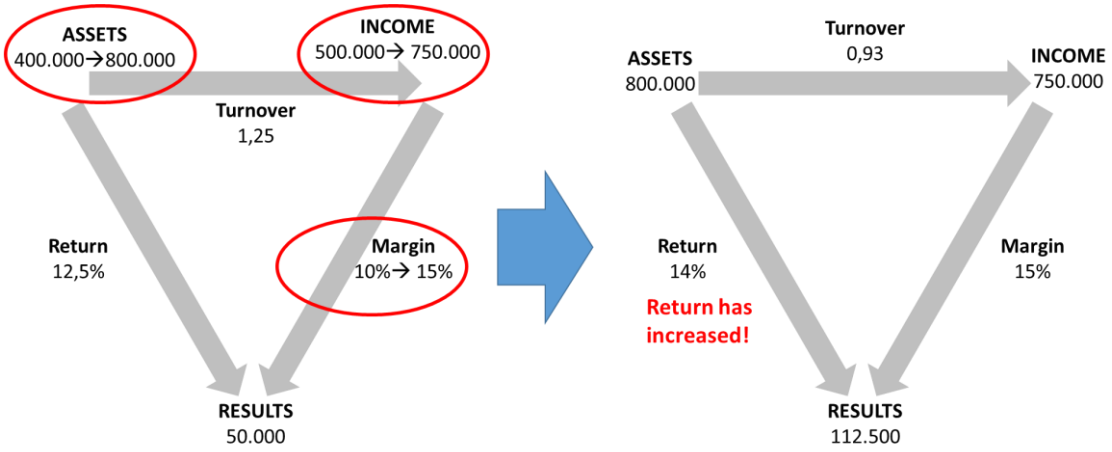

Figure 5: Du Pont Formula

5.6. FIGURA O IMAGEN 6

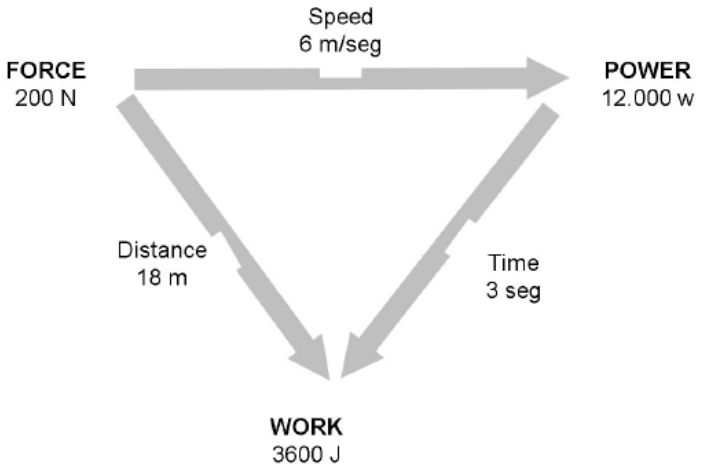

Figure 6: Application of MNT to Physics relations between Force, Power and Work.

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