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Mathematical Operations Visual Dictionary: An Interactive Support to Teach Math to Children Not Speaking Italian †

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Abstract: The ever-increasing presence in Italian school of Italian L2 children is an established reality. Language learning is a priority: it is the gateway to all school subjects and "social life" in the new country. Unfortunately, language learning has its own times, which often collide with schooling. Consequently, while a child is learning a language, he/she is excluded from many other subjects, especially scientific, thus accumulating gaps. The mathematical operations visual dictionary takes traditional language access tools (visual dictionaries) and verge them for mathematical concepts, implementing traditional illustration with the interactive media declined through the principle of understanding by doing.

Keywords: illustrations for children; digital book; Image based technologies for teaching; understanding by doing

1. Introduction

The ever-increasing presence in Italian school of Italian L2 children is an established reality. Language learning is a priority: it is the gateway to all school (academic) subjects and "social life" in the new country.

Unfortunately language learning has its own times, which often collide with schooling. Consequently, while a child is learning a language, he/she is excluded from many other subjects, especially scientific, and he/she might accumulate gaps: "Li Li and Alban, like many other foreign children, are actually learning many languages at the same time: Italian oral, written language, disciplinary knowledge and rhetoric, school communication" [1].

The *Mathematical operations visual dictionary* [2] takes traditional language access tools (visual dictionaries) and verge them for mathematical concepts implementing traditional illustration with the interactive media declined through the principle of *understanding by doing*.

The interactive dictionary was created by an Italian software PubCoder® that allows to create multiplatform apps and books without having to program. The visual dictionary is divided into three parts:

- The first one is a classical visual dictionary. It introduces a visual code, independent from the language spoken by the users. This part contains the visual translation of numbers from zero to twenty and introduce the symbol *equal* and *different*.
- The second one is the most interactive part. Here, the four basic operations will be explained by adding the user's gesture to the traditional visual dictionary: the user can then try the actions

for adding, subtracting, multiplying, and dividing on a sort of *augmented* digital abacus built with the shared code in the first part of the dictionary.

- The last part is an *Exercise book*. It will be physically and conceptually separated from the dictionary: it is only available by turning the tablet or mobile phone vertically. Here you can repeat the operations in the dictionary on several variants; have feedback whether you are operating correctly or not. It also a way to check if a math operation was properly understood; It is based on pure mathematical calculation with numeric symbols.

2. Materials and Methods

2.1. The Project

The choice of using the visual dictionary as a starting point was based on the knowledge of the instrument, the experience gained in multicultural environments during years of didactic laboratories, and on the study of *Blissymbols* or *Blissymbolics*: an ideographic writing system called *Semantography* consisting of several hundred basic symbols, each representing a concept, which can be assembled to generate new symbols that represent new concepts. *Blissymbols* differ from most of the world's major writing systems in that its characters do not correspond at all to the sounds of any spoken language.[…] *Blissymbols* was invented by Charles K. Bliss (1897–1985), born Karl Kasiel Blitz in the Austro-Hungarian city of Czernowitz (at present the Ukrainian city of Chernivtsi), which had a mixture of different nationalities that "… hated each other, mainly because they spoke and thought in different languages. […] Since the 1960s/1970s, *Blissymbols* have become popular as a method to teach disabled people to communicate. In 1971 Shirley McNaughton started a pioneer program at the Ontario Crippled Children's Centre (OCCC), aimed at children with cerebral palsy, from the approach of augmentative and alternative communication (AAC)" [3].

In Italy it was very useful for me follow Professor Gava [4] in schools and during some courses to see how children combine *Blissymbols* to communicate abstract concept and actions.

2.2. Illustrations and Interactivity: Building a Universal Visual Code for Mathematical Operations

As previously mentioned, the dictionary will be divided into three parts:

- The visual dictionary to introduce the mathematical code: numbers from zero to twenty and the same and different symbols, to be learnt before to the part related to mathematical operations.
- The interactive part: the visual dictionary for addition, subtraction, multiplication and division operations.
- The exercises

All illustrations have been aesthetically cared but, following the principle that the form should follow the function, they are not considered narrative illustrations, but visual codes [5]. The first part of the dictionary will work on the construction of this code by *translating* visually the equal and different symbols. This is made possible by repeating a number of examples, sufficient to make it easy to isolate the '=' symbol meaning (See Figure 1a). Always in the attempt to disambiguate as much as possible the concept of equal, it is also decided to introduce its opposite: *different*.

Once the meaning of the symbol '=' is clarified, it will be used to introduce numbers from *zero* to *twenty* (see Figure 1b).

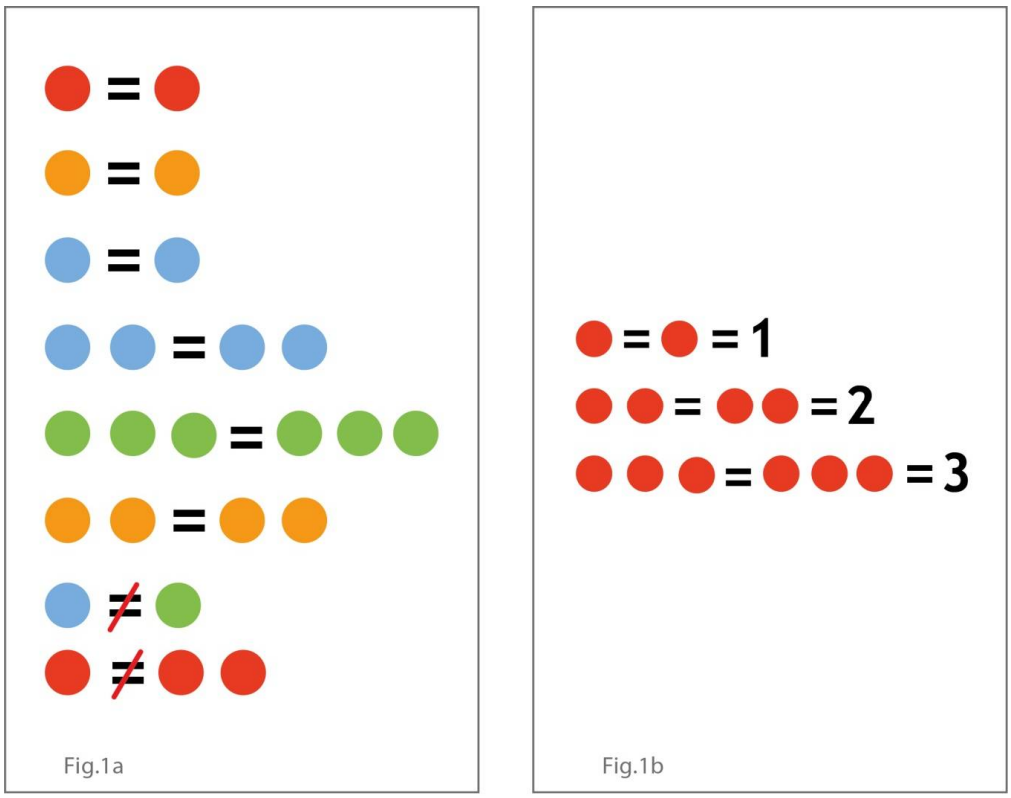

Figure 1. Creating the visual code. (**1a**) Equal and different; (**1b**) Numbers.

After establishing this first code level, the dictionary moves to *translate* the addition, subtraction, multiplication and division concepts, mediated by their corresponding mathematical symbol '+', '−', '*x*', ':'. This more complex transition needs interactivity. For its design, we have applied the same methods applied by Munari in its laboratories [6]: *Do to understand*.

Pages have been constructed as an *interactive abacus* on which a child can only do the actions necessary to understand the concepts of '+', '−', '*x*', ':': add, subtract, multiply and divide.

This was possible thanks to the ductility of the PubCoder® software, which, although not requiring programming, is sufficiently modular for experiments of this kind, and allows to update the interactivity very quickly during the test phase (see Figure 2).

The last part of the tutorial is slightly different from the previous chapters: we add some real-life photographs at iconic illustrations and mathematical symbols, to recall classroom problems and to connect reality and abstract mathematical language.

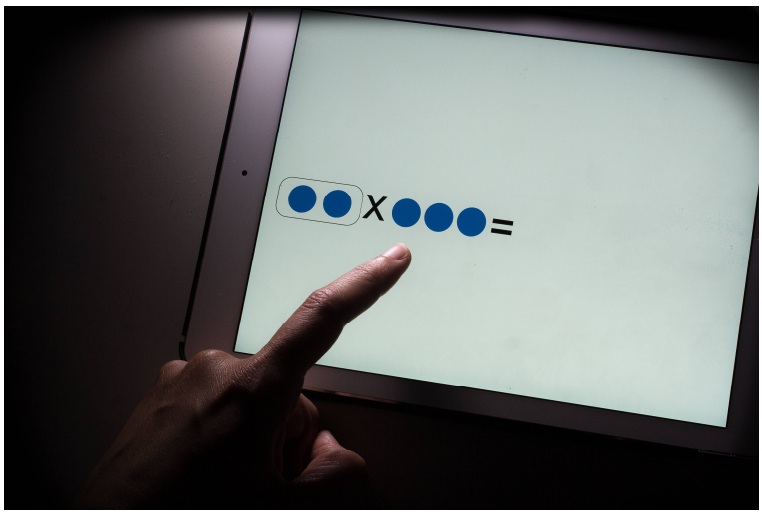

Figure 2. Interactive abacus.

2.3. Sound Environment

Choosing the sound environment in an app is not secondary to graphic or text choices and it is extremely delicate. That is why we have made some very specific choices:

- The app could be used in silent mode without losing any basic information.
- It will not contain any continuous or gingle sound. That is because the app could be used by the teacher to mediate the explanation in the spoken language according with our secondary objective: use mathematics explanations as a language access tool by connecting sounds abstract from the Italian language as *more*, *less*, *equal*, with their mathematical concept. Hence, a gingle could be intrusive or disturbing.
- However, it was decided to give a very discreet sound feedback to the user's actions. It makes the app more clear and endearing in the case of child's stand-alone use.
- As an iconic and functional style was chosen for the illustrations, we decided to take advantage of the audio to make the app less aseptic: we created the sound feedback system with a traditional South American toy, a bird ring in ceramic to warm the user experience.

2.4. Distribution

One of the critical aspects in apps production is distribution: although we release a free content, its visibility in stores is related to search for keywords and number of downloads. That's why we decided to include it in the *Edook project*, an APP/library that collects projects designed for children, teenagers, teachers, educators, students and creatives; all contents are uploaded free of charge from PubCoder® and released for free. Projects are available on tablets, cell phones, and LIMs.

There are already two visual dictionaries on the *Edook platform*: *Benvenuto in ABC* (*Welcome in ABC*) [7], a multilingual visual dictionary designed for associations and operators who give the first aid to refugees and asylum seekers. The dictionary consists of 189 interactive illustrations translated into Italian, English and Arabic. The illustrations were made by about 120 volunteer illustrators and mounted with the PubCoder® software. His twin app, *Welcome to ABCinese,* is expanded and declined for Chinese language.

3. Expected Results

The expected result is to promote math learning in children who do not speak Italian yet, and at the same time use the mathematical symbol as a moment of access to the second language by connecting sounds belonging to the Italian language as *more*, *less*, *equal* with their mathematical concept.

4. Discussion

The visual dictionary project was born a few years ago as a pop-up book. The problems started when we understood that is crucial for the child understanding to do a series of moving actions as explained in the section on interactivity. To permit this kind of action on a pop-up page the project would require a very complicated paper engineering and therefore an exaggerated user's cost, in addition the book would be extremely fragile: it could not be a real educational material, but an object for enthusiasts of the matter.

Interactivity has freed itself from paperwork constraints and allowed to create the dictionary and distribute it for free. Thanks to the version that can be used on the LIM, you can take advantage of existing classroom equipment without additional costs for the school or teachers. We believe that, in this case, choosing an interactive tool instead of paper does not impinge on the child's experience but it is an added value. The experience in traditional publishing was crucial in the final dictionary review. We applied the same analysis method on our interactive dictionary that system artists such as Suzy Lee do on paper book, for example in his *The trilogy of limit* [8]: the plot and illustration are a game about border between right and left page created by binding. The method of analysis on the book is also applied by Hameling [9] network through their own magazine, and the *Transbook* [10]

network. In doing so, we apply the traditional analysis on paper book on interactive book, we discard what was not of interest and enhance what we needed. In concrete terms:

- We abandoned the binding issue, but we have exploited the possibility of having two overlapping and interchangeable pages to explain the commutative property.
- In the matter of tactile experience, we realized that the screen took away all the possibilities of paper and its variations, but we were able to explore all the possibilities related to the user's gesture and exploit and gesture/cause/effect concatenations.

5. Conclusions

So we think this dictionary is a reflection experiment on a new language and it certainly must and will always have a lot to the book, but it cannot stop at a mere copy with a soundtrack of his older brother.

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Conflicts of Interest: The authors declare no conflict of interest.

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