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Body Cognition and Math Education for Pre-School Children

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Abstract
In every type of dance, from the traditional and the classical ones up to the modern, there are many mathematical concepts. Some of them are unconsciously used, both to find harmony of human bodies in the space, and for the logic. In contemporary dance techniques some choreographer noticed the strong presence of math and decided to taking inspiration from them. With this project we explore the connections between mathematics and dance, understood as a movement of the body itself. The Dance show "Intrecci" is presented in a video (15' long): it shows the presence of topological and geometrical elements not only for help public to see some abstract object, but also to make the audience aware of how maths is presented in everyday life. Words, scenography and images are essential and helpful for the audience to focus the attention on the dancers' lines and bodies. The music has been chosen with attention: "Knee 5" from "Einstein on the beach" and "Metamorphosis 1" were composed by Philip Glass; their melody and sonority allow to exalt choreographs elements. The "Body Percussion Song" is a clapping music song, that is music composed only whit body, voice and percussion; it was chosen for its energy. The performances that can be seen in this video can be used for every level school project. In fact, we experimented it in a kindergarten (I.S. Serravalle (MC)). The idea is to use the human body and the space that surrounds it in order to introduce important concepts of Geometry and, in general, Mathematics.

1. Dance

1.1 Introduction
With this project we explore the connections between mathematics and dance, understood as a movement of the body itself.
Starting from the perception of the body in the space, every dancer has to be perfectly awake to understand his role in the tridimensional space. Indeed, every choreography is composed by lines, volumes, geometrical and symmetrical figures which move in the space according to a specific sequence. We wanted to use contemporary dance techniques for different reasons: first of all, this type of dance starts from the study of everyday life movements; in fact, as Pina Baush said "To understand what I am saying, you have to believe that dance is something other than technique. We forget where the movements come from. They are born from life. When you create a new work, the point of departure must be contemporary life - not existing forms of dance."
Another reason is that this type of technique gives a lot of freedom of movement and it allows to create different lines and volumes with dancers bodies.
Our work was also inspired by Wayne McGregor, Karl Schaffer and Erik Stern.
McGregor is a British choreographer who created works for Paris Opera Ballet, San Francisco Ballet, Stuttgart Ballet, New York City Ballet, among others. His works are also in the repertories of the leading ballet companies in the world including the Bolshoi, Royal Danish Ballet, National Ballet of Canada, Boston Ballet, Joffrey Ballet, Alvin Ailey American Dance Theater and the Mariinsky Ballet. In is works he gets inspiration from science. Our main source of inspiration came from two of his works: *Entity* and *FAR*.
Karl Schaffer teaches mathematics at DeAnza College in Cupertino, California, Erik Stern teaches dance at Weber State University in Ogden Utah. Their math dance work grew from two seeds; as choreographers, much of their work springs from playing with mathematical ideas. As teachers, they have found that mathematical ideas become more exciting when you act them out with your whole body. So they have developed a series of performances and workshops on math dance, which they have given hundreds of times in schools and conferences.
We also decided to work with younger dancers, not only because they are students of the dance

school in which Ilaria works, but also because we were interested to observe they reaction toward the relationship between math and dance.
The Dance show “Intrecci” is presented in a video (15’ long): it shows the presence of topological and geometrical elements not only to help the public to see some abstract object, but also to make the audience aware of how math is present in everyday life. Words, scenography and images are essential and helpful for the audience to focus the attention on the dancers' lines and bodies.
The introduction is useful to understand our intentions and our thinking about this work.
The fist choreography is called “Identity”. We tried to explain *who is a mathematician*. We started tasking ourselves who we are, who we want to be, what kind of researcher we want to be. We answered these questions in different ways, but we agreed about some points: the mathematician is curios, methodic, a person who question himself, who want go over his limits. Then we associated to every characteristic a movement. For the music, we choose the poem “Delirio matematico” by Stefano Bruno, and we combined it with music by Marcello Ciampa, to predispose the audience to see math not as scarred subject, but as a science close to our life and our humanity.
The second choreography is called “Phi”. We worked with *symmetries*; we based the sequence of movements on numerical series and we showed the construction of the aurea section starting from the aureo triangle. For the music, we choose a track from *Einstein on the beach*, by Philip Glass and Robert Wilson: its title is "Knee n°5”, and we selected it essentially for the atmosphere it creates.
The third choreography is called “Move”. With this one we wanted to illustrate *geometrical transformations* such as *translation*, *rotation* and *homothety*. Indeed all this composition is based on the movement of a square in the plane and then in the space. In this case we choose a different kind of music for different reasons: first of all, *clapping music*’s structure is based on a repetition of a series of sounds, and this gives the sensation to see something linear; on the other hand, it is very joyful and complies with the age of the dancers.
The fourth choreography is called “Twine”. We started with the representation of *inverse functions*: if we imagine every movement as a function which warps the dancers’ bodies and the figure of the *corps de ballet*, we can perform the inverse movement to return to the original position. We inserted also knots and brides in the choreography, not only for creating scenic figures, but also for helping the audience to visualize these abstract mathematical objects. We wanted to emphasize the dancers' movements, so we choose a discrete but emphatic music, “Metamorphosis 1” by Philip Glass.
The performances that can be seen in this video can be used for every level school project. It could be a starting point from which it can be set up a Laboratory on Math and Body. In particular, we think that it perfectly fits with Pre-school, Elementary school children, and for children with disabilities.

1.2 Beyond dance: body cognition and math education

Since several years [1] it has been established the importance of the body and movement in cognitive processes. This awareness has resulted already in the Italian ministerial programs of 1985 for primary school: it showed up the term “physical education”, substituting the old "physical activity", highlighting this way the educational potential of the physical activities. In the text of those programs (1985) there is underlined "the close relations that exist between physical and mental activities".
The body has a leading role in the educational process: is the mediator of the knowledge and the first-actor of the communication.
The theoretical base for these ideas can be found in papers by A. N. Leontjev, and later on in the pioneering works by J. Le Boulch [2], A. Lapierre and P. Vayer. Moreover, we mention the *Embodied Cognitive Science*, a quite recent interdisciplinary research field which aims to explain the mechanisms that underlie intelligent behaviour. Finally, we mention the works by Daniel Goleman [3], concerning emotional intelligence.

2. Math education for pre-school children: an experimentation

2.1 Introduction

We made the first experimentation on this idea of laboratory in a kindergarten-Scuola di Infanzia in Serravalle (MC)-(“U.Betti”).The idea is to use the human body and the space that surrounds it in order to introduce important and in this case basic concepts of Geometry.
We have organized three weekly meeting from the 28th of April to the 12th of May. In this kindergarten there is an unique class, made up of 18 children: 4 of 5 years old, 5 of 4 years old and 9 of 2.5-3 years old).

2.2 Description of the meetings

First meeting: “Harmony and symmetry” – Aim: identify harmonic proportions and symmetries.
After having met the class and introduced ourselves, we gave the children lighter, stronger and unbreakable plexiglass mirrors. We left time for children to play with these objects and to understand how these objects work. After 15’ almost all the children were capable of explaining the rule and the law behind the object-mirror. Then we started to use the mirror in order to understand the symmetries in the objects around us and those symmetries that are in our body. Finally we played the *dance of the mirror*: the class was splitted into two parts. Half of them could move freely and the others had to be "mirrors": every "child-mirror" should imitate the behaviour of the child in front of him
Second meeting "Points and lines" - Aim: understand the concept of point, line (broken, continuous, curve,..), rotation and translation.
We put in the floor of the room little red disks (that later on were called “nest”). We asked each of them to occupy one nest, as a “little bird”. Then we started to propose a series of different rules that have to be used in order to go “from a point (disk-nest) to the other”, associated with different songs. Later, we gave all the children a “beak” and we introduced the concept of translation and rotation. Finally we moved to another part of the room where there was a big white poster. We asked the children, wearing plastic “socks” soaked in red tempera, to walk in different ways. At the end we watched the tracks of the different walking left on the poster.
Third meeting "Knots" - Aim: discover the concept of geometric knot.
The last meeting was focused on how to use the body in order to discover the theory of knots. We asked the children to draw a knot and describe with word how is it. Then we started to play creating knots with the children bodies ("human knot"), creating braids and challenging them to "play to the game of the handcuffs."

2.3 Materials

The materials are not expensive and recyclable. We preferred to work with objects that children can get in the classroom. Each meeting is characterized by a peculiar object: mirrors, red disks, rope. The materials, however, are useful only to make clear the concept: actually the body itself rules the roost. Thus they have discovered all those Mathematical concepts thanks to their bodies.

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