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Case Study of a Mathematical Dance Performance "Point Has No Parts"

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ABSTRACT

This paper describes a process of developing dance performance based and inspired by mathematical concepts and development of mathematics through history. The performance was included in the manifestation of the May month of mathematics in Serbia and prepared in collaboration with mathematicians, choreographers, dancers, science communicators and designers. The mathematical-dance performance was called "Point has no parts" and covered development of several important mathematical concepts and highlighted its influences on the contemporary world saturated with technology.

Keywords: mathematics, dance, performance

INTRODUCTION

The idea of embedding mathematical concepts purposefully into mathematical performance has been previously examined by researchers (Kátai et al., 2016; Parsley and Soriano, 2009; Milner et al., 2019) who highlight some of the essential connections between mathematics and dance, such as pattern recognition and manipulation, defining problems and seeking for solutions. Both disciplines start with concrete problems and strive for abstract ideas, or vice versa and both are genially integrated to cultural values and biases while involving aesthetics (Shaffer and Stern, 2010). Also, authors state that both disciplines require sweating in the meaning of planning, hard work and exercising (Shaffer and Stern, 2010). Even though mathematics is mostly considered as abstract and neutral, there is an increasing tendency of connecting non mathematical concepts to mathematical research and education such as body and mind, experience and thoughts, proofs and imagination (Kátai et al., 2016; Parsley and Soriano, 2009; Milner et al., 2019).

The importance of embodied, multisensory, artistic experiences as a central component in conveying mathematical content has been examined by educators and cognitive scientists, since dance has a great potential for sensory and mathematical engagement (Gerofsky, 2013). The question that remains is how. That was the question that we faced when we got an opportunity to create a mathematical dance performance as a part of manifestation May Month of Mathematic during 2020 and 2021.

The connection between mathematics and art is evident and demonstrated in many ways, through paintings, designs, musical patterns, but also through poetry and dance. Some connections are more evident, than the others, easier to describe or to feel, while others are indescribable or unproved in the scientific and mathematical sense. One of those is the connection between mathematics and dance. Even though choreography could be considered as a mathematical pattern and it usually follows mathematical laws, the question that we tackled in this paper

considers dancing and performance as a way of mathematical communication in order to introduce the audience with the development of mathematics and its importance to the everyday world saturated with technology and inventions.

In this paper we describe the process of developing a mathematical dance performance called "Point has no parts", which included embodying mathematical concepts by an artistic, in our case, dance. The importance of embodied and artistic experiences, as educators and cognitive scientists have examined, as a central component in conveying mathematical contents have a great potential for mathematical engagements. In this paper we are trying to answer how this can be achieved. Prejudices about mathematical knowledge are potentially hindering many interdisciplinary collaborations therefore changes in public perceptions of mathematics as a scientific field are needed in order to raise attention as to the importance of mathematics.

CREATION PROCESS

In the creation process, we agreed that the performance would consist of four phases representing references to what some call "big ideas" in mathematics. While researching and developing ideas, we had in mind that many big ideas in mathematics were discovered in the freedom of mind, and by extreme passion, all attributes that can be attached to the art of dance. We made groups of ideas and developed the story around each idea. Those "big ideas" are Euclidean geometry, Theory of numbers, Functions and modern mathematics. Each part of the performance got a title. The Euclidean geometry was called "a point" that was represented with the actual sign "·", as well as a part dedicated to the functions "$y = f(x)$". The theory of numbers has an intriguing questioning title "Is everything a number?", while modern mathematics was called "Trafficappiling", suggesting a new word that explains the influence of mathematics through technology to our everyday life. In order to make the performance closer to the audience we made a leaflet, or libretto that shortly explained the concept. The libretto was the following:

"Point has no parts"–Math dance performance reflections

Mathematics is not a careful walk on the solid roads, but it is a wild travel through ideas. This is dancing research of mathematical ideas whose beauty is in the freedom discovered by passion. Move does not lie. Nor does mathematics (Mlodinow, 2002). Imagine an absolutely incorruptible and free activity of mind. That is what Euclidean geometry is like, an exciting mathematical theory, completed from basic ideas rolled through time, shaken by theological beliefs and philosophical views. Today it leads us to reexamine our own place in the Universe. Development of geometry of simple description delivered mathematical ideals such as point, line and plane. Euclid's Elements says: "Point has no parts, line is length without width". Thousands of years ago people were watching geometry through a window opened by Euclid, which evolved from measurements of land to a discovery tool. Today we know that, besides Euclidean, there are other kinds of geometry.

Is everything a number?

Odd and even numbers, prime and compound, quadratic, friendly, but also perfect and defect, alike to our human virtues and flaws. Numbers are in living beings, and nature of numbers is connected to music or cosmic order. Pythagora says: "Everything is a number".

$$y = f(x)$$

After many centuries Rene Descartes translated space into numbers with his project of universal science. With that he helped that even the most extraordinary things can be explained to the wider audience. Fact that a line or parabola can be defined by an equation opened completely new possibilities for science. Cartesian coordinates can help to determine regularities among data and visualize its functional relations. What is depending on what? By translating our everyday life to mathematical language we can describe finance, pandemics, transport, but also emotions or popularity in the media.

Trafficappiling

"As Google says, 5 exabytes of data was created from the beginning of civilization to 2003. Today, that is the number which is created in 48 hours. Some of the data are useless, some are precious, some we miss, some make our day. Theory of graphs is used for mathematical description of data. Graphs consist of points and lines, known

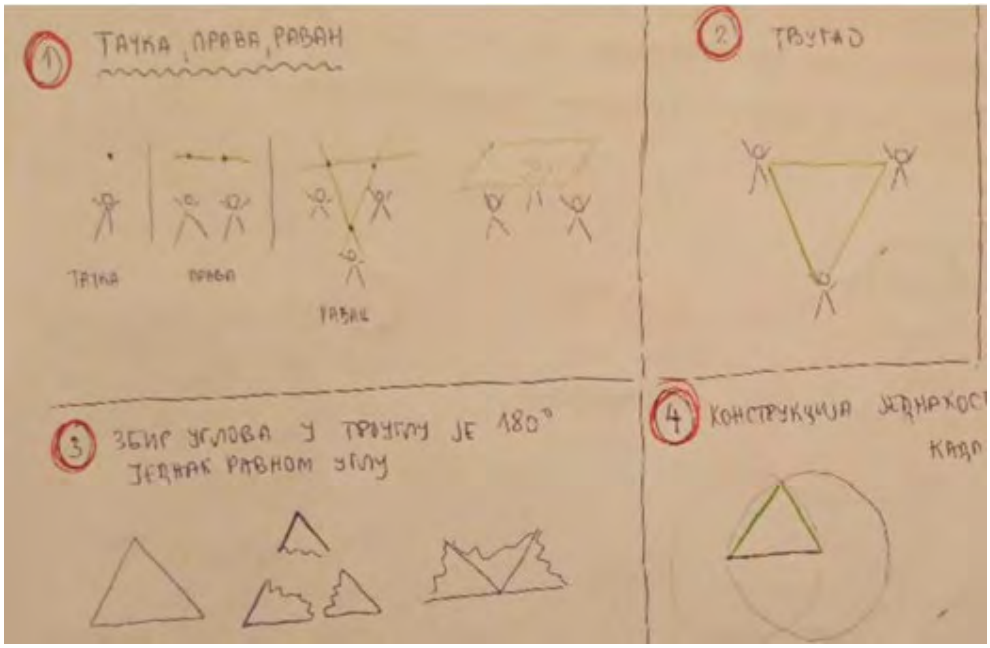

Figure 1. Sketch of mathematical theorems discussed with the choreographer

as knots and branches, which represent internet communication. Imagine that you intercept messages flying wirelessly above your head."

After agreeing on the idea of the performance, the major challenge was to explain deep mathematical concepts to the dancers who are not mathematicians and had no connections to the world of mathematics. Our collaboration started with analyzing geometrical constructions, proofs, and mathematical concepts that could resemble a choreography, and who have an active nature. Many mathematical concepts, for example, geometrical have the visual representation that could be embodied and artistically represented.

We started with Euclidean geometry which we wanted to represent as an absolutely incorruptible and free activity of mind, exciting mathematical theory rolled through times, shaken by theological and philosophical views. The basic inspiration for this part was to reexamine our own place in the Universe from a simple description of mathematical ideals such as point, line and plane. Euclidian, but also many other mathematical proofs are abstract, existing only in the imagination, but people try to represent them. For example, a point is infinitely small, but we draw it with the real size.

This phase of the performance preparation was kind of an icebreaker needed to establish acceptable communication among mathematicians and choreographers in order to understand each other and produce a desirable outcome. For that purpose we chose geometry since the connection to the physical world is the most evident. Shapes, angles or lines are also part of different aspects of dance. Some of the questions that we elaborated are what is the most beautiful, on what to put emphasis, what is practical, what is a clear mathematical explanation to non-mathematicians, what is creative, what is the idea and what is its representation. The idea was to add a visual dimension to the representation of mathematical concepts with dance where the dancer gets an active role and responsibility for clarifying mathematical concepts.

For centuries, people were examining geometry on the Euclides' postulates which evolved to a discovery tool, and today we know that there are other kinds of geometry. In **Figure 1** we can see the sketch of basic mathematical notions, such as point, line, and plane and the mathematical theorem that the sum of the angles of a triangle is equal to the 180 degree angle described to the choreographer, with physical representation. We can see that the points are represented with the sketches of humans, so dancers could easily connect to the topic.

In **Figure 2** we can see the performance of the theorem on the stage. Dancers with their movements represent the angles of the triangle, and by lying on the dance floor they represent a sum of angles. The scene is supported by visual design behind.

The next part of the performance was dedicated to number theory and inspired by Pythagoras' citation "Everything is a number". Pythagoras' citation "Everything is a number" but we presented it as an interrogative sentence, in order to highlight the importance to question mathematics and its place in everyday life. We wanted to tackle an idea that from the mathematical and scientific point of view numbering everything is acceptable, but from a human and artistic point of view it can be even dangerous. The dance scene was created as an ever-emerging vibrant city of digits filled with people who carry their stories. The rigid movement and joint shapes created by dancers addressed this issue of misinterpreted numbers or results. This part of the performance included statements such as: "Most girls lose interest in mathematics at the age of 13." or "140603 is the number on the

Figure 2. Performance of mathematical theorem

Figure 3. The artistic representation of linear function

hand of Sam Rosenzweig, a surviving Auschwitz victim" in order to illustrate how numbers might strip the richness of the meanings. As above mentioned this is also the most critical, socially engaged scene in the performance.

We are witnessing describing everyday life and events such as pandemics, transport but also popularity into mathematical language with determining regularities among data and visualizing functional relations. Development of mathematics and its use in technology provided us many benefits that we enjoy today. In **Figure 3** we can see artistic performance of a linear function, and in **Figure 4** we can see a dancer performing an exponential function $y = a^x$, which describes artistic expression of an exponential growth. The notion of functions was explained to dancers by real world examples, due to the fact that functions can be related to relevant concepts from real life such as velocity or bacterial growth. We explained different types of patterns and functional relationships, but also we used simple mathematical models to analyze changes mostly in real context.

Figure 4. The artistic representation of exponential growth

Figure 5. Representation of modern communication based on mathematics at the rehearsal

The most challenging part in the performance creation was to mathematically and simply explain and perform the development of modern mathematics and its influence to the modern world based on the technology. **Figure 5** represents that situation and the moment from a rehearsal. The Internet and reality based on different kinds of communication have mathematical foundations. For example, the theory of graphs is used for mathematical description of data. Our idea was to direct performance to wireless and virtual life that we all experience by using the Internet and that by sending a message there are many mathematical calculations and operations behind the process, for the most part unknown to the user. In order to make this advanced topic close to the dancers we have introduced them with the applicability and usefulness of graph theory, even though in the beginning dancers were reluctant at the beginning of preparation of the final phase of the performance. What was important for the artistic expression was to grasp the fact that graph theory represents a study of relationships. A set of nodes and connections could abstract everything from city layouts to data, simplifying moving parts of dynamic systems. Theory of graphs is used everyday to give answers for many arrangements, networking matching or operational problems. For example, the theory of graphs is one of the bases of informatics. That is why we directed performance to wireless and virtual life expanded by use of the Internet. Repetition of above: The scene of binary code rain intersected in joints of a graph was representing "caught" messages. This scene was driven by a mental experiment. If we imagine one square meter of the air above our head, let us ask ourselves what kinds of messages are transmitted via wireless signals? Some of the possible messages were shown by dancers, such as: "Enjoy the

work dear!", "I am having a fever again :(", "Send kisses to grandma and grandpa!", "Would you ever admit I was right?!" or "She is coming out of hospital today!".

Once established the concept and story line, we have dedicated significant time to music that followed performance, where we have taken into account that music should follow the dynamic of movement and the artistic idea. Whole performance was followed by powerful digital stage scenography fully inspired by mathematical concepts.

CONCLUSIONS

During the process of co-creation we faced many challenges and limits. It was quite hard to overcome many prejudices about mathematics. Dancers' previous negative school experiences with mathematics and their perception of mathematics as something hard to understand was quite difficult to overcome in the creation process. At the beginning of the process insecurity inhibited their creative and artistic expression, which we overcame with rehearsals and working on the narrative and storyline. We tried to explore their views about mathematics and tried to build them in the movements, but this remained the strongest challenge in the process.

Performance "Point has no parts" attempted to employ dance as an inspiration for the audience to think about abstract mathematical concepts as a tool for understanding everyday life. We combined intuition and mathematical proof, emotions and technology, humans and machines in order to explore the problems today's world is facing due to overuse or improper use of mathematical achievements. The awareness of this interaction between mathematics and dance could help us understand both areas in a new way, and open possibilities for new research areas. The idea of the performance was to employ a flexibility of mind in combining artistic and scientific methodologies, where mathematics and dance work together in synergy. We have recognized dance as a bridge between general understanding of mathematics and the public view of mathematics. Performance "Point has no parts" was a kind of experimental mathematical communication and it was presented to the wide audience at the open scene at the Kalemegdan fortress in Belgrade in September 2020. We believe that the unusual combination of mathematics and dance art nurtured the materialized conversation between the mathematics, art and general public and provoked continuous challenges to explore things around us and ideas created in our minds in a way of uncommon performance.

We have recognized dance as a bridge between general understanding of mathematics and the public view of mathematics. The performance "Point has no parts" enhanced mathematical communication and provoked understanding of many mathematical concepts to the wide audience at the open scene at the Kalemegdan fortress in Belgrade in September, 2020. We believe that the unusual combination of mathematics and dance art nurtured the materialized conversation between the mathematics, art and general public and provoked continuous challenges to explore things around us and ideas created in our minds in a way of uncommon performance.

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