Mathematical Dance Performance "A Point Has No Parts"

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Abstract

This paper describes the process of developing a dance performance inspired by mathematical concepts. The performance was included in the Serbian manifestation of the May month of mathematics, and it was prepared in collaboration with mathematicians, choreographers, dancers, science communicators, and designers. The unique mathematical performance was called "A Point Has No Parts" and covered the development of several mathematical concepts through history and highlighted its influences on the contemporary world saturated with technology.

Introduction

In this paper we describe the process of developing a mathematical dance performance called "A Point Has No Parts", [1, 2]. The process included embodying mathematical concepts in an artistic expression, in our case, a dancing expression. 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 multisensory and mathematical engagements [3]. The question that remains is how it can be achieved. That was the question we faced while creating a mathematical dance performance for the manifestation of the May Month of Mathematics. The manifestation of the May Month of Mathematics is organized by The Centre for the Promotion of Science and has a ten-year long tradition with the goal of promoting mathematics in an engaging way to wide audiences. Prejudices about mathematical knowledge are hindering many fruitful collaborations, so changes in public perceptions of mathematics as a scientific field are certainly needed [4, 5, 6, 7]. Thus, artistic research methodologies and approaches could make important translations in our visual culture [8]. The idea of embedding mathematical concepts purposefully into dance performances has been previously examined by researchers [9]. They highlighted some of the essential connections between mathematics and dance, such as pattern recognition and pattern manipulation, defining problems and seeking for solutions. Both disciplines begin with concrete problems and strive for abstract ideas, or vice versa, and both are generally integrated to cultural values and biases while involving aesthetics [10].

Preparation Phase

The preparation phase focused generating directions and ideas for the performance by the trans-disciplinary team. It included a mathematician (the first author), a choreographer, two science communicators (the second and third author), an animation designer, a stage designer, a multimedia artist and three dancers. The concept and the storyline were developed by the mathematician, the choreographer and the science communicators, while the rest of the team was included sequentially. This approach provided an opportunity to gradually develop the performance, which consisted of four phases representing references to what some call "big ideas" in mathematics. While researching and developing these ideas, we had in mind that each big idea in mathematics was discovered in a freedom of mind, spirit and by extreme passion, all attributes that can be attached to the art of dance. Those big ideas were

Euclidean geometry, theory of numbers, functions and modern mathematics. As a base for the direction in developing ideas we used the resources and materials developed that connect mathematics and dance such as "Dance your PhD" [11] and the study "Dancing Euclidean Proofs" [12].

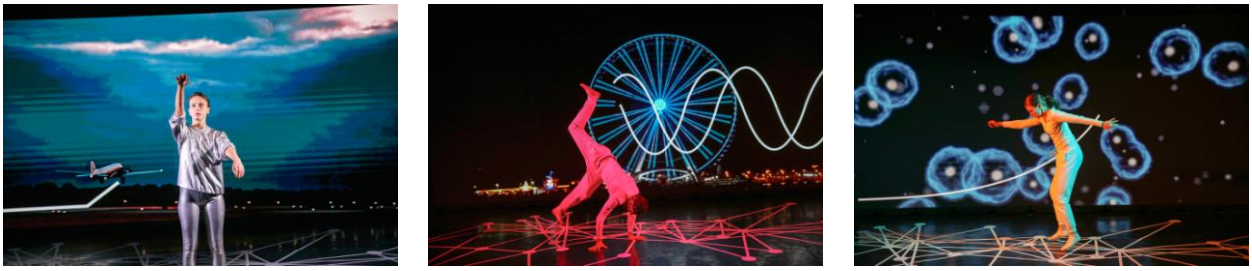
The Process

The creation started by exploring Euclidean geometry and the first step was introducing basic mathematical notions such as point, line and plane. We started with geometry since it is the most apparent and its connection to the physical world is the most evident. Shapes, angles and lines, are also part of different aspects of dance. Once the dancers grasped knowledge of the basic notions and the concept and how they could be represented in the world of dance, we moved on to more advanced notions such as triangles and theorems related to triangles. The dancers and choreographer were encouraged to think about those concepts in the sense of the body-movement combination and their feelings regarding them. For example, while working on the part "Is everything a number?" at the beginning we were analysing odd and even numbers, then prime numbers, while continuing with interesting features of friendly numbers. In that way the numbers were infused with meanings of real-life situations. For each part of the performance, we were following the same patterns: starting from the basic mathematical notions, adding up more complicated concepts and investigating them in the context of body and movement, navigating the imagination of the dance artists to the abstract mathematical ideas. After each phase we conducted critical observations, aiming to shape the ideas and make the content of the performance more approachable and appealing to the general public. Some of the questions that we elaborated were about what is beautiful in the sense of mathematics or dance. What to put emphasis on? What is practical? What is a clear mathematical explanation to non-mathematicians? What is creative? What is an idea and what is its representation? The choice of music was also important since it was supposed to resemble the spirit of the concepts along with the movement. We decided to use instrumental and rather diverse music across each scene. The dance and the choreography were supported by visual representation of a graphics animation. The design followed the dance, the music and the visually completed concepts by clearly stating links with everyday life.

The Performing Phase

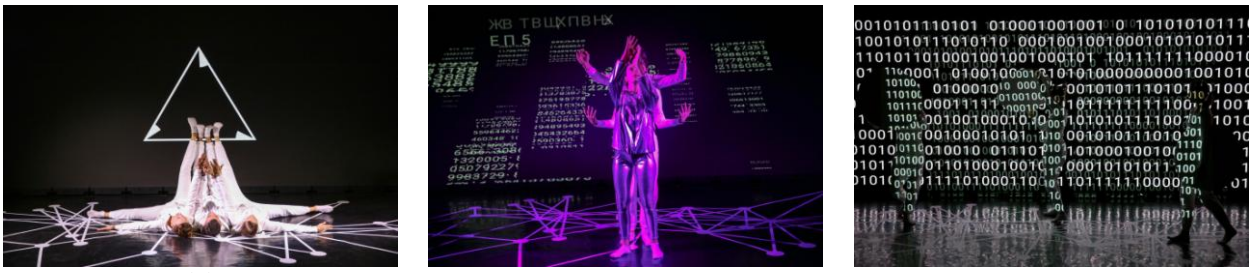
After a period of five months, we have established the final performance as a collage of four separate scenes. The first scene started with Euclidean geometry from a simple description of mathematical concepts such as point, line and plane. Euclidian, but also many other mathematical proofs are abstract, existing only in the imagination, but people are trying to represent them. For example, a point is infinitely small, but we draw it with the real size. For centuries, people were examining geometry from Euclid's postulates [13] which evolved to a discovery tool, and today we know that there are other kinds of geometry. The second part of the performance was dedicated to number theory and inspired by Pythagoras' quote "Everything is a number" but we presented it as an inquiring sentence, in order to highlight the importance to question mathematics and its place in everyday life. We wanted to tackle the idea that from a 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 emerging vibrant city of digits filled with people who carry their stories. The rigid movements created by the 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 hand of Sam Rosenzweig, a surviving Auschwitz victim" in order to illustrate how numbers might strip the richness of the meanings. The third part of the performance was dedicated to the concept of the functions. Our everyday life, including pandemics, transportation, and even social media popularity could be translated into mathematical language. Figure 1. image (a) shows a dancer representing a linear function with rather deprived and limited movements, while image (b) shows sine and cosine functions

presented by typical break-dance movements. In both cases the dancers were determining regularities among the data and visualizing their functional relations. In image (c) we can see a dancer performing an exponential function $y=a^x$. An embodiment of an exponential growth brought a dramatic experience to the scene while representing the regularities of growth of pathogens. Figure 2. (a), (b), and (c) shows Euclidian geometry, number theory and modern mathematics as technology base, respectively.



(a) **(b)** **(c)**

Figure 1: *Artistic representation of: (a) Euclidian geometry, (b) trigonometric function (c) exponential function*



(a) **(b)** **(c)**

Figure 2: *Artistic representation of: (a) Euclidian geometry, (b) numbers (c) modern mathematics*

The fourth scene was the most challenging since it was rather demanding to explain the development of modern mathematics and its influence on the modern world based on technology. The idea was to raise attention to the enormous impact of technology on human life in general. Technology that we know today-the Internet and our reality that is based on different kinds of communication-has solid mathematical foundations. For example, the theory of graphs is one of the bases of the informatics. Even to send a short message, there are many mathematical calculations and operations behind the scenes, for most of us these are a mystery. The scene of binary codes rain to intersect the joints of a graph was representing "caught" messages. This scene was driven by a mental experiment. If we imagine one square meter of the space above our head, let us ask ourselves what kinds of messages are transmitted through that space via wireless signals? Some of the possible messages were showed by dancers, such as: "Enjoy the work, dear!" or "I am having a fever again :(".

During the process of co-creation, we faced many challenges and limits. It was quite difficult to overcome the many prejudices about mathematics which inhibited the creative and artistic expression of the dancers at the beginning. Fortunately, this difficulty was overcome with rehearsals, working on the storyline and exploring the dancers' views about mathematics. Also, it was hard to strike a balance between banal and obvious representations and deep mathematical and artistic meaning. Weak points were strengthened by a continued review of the concept and by critical communication. The team was

aware that we might face with public criticism, but we were encouraged by the fact that we were creating an unusual performance with a possibility to open new horizons on mathematical communication and its promotions through the arts. It seems to us as a risk worth of trying.

Conclusions

The performance "A Point Has No Parts" was presented to the wide audience at the open scene at the Kalemegdan fortress in Belgrade in September 2020. It 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 interaction between mathematics and dance could help us understand both areas in a new way, and open possibilities for new research directions.

Acknowledgements

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References

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