Science Spaces: An Open Workshop Concept to Create Science Exhibits

Bianca Violet[1] and Milena Damrau[2]

[1]IMAGINARY gGmbH, Germany; bianca.violet@imaginary.org
[2]Faculty of Mathematics, Bielefeld University, Germany; milena.damrau@uni-bielefeld.de

Abstract

We introduce and outline a workshop concept called *Science Spaces* aimed at High School students, which combines mathematics and natural sciences with art to strengthen creativity, imagination, and perceptual abilities. The workshop guides the participants through the process of designing and implementing a public exhibition.

The Concept

The *Science Spaces* workshop concept is one of the latest projects of IMAGINARY, which is a non-profit organization that creates and distributes interactive exhibits that communicate modern mathematics to the general public [4]. The goal of each *Science Spaces* workshop is to develop science related exhibits, which will then be presented in a public exhibition (see Figure 1). The scientific content of the exhibits is important in these workshops, as are the interplay with art and science, sustainability and science communication.

Figure 1: *Public Science Spaces exhibition at Green Hills Academy, Kigali, Rwanda*

Science Spaces was designed with the Goethe-Institut in mind. The concept is centred around STEAM themed workshops that form part of German as a foreign language courses in schools around the world, deepening both scientific understanding as well as improving foreign language skills in German. IMAGINARY offers the *Science Spaces* workshops to German language classes run at schools that are part of the "Schools: Partners for the Future" (PASCH) initiative. This initiative consists of a global network of more than 1,800 PASCH schools, with each of them having a particular tie to Germany. The Goethe-Institut supports around 550 PASCH schools as part of the national education systems in over 100 countries [6]. However, the language component is not the only aspect that is special about the *Science Spaces* workshops. It is also the didactic approach which distinguishes these workshops from traditional school science fairs. The participants decide for themselves what exhibits they would like to develop. The IMAGINARY instructors only guide

them through the process, providing just the right amount of input and knowledge necessary. While *Science Spaces* is currently run in German, the overall concept is readily adaptable to other languages, with the idea of combining foreign language classes with the design and development of scientific exhibits.

A Typical *Science Spaces* Workshop

A *Science Spaces* Workshop is intended to run for three to four days, but that can be adapted to suit the needs of the school. For groups of 12–15 participants, IMAGINARY will usually provide two workshop guides. It is important to establish some background information on the participants early on, such as age, language skills, scientific education, etc. IMAGINARY has prepared several helpful documents (i.e. general workshop concept, questionnaire for preparations, list of supplies, and technical equipment) which are openly available [7]. However, it is worth mentioning, that there are no requirements or prerequisites to meet in order to host a *Science Spaces* workshop. The flexible design of the workshops means it is versatile and adaptable to the local resources.

The primary goal of a *Science Spaces* workshop is to jointly create exhibits for a science exhibition. Whenever possible, the IMAGINARY instructors bring examples of possible exhibits, hands-on games and experiments to show the attendees in the beginning of each workshop. The experience with hands-on exhibits produced by the Museu de Matemàtiques de Catalunya [5] has been particularly positive. The instructors also introduce software exhibits, such as SURFER (about the connection between formulas and shapes), MatchTheNet (about polygons and their net representation, improves spatial apprehension), Mappae Mundi (exploring the geometry of map projections) and Math to Touch, which have been presented in many IMAGINARY exhibitions [3] (see examples for hands-on games and software exhibits in Figure 2).

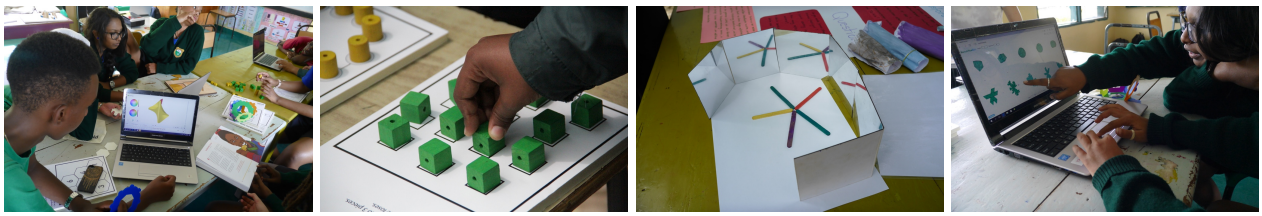

Figure 2: *Examples for mathematics exhibits, used in the introduction part of the workshop*

At this stage, the IMAGINARY instructors – all with strong scientific backgrounds and long standing experience in science communication – give an introduction to different fields of mathematics and other natural sciences. Topics include cartography, algebraic surfaces, polyhedra, fractals, relation between math and music, symmetry, minimal surfaces, the solar system, other physics and chemistry related experiments, etc. Any interest or question of the participants will be investigated in detail and can lead to a new exhibit. The instructors always aim to give the participants an understanding of recent mathematical research (like the pentagonal tilings) and open problems to show that it is not at all "complete" as some might think. The workshop participants explore example exhibits, learn about their scientific background and their connection to art [2]. They can then discuss pros and cons of each exhibit and come up with general demands and requirements for fun exhibits and a successful exhibition. Breaking up into smaller teams for brainstorming about possible new exhibits works well and leads to some initial research and sketches around the exhibit idea. If the schedule allows, the first day ends at this point, so that participants can continue to think about their idea until the next day.

The second day may start with presentations of the concepts of each of the subgroups leading to further discussions amongst all workshop participants. The scientific and artistic concept for each exhibit will be developed, tools and materials needed are discussed and organized. The workshop instructors will guide this process, answer questions and provide tips and tricks. However, it is the intention of a *Science*

Spaces workshop to only offer just as much help as necessary and to go along with the original ideas of the participants.

Another important task is to plan the upcoming exhibition. Venue and dates are usually already fixed, and there is an idea about what kind of audience to expect. Options for the layout and organization of the exhibition need to be discussed and a team of participants can work on a marketing campaign, design and hang posters and do other types of announcements and invitations. As the production of the exhibits progresses, more and more details of the exhibition setup become tangible.

Exhibits may be presented with labels or description boards, hands-on exhibits might need instructions or suggestions for the user (see examples in Figure 3). The teams need to be aware of each other's work during the whole production phase in order to create an appealing and consistent exhibition experience for the visitors.

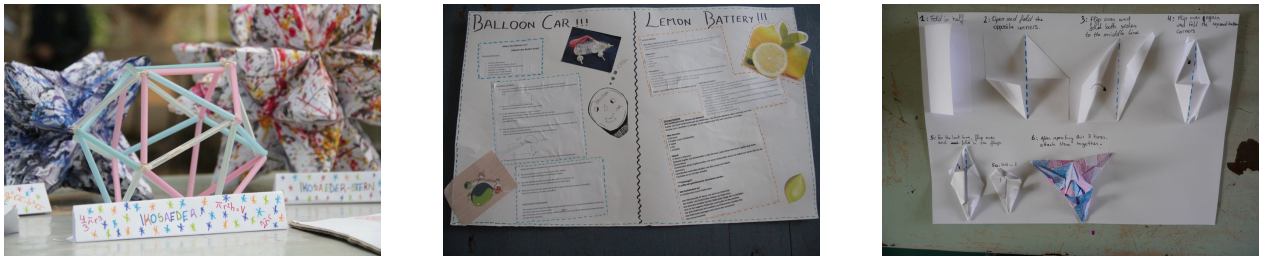

Figure 3: *Labels, description boards, and instructions*

Example Exhibits and Exhibition Setups

Since each *Science Spaces* exhibition depends on the participants creating the exhibits, every exhibition is different. In this section, we present some specific exhibits and exhibition setups of past *Science Spaces* workshops. In every exhibition, there have been several exhibits regarding different topics. One example is the Bascetta origami star [1] (see Figure 4). It became an all-time favorite in the *Science Spaces* workshops. The Bascetta star combines the mathematics of polyhedra and three-dimensional symmetry with artistic techniques using simple materials such as paper. Starting from 2-D shapes, mathematical and geometric concepts are intuitively perceived and spatial understanding is stimulated.

Figure 4: *Bascetta Star, details and setup in the exhibition*

There have been exhibits explaining physical concepts including the lemon battery, a balloon car, additive color experiments, bridge constructions, a model of the solar system, a wooden double pendulum, soap film experiments, and many more. A team of students in Vietnam developed a new strategy game, promoting logical reasoning. The IMAGINARY instructors encourage the development of interactive exhibits. In the Bascetta Star example, paper and folding instructions for the visitors were provided. Also, visitors could create their own additive color light art using three different flash lights as well as prepared stencils of different

shapes and activity guides. The students particularly enjoyed explaining their exhibits to schoolmates, teachers, parents and general visitors (see examples in Figure 5).

Figure 5: *Student exhibition guides*

Conclusions

So far, there have been four *Science Spaces* workshops in four different countries; Rwanda, Vietnam, New Zealand, and Uzbekistan, with more being scheduled. Experiences in all countries have been very positive and the concept proved to be highly effective for several disciplines: Using scientific methods, being creative and producing a concrete output, while also using a foreign language in a more natural environment than a restricted class room atmosphere. Imagination and perceptual abilities are strengthened, teamwork and personality development are supported. The participating teachers were impressed by the didactic approach and the effect it had on their students' learning and motivation. Some requested additional teacher training, so that they can make use of the methods themselves. IMAGINARY is now developing additional material for teachers and will offer trainings for math and science teachers in addition to the *Science Spaces* workshops. The workshop concept as well as the developed exhibits are open source and will be collected on the IMAGINARY platform (www.imaginary.org). Anyone is invited to use and adapt them. Through this project, the understanding of artistic and scientific concepts as well as the joy found in doing so is promoted worldwide. It empowers young people to organize local exhibitions and to disseminate math-art across the world.

Acknowledgements

We would like to thank Antonia Mey and Hernán Villamizar for feedback and assistance with the article.

References

[1] P. Bascetta. Bascetta Origami. http://paolobascetta.format.com/.

[2] H. Bosse, L. Walter and B. Weygandt. "Symmetrie—Mathematik und Schönheit." *Hessische Schülerakademie*, Burg Fürsteneck Akademie für Berufliche und Musisch-kulturelle Weiterbildung, 6/2016.

[3] IMAGINARY. https://www.imaginary.org/programs.

[4] A. D. Matt. "IMAGINARY—a How-to Guide for Math Exhibitions." *Notices of the AMS*, 64, 2017.

[5] MMACA. Catàleg Botiga. 2016. https://www.mmaca.cat/images/mmaca/downloads/cataleg_botiga_web.pdf.

[6] "Schools: Partners for the Future" Initiative. https://www.goethe.de/en/spr/eng/pas.html.

[7] Science Spaces Project Page. https://imaginary.org/project/science-spaces.