

IMAGINARY—Mathematical Creations and Experiences*

Gert-Martin Greuel

IMAGINARY is the name of a collaborative mathematics outreach project that aims to improve the image and understanding of mathematics and in this way awakes an interest and fuels passion for the subject in children and adults. This goal is achieved in different ways: on the one hand by showing the beauty and art in mathematics and on the other hand through surprising applications.

IMAGINARY is a project of the Mathematisches Forschungsinstitut Oberwolfach (MFO) and it was born in conjunction with the Year of Mathematics in 2008 in Germany. It started with the travelling exhibition “IMAGINARY – through the eyes of mathematics”, shown in many cities in Germany.

Exhibitions

Exhibitions are the IMAGINARY way to reach out to a broad public in real life. They are shown in galleries, at museums, in schools, banks, universities, parks or train stations. Exhibitions are diverse: they can include images, interactive programs, sculptures, puzzles, games, text boards, etc.. Visitors can take print-outs of their creations home and everybody can easily stage an own exhibition. In fact, many of the exhibitions were self-organized.

Let me give an impression of the original travelling exhibition. Since 2008, it has been shown in over 60 cities in Germany alone. But it has also travelled further afield to 4 continents, 29 countries and over 120 cities with more than 1 million visitors in total. In Europe, IMAGINARY has been presented in 17 countries with talks, workshops, media activities and, in most cases, exhibitions.

What made the exhibition unique from the beginning, is its highly interactive and intuitive nature and its open access and open source philosophy. This is also reflected in the many positive comments left in the guest book by visitors having experienced the unexpected beauty and the “joy of comprehension”:

*- This already beautiful exhibition is obtaining a special liveliness by excellent leadership.
- Super, especially that you can also use the program in the school. - A wonderful exhibition. I have spent much time here and met many beautiful things, it had to take place more often and actually as a permanent event! - Thank you and keep it up! - It is a fantastically beautiful exhibition. - The magic world of mathematics is not easy to understand. But you can bring them closer. - We were again there, because it was so fascinating. - I should have perhaps studied math - Simply gorgeous, cool programs. - Mathematics makes happy.*



Exhibition at the Leibniz-University Hannover, 2008



Cedric Villani inaugurating the IMAGINARY exhibition in Paris, 2010

SURFER Creations

One of the main attractions of an IMAGINARY exhibition is the SURFER, a program that calculates and displays algebraic surfaces in real time. Visitors can enter and change polynomial equations on a large touchscreen with their fingers, shift parameters, determine the colours of the surfaces and turn the figures as they like. The great thing about SURFER is that you don't have to understand the underlying mathematics (algebraic geometry) a priori, you can experiment, try, follow your intuition and creativity and this way learn mathematics and create unique art work like pictures or animations.

SURFER was developed by the MFO in collaboration with the Martin Luther University Halle-Wittenberg and the University of Kaiserslautern, mainly by Christian Stussak. Many visitors of an IMAGINARY exhibition downloaded the SURFER and created their own algebraic surfaces, with sometimes really surprising results.



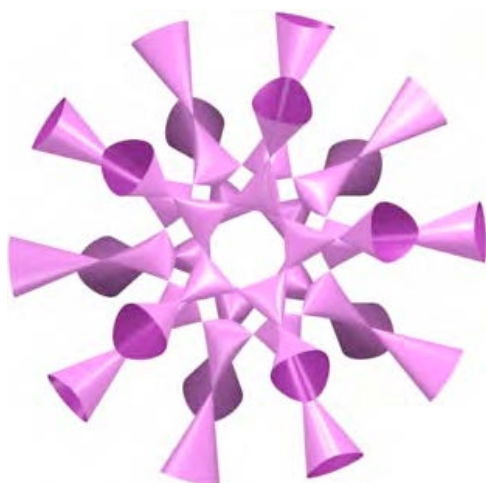
"Cappuccino" by Valentina Galata



"Sunflower" by Torolf Sauermann

For example, Valentina Galata started in 2008 when she was a 17 years old high school student to remodel 'real world objects' based on algebraic surfaces with the SURFER. Other users of the SURFER created really artistic pictures of algebraic surfaces, like the beautiful Sunflower image by Torolf Sauermann.

Relation to Research



The origin of the SURFER is very closely linked with current mathematical research. A first version goes back to Stephan Endrass, a student of the mathematician Wolf Barth, who discovered the "Barth sextic". The Barth sextic is a beautiful surface of degree 6 with the symmetry of an icosahedron (and with a terrible complicated equation). It holds the world record with 65 simple nodes, the maximum possible number of singularities. From degree $d=7$ on, the maximum number of singularities on a surface of degree d is unknown.

A new IMAGINARY project is to connect modern mathematics and current research to outreach. Mathematicians visiting the MFO are asked to write about their current work but for

a general public. These so-called “snapshots of modern mathematics” are then reviewed and edited and distributed through the project. For details see the overview by Carla Cederbaum in this article.

IMAGINARY in schools and classrooms

First schools started to copy the exhibition or parts of it, for example the pictures or the programmes by a high school in Saarbrücken. Also first self-organized exhibition were held e.g. in Kiev and IMAGINARY competitions were organized e.g. by a newspapers in Greece. The Girls’ Day at the TU Berlin was a one day event to attract school girls to study mathematics by using the SURFER. Especially the programme SURFER is ideal to be used in the “school context”, for example a 4-days workshop for school students aged 12-14 in Vienna, called “Kinder-Uni-Kunst”. The idea was to create mathematical animations with music and while making the films with SURFER learning basic underlying concepts of algebraic geometry. See also the personal point of view by the mathematics teacher David Grünberg about IMAGINARY in school in this article.

A collection of IMAGINARY worksheets of different levels of difficulty has been developed for school children aged between 5 and 17 years. IMAGINARY booklets with questions and explanations are used during exhibitions for guided school tours or at special workshops. The so-called “Entdeckerbox” (discovery box) is primarily aimed at use in the classroom and provides resources for teachers in order to make mathematics lessons more interactive and interesting for the pupils. It contains 3D-sculptures, nine programs and films and, as a special highlight, the booklet “Problems for children from 5 to 15” by V. I. Arnold. This text has been translated into 6 languages and may be downloaded at imaginary.org/search/node/arnold.



The mathematics of planet earth

However, the original exhibition was not enough; it focused on a very beautiful yet small part of mathematics. The project needed to grow further and the Mathematics of Planet Earth Year 2013 (MPE) presented a good opportunity to do so. A competition for virtual exhibition modules themed around MPE was announced, and IMAGINARY provided the required web infrastructure in order to make the modules of the competition available online. At the launch of the MPE year in Europe at the UNESCO in Paris, the web

interface to IMAGINARY - open mathematics (imaginary.org) went live, displaying entries for the competition and, of course, the winners.

At the same time, a complete MPE exhibition is also available, consisting of a series of modules with a more applied mathematics focus, such as a program that calculates the displacement of volcanic ash clouds (Dune Ash) or a film discussing how mathematical modelling of glacial movement works in order to predict the future behaviour of glaciers.

International spreading

The "travelling exhibition" IMAGINARY developed into a "spreading exhibition" through many partners who independently started to stage it and further expand it. IMAGINARY exhibitions were shown in 4 continents, 29 countries and over 120 cities with more than 1 million visitors. An example is the RSME (the Royal Spanish Mathematical Society) who took the exhibition at the occasion of its hundreds anniversary, added new texts and translations and staged it in more than 13 cities. Another wonderful example is the cooperation with National Institute of Mathematical sciences (NIMS) and the ICM 2014 in Korea that was made possible mainly by Hyungju Park. The exhibition NIMS IMAGINARY during the ICM was visited by about 12.000 visitors, among them many school classes, and attracted a lot of media coverage.



The exhibits were also installed and shown in science and mathematics museums. For example the MiMa museum for minerals and mathematics in Oberwofach, the new MoMath in New York, the "Mathematisches Kabinett" in the Deutsches Museum in Munich, the Formula & Formas exhibition in the National Museum of Natural Sciences and History in Lisbon, and the CosmoCaixa museums in Barcelona and Madrid.

In 2014, many new exhibitions have been launched around the world. In particular, IMAGINARY has started a collaboration with the African Institute for Mathematical Sciences (AIMS) and, in association with AIMS, an interactive IMAGINARY event was organised for the first time in Africa at the 10th anniversary pi-day celebrations in Dar es Salaam, Tanzania. In November 2014, a workshop and exhibition will be organised in Cape Town to plan future mathematics communication activities with partners on the African continent. IMAGINARY's exhibitions are currently on tour or planned in Germany, Russia, Spain, Norway, Portugal, and Hungary, and new project in France and in Turkey are on the way.



Who stands behind IMAGINARY?

IMAGINARY is a project by the MFO, accounted by its director Gerhard Huisken, with funding from the Klaus Tschira Stiftung. It is maintained by a committed core team (mathematicians, software engineers, graphic designers, etc.), who run the project, develop the Internet platform and give advice on how to coordinate exhibitions, but also dream up new ventures of where IMAGINARY will go in the future. The excellent achievements and the impact of the project was acknowledged in November 2013 by the Deutsche Mathematiker Vereinigung (DMV) when the German Media Prize for Mathematics was awarded to Gert-Martin Greuel, the former director of MFO and scientific advisor of IMAGINARY, and Andreas Daniel Matt, the curator and project manager of IMAGINARY.

Besides the core team, and most importantly, IMAGINARY it is a community driven project by and for the community. This means that anyone who has an interesting piece of software, film or other type of interactive material can upload this to the website and make it available to the rest of the community. Of course, anyone can just use the material and create a mathematics event, exhibition or workshop. In this way, the community becomes an integral part in the communication process by not only experiencing but also creating content and thus advancing mathematics communication to the 21st century. We hope that many institutions make use of the content and infrastructure of IMAGINARY, and take an active part in shaping its future.

* In: Carla Cederbaum, Alicia Dickenstein, Gert-Martin Greuel, David Grünberg, Hyungju Park, and Cédric Villani: IMAGINARY PANEL: Math communication for the future – A Vision Slam, Proceedings of the ICM Seoul, Vol. I, 2014.