# Feedback from students

### SCIENCE HOLIDAYS AT JOHANNES KEPLER UNIVERSITY

We had the opportunity to conduct workshops with about 60 students during the Covid pandemic in the summer of 2020. In total about 200 children had access to the game. We first let the students between 9 and 12 years of age explore a 2D open game called Points and Edges and afterwards, we tested some easier exercises from the mathematics part of the Logifaces exercise book.

***Figure 15:*** *Students during the JKU Summer Workshops creating Logifaces blocks with their bodies*

***Figure 16:*** *Explaining the game to students so they can create their own artwork in pairs or alone*

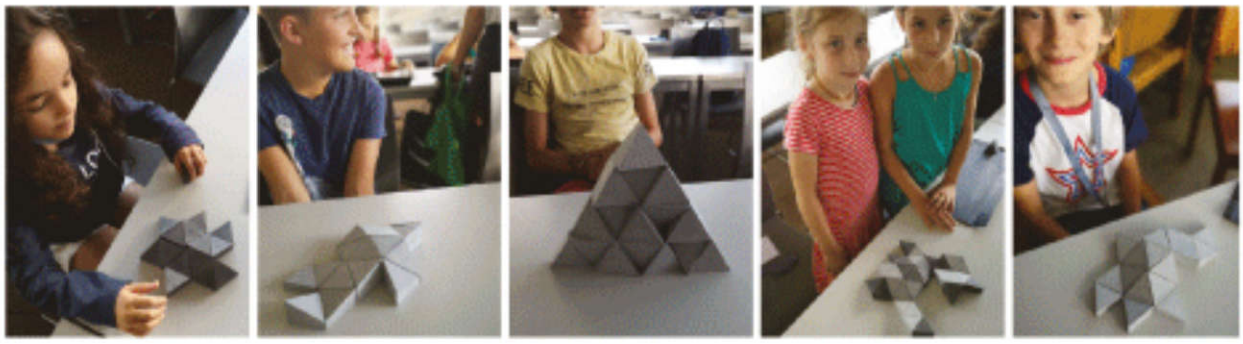


***Figure 17:*** *Proud students presenting their artwork*

We first started introducing mathematics by showing the students where mathematics surrounds them in their daily lives. We asked them to tell us about examples of where they suspect mathematics is involved and then showed them how mathematics can be found in nature. We emphasised the connection between mathematics and vegetables such as broccoli or leaves or the growing of trees or the shape of the human body. Then we showed them how games can support maths or how other subjects such as art can be connected to mathematics. In the end, we first asked them to get comfortable with a 2D maths game with open solutions called Points and Edges created by Julia Handl and then gave them Logifaces, first just for playing with and then later for doing some of the exercises developed for the Logifaces project.

***Figure 18:*** *The lesson plan was tested and put in operation during the Johannes Kepler University Summer Workshops in August*

The students were asked to fill out a survey after the workshop to help us understand how they perceived using Logifaces as a game and in the exercises. A total of 28 students between 8 and 12 years of age gave us feedback on their experiences, especially with the exercises. 12 of them were boys and 14 were girls, two did not want to state their gender.

Students were very engaged and gave us the following feedback:

> *A surprising number of 10 students answered that mathematics was one of their favourite school subjects. Only physical education was more liked, being mentioned 12 times. After mathematics were arts and crafts with seven mentions. One student wrote that they previously did not count mathematics as one of their favourite subjects but now they did not perceive it as "that bad" anymore ("Deutsch und englisch aber jetzt finde ich Mathe auch nicht mehr so schlecht/German and English but now I think maths is not so bad either").*

We also asked questions about the exercises and the maths experience they had. 18 Students answered that they fully agreed with the statement that using Logifaces was a fun way to learn maths and eight answered that they partly agreed. Only one student stated that they did not think the game was a fun way to learn maths and another did not want to give a comment.

In addition, we asked them about their favourite exercises and about what they think they learned during this workshop. They answered that they loved creating forms, especially pyramids, enjoyed building things and were also happy about the group work. Many of them answered that they think they learned a lot about geometry, about patience, about focus and concentration, and many answered that they learned that mathematics is part of everything around us.

We created an online workshop with this information in mind to give more children the chance to get to know Logifaces, learn about mathematics, and to communicate and discuss mathematical concepts during the pandemic. It can be used for remote teaching or individually by students.

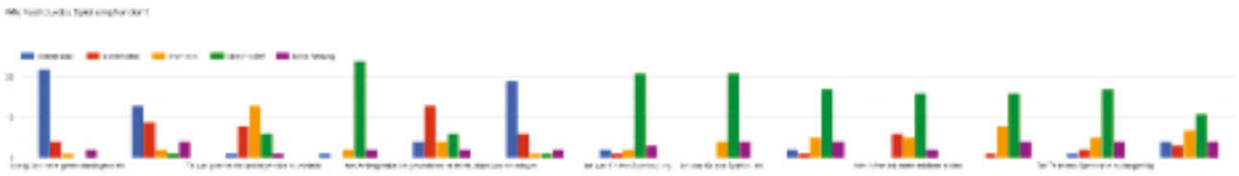


***Figure 19:*** *The lesson plan was tested and put in use during the Johannes Kepler University Summer Workshops in August*

## SPECIAL NEEDS

Discovering the myriad of interactions between disciplines and applying them to the real world is one major focus in early childhood education[34]. Arts, mathematics and sciences are taught daily and teachers try to combine these different subjects in activities such as completing patterns, searching for shapes and forms in paintings or experimenting with different materials. In this research study, we also worked with students with diagnosed mathematical learning disabilities (MLD). MLD is a generic term for a range of developmental difficulties related to mathematics, with each student facing different challenges. Due to the known specific educational needs of MLD students, we presumed that the development of their mathematical skills would be more easily detectable by the teacher. This will help to find out if and in which areas the use of puzzles and games as manipulatives can be beneficial. Some students may have difficulties learning certain skills if they are not motivated or have cognitive difficulties in an area. Thus, manipulatives can be used in education to support children to develop skills.

We used Logifaces to explore its possible impact on spatial reasoning and pattern recognition of students with MLD in early childhood education. We worked with nine students aged 4 to 6 year and their teachers in an experimental setting to create visual art pieces and recreate patterns[35]. The first findings of this research were increased motivation and engagement in discussions about mathematics and arts during and after the pupils solved open-ended tasks using the game.

---

34 Fenyvesi, K., Budinski, N., Kaukolinna, M., Lakos, D., & Lavicza, Z. (2020). Playful Development of Mathematical Thinking Skills in Primary and Secondary School with the Logifaces STEAM Education Toolkit, LUMAT Research Symposium, p40.

35 B. Haas,Y. Kreis, Z. & Lavicza, (2020). Connecting the real world to mathematical models in elementary schools in Luxemburg. In R. Marks (Hrsg.), Proceedings of the British Society for Research into Learning Mathematics: Bd. 40 (2) (1–6). https://bsrlm.org.uk/wp-content/uploads/2020/10/BSRLM-CP-40-2-06.pdf

The research questions of our qualitative approach were:

1. What impact does using manipulatives, such as the Logifaces game, have on students with mathematical disabilities?
2. Which tasks can enhance the development of students' spatial reasoning and recognising patterns in early childhood education while using the game Logifaces?

We started to collect data through task-based interviews[36] and additional field observations for five weeks in Luxembourg with the help of nine children in early childhood. We aimed to develop tasks that can be carried out in future studies by early childhood teachers.

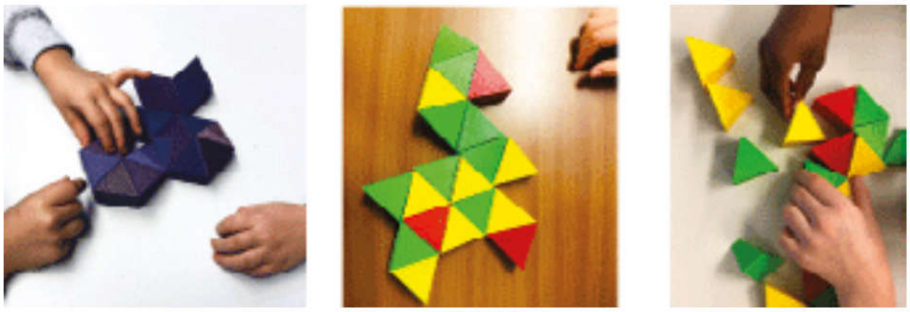
We proposed different game sets and materials to the students at the beginning of our project. Apart from the original game, which is made of concrete and is in different colours, we printed several Logifaces sets with a 3D printer using with PLA and PET-G in different colours. First we let students experiment with the puzzles in a collaborative way with the students in groups of two to three. The differences in how the students experienced the materials were very interesting to observe. Thus, the Logifaces made of concrete were reported by the students as being heavier and easier to manipulate. However, they were more fragile and edges broke when they were dropped. The 3D printed Logifaces were lighter and more robust, but more difficult to use in different combinations since they did not stay in place.

Students tried to organise the Logifaces blocks in the first exercises. Some organised them by colour, some by similar face and some connected two or three Logifaces with the correct side. Depending on the student, the process of categorisation was more or less developed. This could be related to their personal or classroom experience. However, Logifaces incited active discussion among students on how to organise the different pieces. On their own, the students connected the geometrical shapes of Logifaces to several art pieces students discovered incidentally in class, such as paintings by Kandinsky on geometric shapes or architecture like the Louvre's entrance, the pyramid shape. It was important for us to let students discover the materials and try out applications in an open setting to create first connections and indicate possible manipulations to us through task-based interviews. Moreover, students explained how and why they categorised the Logifaces and why they were similar or different to the referred art pieces. One could say these meta-discussions on the connections between mathematics and art were similar to those described by Krauthausen, where students actively explained mathematical concepts and discarded the properties of shapes, forms and patterns[37].

---

36 G.A. Goldin, (2000). A Scientific Perspective on Structured, Task-Based Interviews in Mathematics Education Research. In A. E. Kelly & R. A. Lesh (Hrsg.), Handbook of Research Design in Mathematics and Science Education (S. 517–545). Routledge. https://doi.org/10.4324/9781410602725.ch19

37 G. Krauthausen, (2018). Einführung in die Mathematikdidaktik - Grundschule (4. Aufl.. ed.). Berlin: Springer Spektrum.



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

***Figure 12:*** *Students manipulating the 3D printed blocks (a) creating smooth surfaces, (b) creating animals, (c) creating their own games within the game.*

In the following exercises, students created a series of combinations, this time with the focus on connecting the correct sides. The combinations ranged from two to five pieces, where many creations were made using one axial approach, for instance, one vertical or horizontal row. Only a few students created biaxial works. Within the peer approach, students discussed and invented patterns for their creations, for example, based on colour, shape or surface. We noticed that students developed new strategies in spatial reasoning and laying patterns out while manipulating the Logifaces. Thus, the creations gained complexity regarding the colours and the number of pieces they used in their patterns, driven by aesthetic appeal. Students also became faster in creating these mathematical art pieces. In our last manipulation sessions with Logifaces, the students discussed developing their creations further, by adding new colours with 3D printed blocks and increasing the number of disposable pieces to create landscapes.

The children displayed development in their mathematics and art skills. Due to the students' iterative testing of the materials using a creative approach, over time they felt more confident about solving the open-ended task. They discovered more and more mathematical features of the blocks, thus their development of geometric reasoning and spatial organisation improved. This teachers found this out by listening to the lively conversations of students had among themselves.

Aesthetics played an important role in the patterns the students made. The students developed their artistic skills further in the process; it was just like students were drawing with the blocks, fully in flow in their creative process. The students recognised and created patterns with increasing complexity and figured out the one rule of the game, to always create a smooth surface, by themselves, because they made choices to support their aesthetic preferences.

Other positive findings included the peer interactions that lead to a visible development of student meta-language, and thus allowing different paces for the students. All students showed a high level of motivation and engagement. They enjoyed playing and learning with the blocks so much that they repeatedly requested to use them again in class. The teachers also rated the learning experience with Logifaces very highly and plan on continuing to work with the game. The positive findings spread to other teachers in the school, who are now also happy to use the game in their lessons.

## Discussion and Outlook

The data collected so far in discussions with teachers and interactions with students is encouraging. It indicates that Logifaces can be a useful tool to support educational environments in multiple ways. As became apparent in the teacher interviews there is not necessarily a widespread use of games or technology in classrooms, live or digital. Bringing teachers and students in contact with Logifaces may be the first step to teachers treating games with a more positive attitude and as an innovative tool for students. After gaining knowledge about teachers' beliefs and practices we want to lay the foundations for gamification gaining access to more educational spaces.

The classroom work with MLD students shows that they associated Logifaces not only with mathematics but also with art and they naturally connected the two subjects. Moreover, exploring the possibilities of these manipulatives fostered collaboration between students immensely, which we did not anticipate to the extent experienced. This was also the case in the summer school workshop program at Johannes Kepler University. Both aspects are interesting subjects for further investigation and research and students could, for example, use Logifaces in art history as a tool for understanding and perceiving art more fully. We want to produce high-quality, valid teaching materials for all teachers, not only those involved with MLD students.

The exercises with children with special needs in mathematics and the experience of language teachers show that exercises using the game hold much potential. Children with special needs can be supported from a very young age and language skills can be taught using the Cuisenaire rod example. Colours can be added as an additional data dimension, as used in some experiments we have mentioned that provide additional motivation. The strength of the game lies in its flexibility as a tool, it being fun to play in all age groups and combining different fields of mathematics with art and social interaction. So in the Logifaces project, a wide range of exercises are being created to suit different age groups, school types and school subjects, with each meeting different student requirements.

It is our goal to test these in the field. The Covid-19 situation makes testing the methodology difficult at the moment, but we hope to circumvent this by creating exercises for home-schooling as well. As soon as the situation improves, combining this work with 3D printing and other puzzles and games used as manipulatives will be another interesting direction for our research. The GeoGebra platform may be a useful tool and partner in this too. More research will deepen the knowledge we gained during this project about manipulatives and help us to apply it.