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# Developing mathematical modelling skills for mathematics teachers through 3D modelling and 3D printing (3DMP)

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## Description of Research Topic

Mathematical modelling (MM) skills are considered highly valuable for Science, Technology, Arts, Engineering, and Mathematics (STEAM)-based education. MM is also part of geometry as is used for example in 3D modelling and 3D printing (3DMP). This overlapping can contain new forms of training teachers in an emerging technology, their MM skills, and providing them with tools to teach MM based exercises. MM aims at connecting real world problems with mathematics as means to solve these problems with a feedback improvement loop (Blum & Leiss, 2005). A mathematisation and de-mathematisation process has to be performed as a link from the mathematical model to the real-world solution and after the modelling step, a validation step is performed to investigate whether adaptation is necessary (Jankvist & Niss, 2020). This process has similarities to 3DMP where real world problems are also tackled by mathematising the problem, modelling it, de-matematising it by the following 3D print, and validating the result by iteratively checking whether improving the model is necessary. For example, to receive 8 cookies from a given dough size, a 3DMP cookie cutter could be created where the solution can be tested after printing. This suggests that at least for some areas such as geometry, 3DMP can be used as an instance of a MM process. Approaches to use 3D printing can improve MM skills as research indicates in the training of 50 mathematics teachers in 3D printing that reported perceived improvement of their MM skills as was also visible from their 3D prints (Asempapa & Love, 2021). This trains modelling skills, by transforming real-world information into mathematical concepts and skills, referring to the model of Blum and Leiss (2005), are highly needed for teachers to instruct their students in mathematics education. As both MM and adopting new technologies can be challenging for teachers, ways to improve technological problem-solving skills and exercises teachers can use should gain more attention (Drijvers et al. 2013). In this poster, formatted by A0 size and containing links to GeoGebra resources, we will present data driven elements for a pedagogical framework of a 3DMP course that aims at supporting Austrian pre-service-mathematics-teachers (PSMT). Our question is: what are attributes of a course framework that trains 3DMP and MM skills? We want to find hints for insight into needed ingredients that help them master this technology and provide MM exercises the PSMT's can use in their later lessons.

## Steps Towards a Course Framework and Preliminary Results of the first attempt

The basis of our first course attempt was experiences of 3DMP workshops in 10 schools in Montenegro which were conducted in a design-based research manner introducing the technology and possible exercises. A task for the teachers was to create a cookie cutter with specific constraints such as size- and thickness limitations of the 3D printed version. A theoretical part contained examples of applications of the technology in mathematics lessons and personalized aids for students,

theory about 3D models and modelling as well as the theory about the 3D printing process. A practical part aimed at getting familiar modelling first models, printing and revising them after adaptations to the model iteratively. After a year, we interviewed 37 of them to learn about their view and usage of the technology. During the analysis of the transcripts we found that these teachers reported that the course and working with 3D modelling in particular improved, amongst others, their MM skills. So, the concept of first course modules was based on the structure and experiences of these workshops.

We created three 3DMP modules focusing on 3D modelling for 60 Austrian PSMTs with a content structure similar to the workshops in Montenegro that accompanied a geometry course for second level education. The PSMTs had to create their own projects documented in GeoGebra books. The projects should explain a problem and the models to solve it had to fulfil the constraints of a certain printing time. They had to report their ideas, give feedback to each other's projects and the models had to be revised accordingly. This led to new and improved 3D models similar to the process described by Blum and Leiss (2005). We read through the documentation and found hints that the 3D modelling part was especially useful to train the mathematization step. We took these learnings to design a course structure concept to support 3DMP and MM skill improvement.

### **Discussion and Presentation: A Course Framework Concept for Teachers**

The poster contains a description of the setup of the course, a description of the evaluation of the first course and a framework for upcoming courses. Based on this first course, we will develop a course dedicated only to 3DMP and check the PSMTs MM skills during the course. In the course, 3DMP and MM will be introduced. We give the participants a geometrical modelling task by letting them create mathematical 3D mazes in GeoGebra, then will conduct the course and give them a task requiring similar skills that can also be solved in GeoGebra. This task has to be solved in individual projects. A questionnaire and looking at the documentation in the GeoGebra books about their experiences and possible changes will provides more insight if and which aspects of the course changed their skills in mathematical modelling in geometry. This will help to identify aspects of how a 3DMP course should be shaped that also helps improve MM skills. We hope to create a new possibility of raising the sensitivity of future mathematics teachers for MM by connecting it to 3DMP.

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