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## **MATHEMATICS CULTURE AS TEACHING MATERIALS AND STEAM TEACHER**

### **1. First of all**

In this paper, we will examine what kind of curriculum is needed to train teachers who will instruct STEAM education centered on mathematics and art.

### **2. STEAM education curriculum**

Since the content and methods of STEAM education and mathematics education have not been established, we investigated how they are discussed.

In addition, we are deeply considering "valuable mathematics content" as a topic for consideration. In order to deeply consider the "valuable content of mathematics," activities that allow students to feel that it is effective to use mathematical knowledge and approach from a mathematical perspective and way of thinking when solving problems related to non-mathematical phenomena.

### **3. Training teachers who can teach STEAM education**

In order to realize and put STEM education into practice in arithmetic and mathematics classes, there is an urgent need to discuss the form of teacher education. Gradual development of the qualities and abilities necessary for the development of teaching materials and lesson design for comprehensive STEM education, the introduction of learning activities that allow participants to experience the process of mathematical modeling, and the adaptation of materials in arithmetic and mathematics textbooks to STEM education. We aim to improve.

### **4. At the end**

Based on the trends in education around the world, implementing STEAM education seems to be the default route, but in Japan, theoretical research has taken the lead, and there are not many specific programs for STEAM teacher training.

# MATHEMATICS CULTURE AS TEACHING MATERIALS AND STEAM TEACHER TRAINING

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## PROBLEMS AND RESEARCH OBJECTIVES

STEAM education in Japan has not yet been incorporated into the curriculum guidelines, and most private and public schools are practicing it at research-designated schools, with few examples in public schools. However, it has already been proposed by the Ministry of Education, Culture, Sports, Science and Technology<sup>\*1</sup> and the Ministry of Economy, Trade and Industry<sup>\*2</sup>

The most concise definition of STEAM education in Japan is as follows.

- 1) Learning in two or more subjects in which the characteristics of the subjects are meaningfully related.
- 2) The association of multiple areas is interesting for learners and can motivate them to continue learning.
- 3) Things that are thought to create new culture and value by linking multiple fields.

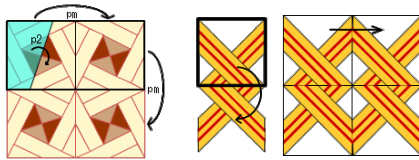
With the exception of programming education, there are few teaching materials that link STEAM education and mathematics education, so it is necessary to develop teaching materials. The author has been developing teaching materials based on the culture of mathematics from the perspective of STEAM education. In this paper, I will introduce the teaching materials that I have developed so far, and I would like you to suggest any other good ideas you have.

Next is the training of teachers who can develop these teaching materials and teach classes. Developing the content and methods of STEAM education and teacher training must be carried out in parallel. This paper proposes conditions and challenges for training such teachers. I look forward to your opinions regarding this paper.

## DEVELOPED TEACHING MATERIALS

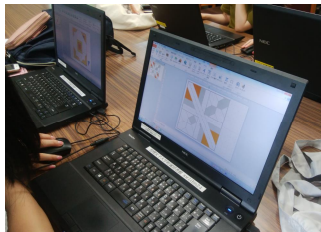
### 1) Geometry education using Hakone marquetry<sup>\*3</sup>

This activity uses the Hakone marquetry pattern, a traditional craft from Kanagawa Prefecture, Japan, as a subject to learn about geometric movements such as line symmetry, point symmetry, and similarity.

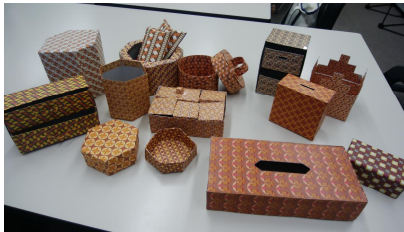


Pic2 pattern rotation

Pic1 Hakone marquetry traditional crafts



Pic3 Pattern design by students



Pic4 Accessories designed by students

### 2) Geometry education using optical toys<sup>\*4</sup>

Using optical toys housed in the Galileo Museum in Italy as the subject matter, this activity involves experiencing how objects appear to have different shapes depending on the perspective from which they are viewed.



Optical toy1(museo galileo)



Optical toy2(museo galileo)



Optical toy3(museon der stadt nürnberg)

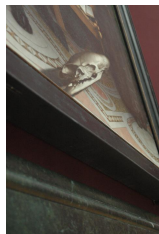


Trick Art1 Edward VI (original aspect ratio)(National Gallery-UK) ↑

Trick Art2(diagonal diagram of TR1) ↓



Trick Art3 Die Gesandten (National Gallery-UK)



↑ Trick Art4(diagonal diagram of TR3)



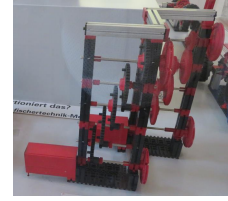
## FUTURE RESEARCH TARGETS

Learn mathematics by recreating a machine created by Italian Galileo Galilei using the German Fischertechnik.



Pic5 Da Vinci's machine (model) (Italy)

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What kind of education can we provide?

Learn the characteristics of line-symmetric and point-symmetric figures using Japanese Kumiko work as a theme.



Pic7 Room decoration with Kumiko using

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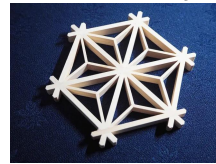


What if children learn traditional crafts?

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What kind of education can we provide?



Pic8 Kanuma Kumiko traditional crafts



## TEACHER TRAINING FOR STEAM EDUCATION

We will consider what methods and content the above students should learn in order to provide STEAM education at elementary school.

In Goto<sup>\*5</sup>, the author proposes the following six points regarding the development of teaching materials that lead to STEAM education.

- ① Teachers are always interested in the colors and shapes of familiar objects and look at them.
- ② Think about the relationship between objects and mathematics
- ③ Discover mathematical elements in objects
- ④ Investigate reference materials and information in detail
- ⑤ Supplementary information on research such as actually visiting the site
- ⑥ Extract mathematical concepts from the object and clarify what kind of theory it is based on

Specifically, the goal is to train students who can perform these six items in sequence. The following learning activities can be considered for each item.

- ① Activities to discover whether there are mathematical elements in the colors, shapes, phenomena, etc. of familiar objects
- ② Activities to think about and investigate what kind of mathematics the object is related to
- ③ Activities to extract mathematics from objects
- ④ Activities to extract mathematics related to objects and investigate its principles and theories

### First half learning activities

It is thought that students have no experience with the six items mentioned above and do not have a concrete image of them. Therefore, in order to understand what STEAM education materials are and how children actually learn, we will explain them to each other based on the materials that have already been developed. I thought there was a need for activities where we could get together.

Next, we decided to set up an activity in which students could play the roles of children and experience the STEAM teaching materials developed by the author, which were based on Hakone marquetry.

We asked the students to discuss what kind of cultural and social education and prior knowledge of mathematics they needed from their studies up to this point, and we set up a scene where they decided on their own what they would need to learn in the future.

### Learning activities in the second half

In the second half of the program, once the students have mastered the basics, they are divided into groups and work on creating STEAM education materials. To do this, follow the six steps of developing teaching materials mentioned above in order. In doing so, students need to engage in learning with an awareness of both the teacher's perspective of developing teaching materials and the perspective of the children learning the materials.

## REFERENCE

- \*1 Ministry of Education, Culture, Sports, Science and Technology(2018), Human resource development for Society 5.0 - Changing society, changing learning. [https://www.mext.go.jp/component/a\\_menu/other/detail/\\_ics\\_files/afeldfile/2018/06/06/1405844\\_002.pdf](https://www.mext.go.jp/component/a_menu/other/detail/_ics_files/afeldfile/2018/06/06/1405844_002.pdf)
- \*2 Ministry of Economy, Trade and Industry(2019), "Future Classroom" Vision - Ministry of Economy, Trade and Industry "Future Classroom" and EdTech Study Group Second Recommendation. [https://www.meti.go.jp/shingikai/mono\\_info\\_service/mirai\\_kyoshitsu/20190625\\_report.html](https://www.meti.go.jp/shingikai/mono_info_service/mirai_kyoshitsu/20190625_report.html)
- \*3 Manabu Goto(2016), Perspectives on developing new teaching materials: Using Hakone marquetry as a teaching material as a case study, Journal of the Society for Mathematics Education, Vol.57, No.3· 4, 159-168. [https://www.jstage.jst.go.jp/article/mesj/57/3-4/57\\_159\\_pdf](https://www.jstage.jst.go.jp/article/mesj/57/3-4/57_159_pdf)
- \*4 Manabu Goto (2017), Developing teaching materials that incorporate overseas mathematics culture - Using optical toys as a case study -, Journal of the Society for Mathematics Education, Vol. 58, No. 1·2, 61-70. [https://www.jstage.jst.go.jp/article/mesj/58/1-2/58\\_61\\_pdf-char/ja](https://www.jstage.jst.go.jp/article/mesj/58/1-2/58_61_pdf-char/ja)
- \*5 Manabu Goto (2024), Development of educational evaluation methods in STEAM teacher training, Proceedings of the Spring Meeting of the Society for Mathematics Education (unpublished)