Bridging Aesthetics and Mathematics Education Using Photography

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Abstract

In this workshop a photography-based aesthetic learning activity will be conducted, and mathematic didactical aspects discussed. The workshop is based on the "Mathematics and photography" research project conducted at Volda University College in the period from 2016-2018. Based on Dewey's theory on aesthetical learning experiences, we developed a photography activity with in-service teachers and studied how teachers' visual attention was influenced by the photography and discussion activity. The workshop will encourage participants to re-see and study the outdoor environment and connect real life to school mathematical contexts.

General Information and Introduction

The term aesthetics is often connected to the beauty, harmony, elegance, and balance of a piece of art, a painting or music. In mathematics, for example the elegance of a mathematical proof or the harmony and balance of the platonic solids are known as aesthetical. However, where is the connection to mathematics in the classroom? School children are not mathematicians. They will not think of beauty and elegance when working with a proof or platonic solid [12, 14]. In this workshop, aesthetics in the fields of mathematics is used in the meaning of visual sense experience, wholeness, and aesthetics learning experience [4, 11, 13, 14, 15, 16]. It is well known that photographing can help to notice previously unseen objects [1, 2, 3, 6]. Participants will increase their visual attention and consciousness for mathematics related objects through taking pictures. With one core field of the mathematical curriculum in mind they will explore the environment of their surroundings with their mobile camera. They will analyse one picture in respect to the mathematical content and aesthetical aspects, create an inquiry task and discuss the outcome with the whole group. Examples will be given.

The photography-based activity was developed as a part of the research project "Mathematics and photography" and has been used for several years, both for in-service teachers at Volda University College and in national workshops for mathematics teacher educators.

Theoretical Background

The basic theories used in the research project and this workshop are derived from Dewey's book "Art as experience" [4] and photographer Barnbaum's writing [2, 3]. Dewey made a distinction between ordinary everyday experiences and *an* experience which can give full satisfaction. Those experiences will be remembered and will give a positive impact on learning. Photograher Barnbaum [2, 3] claimed that such a satisfying experience can be achieved by using photography. Research studies supported that using a camera can expand the perception of objects and details that are not recognized without a camera [1, 6]. There are several approaches integrating photography and mathematics education. For example, Rizzo et al. [12] described a photo contest project. Students used their own photos to establish a relation between the mathematical content, art and their environment. Karadag [8] used photography to provide a real-world context for students' geometrical thinking.

Based on these theories, A. Meier (Volda University College) and M. S. Hannula (University of Helsinki), conducted a mathematics teaching intervention with 43 in-service teachers, using photography in a natural environment [10]. Taking pictures and viewing one's own pictures is commonly connected to positive attitudes and emotions. This is often lacking in mathematics education, both among students and teachers. The aim of this research project was on the one hand to give in-service teachers an inspiring

example to design an aesthetical learning experience for their own students. On the other hand, we wished to study the influence of the photography activity on their visual behaviour. We compared two conditions, an outdoor walk while taking pictures of mathematical objects and an outdoor walk without taking pictures (after a discussion in the classroom). The objects they looked at, and the duration and frequency of their gazes were measured with gaze tracking tools [5]. The results indicated a higher degree of visual attention on mathematical objects while photographing and a higher awareness of new mathematical objects after the activity. Using photography in a natural environment seemed to increase the interest in learning mathematics [10].

Concept of the Workshop

The workshop is tailored to an audience who is interested in a context-based visual aesthetical learning experience using photography. The focus will be on mathematics education, however the transdisciplinary approach should give a positive outcome also for audiences from other disciplines, such as science, arts, arts and craft and architecture.

In this workshop participants will be guided in much the same way as in-teachers were guided in our research activity. They will use their own mobile phones. No prerequisite skill is needed to participate. The time needed for a complete classroom session will be about 90 minutes, but the participants can adjust the time for their own needs in the classroom.

Workshop Outline

At the beginning of the workshop participants will get a brief presentation of the core fields of the curriculum for primary and secondary school mathematics, such as algebra, numeracy, geometry, functions, statistics, and probability. They will then choose one of these fields to work with. During the following work they will be able to notice the connections between objects in everyday life and concepts in the mathematics curriculum. Examples from the research project and a more detailed description follow.

Photographing with mobile phones has become very popular and everybody knows how to handle a mobile camera. However, by using one own´s photographs in mathematics education, participants should have at least two important aesthetical aspects in mind. Firstly, the perspective can be very important. For example, for working with the concept of a circle we wish to take a picture of a round car tire. If we don't bend down and photograph it from the correct angle, we will get a picture of an ellipse, not a circle. Secondly, light and shadows are the essence of photography. Our eyes adjust in a perfect way and we do not recognize the sharp contrasts the same way the camera does. Objects placed in the shadows might not be visible in the pictures. The best conditions to take photographs are in the shade or on cloudy days.

The Task

With these aesthetical aspects and the chosen field of mathematics (algebra, numeracy, geometry, functions, statistics, and probability) in mind, participants will be invited to go out into the natural environment of their surroundings and look for objects that might have a meaningful connection to their chosen field of mathematics (Figure 2). They will be told to take five pictures of different objects. The subsequent tasks are given in the following description.

Figure 2: *In-service teachers take pictures*

Description of the Activity

After taking five pictures (about 20 minutes) participants will gather in the digital workshop room in pairs. First, they study their pictures on their own and ask themselves: "Which picture has the potential for creating a mathematical problem (in my chosen field of mathematics)?" and "Can I manage to create a problem which has something to do with the photographs aesthetical character?" To give some examples: In the field of arithmetic objects with which one can count and calculate would be fine. A task for the geometry area could be made based on a picture of two- or three-dimension forms or symmetry. Second, every participant chooses one picture for discussion with their group-partner (see examples from the research project in Figure 3). In the oral argumentation and reasoning they will discuss both aesthetical aspects and the mathematical field which could be taught based on the picture. For example, the pattern of the stones (Figure 3, on the left) could be used for the concept of counting and the four basic arithmetic operations. The drainage pit and the bicycle (Figure 3, in the middle and on the bottom right) could be the origin for a geometry task (shape, area volume). The car registration number might give ideas for number theory and the basic arithmetic operations.

Figure 3: *Examples of in-service teacher's pictures*

After the pairwise exploration of each pictures (about 20 minutes) the participants will brainstorm together for possible tasks (about 20 minutes). The aim is to design a task for the level of their own students at school (or others). The task can be made in a traditional way, like "count", "calculate", "find the area", etc. However, in the recent curriculum development in countries like Norway, England and Australia, inquiry tasks are more commonly requested [7]. In such tasks, a fixed strategy is normally not given. There might be several solutions, and perhaps not every bit of information is given. At this point, participants should make some notes to gather all ideas and finally sketch the task (and a possible solution).

In the end each participant is invited to present their picture and task to the whole group (about 20 minutes) and have an open dialog about the process. Finally, there will be some time to discuss the value of this learning experience. Will students be able to see the world with fresh mathematical eyes and connect the real-world context to mathematical content? Is there potential for an experience of self-sufficiency in Dewey' sense [4]?

The next section contains some practical ideas, based on each of the photos above (Figure 3). The in-service teachers who joined the research project designed these tasks and conducted them in their own classrooms [9].

Outcome of the Activity - Four Examples

Teacher *Eli* designed an activity for her grade three class (Figure 4). When she presented her picture with the stones in a pattern (Figure 3 on the left), she asked her pupils: "What do you see?" The answers developed from concrete objects (for example "stone with some dirt") to more mathematical expressions (for example "nine", "four-sided figure", "many squares"). When the children were told to count the squares, they were surprised how many different solutions there were, from the most obvious nine to fourteen. Eli continued to work with recognizing and counting some properties of two-dimension figures, e.g. side, corner, and surface. The pupils showed different strategies, some used counting, some used multiplication. All pupils were motivated and worked well, as this task was easy to start with, and had potential to more challenging mathematics as well.

Figure 4: S*tudent's work – Counting 14 squares, arithmetic, geometry*

For his third-grade class teacher *Knut* developed a mathematics session about two- and three-dimensional shapes. He used his picture of a drainage pit (Figure 3 middle), a circle filled with stones. Students were told a story about a mole who dug in the circle to find the hidden figures. They soon realized that all possible figures must have a circular base. Different options were explored in discussions and drawings (Figure 5). "What could be the optimal shape for gathering a lot of water?" was the next question Knut asked his third graders. Students discussed several solutions and were highly engaged to connect the real-world context to the mathematical context.

Figure 5: *Student's work - Geometry*

Teacher *Ulf* developed a place value task for his fourth-grade class, based on the numbers on a car licence plate (Figure 3 on the top right). He started with a more traditional task to be sure that all pupils understood. Then they could unfold their creativity in an inquiry task. He told the story of Georg who got the following task in his job interview for the police code-cracking department: The order of the digits shown is wrong. You must find the right order. The following information is given:

- The value of the number is under 70 000.
- The digit with the highest value is placed at the ones place.
- There are no hundreds.
- The sum of the digit at the ones place and the tenth place will be 14.

Figure 6: *Student's calculating*

Pupils were enthusiastic to help Georg to find the code and they managed this after only three minutes. Then they were asked to make their own task and story, based on the same picture. They presented their tasks for the whole class afterwards. While most of the pupils worked well and autonomously, this kind of work was challenging for others.

Teacher *Amelie* presented a photo of a bicycle (Figure 3 on the bottom right) to her second-grade students and asked them to identify, count and mark all shapes (Figure 7 on the left). Together they named the shapes and described the properties. Students were then asked to create their own geometrical bicycle with colourful paper (Figure 7 middle and right).

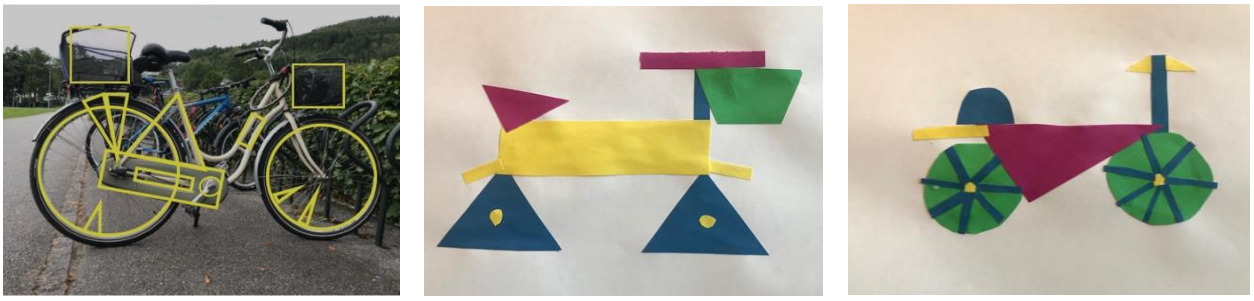

Figure 7: *Examples of student's work – Geometry - bicycle*

Further Discussion

During the activity new questions might come up, such as: Will it make a difference for motivation and learning whether pupils a) take their own pictures and create a task by themselves, b) get a picture from the teacher and create a task or c) get a picture and a task from the teacher?

To be active is important for all learning processes. The activity of taking pictures of real-life objects in an outdoor environment is easy to do for pupils of all ages and levels. However, the subsequent work of creating a task is not something pupils usually do. With some teacher assistance several will manage to create a good task. However, it might be too challenging for many pupils. The teacher, who knows her own class best, has to adjust the task for the actual level in her classroom. During the workshop we will discuss these questions and share our thoughts about options and limitations of this activity.

What will Participants Gain?

Participants will not go home with a finished product, but with both inspiring photos and many ideas on how to implement a photography activity in their own teaching, either in mathematics education or other subjects. As the mobile camera is accessible at any time, it is easy to achieve a satisfying result for everyone.

Conclusions

Photography is a tool that helps us to stop, use more time to observe, explore and see in depth. Participants will experience the whole process of photography: In-depth seeing, taking pictures, analysis of pictures and using them in new contexts of teaching and learning. Furthermore, the visual awareness of real-life objects will increase [8, 10] and they will experience how real-life objects in the outdoor environment can be connected to and might increase the learning of mathematics concepts in the classroom.

Acknowledgements

I would like to express my special thanks to Markku S. Hannula (University of Helsinki) and his colleagues for collaboration and support, and for sharing their gaze-tracking competence. In addition, I would like to thank the in-service teachers who gave permission to use their pictures and work for this workshop.

References

[1] A. Barasch, A. K. Diehl, J. Silverman and G. Zauberman. “Photographic Memory: The Effect of Volitional Photo Taking on Memory for Visual and Auditory Aspects of an Experience.”, *Psychological Science*, vol. 28, no 8, 2017, pp. 1056-1066.

[2] B. Barnbaum. *The Art of Photography: An Approach to Personal Expression*. San Rafael, CA: Rockynook, 2010.

[3] B. Barnbaum. *The Essence of Photography - Seeing and Creativity*. San Rafael, CA: Rockynook, 2014.

[4] J. Dewey. *Art as Experience*. New York: Perigee Books, 1980 [1934] (original work published 1934).

[5] A. Glöckner and A. K. Herbold. “An Eye-tracking Study on Information Processing in Risky Decisions: Evidence for Compensatory Strategies based on Automatic Processes.” *Journal of Behavioral Decision Making*, vol. 24, no. 1, 2011, pp 71-98.

[6] L. Henkel. “Point-and-Shoot Memories: The Influence of Taking Photos on Memory for a Museum Tour.” *Psychological Science*, vol. 25, no. 2, 2014, pp. 396-402.

[7] Inquirymaths. Log in page. https://www.inquirymaths.com/home/inquiry-and-curriculum.

[8] Z. Karadag. “Artefacts to Enhance Geometrical Thinking.”, *Bridges Conference Proceedings*, Jyväskzlä, Finland, Aug. 9-13, 2016, pp. 173-178.

[9] A. Meier. “Utforskning med Kamera.” *Tangenten*, vol. 2020, no. 1, 2010, pp. 2-7. Caspar Forlag, Bergen.

[10] A. Meier, M. S. Hannula and M. Toivanen. “Mathematics and Outdoor Photography Experience–Exploration of an Approach to Mathematical Education, based on the Theory of Dewey’s aesthetics.” *LUMAT: International Journal on Math, Science and Technology Education*, vol. 6, no. 2, 2018, pp. 146-166.

[11] K. J. Pugh and M. Girod. “Science, Art, and Experience: Constructing a Science Pedagogy from Dewey's Aesthetics.“ *Journal of Science Teacher Education*, 2007, pp. 9-27. doi:10.1007/s10972-006-9029-0.

[12] K. A. Rizzo, L. S. del Río, M. E. Manceñido, Z. Lavicza and T. Houghton. “Linking Photography and Mathematics with he Use of Technology.” *Open Education Studies*, vol. 1, no. 1, 2019, pp. 262-266.

[13] N. Sinclair. “The Role of the Aesthetic in Mathematics Inquiry.” *Mathematical Thinking and Learning*, vol 6, no. 3, 2004, pp. 251-284.

[14] N. Sinclair. *Mathematics and Beauty. Aesthetic Approaches to Teaching Children*. Teacher Colleges Press, Columbia University, New York and London, 2006.

[15] P. B. Uhrmacher. “Toward a Theory of Aesthetic Learning Experiences.” *Curriculum Inquiry*, vol. 39, no. 5, 2009, pp. 613-636.

[16] E. Østergaard. “Sensing Beauty: The Aesthetics of Science.*” Nordic Studies in Science Education*, vol. 16, no. 2, 2020, pp. 228-233.