

The Project Math Picturebooks / Das Projekt Mathematische Bilderbücher

1. Introduction

The picturebook is a multimodal and playful form, interactive by definition; it encourages its audience to read it in their own way and at their own pace, choosing different trajectories, and it also prompts multiple re-readings (Mourão, 2013; Narančić Kovač, 2015). If it is well designed, it offers various levels of complexity of meanings for individual readers, and because of that, hardly ever loses its appeal.

A math picturebook communicates math concepts and ideas by means of two separate semiotic modes, words and pictures, and combines them into a new artistic whole, fully intermedial and multimodal in its nature (Balić Šimrak et al., 2016). As such it makes it possible for children to relate visual representations of mathematical concepts to their names and to adopt new ideas while playing the meaning-guessing game.

These features of picturebooks inspired a group of researchers to initiate an interdisciplinary project *Math Picturebooks – Artistic and Literary Activities as an Encouragement to Young Learners* (MASLIK), which is in progress at the Faculty of Teacher Education, University of Zagreb. The project team established conceptual foundations for designing materials in the form of picturebooks that would facilitate the process of acquiring mathematical concepts by pupils. The texts were written and the picturebooks illustrated and designed by students, supervised by the project team members. Then they were used in class with the aim to examine their role as artefacts in the socio-didactical relationships in mathematics education.

2. Theoretical background

The term artefact refers to the production or reproduction of human social activities (Wartofsky, 1979). In that context, the picturebook, used as an educational tool, can be regarded as an artefact. Engeström (1998) developed a model of the activity system in which instruments, subjects and objects are influenced by social and institutional factors such as rules, community, etc. Leaning on Engeström's model of activity theory, Rezat and Sträßer (2012) implemented it in the systems of teachers and students, and proposed the model of the socio-didactical tetrahedron (SDT). The basic didactical tetrahedron with the vertices *artefact-student-teacher-mathematics* is extended by social and cultural factors, forming a socio-didactical tetrahedron. Following the basic vertices *student-teacher-mathematics*, the new bottom vertices in the SDT are named: conventions and norms about being a student

and about learning, conventions and norms about being a teacher and about teaching, and the public image of mathematics. Since these social and cultural parameters lay in a set of complex relationships, other points on the bottom edges are highlighted, such as institution, noosphere and peers and family (Rezat & Sträßer, 2012).

Recent research has shown that the SDT model is a powerful tool which points to social impacts as important factors which influence pupils' use of math textbooks (Rezat, 2013; Jukić Matić & Glasnović Gracin, 2016).

Such an important role of the socio-didactical tetrahedron (SDT) in understanding the use of artefacts in education inspired two research questions of this study: How can a math picturebook contribute to acquiring math concepts? Which connections among the vertices of the SDT become most prominent and most empowered during the process of using a picturebook in class?

3. Methodology

The study involved two experienced elementary teachers (T1 and T2) of the first grade, their 6- or 7-year-old pupils and their parents. The artefact involved was the math picturebook *How Leo Got to Know Numbers* (Klarić & Kalić, 2016) about learning numbers up to 10. The picturebook involves cardinal and ordinal numbers as well as one-to-one correspondence in the number set to 10. The pictures are based on soft sculpture, involving such techniques as sewing, embroidery and crochet.

In this study we used qualitative methods in the form of classroom observation, interviews, document analysis and parent surveys. These methods provided deeper understanding of the relationships among the SDT vertices. Teachers were given the picturebook and they independently prepared math lessons using the picturebook in the first grade. These lessons were observed. Further, the interviews with teachers were conducted. The next step was an activity named “a journey of the picturebook through the class”: each pupil had an opportunity to take the picturebook home and to keep it a couple of days in order to interact with it more systematically, to spot as many details as possible, and to read it with his or her parents. The parents were asked to answer the survey questions about reading the math picturebook at home.

4. Results and discussion

The results provide information about two aspects of using picturebooks in mathematics education: learning math concepts and generating positive motivation for mathematics through using picturebooks. The interviewed teachers claimed that the pupils were fascinated by numerous elements in the

pictures which they spontaneously counted. The observation confirmed that pupils initiated counting things in the pictures themselves. These findings reflect the face of the SDT *artefact-student-mathematics* because the activities with the picturebook contributed to new mathematical knowledge as well as to pupils' motivation. The same face of the tetrahedron involves the point *peers, family and tutors*. The findings related to reading the picturebook at home showing connections of this point to the other vertices of the tetrahedron.

Quotation (interview, T1): The journey of the picturebook through the class is useful because... "it faces the parents with a situation where they need to be active in the relationship with their children [...]. They can use [the picturebook] to revise counting and raise [the children's] interest in numbers."

Both teachers independently prepared a set of lessons around the math picturebook in which pupils experienced an integration of learning mathematics with learning other subjects.

Quotation (interview, T2): "I find it important for them to understand that a number denotes how many of something there is, their verbal expression was important to me and this link with the picturebook; image, word, speech."

Quotation (interview, T1): "This is a beautiful thing that happens when subjects are spontaneously integrated so that you cannot really decide if it has been a lesson of Croatian, Math, or Music, and all the teaching goals are accomplished."

Besides, teachers described such a natural integration of subjects by means of the picturebook as „up-to-date teaching". It matches the vertex *belief about being a teacher* on the face of the tetrahedron *artefact-teacher-math*.

The lesson observation has shown an interaction of teachers and pupils with the picturebook: they were sitting in a circle around the teacher, involved in a conversational reading. This refers to the tetrahedron face *artefact-teacher-student*. The teachers stated their beliefs about being a teacher and a student:

Quotation (interview, T1): "The role of the teacher should remain that of a supervisor and supporter. The teacher should lead the process, emphasize what is important, draw attention to things that go astray. Pupils should be active participants in the educational process."

5. Conclusions

The study reveals that the use of the picturebook in mathematics education is a social process involving various factors. The relations among the points and vertices of the socio-didactical tetrahedron show to what extent the process of teaching and learning is complex and multi-layered. The primary

teachers who participated in the study emphasized that introducing numbers to first-graders should be integrated with teaching language and arts. This requires thorough preparation by teachers, as well as their proper understanding of the learning process in mathematics, of the potentials of media involved and of specific characteristics of young learners. These factors refer to the SDT point *believes about being a teacher*.

The project *Math Picturebooks* has guided us towards the understanding that math concepts are important not only for the intellectual development of a child, but for the development of a child's personality as a whole.

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