

Informal mathematics experiences in museums: what potential for teacher professional development?

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Informal mathematics education

In informal mathematics education research, learning spaces other than school are explored, and experiences with mathematics that are different from the traditional ones offered by the educational institution are lived. According to Nemirovsky and colleagues (Nemirovsky et al., 2017), informal mathematics education contexts differ from school-based mathematics activities mainly due to three structural features: the voluntariness of learners' participation, the fluidity of disciplinary boundaries, and the absence of traditional forms of assessment. In recent years, we have been involved in projects aiming at preventing school dropout in disadvantaged neighborhoods of some Italian cities, namely the Proud of You project (Carotenuto et al., 2020) in Napoli and the Next-land project in Torino. In both projects informal mathematics learning was chosen for its potential to convey alternative visions of mathematics and to engage all learners in ways that are creative and different from usual school practice, with the underlying hypothesis that engaging students and changing their vision of mathematics may contribute to prevent school dropout. In accordance with the perspective of Culturally Responsive Mathematical Education (Gay, 2010), we decided to situate the informal mathematical learning activities in the history and culture of the students' own territory, allowing them to create, recreate, and shape their meanings. In our experience, two elements emerged as crucial for reaching the desired aims: the collaboration with teachers in co-designing the activities, and the relationship between informal and formal mathematics learning. They need further investigation, and in this contribution we will focus on the idea of exploiting the informal settings provided by museums (and specifically non-scientific museums) in a teacher development perspective. Our starting point is our experience of co-designing informal mathematics learning activities with museum experts. This was accomplished within the Next-land project, which we will briefly introduce.

The co-design experience in the Next-land project

In the Next-land project (<https://www.next-level.it/progetti/next-land/>), grade 7 students from disadvantaged areas of Torino (Italy) are involved in out-of-school workshops, during the first two weeks of school in their curricular hours. Workshops vary a lot as regarding locations and content. Our research group¹ is responsible for the mathematics workshops, which are located in four museums (Egyptian Museum, Museum of the Risorgimento, Palazzo Madama, Park of Living Art). In collaboration with the staff of each museum, we co-designed four workshops aimed at learning mathematics through the discovery of historical and artistic heritage of the City of Torino, involving students in experiences of observation, exploration and manipulation.

¹ The research group is composed by the authors and by two teacher-researchers: Valentina Leo and Chiara Pizzarelli.

In Autumn 2020, about 200 students, accompanied by their teachers, took part in the workshops, led by the staff of the museums. From our own field observation and the feedback given by the teachers, the students and the museum staff, we gained evidence of some positive results with respect to the project aims. However, we found also that the lack of the teachers' engagement in co-designing the activities limited the workshop experience to just an interesting activity that had no further implication on the students' mathematics experience, and therefore on the possibility of changing their view of mathematics on the long run. But how may teachers be involved in co-designing informal mathematics education activities in collaboration with mathematics educators and museum experts? The need for teacher professional development emerged in a striking way.

What potential for teacher professional development?

Based on our co-design experience with museum experts, we are convinced that informal learning in non-scientific museums may be exploited to engage teachers in rethinking their teaching practice and their relationship with mathematics. The informal character of teaching by workshops in museums and the encounter with different knowledge coming from other domains (like history and art) will favor the teachers' creativity in designing tasks to be carried out, with the perspective to develop in students an *emergent learning* rather than achieving predefined goals. Since informal education is still under-researched in relation to student learning, and to our knowledge has not yet been studied for teacher education, we plan to work by letting teachers first experience the workshops of the Nextland project, and then co-design more workshops with museum experts and mathematics educators. It is our hypothesis that the museum collections can be the boundary objects (Akkerman & Bakker, 2011) connecting the three communities, prompting a discussion about an epistemological analysis of mathematics and bringing to the fore different visions of mathematics itself.

The teacher development process will be the focus of a PhD study aiming to answer the following research questions: What difficulties may teachers experience in designing informal mathematics workshops, and how may they overcome these difficulties? What actions can be implemented to support teachers? What changes can be generated in teachers' practices and beliefs? What impact on the usual classroom activity? To answer these questions, we will collect data through questionnaires, focus groups and audio/video recordings of meetings, which will be analyzed under a qualitative lens.

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