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# Informal Mathematics Education in Museums: An Exploratory Study on Teacher Education

## Abstract

This PhD thesis explores how informal mathematics education (IME), particularly in non-scientific museums (meaning art and history museums, but also anthropological and ethnological museums that are not directly related to science), can be leveraged to enhance teacher education and how informal mathematics education experiences in museums can be bridged to the classroom context. The thesis focuses on uncovering innovative educational strategies that incorporate informal learning environments and non-traditional educational resources. The study provides a thorough investigation into how museums, through their art and historical exhibits, can support mathematics education and professional development for teachers.

### *Rationale of the thesis*

In recent times, there has been a proliferation of mathematics communication activities in various informal settings, such as museums, science festivals, or mathematical exhibitions. The question arises, then, how to exploit these contexts so that the mathematical activities carried out there can be not only engaging but also educating? Among the possible ways to accomplish this feature, the two identified and addressed in this thesis are (i) to root the informal activities more deeply in the classroom curriculum and practices, in order to make them not extemporaneous but a significant moment in a larger learning journey, and (ii) to educate teachers in the informal mathematics education approach, enabling them to become experts in the field but also central actors in realizing informal mathematics education activities.

### *Aim and scope of the thesis*

The goal related to (i) is to study the integration between the informal mathematics education activities and the classroom. From a theoretical perspective, to develop theoretical constructs that enable the integration of IME activities into teaching practice in the school context. From a methodological point of view, to develop tools that facilitate such integration. From an empirical point of view, to gather the voices of the teachers who participated in the integration of an IME workshop into the teaching practice of their classrooms.

In relation to (ii), the goal is to understand how to undertake mathematics teacher education in the context of non-scientific museums. From a theoretical perspective, to study on what design principles to base a teacher education programme on IME themes. From a methodological perspective, to investigate how these theoretical principles inform the methodological aspects for such teacher education initiative. From an empirical perspective, to collect the voices of teachers participating in the training programme as qualified observers.

### *Research questions*

The study aims to answer three main research questions.

GRQ-A. How can a teacher education programme that leverages the potential of non-scientific museums for the in-service professional development of primary and middle school mathematics teachers be designed?

GRQ-B. What are the participating teachers' viewpoints on such a teacher education programme?

GRQ-C. How can informal mathematics education activities in non-scientific museums be integrated within the mathematics teaching and learning practices in the classroom?

### *Theoretical framework*

To establish the theoretical framework on which the thesis is based, literature belonging to three areas was reviewed: (1) informal mathematics education; (2) teacher education in and about informal contexts; and (3) bridging classroom and museum mathematics. Through this review, the three foundational pillars of the research work were outlined: (a) emergent learning pedagogies for teacher education; (b) the dialogical approach to learning; and (c) learning from museums.

### *Methodology*

The research is qualified as educational design research (EDR) and employs a qualitative approach to investigate the role of museums in mathematics education. Two kinds of data were collected and analyzed. Teachers' personal essays, transcription of focus groups and semi-structured interviews with teachers underwent to qualitative content analysis with inductive categories formation. Two teaching experiments (TEs) were conducted with two sixth-grade classes. The TEs were fully videotaped and student protocols and field notes of the researchers and teacher-researchers involved in the TE were collected.

### *Key Findings*

Complementarity of Contexts: The study identifies the complementary strengths of classroom and museum contexts. Classrooms provide a structured environment for repeated learning and reinforcement, while museums offer immersive, stimulating

settings that challenge students and inspire further exploration through "aesthetic disorientation."

**Holistic Professional Development:** The IME activities contribute significantly to teachers' personal and professional growth. They improve teaching practices and extend development to personal spheres, aligning with a holistic model of professional growth.

**Collaborative Learning:** The study highlights the value of collaborative learning between teachers and museum experts. Their collaboration can help in guiding students in exploring interdisciplinary topics like history, art, and architecture, fostering a unique way of engaging with mathematics.

**Emergent Learning Opportunities:** Informal mathematics activities create emergent learning opportunities. They challenge students, teachers, and museum experts, encouraging innovative approaches to mathematical exploration.

### *Conclusion*

In summary, "Informal Mathematics Education in Museums: An Exploratory Study on Teacher Education" provides a comprehensive analysis of the role museums can play in enhancing mathematics education for teachers. It reveals the potential for informal settings to deepen understanding, improve engagement, and promote interdisciplinary learning, ultimately enriching the educational experience for both teachers and students. The study makes a compelling case for integrating informal mathematics education into mainstream teacher education programmes, advocating for cross-sector partnerships to harness the educational power of museums.

### *Emerging Themes for Future Research:*

**Deeper Exploration of IME:** Future studies should explore IME activities with students to understand better how opportunities identified by teachers translate into student learning.

**Museum Experts' Role:** Further investigation into the role and training of museum guides can reveal their unique contributions to informal mathematics education.

**Collaborative Design Work:** The insights from collaborative design work between teachers and museum guides can shed light on the potential for emergent learning across both groups.