Transforming the Learning Difficulties to Teaching Moments

Mi Song Kim, Xiaoxuan Ye, Nayang Technological University, 1 Nanyang Walk, misong.kim@gmail.com

Abstract: This study aims to uncover what knowledge is brought forth in an embodied modeling mediated activity by prospective teachers (PT) and how these learning experiences are connected with their teaching practices in an informal learning context. We employ qualitative methodologies to investigate these questions. Finding shows that based upon learning-through-modeling experiences, PTs effectively transformed their learning difficulties to valuable teaching moments for their workshop participants. Implications of this study are discussed.

Introduction

Previous studies have shown that despite of affordances of modeling-based learning and teaching, most teachers experience difficulties (Kenyon, Davis & Hug, 2011). Through adopting a design-based research, we have co-designed an 'Embodied Modeling Mediated Activity' (EMMA) with an experienced teacher in informal learning contexts to offer observation-based authentic experiences and related follow-up multimodal modeling activities for prospective teachers (PTs) in informal learning contexts. We hope to not only provide PTs with modeling-based learning experiences but also offer them opportunities to co-design and conduct EMMA activities. The study specifically looks into what knowledge is brought forth in an embodied modeling mediated activity by prospective teachers (PT) and how these learning experiences are connected with their teaching practices in an informal astronomy workshop concerning the concept of size and distance.

Theoretical Background

The concept of size and distance has been under-researched and even under-taught (Lelliott & Rollnick, 2009). Students' difficulty lies with their lack of life experiences related to vast distance and misinterpretation of their observation (Bakas & Mikropoulus, 2003). Modeling-based learning has been proved to improve students' conceptual understanding (Kenyon, Davis & Hug, 2011). Creating opportunities for students to teach can promote their content knowledge and pedagogical content knowledge as well as maximizing their potential (Cortese, 2005). Our project has endeavored to provide the workshop participants with teaching experiences based upon their learning experience in EMMA workshops.

Methods

Five youth volunteers as PTs (aged 17-18) were engaged in this qualitative study. The commitment of conducting an astronomy workshop through participating in the EMMA I and II workshops motivated them to equip themselves with astronomy content and pedagogical knowledge. Their learning activities were co-designed by the research team and one expert physics teacher (HJ, pseudonym) with strong interests and rich content knowledge in Astronomy. EMMA III was specifically designed toward authentic, embodied experiences of sky observation and multimodal modeling activities situated in an overseas field trip. Finally, EMMA IV was designed for PTs to conduct an astronomy workshop in a community center for facilitating 30 secondary school students. For deeper understanding of PT's learning and teaching experiences, multiple data sources were collected such as videotaping of the workshops, artifacts, surveys concerning PTs' perceptions of the nature of science and metamodeling, post-interview, and field notes. Data were analyzed using constant comparison methods (Strauss & Corbin, 1990). Three researchers went through an iterative process of the following steps using NVivo. First, modeling processes were identified in the EMMA III and IV workshops. Secondly, episodes were defined based on astronomy related topics in a group discussion. Thirdly, micro-level analysis was conducted to understand how PTs' learning experiences were connected with their teaching practices.

Findings

During the EMMA III workshop, the mentor, HJ, intentionally put forward a geocentric model argument and asked PTs to construct their models to prove that his geocentric model of planets was wrong. While constructing their planet models, PTs faced two main difficulties and their actual teaching indicated their abilities to transform their own learning difficulties to teaching moments, as elaborated in the following findings.

Making both Distance and Size on the Same Scale

In EMMA III, HJ purposefully encouraged PTs to combine both the distance and size of the planets on the same scale for constructing the model. PTs' initial model was poorly scaled (Figure 1). After receiving feedbacks from HJ, they started to appreciate the vast celestial scales and applied the strategy of eliminating oversize or distant objects to make their scaling model feasible for construction (Figure 2).

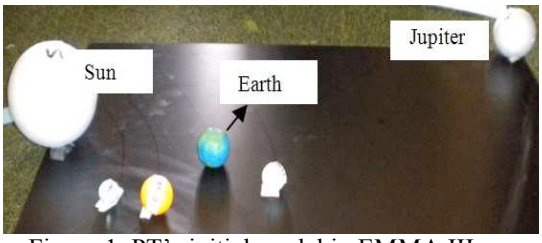

Figure 1. PT's initial model in EMMA III.

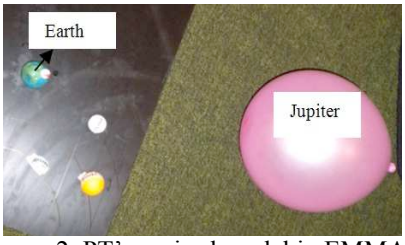

Figure 2. PT's revised model in EMMA III

This allowed them to pay more attention on the accuracy of distance and size, which in turn decided to create a guided modeling activity for their own students in which the topics of 'size' and 'distance' were separately introduced rather than combining them in a same scale. PTs guided the workshop participants by questioning about the accuracy of their models. Hence, the workshop participants improved the accuracy in scaling (Figure 4) compared to their initial model of the planets arranged at a same distance from each other (Figure 3).

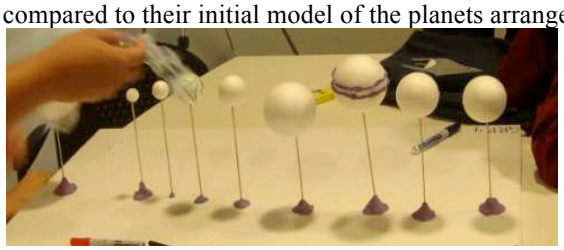
Figure 3. Participants' initial poorly-scaled model

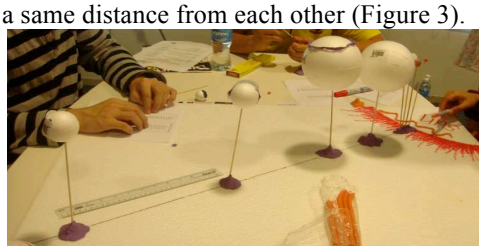
Figure 4. Participants' revised better-scaled model

Using models to explain observations from different perspectives

To debate with HJ's argument of the geocentric model, PTs needed to reconstruct their initial model (Figure 5) that simply represented the alignment of planets that appeared in the sky photo. HJ advised PTs to use a red pin to represent their position on the Earth so as to help them perceive 3D spatial perspectives. PTs eventually revised their model that was able to explain why the Moon appeared higher and bigger than Jupiter (Figure 6). The revised model showed they have transformed the 2D representation with 3D spatial reasoning.

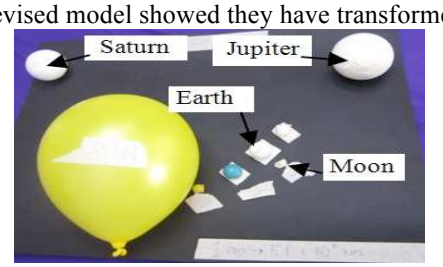

Figure 5. Planetary alignment model before revision

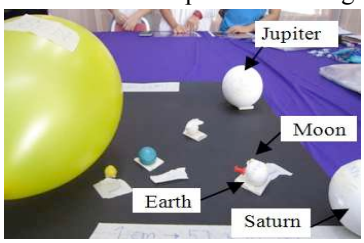

Figure 6. Planetary alignment model after revision

Based on their own hands-on modeling learning experiences, PTs effectively employed a real-time simulated observation picture to generate an argument and requested the workshop participants to argue each other using their own models. Although most workshop participants tended to pay more attention on displaying factual information without making connections with their models explicitly, it is worth mentioning that PTs noticed the explanatory power of models and explicitly asked the workshop participants not only to use the model to explain their reasoning but also to address the limitation of their own models.

Discussion and Implication

Modeling of planets required PTs to understand the complex interrelationships among distances, sizes and positions of celestial objects, as well as viewing them in different perspectives. Hence, this study demonstrates that observation integration in multimodal modeling affords PTs to overcome their learning difficulties and develop spatial reasoning. As indicated above, PTs designed activities for engaging participants in experiencing, collaborating and arguing through modeling rather than direct teaching. This implies the important role of teachers' authentic learning experiences.

References

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