PRACTICES OF FACILITATORS WHEN PLANNING MATHEMATICAL MODELING ACTIVITIES IN AN INFORMAL SETTING

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This qualitative study used Yinger's (1980) process model to investigate mathematical modeling facilitators' planning practices. Four university-based facilitators planned and implemented mathematical modeling tasks during a summer camp for middle and high school youth. Analysis of interviews and planning documents revealed that in the problem-finding phase, facilitators engaged in joint work (brainstorming) and used necessary resources (social, material, and conceptual) and prepared lesson plans. In the second phase, facilitators elaborate on the instructional ideas they had generated at the problem-finding stage. Finally, in the third phase, they categorize their solutions as successful or not and could either add to their repertoire of knowledge (routinization) or go through the process all over to come up with a refined solution. Strategies employed by participants in this study extend our knowledge regarding the facilitators' practices at the planning phase of modeling activities

Keywords: Modeling; Instructional Leadership; Teaching Tools and Resources; Instructional Activities and Practices; Informal Education

Introduction and Background

Mathematical modeling, an emerging branch of K-12 mathematics learning, is a process by which mathematicians develop and use mathematical tools to represent, understand, and solve real-world problems (Lesh and Doerr 2003; Ang, 2004). Students do not always see connections between life and mathematics and miss opportunities to apply what they learn in mathematics to the situations around them (Tran & Dougherty, 2014; Verschaffel, De Corte, & Vierstraete, 1999). Mathematics teachers play a significant role in making students see the relationship between mathematics and the real-world through effective teaching.

Effective teaching is a product of a well-planned instructional process. Efficient planning is essential in teaching mathematical modeling because of its demanding nature for teachers during its implementation. This demanding nature occurs because teaching is more open and less predictable in modeling situations (Carlson, in press; Cai, et al., 2014). During planning, teachers anticipate and prepare to respond to students' mathematical ideas, questions, and challenges. They consider strategies students are likely to use, develop responses to them, as well as strategies that might be productive to highlight during the lesson (Smith & Stein, 2012).

Purpose of the Study

This study describes the planning practices of four facilitators (faculty members) of modeling activities during a summer camp for middle and high school youth. This study will provide insights for researchers who are working to understand how facilitators plan and implement mathematical modeling activities, especially in an informal setting. In this study, an informal setting refers to the modeling environment where activities are independent of the class curriculum, age, or grade. Research questions investigated are: What problem-finding strategies do facilitators exhibit when planning modeling activities? How do facilitators elaborate, investigate, and adapt these strategies in their planning of modeling activities? How do facilitators evaluate these strategies?

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Conceptual Framework

Yinger (1980) identified three stages of planning: the problem-finding, problem formulation/solution design, and implementation, evaluation, & routinization. He theorized that the problem-finding step is the discovery of a potential instructional idea that requires further elaboration at the problem formulation stage. At the formulation stage, the dilemmas from the problem-finding stage are continually expounded and verified mentally until a desirable solution is obtained through elaboration, investigation, and adaptation. The planner relies on their repertoire of methods for solving problems during elaboration and investigation phases. Yinger viewed the implementation, evaluation, and routinization phase as part of teacher planning, and this is where the formulated solutions are tried out and assessed. Whatever the outcome is at this stage, successful or not, it forms a basis for knowledge and experience for future planning.

Methodology

Setting and Participants

This study is a part of a larger project focused on rural youth learning to use mathematical modeling to investigate issues in their home communities. Twenty-nine youth and nine adult mentors from six rural communities participated in a summer camp where they worked on modeling activities. The facilitators were the participants for this study, and they are all university mathematics teacher educators and researchers on the larger project.

Data Collection

Data sources included planning documents of modeling activities during camp and semi-structured interviews with the four participants. See modeling activities in Table 1.

Table 1: Description of modeling activities at the summer camp

Task	Description	Purpose
Cookie Task	This activity allows youths to decide what chocolate chip cookie is "best." The problem springs from a real-world situation, and its solution allows approaches from many perspectives.	• To use qualitative attributes in a mathematical model - How do we deal with a primarily qualitative question like "best" in mathematical modeling.
Agent-Based Modeling	This activity models some complex systems in the world. For instance, modeling a population involving healthy and sick people and how the system evolves with time.	• To learn how a technology-based approach could be used to model a real-life scenario—for instance, using NetLogo to model sick and healthy people.
Mapping Activity	Activity that enables modelers to create representations of their lived experiences in map format.	• To know the importance of maps and realize how values effect info stored on maps.

The planning documents for these activities were studied and used to develop an interview protocol that served as the primary data source. I conducted an average of 60 minutes of semi-structured interviews with each participant roughly 18weeks after the camp. I coded the transcripts, organized the codes into themes, and then organized the themes around phases of the process model.

Data Analysis

I commenced the analysis by looking at lesson plans facilitators prepared for camp activities. Essential keywords that captured the initial analysis of facilitators' intentions formed the basis for the interview protocol developed for the interview. These keywords include activity goals - modeling

goals, mathematics goals, & statistical goals; resources for facilitation; modeling practices; anticipated challenges and strategies to respond; and modelers' exploration. I organized raw data from participants' interviews to make sense of the contents and then conducted open and axial coding (Corbin and Strauss, 2007). Then I looked for connections that linked categories of codes to the three phases of process model: problem-finding, problem formulation; Implementation, evaluation, and routinization.

Results

I organized the findings of this study by the three stages of the process model to provide a holistic understanding of the data collected.

Problem-finding

When planning modeling tasks, facilitators engaged in joint work (brainstorming). They used social, material, and conceptual resources, prepared lesson plans and relied on teaching experiences. They also embraced multiple perspectives, constructed questions to launch the activity, guessed modelers' ability, and considered the interest of modelers. Sally, in her words, said: "Theresa and I met and kind of just worked through it. Furthermore, during the prep week, actually doing it and getting feedback from there helped us figure out more details of how we are going to facilitate it." Facilitators also conducted ethnographic research about modelers' environment and their interest in understanding youth characteristics. About the Agent-Based Model, Edward said:

> One of the groups talked a lot, during our ethnographic research in their community, about physically closing off some lanes of traffic and one of the ways that you can understand or make predictions about that is through an agent-based model.

Knowledge and past experiences of facilitators interrelate with teaching goals and materials (resources) when finding instructional ideas for a new modeling task. Edward described how his previous experience with Agent-based Modeling directed him to locate the right human resource who helped out in his planning.

> I have some familiarity with the Agent-Based Modeling from doing it in some of my classes as a graduate student. Nevertheless, it was not really on my radar. Here is what happened, Kelvin, who was sort of founding participant in this project, is vast into technology. One of the technologies that he was thinking about was agent-based modeling, which made sense to me because I had experience with it.

When giving an account on how her background knowledge with modeling interrelates with the teaching goals when preparing for the cookie task, Isabella, said the following:

> Thus, the cookie task – we thought of a few reasons for choosing it. One is that we thought it was something that would be fun and low stakes for the first night of camp. We thought that it would be something that all students know something about it. Moreover, we also thought that it was an activity that would facilitate work through a lot of the modeling cycle.

These scenarios show how facilitators discover potential instructional ideas for efficient planning. These ideas are then elaborated at the problem-formulation stage of their plan.

Problem formulation

At the problem formulation stage, knowledge and experiences of facilitators played essential roles. Their past experiences enabled them to anticipate what modelers might do on the tasks. To do this efficiently, they needed to elaborate on the instructional ideas they had generated at the problem-finding stage. At this stage, elaboration means creating a suitable response to the ideas discovered in the problem-finding phase. Isabella described doing this via deep thought: "As a team, we thought deeply about kind of different knowledge bases they might bring to bear on problems, especially their local problem-solving practices."

When elaborating, facilitators perceived their roles like that of a "coach" who gives support Theresa recounted that her role is to set modelers up to interpret the real-world to their mathematical world with little or no help from the facilitator. To achieve this, facilitators needed to anticipate modelers' behavior during Implementation. They narrated that modelers bring different initiatives to modeling space, a situation that facilitators must speculate when planning.

Implementation, evaluation, and routinization

Implementation, evaluation, and routinization is the last phase in the instructional planning process. In this phase, facilitators try out solutions developed at the problem-solving stage. Facilitators in this study did this through the preparation week preceding the camp week for evaluation. Sally gave the following response to a prompt: "And during the prep week, actually doing it and getting feedback from there helped us to figure out more details of how we are gonna facilitate it." At this stage, facilitators considered solutions to be successful or not. If successful, they would add the solutions to their repertoire of knowledge (routinization). Otherwise, they would iterate the process for a refined solution.

Discussion and Conclusion

This study sought to document facilitators' planning practices of modeling activities. From the results and analysis, I found some practices to be general to facilitators in this study. These results suggest that facilitators build on their previous facilitating knowledge to anticipate what modelers would do. The facilitators paid attention to modelers' interests and what they care about when engaging in problem-solving. Facilitators also considered how modelers would engage with the task and think about multiple perspectives modelers would bring into the modeling space. Facilitators anticipate what modelers will do and will not do on a task and identify where and when modelers might deviate from a better approach to solving a task.

For this reason, facilitators thought about modelers' possible approaches to solving modeling tasks. Facilitators considered necessary resources to accomplish tasks and considered multiple perspectives in their approaches by brainstorming with colleagues to anticipate what modelers would do in various dimensions. Finally, they thought about questions modelers could ask and then prepare some canned responses. This study agrees with Munthe & Conway (2017) on how planning involves shared knowledge construction and professional learning. This study also finds that planning is a process of preparing a framework guiding teachers' actions. As Young (1998) found what teachers do at planning to include identifying content, developing a timeline, identifying goals, skills, and objectives, deciding on instructional materials and so on, this study finds that facilitators of modeling identified settings, resources, and teaching goals as necessary when planning modeling tasks. As this study took place in an informal setting, findings herein may not necessarily be generalizable to a curriculum-based classroom but can be helpful. For future work, researchers may consider investigating facilitators' planning practices in a formal setting. The findings from this study are productive strategies that could be reproduced by researchers, especially in an informal setting.

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