USING MODELING-BASED LEARNING AS A FACILITATOR OF PARENTEL ENGAGEMENT IN MATHEMATICS: THE ROLE OF PARENTS' BELIEFS

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Being part of a larger research project aimed at connecting mathematics and science to the world of work by promoting mathematical modeling as an inquiry based approach, the present study aimed to: (a) describe parents' beliefs about inquiry-based mathematical modeling and parental engagement, and (b) explore the impact of a modeling-based learning environment on enhancing parental engagement. Results from semi-structured interviews with 19 parents from one elementary school classroom revealed strong positive beliefs on their engagement in their children learning, an appreciation of the modeling approach for bridging school mathematics and home, and their willingness to collaborate with teachers. Implications for parental engagement in mathematics learning are discussed.

INTRODUCTION

This study argues for an inquiry-based approach (IBL) in the teaching and learning of mathematics, one that is based on a models and modeling perspective (Lesh & Doerr, 2003). A modeling based IBL approach can serve as an appropriate means for bridging complex real world problem solving with schools mathematics (English & Mousoulides, 2011). This connection is necessary, as complexity gradually appears in all forms of the society and the education, and new forms of mathematical thinking are needed. Further, a modeling based IBL approach could contribute in enhancing students' abilities in designing experiments, manipulating variables, working in teams, and communicating their solutions with others (Mousoulides, 2013).

Integrating such an innovative approach in mathematics is not an easy process. It conflicts with various factors, including national curriculum requirements, teachers' beliefs and practices, and parents' beliefs and attitudes towards such innovations. The significance of parents' role has been documented in a number of studies (see Epstein et al., 2009), and parental engagement has been documented as a positive influence on children's achievement, attitudes, and behaviour. However, achieving appropriate parental engagement is a difficult and long-term process, and teachers should collaboratively work with parents to find the best appropriate methods. The present study targets the identified lack of studies, and examines parents' beliefs on their engagement in their children learning in mathematics, and on communication with the classroom teacher and students, by focusing on a teaching experiment on mathematical modeling.

2014. In Liljedahl, P., Oesterle, S., Nicol, C., & Allan, D. (Eds.) Proceedings of the Joint Meeting of PME 38 and PME-NA 36,Vol. 4, pp. 265-272. Vancouver, Canada: PME.

THEORETICAL FRAMEWORK

The theoretical framework focuses on two strands: (a) instructional interventions to promote mathematical inquiry through a modeling perspective, and (b) parental engagement in the mathematics classrooms with an emphasis on parents' beliefs.

A Modeling Perspective in Inquiry Based Learning in Mathematics

In successfully working with complex systems in elementary school, students need to develop new abilities for conceptualization, collaboration, and communication. In achieving these abilities, a number of researchers propose the use of an inquiry-based approach in the teaching of mathematics, one that builds on interdisciplinary problem-solving experiences that mirror the modeling principles. In this study we adopt the use of *Engineering Model-Eliciting* Activities (EngMEAs); realistic, client-driven problems based on the theoretical framework of models and modeling (English & Mousoulides, 2011).

EngMEAs have been in the focus of our work for the last few years (see Mousoulides, Sriraman, & Lesh, 2008; Mousoulides, 2013). EngMEAs provides an enriched modeling approach by offering students opportunities to repeatedly express, test, and refine their current ways of thinking as they endeavour to create a structurally significant product for solving a complex problem. The development of the models necessary to solve the EngMEAs has been described by Lesh and Zawojewski (2007) in terms of four key, iterative activities: (a) Understanding the context of the problem / system to be modelled, (b) expressing / testing / revising a working model, (c) evaluating the model under conditions of its intended application, and (d) documenting the model throughout the development process. The cyclic process is repeated until the model meets the constraints specified by the problem.

Parental Engagement

Parental engagement has been documented as a positive influence on children's achievement in mathematics, regardless of cultural background, ethnicity, and socioeconomic status (Epstein et al., 2009; Ginsburg-Block, Manz, & McWayne, 2010). Active parental engagement, however, is quite difficult to be maintained. Therefore, programs of parental engagement should be carefully designed and implemented, taking into account all related variables and barriers (Vukovic, Roberts, & Wright, 2013). Musti-Rao and Cartledge (2004) suggest inviting parents' experiences in into discussion, and including parental engagement strategies in teacher professional development courses. They also propose a number of strategies for engaging parents, such as mathematics and science fairs, community involvement utilizing engineering experts, and the establishment of a clear communication between teachers and parents, in an attempt to bridge teachers' and parents' beliefs and expectations (Musti-Rao & Cartledge, 2004; Vukovic et al., 2013).

Epstein and Van Voorhis (2001) identify teacher and parents beliefs as an important barrier to creating effective relationships between home and school. Parents' beliefs on

mathematics teaching and learning and the significance of their engagement might also impact parental engagement. Often, the beliefs and expectations between families and educators are not shared collectively, and in many cases parents might have negative beliefs that can lead to stereotypes regarding the relationship between them and teachers. In order for parents' beliefs to change into positive ones, parents should be open to invitations to be engaged in school mathematics, while more parental engagement training on how to work with parents and communities is needed for teachers (Epstein, et al., 2009; Ginsburg-Block, et al., 2010).

THE PRESENT STUDY

The Purpose of the Study

This study investigated parents' beliefs on their engagement in their children learning in mathematics, during the implementation of two complex modeling activities, in an elementary school classroom. Specifically, the study focused on parents' beliefs on the learning environment that was generated, parents' beliefs on their engagement, and their experiences with regard to collaboration and communication.

Participants and Procedures

The research presented in this study was part of MASCIL, a larger research design that includes: (a) inquiry-based mathematics and science instruction, (b) integration of engineering model-eliciting activities as a means to connect school mathematics to the world of work, and (c) examination of the appropriateness of various forms of parental engagement, including workshop participation, participation in classroom activities, and communication with teachers. During her participation in MASCIL, a longitudinal four-year project on Inquiry and Modeling Based Learning in Mathematics and Science, Nefeli (pseudonym) an elementary school teacher in a public K-6 elementary school in Cyprus, participated in a five-day professional development course on inquiry- and modeling-based teaching and learning in mathematics. Following her participation in the training, Nefeli organized the implementation of two modeling activities in her 6^{th} grade (12 year olds) classroom.

Prior to the implementation of the modeling activities, the parents of all students in Nefeli's classroom (36 people) were invited to attend a presentation on the role of IBL and modeling in the learning of mathematics. Twenty-seven parents attended the presentation. Based on the feedback received by the participants, two three-hour workshops for parents were designed and delivered, prior to the implementation of the modeling activities. Nineteen parents and the classroom teacher participated in both workshops. During the workshops parents had the opportunity to work in groups in solving a modeling problem, and to discuss with the researchers and the teacher on how parental engagement could facilitate students' learning in mathematics. During the second workshop parents had the opportunity to familiarize themselves with the two modeling activities that were to be implemented in the classroom. Parents were also introduced to Twitter® and on the possibilities it could provide for the

mathematics classroom, as an online technological tool which can break down the rigid classroom schedule barriers and allow teachers, students, and parents to collaborate. During the implementation of the modeling activities parents were encouraged to reflect on and comment on their children developments in the classroom, using Twitter®.

The Implementation of the Model Eliciting Activities

The two modeling activities (Water Shortage and Bridge Design) followed the design principles of the model eliciting activities, as these are described by Lesh and colleagues (Lesh & Doerr, 2003). Activities are not presented here due to space constraints; however a detailed presentation of the activities can be found elsewhere (see Mousoulides, 2013; English & Mousoulides, 2011). Each model eliciting activity entailed: (a) a warm-up task comprising a mathematically rich newspaper article, designed to familiarize the students with the context of the modeling activity, (b) "readiness" questions to be answered about the article, and (c) the problem to be solved, including complex tables of data. The *Water Shortage* activity asked students to assist the local authorities in finding the best possible country that could supply Cyprus with water. The *Bridge Design* activity required students to develop a model for calculating the cost for various bridge types. Both activities required students to develop their models for solving the problems by integrating both quantitative and qualitative factors.

The activities were implemented by the classroom teacher and the author. Working in groups of three, the students spent five 40-minute sessions on each activity. During the first two sessions the students worked on the newspaper articles and the readiness questions and familiarized themselves with software that was used for solving the problems (Google Earth & Spreadsheets) and for communicating their results (Twitter® & Wikis). In the next two sessions students worked on solving the problems. They developed a number of appropriate models for solving the problem, and shared these models with their teacher and parents. During model development students were prompted by teachers to share their ideas with their parents. To facilitate model sharing, a public Wiki was created, in which students could easily upload their files. Student then shared the links to their models with their parents, using appropriate tweets. The great majority of parents participated in the implementation of the activities, by following student groups' tweets and provided feedback and suggestions to students' models using Twitter® and the Wiki. All communication was held on an entirely anonymous basis, as to avoid only interactions between parents and their child; student groups were assigned random names (e.g., Aristotle, Plato etc.), and parents were also assigned names like parent 1, parent 2 etc. During the last session students wrote letters to local authorities (as required by the activities), explaining and documenting their models/solutions. Finally, a class discussion focused on the key mathematical ideas and relationships that students had generated took place.

Interviews

All nineteen parents were invited to participate in individual interviews. Seventeen parents (representing thirteen families) accepted the invitation and participated in individual semi-structured interviews. Three areas of interest were investigated: (a) parents' beliefs on the environment generated, which was based on mathematical modeling, and the implementation of the EngMEA, (b) participant's beliefs on parental engagement, and (c) her/his experiences during the EngMEA implementation with regard to collaboration and communication with the teacher and the students. The interviews were conducted right after school or in the early evening. Each interview lasted between 30 to 45 minutes and all interviews were audio recorded and later transcribed. Data were summarized through sequential analysis, and a grounded theory approach was adopted. Themes were identified and clustered through axial coding, which was conducted in AtlasTI software.

RESULTS

Results are based on the qualitative analysis of the interviews. The results are presented in terms of the themes that arose from the sequential analysis of parents' beliefs, with regard to the role of the mathematical modeling environment that was generated, and with regard to the collaboration and communication with the teacher and their children.

Parents' Beliefs on the Role of the Modeling Environment

Parents reported very positive beliefs with regard to the modeling activities, and the learning environment that was generated. They commented that the activities were interesting and challenging. They were also very emphatic on how positively their children worked on the activities. One parent mentioned: "It is not very often that we discuss at home in such an explicit and detailed way her (his daughter) work in mathematics […] she liked the bridge problem so much […] it (the activity) was very challenging also for me, and we spent like at home to explore various things on bridges." Another parent said: "Such activities could help our children to develop important skills, needed beyond school […] I am very pleased that Nefeli is using such innovative approaches."

The vast majority of parents mentioned that such activities were challenging, not only for their children, but also for them. One parent who was actively involved in the activity commented: "It was challenging to see interesting problems with no clear answers. I even discussed the activity with my husband a few times, and we both enjoyed the discussions with Andreas (their son)." She continued by clarifying: "I frequently visited the Wiki and commented on students' tweets. It was great! And my son also liked it very much. Believe it or not, he even discussed the activity with his cousins." Another parent expressed: "Students had a challenging opportunity to ask like professionals […] take into account various constraints, working with complex

data, drawing assumptions, and looking for more data on the Internet […] such skills are so powerful and important."

Less positively, some parents mentioned that the activities were interesting, but rather difficult, especially the *Bridge Design*. Three parents mentioned that the activity was quite complicated, even for them. They expressed that their children experienced various difficulties in working with the problem, and that they would prefer their children to work with similar activities (model eliciting) but rather easier ones.

Parents' Beliefs on Communication and Collaboration

To improve their engagement, parents seemed to unanimously agree that good communication and active engagement was key. A parent noted: "I enjoyed the two workshops very much, although it was easy to participate […] workshops helped me a lot in understanding the concepts that were taught in the activities and in handling the Wiki." Another parent added: "Working with our children in this project is very promising […] we like it, and we also see that our engagement is appreciated by our teacher."

Although quite satisfied with the situation, parents explicitly mentioned that they expected from school and teachers to do more, in order to enhance their (parental) engagement. It was revealed that school's climate had a significant impact on the overall effectiveness of parental engagement. From parents' responses a number of factors were uncovered, showing what schools should do in order to encourage and enhance parental engagement. A parent mentioned that schools should promote parental engagement using various methods, and not only by expecting from parents to be engaged. She said: "Schools and teachers must actively seek and promote the parental engagement. Not all parents are engaged by default". The importance to implement initiatives that engage students was also mentioned by two parents. One of them mentioned: "Such activities are one of the best ways to engage parents, because their children are also much engaged. When children are excited and discuss their mathematics work at home, parents are more inclined to be engaged in mathematics.

All parents underlined the necessity for open communication in order to improve parental engagement. One parent noted that open communication was the key to accessibility. He commented that: "Parents should feel comfortable enough with the teachers to ask content-related questions, and even spend time on working on activities, if we are expected to assist our children at home." Another parent highlighted the importance of constant communication. She explained: "Every parent wants to be involved in her learning […] this should be welcomed by teachers and the school Head, and we should be able to freely communicate with them. An appropriate atmosphere is needed for successful parental engagement."

Although quite satisfied with the situation, parents explicitly mentioned that it was expected for school and teachers to do more in order to enhance parental engagement. It was revealed that a school's climate and culture impacted the overall effectiveness of parental engagement efforts in a significant way. From parents' responses a number of

suggestions emerged for what schools should do in order to better encourage and enhance parental engagement. Parents explicitly highlighted how the activities assisted in building a partnership climate between parents and teachers. The activities opened a whole new space for fruitful collaboration and created better communication channels among parents, teachers, and children. "I had the feeling that we (parents and teachers) were equal partners," one parent commented. She continued: "It was far better than sitting at the back in the classroom and watching a lesson. We were actively involved and we had constant communication with our children and the teacher. It was really good." Another parent added: "I found those messages [tweets] a much more appropriate method of communication than signing tests […] I knew exactly what my child did in the activity, and even better I could now observe the process, not only the results."

DISCUSSION

The purpose of this study was to examine parents' beliefs on parental engagement in mathematics teaching and learning, with a focus on modeling as a problem based approach. The results supported the expectation that such an approach was likely to positively affect teachers-parents' partnership and possibly student outcomes (Epstein et al., 2009). The environment generated, provided opportunities for parents and teachers to establish appropriate communication and collaboration venues, which resulted in improved students' models (English & Mousoulides, 2011). The modeling activity implementation as a means to engage parents in school mathematics could be considered successful, while parents responded positively to their new roles as engaging partners in their children learning. During interviews, parents revealed positive beliefs towards innovations like a models and modeling perspective. Parents also reported significant positive beliefs towards their engagement in schools, indicated at the same time the necessity for the school and teachers to take actions. Parents identified that a clear and constant bidirectional communication venue was urgently needed and they stressed that the modeling environment could be a successful method to achieve this goal.

The findings from this study suggest a need for researchers to expand their definitions of parental engagement, beyond traditional ideas of school and classroom norms, to include a dimension related to active parental engagement and technology rich modeling environments. Despite its limitations, this study provides new insights into the importance of modeling related parental engagement practices in mathematics teaching and learning. It suggests that teachers and schools that have positive beliefs towards parental engagement and facilitate the use of inquiry- modeling-based approaches are more likely to have positive active parental engagement and probably better students' learning results. Unquestionably, students need high-quality instruction to improve mathematics learning. However, if schools, teachers, and parents work together in creating appropriate, collaborative environments, they are more likely to see higher students' learning outcomes.

Acknowledgement

This paper is based on the work within the project MASCIL – Mathematics and Science for Life (www.mascil-project.eu). The research leading to these results/MASCIL has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 320693. This paper reflects only the author's views and the European Union is not liable for any use that may be made of the information contained herein.

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