

SOCIAL AND DIDACTICAL ASPECTS OF ENGAGEMENT IN INNOVATIVE LEARNING AND TEACHING METHODS – THE CASE OF RUTH

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Mathematics educators emphasize the need to change mathematics teaching and learning. Despite the fact that great endeavors are invested for that matter, changes are not as widespread as was expected. Working with prospective teachers, we enable them to experience various innovative teaching approaches, hoping that they will decide to implement these methods in their future classes. However, we realized that prospective teachers express resistance towards changes. In this paper we present the case study of Ruth, a prospective teacher who was engaged in learning via a computerized project-based learning approach. Through Ruth's reflection on her experiences we realized that her resistance can be attributed to the social norms she adopted, as a result of her past experience as school student.

INTRODUCTION

The last two decades were characterized by the intensive calls for employing reforms in mathematics education (e.g. NCTM's standards, 2000). It is anticipated that the teachers should be the ones that put the innovative approaches into practice. However, real modifications are not as extensive as was expected (Stigler & Hiebert, 1999). A variety of explanations can be suggested in order to explain this "stagnation". One possible explanation might be related to what Desforges (1995) had found in his review of literature: teachers are satisfied with their practices and do not tend to question educational processes. They often disregard data that is inconsistent with their beliefs and practice and tend to avoid new experiences. Instead, they prefer to stick only to those practices that match their existing system of beliefs. A question to be asked is: What are the factors that cause this tendency and why is it so widespread? Since teachers' beliefs are influenced, among others, by social and cultural norms and it is within these contexts that teachers make sense of their role (Lee, 2005), we believe that in order to be able to answer the above question teachers' beliefs and their relation to the social and cultural environment have to be examined.

Prospective teachers (PTs) begin their training with explicit beliefs regarding various issues that concern teaching and learning (Tilema, 1995). These beliefs are result of their past experience as school students (Lee, 2005). Consequently, it is reasonable to assume that PTs' beliefs regarding teaching and learning resemble those of their teachers. PTs are the next generation of teachers. In order to be able to teach in the spirit of the reform, they have to be convinced that these teaching methods are beneficial. We believe that one of the ways to enable them to recognize the benefits

of innovative teaching approaches is by involving them in challenging their existing beliefs and examining the adequacy of these beliefs to the changes that are recommended by the reform. In this paper we describe an experiment made with a group of PTs, aimed at making their beliefs about teaching and learning mathematics explicit, and assist them in examining the compatibility of these beliefs to the spirit of the reform. We present the case study of Ruth, a member of the PTs group that were engaged in a Computerized Project-Based Learning (CPBL) activities (Krajcik, Czerniak and Berger, 1999). We chose to focus on Ruth from two reasons: first, her expressed beliefs reflected the common beliefs of the majority of the study participants; second, comparatively to the other PTs in the class she demonstrated outstanding self expressive abilities.

THEORETICAL BACKGROUND

This paper describes and discusses the expressed beliefs of Ruth while engaging in CPBL. These beliefs relate to teaching and learning of mathematics and reflect the social environment in which Ruth and her classmates were educated. The theoretical framework of this paper focuses on the meaning of ‘system of beliefs’, and on social and sociomathematical norms, which are among the constituents of such a system.

System of beliefs. Beliefs are perceptions and attitudes towards a certain reality. According to Tilema (1998), a system of beliefs does not require external approval. The influence of beliefs is strongest on the meanings which people attribute to occurrences, and on activities they choose to carry out. PTs hold beliefs regarding various aspects relating to teaching and learning, among them: their role as teachers, students’ learning processes, curriculum suitability, and so forth (Van-Dijk, 1998). Their beliefs reflect their values in terms of what is “desirable”. These beliefs are result of thousands of hours in an “apprenticeship of observation”, which inspire school students’ perception regarding teaching and learning (Lortie, 1975). Unfortunately pre-existing beliefs about teaching, learning and subject matter are resistant to change (Foss & Kleinsasser, 1996; Lee, 2005), consequently, PTs graduate the university holding the same beliefs with which they arrived (Kagan, 1992). Namely, PTs’ personal beliefs and images are not affected by their training practice and generally remain unchanged. They tend to utilize the information they are exposed to during their training mainly to strengthen their existing beliefs and perceptions. That means that the topics that are being presented in teacher education programs are subjected to interpretations according to PTs’ pre-existing beliefs (Tilema, 1998). Those interpretations also affect their performance in class (Kagan, 1992), since they rely on their own subjective theories of teaching or on what they believe will work in class. For example, many PTs believe that teachers ‘deliver’ knowledge to their students, and learning means memorizing of contents (Richardson, 1996). Their memories of themselves as learners influence their expectations of their future students as well as their views regarding “proper” teaching strategies. The image they possess regarding “good teaching” relates to the

kind of teachers they see themselves becoming. As a consequence PTs tend to exhibit conservative teaching, replicating their own teachers.

Social and socio-mathematical norms. The theme of classroom norms has been addressed by various researchers in recent years. Cultural and social processes are integral to mathematical activity, and the culture of the mathematics classroom, is central to the development of mathematical disposition among students and bring change in mathematical beliefs (Yackel and Cobb, 1996). Yackel and Cobb (*ibid*) distinguished between general classroom social norms (for example: the need to explain or justify) and norms that are specific to the mathematical activities of the students, termed as socio-mathematical norms (for example: what counts as mathematically efficient, mathematically sophisticated, mathematically elegant, acceptable mathematical explanation and justification). The teachers' and the students' beliefs serve as key factors for negotiating classroom norms. The teacher-students verbal interactions provide the opportunity to negotiate the socio-mathematical norms, which are continually regenerated and modified, and might differ substantially from one classroom to another. Yackel and Cobb (*ibid*) suggested that there is a reflexive relationship between beliefs and classroom norms: the student beliefs influence the classroom norms and those norms, in turn, influence the beliefs of students.

Various classroom norms and socio-mathematical norms develop in various settings, in accordance with the acceptable teaching/learning approaches. In each class different classroom norms are established via the students-teachers interactions. In our class of PTs the teaching/learning approach was based on inquiry activities via CPBL. In order to enable the PTs to appreciate the benefits of this method, we supported them in developing self-awareness to their pre-existing beliefs and challenge the adequacy of those beliefs to the new setting.

THE STUDY

The learning environment. This paper presents the case study of Ruth who participated in an annual method course which focuses on theories and didactical methods implemented in teaching and learning geometry and algebra in junior high-school. 25 college students (8 male and 17 female students) in their third year of studying towards a B.A. degree in mathematics education attended the course. This course was the second method course they were participating. The CPBL approach was one of the main teaching/learning methods discussed in the course. The PTs used dynamic geometrical software in the various stages of their work on the project. During the engagement in the project the PTs were asked to write a portfolio describing their experiences and reflect on them.

In order to clarify to the PTs the principles of the CPBL approach and what we believe should be the phases of the work, we presented a ready-made project which was based on Morgan's theorem (Watanabe, Hanson & Nowosielski, 1996). This

theorem is a mathematical discovery of a middle school student, which occurred while Morgan's teacher engaged his class in an inquiry assignment. The PTs had experienced CPBL approach, which included the following phases (Lavy & Shriki, 2003): (1) Solving a given geometrical problem which served as a starting point for the project; (2) Using the "what if not?" (WIN) strategy (Brown & Walters, 1990) for creating various new problem situations on the basis of the given problem; (3) Choosing one of the new problem situations and posing as many relevant questions as possible; (4) Concentrating on one of the posed questions and looking for suitable strategies in order to solve it; (5) Raising assumptions and verifying/refuting them; (6) Generalizing findings and drawing conclusions; (7) Repeating stages 3-6, up to the point in which the student decided that the project has been exhausted. The research data included: (a) transcripts of videotapes of all the class sessions; (b) two written questionnaires; (c) students' portfolios that included a detailed description of the various phases of the project and reflection on the process; (d) informal interviews. During the class sessions the PTs raised their questions and doubts, asked for their classmates' advice, and presented their work.

Methods. We focused on Ruth, one of the PTs, and used case study methods (Stake, 1995) for analyzing her system of beliefs during the various phases of the project. Ruth was chosen since she tended to be more reflective than the other students in class. As a consequence, her portfolio was rich and detailed in comparison to others. The methods for analysis included use of an analytical model for analyzing data to identify critical events. In order to clarify and elaborate some of Ruth's written reflections we interviewed her after each phase of the project.

RESULTS AND DISCUSSION

At the beginning of the research we assumed that the PTs would face some difficulties while trying to internalize the various aspects associated with the unfamiliar CPBL approach, but we could not anticipate their source and nature. Analyzing Ruth's portfolio and her interviews revealed that the source of those difficulties can be attributed to Ruth's tendency to interpret her new experiences through her pre-existing beliefs (Tilema, 1998). Namely, she failed in her attempts to challenge the compatibility of her existing beliefs with the new information gained while engaging in the project. During the process of work on the project we could identify several types of existing beliefs. These beliefs related mainly to learning and marginally to teaching and to our educational system.

Although Ruth was an average student, she had a significant contribution to the class discussions, in which various aspects concerning the project were elucidated. She often used to ask for further clarifications regarding issues raised by her other class mates and teacher. At the beginning of the process Ruth was motivated by her wish to discover new mathematical regularity, saying: "*I want to be like Morgan, I want to discover a new regularity*". At the initial phases of the project Ruth decided to focus on a problem situation in which she changed two of the problem original attributes.

After a period of time, during which she kept on looking for regularities, she had managed to find only marginal discoveries. In what follows are some of her reflections during the various phases of work on the project.

By the end of the first class session in which we explained the constituents of the project and demonstrated Morgan's work, Ruth wrote in her portfolio:

“At the beginning I asked myself whether there is any connection between what we ought to teach in school and what we have to do in this project. No one at school will ever let us teach in that manner. Schools do not welcome such an approach. So at the beginning I was not enthusiastic at all, until I heard about Morgan and his discovery. Only then I felt like I really want to do that - to explore and discover”.

First glance at the above excerpt raise the question: why Ruth felt resistance towards the whole idea of the project, even before starting to work on it? It should be mentioned that this resistance was expressed in most of the study participants' portfolios. It appears that the PTs were intimidated by the new and unfamiliar learning approach. The excuse Ruth provided for justifying her reservation relied on external factor – schools will not welcome such teaching approach. According to Ruth's beliefs, schools represent the authority which determines what and how to teach. Moreover, she believes that schools are not open to new teaching ideas. These beliefs imply on how the educational system is conceived by Ruth – rigid and conformist. Ruth's perception of the educational system, stem from her past experience as school student (Lortie, 1975). Ruth's beliefs were so dominant that they instinctively 'withheld' her motivation to experience innovative approach to learning and teaching. However, the case of Morgan stimulated and motivated Ruth to reconsider her resistance and she was willing to take an active part in the new experience. The fact that a 9th grade student (Morgan) succeeded in discovering new mathematical regularity, added a competitive dimension to her system of decision-making, and she was determined to succeed (“*explore and discover*”). Ruth began working on the project with a great enthusiasm. After the second phase of the project, in which she had to use the WIN strategy for creating various new problem situations on the basis of the given problem, she wrote:

“After I wrote the list of various new problem situations I felt good as if I was going to discover something new in mathematics – I really love it!”.

Despite her initial resistance and doubts the actual engagement in the project reinforced her enthusiasm, believing she was capable of discovering new mathematical regularity. This process was accompanied with a strong emotional reaction (“*I really love it!*”).

After the 4th phase (concentrating on one of the posed questions and looking for suitable strategies in order to solve it) Ruth reflected:

“The work was very interesting and challenging. At the beginning I felt a sense of anxiety, afraid I would choose to concentrate on an 'inappropriate' attributes, and it

would be a waste of time. But shortly after I felt confident and it was clear to me that I will gain something meaningful from this project. I believe I will discover a new regularity”.

From the above excerpt we can learn that during the work on the project Ruth was emotionally rather than rationally involved. It can be inferred from her use of words such as: love (in the previous excerpt) anxiety, afraid and confident but no references to rational expressions, that might indicate that the process was also rationally examined. While at the beginning of the process Ruth ‘blocked’ herself even from considering any involvement in the project justifying it by excuses that relate to school system, when she began to work on the project, she found this process to be interesting and challenging. The new feelings were accompanied by a sense of anxiety which was originated by her exiting beliefs referring to waste of time which might cause by the choosing of inappropriate attributes.

When we asked Ruth to clarify what she meant by concentrating on ‘*an ‘inappropriate’ attributes and it would be a waste of time*’ she said: ‘*it is like I am standing in a junction from which several directions are possible. I have to decide which one is the desirable road to choose... I mean in which road I will manage to find an interesting regularity. If I will not succeed in choosing the proper way – it will be a waste of time since it will end up with no results*’. From these utterances we can see that Ruth believes that mathematical assignment must end up with a result or product. She could not realize that one can learn merely from the engagement in the process itself. These expressed beliefs reflect the socio-mathematical norms (Yackel and Cobb, 1996) Ruth internalized as a school student. During the 5th phase she wrote:

“Sometimes during the work on the project I felt a lack of motivation. Perhaps it is because I am not used to activities of this kind. During my school years I was asked to prove existing mathematical regularities, and now we are asked to do something different, something that we are not used to – to discover something new”.

Ruth’s further involvement in the project raises some conflict feelings. On one hand “*I felt confident and it was clear to me that I will gain something meaningful from this project*”, and on the other “*I felt a lack of motivation*”. Ruth justifies her lack of motivation using her past experience as school student: “*During my school years I was asked to prove existing mathematical regularities*”. Proving existing and unquestionable regularities is what Ruth experienced as a student, and consequently she believes this is the proper way to learn and teach mathematics. In the project she had to deal with a new learning approach, in which she had to look for a new regularity and then prove it. The different approach decreased her motivation and raised negative and ambiguous feelings towards the process. One might say that Ruth’s resistance rose because she did not discover something meaningful. However, it still points to the fact that Ruth was focused on the final products rather than the process she was involved in.

In her final reflection Ruth wrote:

“...Contrarily to what I had said before I must say that when I observe and examine what I had gone through during the work on the project, I realize that only a minor part of the sessions contributed to my professional growth. As part of my educational duties I have to teach in various classes. I don't know yet how to teach and handle class situations in the traditional way, and you expect that I will adopt and implement innovative teaching approaches which I do not see their relevance to my work”.

In the above excerpt Ruth refers to two existing beliefs. First, Ruth perceives professional development as a process in which she will be ‘equipped’ with tools and methods that will assist her in handling class properly. Second, she raises crucial points: she wants first to experience and gain confidence in teaching in the traditional way and only then to consider innovative teaching approaches.

We asked Ruth to clarify what she meant by saying: “*I don't know yet how to teach and handle class situations in the traditional way*”. According to Ruth, ‘traditional’ ways are:

“When I was a student, all mathematics lessons were handled in the same routine – the teacher explained the new topic, and then provided a solved example. Afterwards, we were asked to solve several related exercises. The teacher solved some of the problems in class, and usually asked us ‘to help’ her. This is what I perceived as ‘traditional way’”.

Ruth’s reply is consistent with Richardson (1996) according to which PTs believe that the teacher’s role is to deliver knowledge. Ruth describes the mathematics lessons as a well known routine, with no surprises or unexpected occurrences.

To summarize, we can trace Ruth’s shifting from enthusiasm to frustration during her work on the project. Ruth started the project with a rigid set of classroom beliefs regarding teaching, learning and school functioning: school has its rules regarding ‘proper’ teaching methods, and inquiry-based learning is not part of them. The case of ‘Morgan's theorem’ made Ruth to temporarily distract from her existing classroom norms and to open her mind to the thought that if a young student had the ability to discover a new formula, so can she. When Ruth felt that she was about to uncover a new mathematical regularity, she was willing to consider a new perspectives regarding learning according to which: students are able to discover new mathematical regularities and not just prove existing formulae; teachers are not the only source of knowledge. However, as a result of unfulfilled self-expectations, Ruth's enthusiasm began to fade. When Ruth faced a situation in which she did not manage to discover any meaningful regularity she started to feel that she was not accomplishing her aim. This situation resulted in a retreat to her pre-existing beliefs (Foss & Kleinsasser, 1996), and enabled her to justify her failure. In fact, she did not take responsibility for her lack of success. Instead of searching for new directions of inquiry, or analyze the process in a rational manner, Ruth withdrew and relied on her existing system of beliefs as an ‘alibi’ for her lack of success. In fact, she ‘justified’

her failure by the fact that she was not familiar with this kind of learning, and by the fact that it was not the way she believes school students should learn. During Ruth's engagement in the project it can be observed that she tried to 'confront' her pre-existing beliefs concerning teaching, learning and the educational system with the new reality to which she was exposed. She emphasized the final product rather than the process itself and the challenging of her pre-existing beliefs was emotional rather than rational.

CONCLUDING REMARKS

Teacher education programs have a slight influence on PTs' perceptions regarding teaching and learning (Kagan, 1992, Tilema, 1998). It appears that one of the reasons for that phenomenon is the fact that PTs' systems of beliefs do not require external approval (Lamm, 2000). In order to be able to change, PTs have first to acknowledge the need to change, namely - to be convinced that alternative teaching methods have the potential to stimulate better learning and understanding of mathematics. In addition, they have to overcome the instinctive human tendency to resist changes. For that matter they have to challenge the adequacy of their pre-existing beliefs to the new information they are facing. This internal process of examination is social, cultural, environmental and personal dependent.

Ruth's beliefs reflect the educational system she was educated in over the years, as well as the common expected norms of our society. Lacking teaching experience, most of her expressed beliefs concern the learning of mathematics and only marginally the teaching of mathematics and the educational system. The prominent beliefs of Ruth's reflect several characteristics of our society:

- (i) Since the educational system is a conservative organization, educational changes are hard to accomplish.
- (ii) We live in a competitive society, therefore integrating a competitive dimension to the process of learning might increase its attractiveness.
- (iii) Our society puts an emphasis on the final product rather than the process that goes along with its accomplishment. This is consistent with the former (ii), since in competitive society achievements are measured and assessed merely by the quality of the final product.
- (iv) The final product should be achieved rapidly. Failing to get the desirable product implies on the failure of the entire process.
- (v) Coping with challenges is difficult. Hence, there should be social awareness to the importance of setting challenges and learning to cope with them.
- (vi) There is a tendency to avoid taking personal responsibility. Instead, failure is often attributed to external factors.

Considering the above, as teacher educators we may ask ourselves whether it is possible to bring any change into the educational system. Since social norms are very

dominant and serve as inhibitors to the accomplishment of this change, PTs have difficulties in internalizing the need to change the teaching approaches. It appears that we have to find ways and means for overcoming this barrier, and break the cycle. We believe that continuous engagement in profound examination of self-beliefs regarding teaching and learning might increase the plausibility of challenging the PTs' beliefs. A further research is needed in order to examine the nature of their resistance to implement innovative teaching/learning approaches and its relation to the accepted norms of the society in which the PTs are practicing. Identifying these relations might pave the road to the desirable change.

In order to educate a new generation of teachers who will appreciate innovative teaching approaches, we have to create learning environments which will encourage PTs' openness and provide them with the required support needed for recognizing the advantages of such approaches.

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