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Teaching mathematics through storytelling: Engaging the 'being' of a student in mathematics

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The paper draws from a hermeneutic phenomenological research study, which aimed at exploring the meaning of teachable moments from the lived experiences of grades 6–8 mathematics teachers. A primary and important stage of hermeneutic phenomenological study is for researchers to begin their research with a personal story. This paper presents the results of this primary stage, which focused on one of author's experiences of storytelling in a grade 6 to 8 mathematics classes for the purpose of humanizing mathematics as a way of engaging both the 'being' of mathematics students and their cognitive faculties. Data was collected from personal teaching stories of one of the researcher/author. The paper argues that teacher's storytelling humanizes mathematics in ways that engages both the 'being' and cognitive faculties of a student.

Keywords: Humanizing mathematics, teaching, learning, storytelling.

INTRODUCTION

What does it mean to teach mathematics? Researchers in mathematics education address this question in various ways. On one side, mathematics education researchers tackle this question by focusing on the question of how one can be an effective mathematics teacher. With regard to the question of an effective mathematics teacher, research tends to focus on teachers' content knowledge and/or pedagogical knowledge, or an integration of the two. Foote, Smith and Gillert (2011) suggest that teachers seeking to communicate a subject effectively and comprehensively should be equipped with an in-depth understanding of content knowledge, whereby they are able to provide alternative explanations for the same concept or topic in order to fully explain the subject. However, having an in-depth understanding of content knowledge in mathematics does not necessarily equate to or result

in teaching mathematics effectively. Researchers argue that in order to be a successful mathematics teacher, "[one] must develop multiple expertise in knowledge of mathematical content, pedagogy for teaching mathematics, and knowledge of students" (Foote et al., 2011, p. 71). Some researchers are concerned with the question of how the two categories of knowledge, mathematics (subject matter) and teaching (or pedagogy) can be integrated. An initial articulation of this integration comes from Shulman's (1986) work on pedagogical content knowledge. Building on Shulman's work, Ball and Bass (2000) elaborated on pedagogical content knowledge using the term 'mathematics knowledge for teaching' to capture the complex relationship between knowledge of mathematics content and knowledge of teaching. Even though researchers seem to agree on the importance of teachers' knowledge, there is little agreement over what teachers actually need to know in order to become effective mathematics teachers.

On the other side, mathematics educators and researchers suggest that to effectively teach mathematics means to humanize mathematics for its learners. While talking about the role of education, Doxiadis (2003) states that, "[it] should be, at its best – a process involving the complete human being" (p. 2). In this sense, humanizing mathematics requires teaching mathematics in a way that focuses on the 'being' of a student as a participant in mathematics, which is beyond delivering content of mathematics or teaching certain skill sets. From a humanistic perspective, Chapman (2008) reveals that, storytelling is "... a way of specifying experience, a mode of thought, a way of making sense of human actions or a way of knowing" (p. 16). Therefore, storytelling humanizes mathematics, where students are able to relate to mathematics at a personal level. Humanistic mathematics involves interdisciplinary connections between mathematics and other worlds of thought and methods of learning

(Tennant, 2014). According to Cernajeva (2012), it is important to humanize a study process, which means to approach educational content and its acquisition process using the principles of humanistic recognitions, while taking into consideration the interests and abilities of its learners. Consequently, humanistic approach to education may allow for one to develop human values, self-confidence, self-values, and gives room for self-reflections while at the same time it may increase awareness of others' need, which may result in sense of belonging in mathematics for students.

Doxiadis (2003) states that mathematics education will not change for its perspective learners unless what counts as mathematics changes. He adds that what counts as mathematics needs to include the stories of doing mathematics, where its participants are able to relate to the subject by talking about mathematics. Without stories, mathematics is stripped off of its humanity. Students need to be involved in complex mathematics, where they are given the opportunities to think in depth, rather than to adopt easy to use mathematical procedures. Stories in mathematics provide such opportunities. In his presentation, *Mathematics through an Arts lens*, Gadanidis stated that students in mathematics crave to be surprised, where they can flex their imagination and gain new mathematical insights. Further, Gadanidis indicated that story is a biological necessity, an evolutionary adaptation that prepares and trains one to explore the possibility of mathematics in actuality, effortlessly and playfully, which in turn has the capacity to make all the difference for mathematics students. Stories in mathematics highlight one as a human 'being' and enhance one's experience of learning mathematics (Gadanidis, 2012). Storytelling provides opportunities to solve puzzles in artistic way where the storyteller creates situations for its audience to experience the pleasure of surprise and insight in mathematics (Gadanidis, 2012).

Our work aligns with this research which is premised on the idea that to teach mathematics effectively, means humanizing it for learners. By humanizing we mean making the subject more humane and relatable so that learners appreciate mathematics by developing a personal connection with it. This paper draws from a hermeneutic phenomenological research study, which addresses the question: what does it mean to teach mathematics? The purpose of the research is to explore the meaning of teachable

moments from the lived experiences of grades 6 to 8 mathematics teachers. Here, the term teachable moment is defined as an opportunity that arises when connections have been made to advance learning by a learner and/or an educator. More specifically, the term moment is distinctly defined as an expected or unexpected occurrence that allows learners and/or educators to deepen their understanding. The paper presents findings from one of the author's experiences of storytelling in a grade 6 to 8 mathematics classes for the purpose of humanizing mathematics in ways that engage both students' 'being' and cognitive faculties in mathematics

STORYTELLING AS A WAY FOR HUMANIZING MATHEMATICS

From the beginning, storytelling has been used as a fundamental method for transferring knowledge. While discussing about the reason for many cultures to retain their storytelling legacy, Zazkis and Liljedahl (2009) state that storytelling, a traditional way of transferring knowledge, provides a unique way of looking at and understanding the world. On one side where mode of storytelling such as fairy tales, poems, nursery rhymes are entertaining, however, on the other side, they transfer essential information in a memorable way for its listeners (Zazkis & Liljedahl, 2009). Storytelling in mathematics is an approach for creating a safe-learning environment where a learner might openly appreciate, understand and enjoy mathematics (Modi, 2012). Storytelling in mathematics makes learning more accessible, where students are more engaged with their learning. Modi (2012) states that, "the value of story to teaching is precisely its power to engage the students' emotions and also, connecting their imaginations in material of curriculum (p. 31). Modi suggests that storytelling in mathematics classroom creates an environment of imagination, emotion, and thinking, which makes mathematics more enjoyable and more memorable for its participants. Storytelling provides ground for its participants to engage in a mathematical activity, which provides them with the opportunities to think, explore, and understand mathematical concepts and ideas (Modi, 2012). Further, storytelling creates a comfortable and supportive atmosphere in the classroom, and builds a bond between an educator and learners (Modi, 2012).

According to Schiro (2004), type of stories a society narrates, is a mirror of what information is considered important by that society, which contributes to the beliefs and the values it members adhere. Evidentially, type of stories that are narrated in mathematics classroom, might contribute to the beliefs and the values, which the learners may hold onto. For example, storytelling in mathematics classes that highlights the importance of failure as essential step to master a mathematical skill and/or to be successful in mathematics might influence one's perception of mathematics more so as a humanistic subject. According to Modi (2012), stories emerge in various places, where some are real while others are fictional, which may provoke one to think and wonder about the things which they may not have thought before. Though 'story' is defined at times as a 'sequence of events', it is not the events that are of interest here, rather the outcomes, in terms of impact, of storytelling on students in mathematics classroom (Modi, 2012). Modi believes that there are various types of stories that one might experience in mathematics. First type of story provides the background for a mathematical activity. For example, a historical content on mathematics, where the mathematician is given an image of a hero, while highlighting the importance of their initial struggle with a mathematical concept or idea. Second type of story provides explanation. For example, a story which may explain students about Pythagorean's triangle, division by zero, division by a fraction, and the manipulation of negative integers. Third type of story poses a question, for example, 'word problems such as 'does equal mean fair?'

RESEARCH FRAMEWORK

The epistemology of phenomenology centers on didactic meaning as opposed to arguing or developing abstract theory. In their discussion of the theoretical and conceptual framework for a phenomenological study, Savin-Baden and Major (2012) stated that "the essence experience is so central and is to be uncovered before it is categorized, researchers do not tend to use a theoretical or conceptual framework... [because] doing so could impose presuppositions on the meaning of the experiences" (p. 221). Additionally, Patton (2002) informs that phenomenology intends to acquire a deeper understanding of the nature or meaning of one's everyday experiences. Subsequently, the objective of the study here is not to make broad generalizations about experiences of all mathematics

teachers, but instead to examine individual teachers' personal experiences associated with a very specific phenomenon, and to compare and contrast their experiences as well as lived realities. In order to understand what it means to teach mathematics, it is necessary to first gain insight into teachers' lived experiences of teaching mathematics.

Van Manen (1990) considers phenomenology as the most appropriate method to research the phenomena of pedagogical significance, which elaborates phenomenology as a response to how one orients to lived experience and questions the way one experiences the world. Van Manen states that "a phenomenological researcher cannot just have a question – he or she must live it" and that "...lived experiences is the starting point and end point of phenomenological research. The aim of phenomenology is to transform lived experience into a textual expression of its essence – in such a way that the effect of the text is at once a reflexive re-living and a reflective appropriation of something meaningful: a notion by which a reader is powerfully animated in his or her own lived experience" (p. 36). Van Manen informs that "the questions of knowledge always refers us back to our world, our lives, to who we are, and to what makes us write, and read, and talk as educators: it is what stands ironically behind the words, the speaking and the language" (p. 46). A true phenomenological questioning is not possible until the researcher displays his or her interest in the phenomenon as lived. Additionally, Van Manen states that, lived human experiences cannot be captured in "deadening abstract concepts and in logical systems that flatten rather than deepen our understanding of human life" (p. 17).

METHODOLOGY

The question, *what does it mean to teach mathematics*, is a highly subjective phenomenon, which calls for a hermeneutic phenomenological research design. A phenomenological research describes a "lived experience" of a phenomenon. Phenomenology becomes hermeneutical when its method is taken as interpretive manner compared to descriptive as in other forms of phenomenology such as transcendental phenomenology. Heidegger (Savin-Baden & Major, 2012) argues that all descriptions are based on interpretation and every form of human awareness is interpretive. Drawing from Heidegger, Van Manen (Savin-Baden & Major, 2012) offers a methodological structure encom-

passing six themes as a helpful guide to hermeneutic phenomenological research: (a) turning to the nature of lived experience in formulating a research question that concerns a phenomena of deep interest—in this case teachable moments in mathematics; (b) investigating lived experiences by collecting descriptions of lived experience of the phenomena under study; (c) reflecting in a hermeneutic phenomenological sense, by recovering themes constituting the essence of the phenomena (d) writing hermeneutically, describing phenomenological experience of the emerged themes; (e) preserving a strong and oriented relation by maintaining a true interest to the phenomenon; and (f) balancing the research context by considering parts and whole, by creating a structure and a planning work for carrying out the phenomenological research.

These six themes guided our primary data collection and data analysis while mindfully dealing with any ethical concern regarding the study. In “Researching Lived Experiences”, Van Manen (1997) notes that to investigate the notion of teachable moments – in particular storytelling one needs to orient themselves to the question of meaning of teachable moments. And this meaning of the teachable moments needs to be found in the experience of teachable moments. “And so we need to search everywhere in the lifeworld for lived experience material that, that upon reflective examination, might yield something of its fundamental nature” (p. 53). Van Manen offers a number of approaches to gathering or collecting lived experience materials of different forms such as personal experiences, interviews, observations and fictional texts. In our work in this paper we focused on personal experience of teaching mathematics as a lived experience material for reflection on teachable moments.

Van Manen (1990) recommends that phenomenological researchers to begin their research with a personal story as a starting point for a phenomenological study. Further, Mason (2002) states that, “in order to turn from professional development to research, you have to address the questions of convincing others of what you claim to have found out” (p. 176). Keeping this in mind, as a focus of this paper, as well as a primary observation to the research question, we decided to explore one of the author’s teaching experiences of storytelling in her teaching of grade 6 to 8 mathematics classes. Data in this sense was collected from the personal stories of the teacher/author. For the purpose of this paper we present two stories where

the author utilized storytelling in her teaching for the purpose of humanizing mathematics. As in any phenomenological study, the author’s personal experiences of teachable moments are immediately accessible to her in a way that others are not. However as Van Manen (1997) argues, the focus for a phenomenologist is not on private or autobiographical facts but rather “in drawing from personal descriptions of lived experiences, the phenomenologist knows that one’s own experiences are also the possible experiences of others” (p. 54). The stories presented in this paper were selected by the author based on what she thought to be teachable moments and also in collaboration with the second author as what we thought could be possible experiences for others. In describing these stories we tried to align with the phenomenological tradition by trying to describe them in experiential terms focusing on classroom situation and events and refraining from abstractions.

First story

During my first year of teaching mathematics, I tried to make math more realistic and humanistic through storytelling. It was for the first Halloween as a teacher that I decided to talk about the invention of a concept of circle and the impact of such an invention on the world. Therefore, I dressed up like Cleopatra to bring the historical perspective and started talking about how the circle might have developed. First, I talked about how one day someone might have realized that there is a thing called line, which might have led to the idea of two lines intersecting and developing a corner. Next, I talked about the idea of four lines where two lines at a time, intersect, led to the development of four-sided figure like rectangles and squares. Further, I said, that there might have be one day that someone might have asked ‘can a line intersect itself?’ and in the process of examining that they might have connected the two ends of the line and might have made a circle, and this invention of a circle might have contributed to the invention of wheels. The moment I made the connection of circles and wheels, a lively class discussion ensued where one student said, “it may also be the reason why Christopher Columbus discovered the world because he might have realized that there are other shapes than four sided figures”. Then the other student made a reference to spirituality and said, “It could also be when people realized the karma ...you know what goes around is what comes around”. At this point, I was aware that my role was no longer didactic. The students have changed from being passive con-

sumers of mathematics to participants in knowledge creation, a change may see as empowering. As their teacher, I was amazed with this class discussion, but did not know what to do with it other than to say, "That's interesting..." And what did it have to do with teaching mathematics? Even though my intention was to bring a humanistic aspect to mathematics, I knew then that what had just happened was bigger than my intention.

Second story

During one of my lesson on geometry to my grade 6's, I was showing a 3-dimensional objects to my students. The purpose of the lesson was to help student develop understand of the relationship between an object and its net. While using real life examples like chocolates boxes and lunch boxes, I demonstrated for my students (while holding a 3 dimensional object in my hand) that if we open up all the sides of this objects and lay it flat, it would result in a net. And (while demonstrating) that if we put together all the sides of the net together, it will result in a 3 dimensional object. Next, as a class, we discussed about the characteristics of a net, which upon folding can result into a 3 dimensional object. In addition, we talked about what type of net may not make a 3-dimensional object (i.e. missing face in net). After discussion, students were challenged to create various type of net and then to check what type of 3-dimension object their net would turns into.

While students were working, a student asked me, "Ms. Toor, what is a side?" I responded to her by saying, " it is one of the faces of an object." She asked again, " no Ms Toor, what is a definition of side...is a side always straight...because if it is straight, then why do we call a side of a road side when the road is curvy?" At this point I knew that she was thinking beyond what I intended to teach. I was aware that without knowing about different braches of mathematics, she was talking about the difference between Euclidian and non Euclidean geometry. Consequently I knew that had also become a participant in knowledge creation of mathematics. However, I did not know how to guide her thinking so that she would not be overloaded with difference of Euclidian and non Euclidean geometry, causing her to become a knowledge consumer of mathematics.

ANALYSIS, DISCUSSION AND CONCLUSION

The purpose of hermeneutic phenomenological reflection is to try to grasp the meaning of a phenome-

non under study. In order to come to terms with the meaning of the phenomenon like teachable moments a phenomenologist has to engage in a reflective activity and think of the phenomenon described in terms of structures of meaning, meaning units or themes (Van Manen, 1997). Phenomenological themes may be understood as structures of experience and can be uncovered from any description of lived experience such the above stories. More importantly the meaning of phenomenon can only be communicated textually. So in order uncover the theme for this paper we reflected on the concrete situations in the above stories by asking questions such as what does this mean for this student, situation or action while focusing on the meaning of teachable moments. We then proceeded in describing the phenomenological experience of the theme.

Teacher's storytelling has its place in mathematics teaching. Storytelling as a method of humanizing mathematics, in ways that touches the 'being' of a student, was the common reoccurring theme in both of the stories mentioned earlier. In both of the stories there are three different personal experiences, from which students draw their humanistic connection to mathematics. These personal experiences are examples of the aspects that make these students human beings participating in mathematics. From close observation of the first story, we see that there are two personal experiences, historical curiosity and spiritual need, from which students make their human connection to mathematics. For example, in the first story, a student makes reference to Christopher Columbus by connecting it to the invention of circle. Here the student makes connection between mathematics with his historical curiosity. This connection allows for this student to be a human being, participating in mathematics, where he is able to talk about mathematics beyond the classroom boundaries. The spiritual need is another personal experience, an aspect of 'being' human, where a student talks about karma: "It could also be when people realized the karma ...you know what goes around is what comes around". Here, once again, the student draws connections between his personal experience and mathematics, which touches and deepens his connection with his 'being'. This connection, humanizes mathematics for this student where the student is able to explore his spiritual world by participating in mathematics.

Just as the first story, second story also highlights similar connections. In the second story, a student is curious about something that is beyond the curriculum expectation. Here the element that makes her 'being' in mathematics is the process where she question mathematical definitions. The student wonders about the definition of a side and relates it to her everyday life. Just like the other two students from the first story, this student also humanizes mathematics by making a connection to an element that makes her human. In all three cases students are engaged both cognitively and as human beings as they participate in mathematics.

From the researcher's storytelling experiences as a teacher, we have found that stories allow for one to teach and to learn about the things, which perhaps in the purposeful lesson plan would be lost. Near the end of the school year, the students from these classes where storytelling was utilized, often through voluntary verbal feedback inform their teacher that they (the students) viewed stories as a valuable learning tool, which enhanced their understanding of mathematics by acting as memory joggers and in some cases enticed them to further explore mathematics. All too often education becomes the consumption by students of defined knowledge presented by the teacher in a transmission model. Education should involve an exchange of knowledge between the learners and educators, where these experiences can enhance both teachers and students' mathematical understanding. Storytelling as a pedagogical practice is a method where both the teacher and students learn from one another, while engaging in mathematics. The stories that we have presented in this article show that students are able to relate to mathematics in ways that they are able to see themselves as mathematical 'beings' who have abilities to explore and to be curious about mathematics.

The findings for this study, as discussed above, have implications for both educators and further research. This study contributes to mathematics education research by focusing on lived experiences of teachers' storytelling to humanize mathematics, a certain element of teaching which most theories, models, and methods of mathematics teaching tend to ignore or to not address. This study brings awareness for mathematics education researchers and practitioners by highlighting the need for humanization of mathematics through utilizing storytelling as a teaching

tool. Further, the findings from this study allows one to see mathematics teaching (and learning for students) possibilities in ordinary incidents, and to be able convert these seemingly unimportant incidents into significant mathematics teaching (and learning for students) moments – teachable moments.

As much as these stories had positive impact on the students, the teacher/author often found herself questioning her role as a teacher while utilizing storytelling in her classes. As a teacher, the author questioned her decision, and reason behind acting in a certain way especially when facing and dealing with the outcome of storytelling. She wondered if she was guiding her students in right direction, especially when students were engaged beyond the initial aim of story that the researcher intended. Van Manen (1990) states:

In all of our interaction with children, we are constantly involved, whether we like it or not, in distinguishing between what is good and what is not good for them (in contrast, educational research is usually more interested in distinguishing between what is effective and what is ineffective). Yet even (or especially) the best educators temper their practice with the knowledge that we all often fall short and do not know what is best. (p. xii)

There is little research that focuses on the particularity and uniqueness of the day-to-day, moment-to-moment nature of teaching mathematics. It is clear from researcher's experiences of storytelling, that there is a need for further research where the focus needs to be on how decisions are made in a mathematics classes while focusing on, what it means to teach mathematics on day-to-day and moment-to-moment bases. This question will be explored in the bigger research study from which this paper was derived. The authors plan on conducting interviews with mathematics teachers in order to collect other experiences of teachable moments so as to deepen the understanding of the question, what does it mean to teach mathematics.

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