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Effect of Using Conjectures and Story-telling in Mathematics Learning: A Phenomenological Study of Two Teachers' Teaching Styles

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

The purpose of this study was to describe the personal experience on the effect of story-telling and using conjecture in mathematics learning. This research was designed in hermeneutic phenomenological study. Accidental sampling procedure was used in this study since the researcher was as an external observer of B Ed students majoring mathematics. The researcher was innocent of pedagogical approach of student-teachers. Taking two student-teachers and their students of class eight as participants, their perceptions were noticed. Data were collected on the way of practice teaching external observation from two secondary schools of Butwal and Tilottama Municipality and analyzed with hermeneutic phenomenological approach. Research revealed that story telling is the way of humanizing mathematics, motivates students to the subject matter and the conjecture promotes students' cognitive faculties, logical thinking and develop the Heuristic capacity.

Keywords: Conjectures; humanizing mathematics; learning; storytelling; teaching.

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1. INTRODUCTION

Persistent practice in mathematics activities are often burdensome, tasking and creates considerable tension. It makes learning unpleasant, less stimulating and less motivating. Mathematics is a subject which is said to be brain tester. There are so many Mathematics conjectures that sharpen one's logical thinking. Mathematics is beauty which is seen and felt and must be understood to be employed [1]. A clear idea of one's knowledge of what goes on in Mathematics classroom these days reveal that teaching procedures in use makes mathematics instructions boring and uninspiring [2].Teaching and learning mathematics encompasses skills and functions which are a part of everyday life. Presenting a problem and developing the skills needed to solve that problem is more motivational than teaching a skill without a context. Learning mathematics without a context produces classical knowledge. It does not allow the students to see a reason for learning the mathematics and more deeply involved.

1.1 Story Telling in Mathematics Classroom

Teaching through story telling by contextualizing the topic matter can enhance student's logical reasoning, helping people, to be ready to decide what rules, a situation requires, or if necessary to develop their own rules during a situation where an existing rule can't be directly applied. Mathematics educators and researchers suggest that to effectively teach mathematics means to humanize mathematics for its learners. When coming to the discourse about the role of education, Doxiadis (2003) [3] states that, "it should be, at its best – a process involving the complete human being". In this sense, humanizing mathematics requires teaching mathematics during away 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) [4] founds that, story-telling is"…how of specifying experience, a mode of thought, how of creating sense of human actions or how of knowing". 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.

1.2 Using Conjecture in Mathematics Classroom

Mathematical conjectures are important in mathematics. They play a vital role in mathematical development as formalization of conjecture is good and inevitable for mathematics, as large mathematical theories get bigger [5]. Constructing mathematical conjecture involves abstraction and generalization processes related to ideas that are initially hypothetical in nature [6 and 7]. In addition, constructing mathematical conjecture and developing proofs are two fundamental aspects of professional mathematical work and is the first step in invention [8 and 9]. Mathematical conjecture also plays an important role in mathematics instruction. NCTM (2000) stated that a program in mathematics instruction should enable all students to recognize reasoning and proof as fundamental aspects of mathematics, make and investigate.

Conjectures inspire students to think creatively and helps them to work deeply. Conjectures develop emotions associated with various stages of the solution process. Many researchers such as Boero, Garuti, Lemut, and Mariotti (as cited in Manizade & Lundquist, 2009) [10] argue that the student must work through internal arguments and sort through solutions that are plausible, similar to ones that a mathematician goes through when building a proof during the process of constructing a conjecture. Boero, Garuti, Lemut, and Mariotti propose that the process of constructing or building conjecture should be emphasized more in mathematics instruction. Besides, constructing mathematical conjecture or making a prediction has three benefits in the mathematical classroom since it can reveal students' conception, plays an important role in reasoning, and fosters learning.

1.3 Statement of the Problem

Many teachers are under pressure to cover state or school mandated topics within tightly constrained time-periods. They do not have time for story-telling and making conjectures while teaching. In the case of private school in Nepal (for SEE students), teachers are compelled to make drill, activities. And even if they had time, teachers are not trained to know what to do with puzzles, conjectures and story-telling in their mathematics classroom. Many dogmatic literatures are published in many books, journals that story telling and mathematics conjectures

motivate students, promote cognition and logical power of students. It is necessary to know the contextualizing process of story-telling and making conjectures in mathematics classroom as well as find out the perception of mathematics teachers and students in using story-telling and making conjectures. By finding their perceptions, it would be helpful to share the experience to mathematics teachers and apply them accordingly. It was an opportunity to seek the effectiveness of story-telling and mathematic conjecture adopted in grade eight at the period of external evaluation of practice teaching in mathematics at two different schools of Tilottama, Rupandehi.

1.4 Research Question

Story-telling, a traditional way of transferring knowledge, provides a unique way of looking at and understanding the world. Making puzzles and conjectures to juniors and children at bed time and enhance logical power is also worldwide tradition of parents. To make mathematics an interesting and useful subject for life, story-telling and mathematics conjectures are important. But how much degree they help to understand mathematics, support to enhance cognitive level and motivate students as well. So, researcher made the following research question:

- To what extent story-telling and conjectures effect mathematics learning?

2. METHODOLOGY

As the schedule of practice teaching external evaluation, researcher observed many mathematics classes of different schools of Butwal and Tilottama in 2018. The student-teachers were one year B Ed. Two students of separate schools used story-telling and mathematics conjectures in their mathematics class. Being external observer, researcher observed their classes and recorded their stories and mathematics conjectures using mobile. Some gesturing and interesting activities of the teachers' procedures were captured through mobile. The active participation and attention to the lesson were also captured through mobile. The sampling procedure was accidental sampling because researcher was innocent to the sampled subjects and what they would do in their class. Data were collected and put it research frame by filtering, organizing and analyzed in hermeneutic phenomenological research design. 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. 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 (as cited Savin-Baden & Major, 2012) [11] argues that all descriptions are based on interpretation and every form of human awareness is interpretive.

2.1 The First Scene of the Class

The researcher as an observer, went to mathematics class in 8th grade in the school of Butwal metro-politan city. The scenario of mathematics teaching procedure of Bhagat (pseudo name) is described below

2.2 Pedagogical Strategy for Contextualizing Lesson by Story-telling

During class observation of teaching mathematics, the student-teacher tried to make math more realistic and humanistic through storytelling. He wrote the topic of his lesson "circle" on the white board at first. The researcher thinks, he decided to talk about the invention of a concept of circle and the impact of such an invention on the world. Therefore, he dressed up the story with historical perspective and started talking about how the circle might have developed. First, he talked about how one day someone may need realized that there's a thing called line, which could have led to the thought of two lines intersecting and developing a corner. Next, he talked about four lines where two lines at a time, intersect, led to the event of four-sided figure like rectangle and squares. He drew the figures on the white board at the time of telling. Moreover, he talked about the idea of eight lines intersecting two lines at one corner and to make octagon. Further, he 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. In this way, he made the connection of circles and wheels to the story, an active class discussion ensued where one student said, "it can also be the rationale why Columbus discovered the world because he might have realized that there are other shapes than four sided figures". Then another student made a regard to spiritually and said, 'it could even be when people realized the Sun is spherical shape…you know what goes around is what comes around". At now, the teacher was aware that his role was not didactic. The students have changed from being passive consumers of mathematics to participants in knowledge creation, a change may even see as empowering. As being their teacher, he was amazed with this class discussion, but perhaps didn't know what to do and what to say other than this, "That's interesting….". Perhaps he might have realized that what did it need do with teaching mathematics? Even though his intension was to bring a humanistic aspect to mathematics, he knew then that what had just happened was higher than his intension.

After the lesson, researcher asked some questions to the students and teacher, some of the representative answers are given below:

Re: Do you have précis concept of circle?

Student A: Yes, sir. The circle is the limiting position of polygon.

Student B: If sir has defined the circle at the beginning, we would not have clear concept.

Student C: Sir, circle has no vertices.

Re: What is your perception of using story-telling in mathematics classroom?

T: At the beginning of being a novice teacher, I used to define the topics but students felt rigor. It became difficult to motivate students in class. When evaluating students, the result of students in conceptualizing and understanding mathematics seen poor. When I taught 4-5 days using same method such that mathematics is pure science, the achievement of students was same. I consulted with senior mathematics teacher of this school describing my problem. He suggested to humanize mathematics. It became my formula so that I improved my pedagogical style in teaching mathematics. Then after, before planning my lesson, I use to think a story which is suitable for my lesson. Story-telling method helps teacher to motivate students, enhance teacher's creativity and enhance the cognitive level of students.

2.3 The Second Scene of the Class

After two days, I went to observe the class of Kiran (pseudo name) according to my schedule at the school of Tilottama municipality. Kiran was brilliant in my class when he was in college. I was curious to know what types of pedagogical procedure would he use in teaching mathematics. I faced many inquiries of him when I was teaching him in college classroom. As being a teacher, I was eager to know how would he play the role, use appropriate pedagogy, control large class, and deliver mathematical knowledge. But when observing the class, I found that he had done good preparation.

2.4 Pedagogical Strategy for Using Conjecture to Promote Cognition

In another mathematics class, the student-teacher was teaching prime numbers in class seven. According to his lesson plan, one of the objectives was to find the prime numbers between1-100. He told the definition of prime number at first and gave some examples of prime numbers. The student-teacher was aware of the deductive and inductive way of teaching. He used an idea of finding prime numbers by using Oppermann's conjecture. Then he wrote the following conjecture on the white board and asked students to find out the prime numbers using different integer.

2.4.1 Oppermann's conjecture

It states that for every integer $x>1$, there is at least one prime number between $x(x-1)$ and x^2, and at least another prime number between x^2 and $x(x+1)$.

Then students of class seven were engaged in their class work problem to find the prime number. One of the students showed his work by using integer $x=5$ and explained to the teacher in this way:
Let the integer $x=5$, since $5>1$.

We know,

$5(5-1)$ and 5^2 has at least one prime number.

i.e Between $5^* 4=20$ and 25 has at least one prime number.

There are only four numbers 21, 22, 23, 24 between 20 and 25. Among them 21, 22 and 24 are composite numbers. So 23 is the prime number.

For the second condition, he used same integer x=5 to produce another prime number. He showed the solution in this way on white board.

Let the integer x=5, since x>1.

We know,

5^2 and 5(5+1) must have at least another prime number.

i.e, between 25 and 30 must have at least another prime number.

There are four numbers between 25 and 30. They are; 26,27,28 and 29. Among them three numbers 26,27 and 28 are composite numbers but 29 is another prime number.

By the same process, other students also were solving the conjecture to find prime number. The class was silent and the situation of learning was quite activity and student based. As an observer, I felt that mathematics teachers must have the huge knowledge of mathematics conjecture for effective teaching and for the development of cognition of the student. After the class, researcher asked students and teacher to find out their perception on making conjecture. Some representing answers are here:

Re: Can you find all prime numbers between 1-100?

Student A: Yes sir, why not? We have a formula to find out.

Student B: I can find out the three prime numbers before and after 36 between 30-42 by using the formula above.

Student C: It is very interesting to learn the method of finding prime numbers. We can put the different positive integers for x. But Oppermann's Conjecture is silent at x<1, I will try at home, what will be the result.

Re: Do you use these types of conjecture in other topics too?

T: Yes sir, I use mathematical conjectures in most of the topics in my class. This helps students in inductive reasoning and exploration. At the beginning, mathematical concepts were generated in solving human behavioral problems, then after it was developed through inductive approach. By its nature, mathematical induction is very important to produce formulas and know the real world meaning of mathematics. Before planning my lesson, I use to search different conjectures to related topic. If I did not find, I try to pursue inductive approach to understand the real meaning of mathematics.

3. ANALYSIS AND DISCUSSION

The purpose of hermeneutic phenomenological reflection is to try to grasp the meaning of a phenomenon 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 [12]. Phenomenological themes may be understood as structures of experience and can be uncovered from any description of lived experience such the above stories and conjectures. More importantly the meaning of phenomenon can only be communicated textually. So in order uncover the theme for this study I reflected on the concrete situations in the above stories and conjectures by asking questions such as what does this mean for this student, situation or action while focusing on the meaning of teachable moments. I 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 the story of the circle, 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 story, I see that there are two personal experiences, historical curiosity and spiritual need, from which students make their human connection to mathematics. For example, 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 sun: "It could also be when people realized the sun …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 in one school, the student-teacher of another school used mathematics conjecture to make lesson contextualizing and interesting. There were many things going parallel way; the first was motivating to the lesson, second was exploring prime numbers by using the statement of Oppermann's conjecture and the third was using the process of induction to solve the problem of mathematics.

Conjectures inspire students' to think creatively and helps them to work deeply. Conjectures develop emotions associated with various stages of the solution process. Many researchers such as Boero, Garuti, Lemut, and Mariotti (as cited in Manizade & Lundquist, 2009) argue that the student must work through internal arguments and sort through solutions that are plausible, similar to ones that a mathematician goes through when building a proof during the process of constructing a conjecture. As the researchers Boero, Garuti, Lemut, and Mariotti propose that the process of constructing or building conjecture should be emphasized more in mathematics instruction, every mathematics teachers should have the knowledge of using mathematics conjecture. However, it is necessary to evaluate the conjecture whether it is true for all cases or not. While confirming examples may help to provide insight into why a conjecture is true, we must also *actively* search for counter examples. When students believe a conjecture, they are not always rigorous in their search for examples that break the pattern that they have identified. We must help them develop the habit of being more skeptical. One way we can develop this skepticism is by giving students problems that have "false" patterns. Besides constructing mathematical conjecture or making a prediction, it has three benefits in the mathematical classroom since it can reveal students' conception, plays an important role in reasoning, and fosters learning.

4. CONCLUSION

Stories are valuable learning tools, which enhanced students' 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 cognition 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. Similarly, conjectures arouse students' curiosity on mathematics. Until the student understand the mathematical problems and apply them in their real life situations, they do not see the beauty of mathematics. Conjectures are the bases of mathematical induction. Conjecturing can be made a regular strand within any class. Any mathematics topic can be the source of patterns and the chance to generate conjectures. Once students become comfortable with the process of developing conjectures, they will start to initiate explorations based on their observations and research will become a daily possibility. In addition to teaching students about how mathematical knowledge is developed, an emphasis on conjecturing often proves interesting for students. This heightened interest contributes to longer-term recall and mastery of the technical skills that are practiced during the investigations. The relative openness of conjecturing activities also puts students in situations where their confusions or conflicting understandings about an idea are more likely to be exposed and then resolved.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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