

TEACHERS' BELIEFS ON THE NATURE OF MATHEMATICS & ITS IMPLICATIONS TO THE TEACHING AND LEARNING OF MATHEMATICS

Maria Antonieta A. Bacabac^{1*}, Dennis B. Roble¹, Garry Becoy¹

¹University of Science and Technology of Southern Philippines, Lapasan Highway, Cagayan de Oro City, Philippines

*For Correspondence; Tel. +639270265344, Email: antonieta.bacabac@gmail.com

ABSTRACT: *This study determined and compared the beliefs of mathematics teachers on the nature of mathematics among pre-service, senior high school and college mathematics teachers of the University of Science and Technology of Southern Philippines and discussed the implications of the nature of mathematics on their teaching and learning of mathematical concepts. This study involved 120 pre-service, seven (7) high school and 16 college mathematics teachers of the university. Data were gathered using survey questionnaire adopted from TEDS-M and analyzed using mean, standard deviation and analysis of variance (ANOVA). Results indicate that pre-service mathematics teachers showed a different perception as compared to the senior high school and college mathematics teachers which might be due to their maturity and experience in the field. The researchers then recommend that higher education institutions such as USTP need to prepare rigorously pre-service mathematics teachers to have a better belief on the nature of mathematics so they will be job ready when they graduate in their field of study. Further research might also be conducted on the learning and program effectiveness of mathematics and its impact on students' learning and teachers' performance and explore on the relationship of these different beliefs domains and other vital skills needed for mathematics teachers to excel in the profession.*

Keywords: Beliefs of Mathematics, Nature of Mathematics, Pre-Service Mathematics Teachers

1. INTRODUCTION

Beliefs are the core of who we are, what we do, and the success that we acquire. Beliefs are considered as inner convictions, a feeling of certainty about what something means and belief is both mental and emotional and embedded in the mind and in the heart [1]. Mathematics is the science that deals with the logic shape, quantity and arrangement. It is something that is within us in our daily routine [2]. Mathematics is very important to mankind since it is the foundation of our daily lives. Without mathematics, life, in general, would be difficult to imagine.

In mathematics, students failed for a number of reasons and one of it can be attributed to teaching factor. It can be said that the teacher possesses poor pedagogical knowledge, teaching can be very boring and students would have difficulty in grasping important mathematical ideas. Various literature also suggest that mathematics teachers' beliefs can affect students' classroom performance. In fact, many students believe that mathematics is their worst nightmare. Other students noted that if they saw numbers they became dizzy. Beliefs about mathematics as a scientific discipline are different in nature of what literature means about beliefs of mathematics or beliefs about mathematics as taught in school [3]. Teachers' beliefs played a mediating role in the relationship between teachers' mathematical knowledge and instructional practices. According to the National Council for Mathematics Teachers (NCTM), teachers need to engage students in different tasks that promote reasoning and problem solving and facilitate discourse that moves students toward a shared understanding of mathematics. In this manner, students will be able to learn and love mathematics as well. They will be able to make mathematics easier [4]. An effective teacher will give students an appropriate challenge, encouragement in solving problems and support them in any mathematical situation [5].

With these aforementioned views, the researchers would like to determine mathematics teachers' beliefs in teaching

and learning mathematics and show the significant level of each of the following teachers: pre-service, senior high school, and college mathematics teachers.

2. THEORETICAL UNDERPINNINGS

Beliefs of pre-service and in-service mathematics teachers in mathematics and mathematics teaching were the necessity of the learning of students towards mathematics. In this study, there are theories in which this study was anchored. According to Jean Piaget, the human intellectual development progress of an individual was based on four consequential stages, the sensorimotor, preoperational, concrete operational and the formal operational in a chronological order. By this theory, it shows the growing process of an individual. The development and the knowledge of the students will not be able to be rejected but it is in the continuous process. Teachers will develop the potential in teaching and they should know how to manipulate mathematics in any stages. He also defined that intelligence was liked as the ability to adjust in the environment. The teachers should possess the step-by-step process in order to observe the intellectual capacity of students in the same environment he/she took place [6]. The definition of learning had no general agreement. However, some were opposed to the given definition of Romberg. Learning is an observable change in behavior, others mean it's acquiring new knowledge, and other say that it is the creating of a disequilibrium. The teacher will grasp the opportunity to observe the changes in the behavior of their students, the students should be able to acquire new knowledge and manipulate the disequilibrium of their learners [7]. Piaget further said that the role of a teacher is to facilitate and organize situations and activities to be presented to the students. Teachers also must give examples that the students can reflect and can give reasons and answer to the problem given [6]. The above theory was related to the present study because the researchers believe that human intellectual development was consistent with the persons' beliefs on how things work and in the case of students' beliefs on the nature of mathematics, there might be a linear association between these two ideas.

Skemp's theory was about the difference between an instrumental and relational learning in the classroom, especially in math class. This theory was really interesting and important for the reason that it will be the advent of more demanding problem-solving in mathematics. Teachers will consider the aspects and learning of students. Students will be able to use any of the two, instrumental or relational learning in mathematics. Teachers, by the use of instrumental learning, will discuss more enjoyable and happier for it can discuss in a short-term or in an easy way. While in relational learning, it will produce a meaningful learning to the students and the students will understand the relationships in which it gives mathematics structures in a relational term [8]. The theory of Skemp was in a way related to the present exploration since the instrumental and relational understanding of mathematical concepts was perceived to be associated with students' beliefs on how mathematics works and thus make problem-solving in mathematics workable.

Behaviorism theorist believes that there is an existence of knowledge in their own behavior independently and outside the people. In this theory, the teacher needs to have wisdom and encouragement with reinforcement to the students immediately. The behaviorist theory is proof that learning is always affected by students' beliefs. Moreover, Thorndike suggested that in mathematics, students should perform many drills and practice on the correct procedures and facts for them to master the values of mathematics and to strengthen the correct mental bond of the individual. By this, teachers will help the students to perform and have an active mind in answering the problems given. This is true because when students' are engaged in different drills and practice doing mathematics, beliefs of students in mathematics may have been positive because when they learned how to do mathematics, they would feel confident in solving problems and hence perform well in the classroom. B.F. Skinner denied the theory of "mental bonding"; however, the perception of the behaviorism and the associations is somehow similar. There should have immediate feedback or reinforcement to the students who perform well and actively participated while immediate punishment will pursue to those who were not attentively responding to the tasks. This theory will give guidance to the teacher on how they reinforce the students and what are the things to be done in order for the students to participate [9]. Teachers need to take further steps in developing a critical mind setting in mathematics which produces innovative ideas which can help students perform well in the classroom and one way to do this is to change students negative beliefs about mathematics.

3. LITERATURE REVIEW

Beliefs play great role in mathematics learning and teaching. The learning outcomes of students are believed to be strongly associated to their beliefs and attitudes about mathematics. Various literature most of the time explored the beliefs of the students' in the learning of mathematics and there has been scarce studies on the beliefs of mathematics teachers on the nature of mathematics.

In the exploratory study conducted by Muhtarom, Juniati & Siswono on prospective teachers beliefs on the nature of mathematics with descriptors including the definition of mathematics, the relationship of mathematics with daily life and view of mathematics knowledge development. The 172

prospective teachers answered an open questionnaire and a series of semi-structured interviews. The research results showed that most of the students who had instrumentalist beliefs believed that mathematics was an exact science consisting of a set of unchanging rules, proved true not interrelated but useful in life and mathematics knowledge was predicted to remain, unchanged. Others believed that mathematics was dynamic, creative and always developed [10].

Another study was conducted by Zakaria and Musiran on the beliefs about the nature of mathematics, mathematics teaching and learning among trainee teachers from two higher institutions of learning in Selangor, Malaysia. The results indicate that the beliefs of mathematics trainee teachers are positive towards the constructivism approach. Teacher trainees believe that mathematical problems can be solved in many ways. They also believed that teaching mathematics should involve the opportunity to use mathematics in daily situations and in learning mathematics students need to understand the concepts, principles and strategies in mathematics [11].

Ayele & Dadi also conducted a study on students' beliefs about mathematics learning and problem-solving among three grade eleven students in West Arsi Zone, Ethiopia. The data was collected from four schools in West Arsi Zone using multistage sampling. This study displayed that students' beliefs about mathematics learning, and students' beliefs about mathematics problem solving, were neutral; and there was a statistically significant difference in students' beliefs about mathematics learning and problem-solving according to stream, and parents' residence. However, even though the mean of students' beliefs about mathematics learning and problem-solving for male students was greater than that of female students, there was no statistically significant difference between male and female students in their beliefs about mathematics learning and problem-solving [12].

In the study conducted by Breiteig, Grevholm, Kislenko, they found out that 96 % of students agree that mathematics is useful for life and 100 % agree that mathematics is important. 52 % claim that mathematics is boring, while 88 % are sure that they need to know mathematics. 84 % of pupils disagree that there is just one right answer in mathematics tasks. 96 % think that it is important to get good marks and 83 % find it important to cooperate in mathematics class. Everybody feels that it is important to know something about numbers and calculations and to know how to solve practical problems. Most pupils are good friends and have fun during classes and they are quite satisfied with the environment in class and school [13].

Romano also studied the reflections on the course 'Elementary Mathematical Concepts' from the study group for the pre-school teacher education. He found out that pre-service students' beliefs about the importance of mathematics and necessity of mathematics education for the future profession are questionable, i.e., low and insufficient, and their motivation for the course EMC is extremely poor. The researcher believes that these parameters in our university education of this teacher's profile cannot significantly change in the short term [14].

Smith & Gene conducted a study on the impact of secondary mathematics methods courses on pre-service secondary teachers' beliefs about the learning and teaching

of mathematics. They concluded that there is a significant positive relationship was found between the number of methods used in the methods course to challenge student beliefs and the improvement between pre and post-tests. Preservice teachers' beliefs about the learning and teaching of mathematics were found to become more reform-oriented during the course of the methods course [15].

Canto-Herrera & Salazar-Carballo studied the teaching beliefs and teaching styles of mathematics teachers and their relationship with academic achievement. The purpose of this study was to study the relationship between beliefs and teaching styles of teachers of mathematics and their students' academic performance in high schools of Yucatan. For this purpose, a questionnaire was administered to 72 high school mathematics teachers and the student academic achievement score of 1241 were used. A significant relationship between beliefs about constructivist teaching and each of the five categories of teaching styles of teachers of mathematics were found, and also the relationship between teaching style "Delegator" and student academic achievement was found. It was concluded that mathematics teachers maintain consistency between what they believe and how they teach, so it is important to maintain correspondence between the teaching style and belief system to achieve a satisfactory effect in mathematics and the teaching style "delegator "is associated with better academic performance in mathematics [16].

Maksum & Mawarpury conducted an exploratory study on high school teacher's beliefs on teaching and they found out that the data were collected by in-depth interview of three different subject teachers at SMA 6 Lhokseumawe. The study found that teachers' beliefs cannot always take into practice. Teachers believe that they are the key stakeholder for bringing better education, unfortunately, context and situation like the educational system is a big dilemma for teachers to put their beliefs into classroom practice. The result of this study also revealed that all of the teachers are committed to their profession; two participants confessed that they never dreamt of being a teacher but they decided to be a teacher because of some reasons. Besides, all participants have committed not to shift their profession someday [17].

The above studies mentioned are deemed important in the present study because mathematics belief plays an important role in many aspects of teaching mathematics concepts as it also influences the way teachers make decisions and actions in the mathematics classroom.

4. METHODOLOGY

This study utilized a descriptive survey research method. Data were gathered through survey questionnaires on the mathematics teacher's beliefs on the nature of mathematics which was taken from the Teacher Education and Development Study in Mathematics (TEDS-M). There were 143 respondents who took the survey composed of 120 pre-service mathematics teachers under the Bachelor of Secondary Education major in Mathematics of the College of Science and Technology Education (CSTE), seven (7) senior high school mathematics teachers and 16 college mathematics teachers of the Department of Mathematical Sciences (DMS) of the College of Science and Mathematics (CSM) of the University of Science and Technology of Southern Philippines (USTP) located in Lapasan Highway, Cagayan de Oro City. USTP is a state university

established on August 16, 2016, by virtue of Republic Act 10919 through the amalgamation of the Mindanao University of Science and Technology (MUST) in Cagayan de Oro City, Misamis Oriental and the Misamis Oriental State College of Agriculture and Technology (MOSCAT) in Claveria, Misamis Oriental. Both campuses are located in Northern Mindanao, the Gateway to Mindanao, which offers a strategic locational advantage for the institution to train and develop students from all the other regions of Mindanao. This state university envisioned to become a nationally-recognized Science &Technology university providing the vital link between education and the economy.

The data gathered were analyzed using descriptive statistics such as mean and standard deviation and analysis of variance (ANOVA).

5. RESULTS AND FINDINGS

Table 1. Level of Mathematics Teachers Beliefs on the Nature of Mathematics

| Statements | Pre – Service Teacher | | | Senior High School Teacher | | | College Teacher | | |
|---|-----------------------|--------------------|--------------------|----------------------------|--------------------|-----------------------|-----------------|--------------------|-----------------------|
| | Mean \bar{x} | Standard Deviation | Verbal Description | Mean \bar{x} | Standard Deviation | Verbal Description | Mean \bar{x} | Standard Deviation | Verbal Description |
| Mathematics is a collection of rules and procedures that prescribe how to solve a problem. | 5.41 | 0.728 | Agree | 5.86 | 0.378 | Strongly Agree | 5.31 | 0.704 | Agree |
| Mathematics involves the remembering and application of definitions, formulas, mathematical facts and procedures. | 5.61 | 0.598 | Strongly Agree | 5.57 | 0.787 | Strongly Agree | 5.63 | 0.500 | Strongly Agree |
| Mathematics involves creativity and new ideas. | 5.38 | 0.842 | Agree | 5.86 | 0.378 | Strongly Agree | 5.94 | 0.250 | Strongly Agree |
| In mathematics, many things can be discovered and tried out by oneself. | 5.40 | 0.703 | Agree | 5.57 | 0.535 | Strongly Agree | 5.94 | 0.250 | Strongly Agree |
| When solving mathematical tasks, you need to know the correct procedures or else you would be lost. | 4.92 | 1.112 | Agree | 5.57 | 0.535 | Strongly Agree | 5.13 | 0.957 | Agree |
| If you engage in mathematical tasks, you can discover new things (e.g. connections, rules, concepts). | 5.23 | 0.825 | Agree | 5.86 | 0.378 | Strongly Agree | 5.88 | 0.342 | Strongly Agree |
| Fundamental to mathematics is its logical rigor and preciseness. | 5.09 | 0.710 | Agree | 5.86 | 0.378 | Strongly Agree | 5.88 | 0.342 | Strongly Agree |
| Mathematical problems can be solved correctly in many ways. | 5.59 | 0.615 | Strongly Agree | 6.00 | 0.000 | Strongly Agree | 5.94 | 0.250 | Strongly Agree |
| Many aspects of mathematics have practical relevance. | 5.18 | 0.799 | Agree | 5.86 | 0.378 | Strongly Agree | 5.81 | 0.544 | Strongly Agree |
| Mathematics helps solve everyday problems and tasks. | 5.23 | 0.903 | Agree | 5.57 | 0.535 | Strongly Agree | 5.94 | 0.250 | Strongly Agree |
| To do mathematics requires much practice, correct application of routines, and problem-solving strategies. | 5.54 | 0.685 | Strongly Agree | 5.86 | 0.378 | Strongly Agree | 5.81 | 0.403 | Strongly Agree |
| Mathematics means learning, remembering and applying. | 5.47 | 0.744 | Agree | 5.71 | 0.488 | Strongly Agree | 5.75 | 0.577 | Strongly Agree |
| Overall | 5.34 | 0.772 | Agree | 5.76 | 0.43 | Strongly Agree | 5.75 | 0.45 | Strongly Agree |

Legend:

1.00 – 1.49 – Strongly Disagree 2.50 – 3.49 – Slightly Disagree 4.50 – 5.49 – Agree
 1.50 – 2.49 – Disagree 3.50 – 4.49 – Slightly Agree 5.50 – 6.00 – Strongly Agree

Table 1 above shows the mean level of the mathematics teachers of USTP on the beliefs on the nature of mathematics. Overall, the senior high school and college mathematics teachers showed strong beliefs of the nature of mathematics while the pre-service mathematics teachers only showed moderately positive beliefs on the nature of mathematics. This means that senior high school and college mathematics teachers had better beliefs on the nature of mathematics as compared to the pre-service mathematics teachers. In particular, the pre-service mathematics teachers rated strongly agree and highest among all indicators that mathematics involves the remembering and application of definitions, formulas, mathematical facts and procedures while the senior high school mathematics teachers rated perfect the statement that mathematical problems can be solved correctly in many ways while both the pre-service and college mathematics teachers only agree on the statement that when solving mathematical tasks, you need to know the correct procedures or else you would be lost. The senior high school mathematics teachers strongly agreed in all indicators of the beliefs of the nature of mathematics. This means that the senior high school mathematics teachers

showed great appreciation on the nature of mathematics as they teach mathematics for the Science, Technology, Engineering and Mathematics (STEM) strand of the K-12 Curriculum.

Table 2: Comparison of the Beliefs of Mathematics Teachers on the Nature of Mathematics using ANOVA

| Source | DF | Adj SS | Adj MS | F - Value | P - Value |
|--------|-----|--------|--------|-----------|-----------|
| Factor | 2 | 3.297 | 1.6483 | 8.04 | 0.000 |
| Error | 140 | 28.712 | 0.2051 | | |
| Total | 142 | 32.009 | | | |

*significant at $p < 0.05$ alpha level

Table 2 above presents the comparison of the beliefs of the mathematics teachers on the nature of mathematics using analysis of variance. It can be gleaned from the table that the analysis yields an F-value of 8.04 and a probability value of 0.000 which led to the rejection of the null hypothesis at 0.05 level of significance. This means that the mathematics pre-service, senior high school and college mathematics teachers of USTP shared different views on the nature of mathematics where the pre-service mathematics teachers lag behind. This might be due to the fact that experience in the field might a considerable factor to have maturity in their beliefs. However, this needs not to discount the capacity of the pre-service mathematics teachers because they also have experiential learning when they were deployed in the field during their final semester in the university. This result is a wakeup call for the mathematics education department to really hone the pre-service mathematics teachers to be prepared when they exit the portals of their alma mater. They need to be really exposed to the real classroom situation so that they would not have a superficial understanding of how mathematics teaching works in the classroom.

6. CONCLUSIONS AND RECOMMENDATIONS

Student's beliefs of mathematics are important to excel in mathematics while teachers beliefs in the nature of mathematics are also deemed very relevant for them to perform well in the classroom and thus creating a positive atmosphere in the classroom making their students love mathematics and perform better in mathematics. The results above made the researchers conclude that pre-service mathematics teachers need to have sufficient experience to have a greater grasp of how mathematics teaching and learning work. Higher education institutions such as USTP need to revisit their curriculum and study the courses offered in the program to really evaluate if these are all necessary and sufficient for the pre-service mathematics teachers to be job ready as well as life ready. The university envisioned producing innovators and scientist thus honing the skills of pre-service mathematics and exposing faculty to training to produce pedagogical innovations and innovative instructional materials which are potential for commercialization should be prioritized to attain its vision. Further research might also be conducted on the learning and program effectiveness of mathematics and its impact on students' learning and teachers' performance. Researchers may also explore on the relationship of these different beliefs domains and other vital skills needed for mathematics teachers to excel in the profession.

REFERENCES

- [1] Bennett, O. (2009). On religion and cultural policy: notes on the Roman Catholic Church. *International journal of cultural policy*, 15(2), 155-170.
- [2] Hom, E. (2013, September). What is Mathematics? Retrieved from <https://www.livescience.com/38936-mathematics.html> on October 2018.
- [3] Jankvist, U.T. (2015). Changing students' images of "mathematics as a discipline". *The Journal of Mathematical Behavior*, 38, 41-56. doi: 10.1016/j.jmathb.2015.02.002
- [4] National Council of Teachers of Mathematics. (2014). *Principles to actions: Ensuring mathematical success for all*. Reston, VA: NCTM.
- [5] Bell, D. (2016). The reality of STEM education, design and technology teachers' perceptions: A phenomenographic study. *International Journal of Technology and Design Education*, 26(1), 61-79.
- [6] Piaget, J. (1979). Relations between psychology and other sciences. *Annual review of psychology*, 30(1), 1-9.
- [7] Romberg, T. A. (1992). Problematic features of the school mathematics curriculum. *Handbook of research on curriculum*, 749-788.
- [8] Bailey, J. (2017). Embedding problem-solving in a primary mathematics programme.
- [9] Thorndike, E. L. (1922). *The psychology of arithmetic*. Macmillan.
- [10] Muhtarom, Juniati, D., & Siswono, T.Y.E. (2018). Exploring Prospective Teacher's Beliefs about Nature of Mathematics. *Journal of Engineering and Applied Sciences*, Vol. 13 (10):3547-3554.
- [11] Zakaria, E. & Musiran, N. (2010). Beliefs about the Nature of Mathematics, Mathematics Teaching and Learning among Trainee Teachers. *The Social Sciences*, 5 (4): 346-351.
- [12] Ayele, M. A., & Dadi, T. B. (2017). Grade Eleven Students' Mathematics Beliefs about Contexts Support in West Arsi Zone, Ethiopia. *Journal of Studies in Education*, 7(2), 116-135.
- [13] Breiteig, T., Grevholm, B., & Kislenko, K. (2005). Beliefs and attitudes in mathematics teaching and learning. In *Nordisk konferanse i matematikdidaktikk ved NTNU: 15/11/2004-16/11/2004* (pp. 129-138). Department of Geography, Norwegian University of Science and Technology.
- [14] Romano, D. A. (2018). THE BOSNIA AND HERZEGOVINA PROSPECTIVE PRE-SCHOOL TEACHERS' REFLECTION ABOUT THEIR UNIVERSITY MATHEMATICAL EDUCATION. *IMVI Open Mathematical Education Notes*, 8(1), 23-34.
- [15] Smith, I. I., & Gene, R. (2010). The Impact of Secondary Mathematics Methods Courses on Preservice Secondary Teachers' Beliefs about the Learning and Teaching of Mathematics.
- [16] Canto-Herrera, P., & Salazar-Carballo, H. (2010). Teaching Beliefs and Teaching Styles of Mathematics Teachers and Their Relationship with Academic Achievement. *Online Submission*.
- [17] Maksum, C. A., & Mawarpury, M. (2016). WHAT TEACHERS' BELIEFS ON TEACHING? AN EXPLORING STUDY OF HIGH SCHOOL TEACHERS. *Jurnal Pencerahan*, 10(1).