

**EPISTEMOLOGICAL BELIEFS, MISCONCEPTIONS AND ACADEMIC
PERFORMANCE OF COLLEGE STUDENTS IN PLANE
TRIGONOMETRY AND SELECTED CORRELATES**

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ABSTRACT

This study is directed towards investigating the epistemological beliefs about mathematics as well as misconceptions and academic performance of CSU Piat students in Plane Trigonometry and their selected correlates. The study is basically a quantitative research utilizing the descriptive-correlational research design. A total of 261 participants were covered in the study from the three colleges, namely: College of Agriculture, College of Criminal Justice and Administration and College of Information Technology. The Epistemological Beliefs Survey for Mathematics (EBSM) was utilized to measure the Mathematics Belief Scale of the participants. This study adopted various descriptive statistics used for data analysis such as weighted mean, ANOVA and Pearson Product Movement Correlation. Descriptive statistics revealed that first year students of Cagayan State University (CSU) Piat Campus do not meet the minimum competency and mastery level of basic and tertiary mathematics. Such poor academic performance is principally attributed to some misconceptions about essential concepts, procedures and principles in Mathematics. Significantly, they have less developed epistemological beliefs, understandings and appreciations of the nature of Mathematics as a discipline. Furthermore, females and those enrolled in the College of Agriculture have less understanding of the nature and learning process in mathematical knowledge. Interestingly, although females have less developed epistemological beliefs in Mathematics, they nonetheless, performed better in their Plane Trigonometry subject which explains the absence of correlation between epistemological beliefs and Mathematics performance. It must be noted that, academic performance in Plane Trigonometry cannot be attributed to a single factor like epistemological beliefs because there are numerous factors that interplay in one's understanding and mastery of the subject. Finally, the correlates of academic performance in Plane Trigonometry are high school Mathematics grade and first semester College Mathematics grade. This showed a direct relationship between Basic Mathematics and College Algebra grades in influencing one's performance in Plane Trigonometry.

Keywords: *Epistemological beliefs, misconception, academic performance, Plane Trigonometry*

INTRODUCTION

Assumptions or beliefs about knowing and knowledge, termed as “epistemological beliefs,” play an important role in the learning process. To understand how students learn a subject, it is essential to examine their understanding and viewpoints about it. It is said that the goal of education is to foster epistemological development, indicative of broader intellectual development. This is framed on the idea that learning is influenced by the epistemological beliefs that individuals hold.

Epistemology plays a vital role in students’ knowledge, reasoning, study strategy and participation. It can also be a strong indicator for teachers to understand students’ behavior and thinking as well as why they enjoy learning the subject and obtained high academic performance in it. The explanation to this is posited by Schommer-Aikins & Hutter (2012), who asserted that “individuals” beliefs about the nature of knowledge and learning are linked to their comprehension, math comprehension, interpretation of information, and persistence in working on difficult academic tasks. In college, Mathematics is personally observed as a barrier to success for many students. It is viewed as a difficult subject to master due to its symbolic and abstract nature. Students who are unsuccessful in mastering mathematics skills lose opportunities to finish their degree. This can be explained by the fact that students’ success in a developmental mathematics course has a direct effect on success in subsequent mathematics courses and ultimately persistence in college (Penny & White, 2013). Significantly, factors affecting students’ success in mathematics are the students’ personal epistemological beliefs about Mathematics. Educators believed that students’ beliefs about the nature of knowledge in mathematics may affect the way in which they approach the task of learning Mathematics. When students memorize the knowledge in order to learn, they are said to be rote learners. If the students try to understand the knowledge by relating it to other knowledge, then, they are said to be meaningful learners.

Plane Trigonometry is an area of Mathematics that students believe to be particularly difficult and abstract as compared with the other Mathematics subjects. Trigonometry is also an important school

subject, not only in Mathematics but also in other disciplines. It has many important applications in engineering, astronomy, physics, architecture, and so on. In terms of Mathematics, it is one of the fundamental topics in the transition to Advanced Mathematics and its applications. A firm understanding of Trigonometric functions is required in Calculus and Math analysis. Hence, Trigonometry has an important place in the curriculum of Agriculture, Education, Criminology, Information Technology, Veterinary Medicine and the like.

Learning Plane Trigonometry may carry with it some misconceptions. Usually, serious misconceptions can arise when students are introduced to new mathematical meanings. This may be that they are not so ready to exploit the new mathematical meanings or this may be that the new mathematical meanings are so abstract. In order to avoid serious misconceptions, it is essential to assess students' understanding of new concepts by observing their own use of the terminology or concept. Significantly, the misconceptions interfere with students' learning when they use them to interpret new experiences. These misconceptions are big impediments in students' meaningful learning which affect their academic performance in the subject. More importantly, the students' permanent mistakes in this subject create great difficulties for the mathematics educators to reach their goals if these are not resolved on time.

On a personal note, the researcher has observed that numerous students experienced difficulty learning Trigonometry and they manifested numerous misconceptions and low academic performance in the subject. More than 50% of her students experienced difficulty and committed misconceptions in learning Plane Trigonometry. This poses her to ask whether or not the students' epistemological beliefs in Mathematics influence their misconceptions and academic performance. It is in this context that this study has been conceptualized in order to investigate their epistemological beliefs about Mathematics as well as their misconceptions and academic performance of students at CSU Piat in Plane Trigonometry. This is done with the end goal of developing an instructional intervention to address their misconceptions.

Conceptual Framework

The result of the assessment was used to come up with an instructional plan to address misconceptions in Plane Trigonometry. The feedback assessed whether the enhancement program from the output will be attained and will be fitted based on the inputs and processes involved in the study.

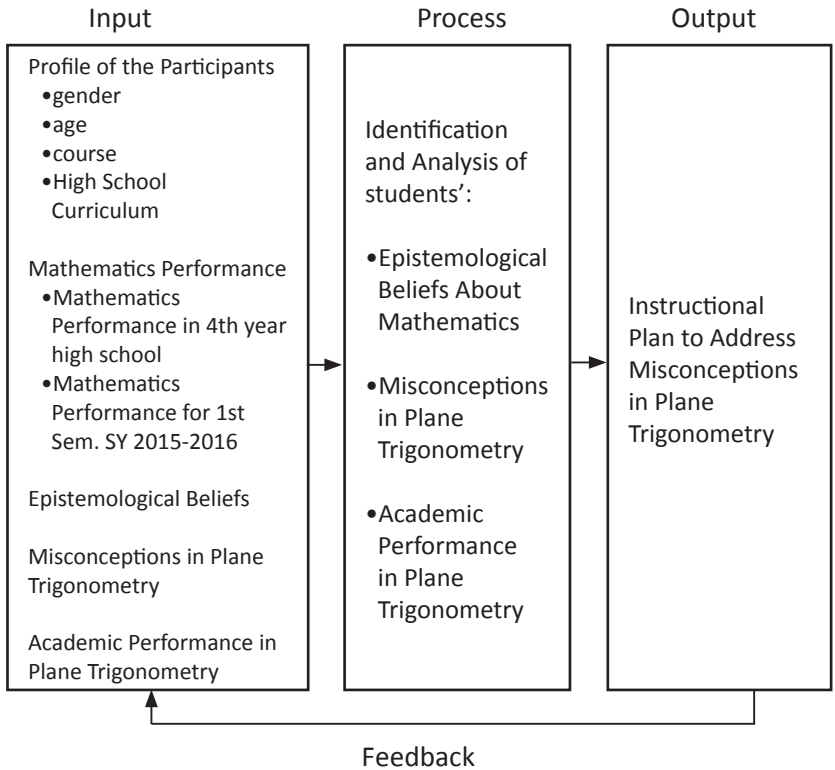


Figure 1. Paradigm of the Study

Figure 1 presents the paradigm of the study. As the paradigm reflects, the input of the study is the profile of students in terms of gender, age, course and high school curriculum students' Mathematics performance, Epistemological Beliefs, Misconceptions in Plane Trigonometry and academic performance in Plane Trigonometry. The process utilized in the study is the identification and analysis of the students' epistemological

beliefs about Mathematics, misconceptions and academic performances in Plane Trigonometry. Unraveling these concepts become the bases for crafting the output of the study, which is the instructional intervention addressing the misconceptions, redirecting unfavorable beliefs and increasing the academic performance of the students in Plane Trigonometry. Moreover, four (4) inferential questions were tested in the study. First, there is no significant difference in the participants' epistemological beliefs about Mathematics when grouped according to their profile variables. Second, there is no significant difference in the participants' academic performance in Plane Trigonometry when grouped according to their profile variables. Third, there is no significant relationship between the academic performance of the participants in Plane Trigonometry with their epistemological beliefs about Mathematics as well as their Mathematics performance. Lastly, there is no significant relationship between the students' Mathematics performance and their epistemological beliefs about Mathematics.

Statement of the Problem

This study is directed towards investigating the epistemological beliefs about mathematics as well as misconceptions and academic performance of CSU Piat students in Plane Trigonometry and their selected correlates.

Specifically, the study investigated the following research questions:

1. What is the profile of the students in terms of gender, age, course, and high school curriculum?
2. What is the students' performance in mathematics as reflected in the mathematics performance in 4th year high school and mathematics performance for 1st Sem. SY 2015-2016?
3. What is the level of students' epistemological beliefs about mathematics with respect to the Source of Knowledge, Certainty of Knowledge, Structure of Knowledge, Speed of Knowledge Acquisition, Innate Ability and Real World Applicability?

4. Is there a significant difference in the participants' epistemological beliefs about mathematics when grouped according to their profile variables?
5. What is the participants' academic performance in Plane Trigonometry?
6. Is there a significant difference in the students' academic performance in Plane Trigonometry when grouped according to their profile variables?
7. Is there a significant relationship between the participants' academic performance in Plane Trigonometry and their epistemological beliefs about Mathematics, and Mathematics performance?
8. Is there a significant relationship between the students' Mathematics performance and their epistemological beliefs about Mathematics?
9. What are the students' misconceptions in Plane Trigonometry?
10. What instructional intervention can be crafted to address students' misconceptions and to enhance students' performance in Plane Trigonometry?

METHODOLOGY

Research Design

The study is basically a quantitative research utilizing the descriptive-correlational method. The descriptive component of the study was the determination of the profile of participants, their mathematics performance in 4th year high school and their Mathematics performance for 1st Semester SY 2015-2016. Other descriptive elements of the study are the participants' epistemological beliefs about Mathematics, their academic performance in Plane Trigonometry and their misconceptions in Plane Trigonometry. On the other hand, a correlational analysis on the academic performance of the participants in Plane Trigonometry with their epistemological beliefs about mathematics as well as their mathematics performance; was undertaken. Further, the study investigated whether

there is a significant relationship between the students' Mathematics performance and their epistemological beliefs about Mathematics.

Participants of the Study

The participants (n=261) of the study were the students enrolled in Plane Trigonometry for 2nd Semester, SY 2015-2016. These students came from three (3) colleges, namely: College of Agriculture, College of Criminal Justice and Administration, and College of Information Technology. The sample size was obtained by using the Slovin's formula at 5% margin of error. Simple stratified sampling was utilized to determine the sample size taken in each college.

Instrumentation

The Epistemological Beliefs Survey for Mathematics (EBSM) was utilized to measure the Mathematics Belief Scales of the participants. The instrument was developed by Peter Kloosterman and Elizabeth Fennema (2005). It is a 75-item instrument that uses a Likert-type format in a strongly agree, agree, uncertain, disagree, or strongly disagree continuum. Essentially, the instrument measures six (6) dimensions of epistemological beliefs, namely; (a) source of knowledge, (b) certainty of knowledge, (c) structure of knowledge, (d) speed of knowledge acquisition, (e) innate ability, and (f) real world applicability. The misconceptions of the students were determined from the results of the summative test in Plane Trigonometry. The items in the summative test were obtained from the test item bank of the researcher. The summative test was thoroughly checked by the adviser and other Mathematics teachers teaching Plane Trigonometry at CSU Piat. The result of this test was analyzed through the solutions presented by the students. Specifically, these learning tasks ascertained the participants' misconceptions related to (a) mathematical object and symbol or given facts; (b) misconceptions related to process; and (c) misconceptions related to prior knowledge. The academic performance of the students was measured using their final grade in Plane Trigonometry. These data, together with their Mathematics grades in fourth year high school and Mathematics grade point average for 1st semester, SY 2015-2016, were obtained from the Office of the Registrar in CSU Piat.

Data Gathering Procedure

After the study has been approved by the panel of examiners of SPUP Graduate School, the researcher sought permission from the Campus Executive Officer of CSU Piat for the conduct of the study. Moreover, similar request letter was also given to the different College Deans to administer the questionnaire on Epistemological Beliefs Survey for Mathematics (EBSM) and the summative test in Plane Trigonometry. Another letter was prepared for the Campus Registrar seeking for the release of the participants' final grade in Plane Trigonometry, mathematics grade point average for 1st semester, SY 2015-2016 and mean grade in fourth year high school mathematics subjects. The questionnaire on Epistemological Beliefs on Mathematics was administered personally by the researcher to the participants. This was done for two reasons. One is to allow her to explain the intent of the study and to ensure that everything was clearly understood. Second is to guarantee 100 percent retrieval of the questionnaires. During the administration of the questionnaires, questions were entertained as well as issues and concerns that the participants need to clarify. The administration of questionnaires to the participants was done as a group through a schedule duly approved by the college deans. It was undertaken in any of the rooms of the different colleges. The examination lasted for 15-20 minutes at an average.

Data Analysis

Descriptive statistics was used to analyze the mean grade in fourth year high school mathematics, mathematics grade point average for 1st semester, SY 2015-2016, epistemological beliefs in Mathematics, misconceptions and academic performance in Plane Trigonometry. These include frequency count, percentage and mean.

Since the items in the Epistemological Beliefs Survey for Mathematics (EBSM) are written in naïve order, the computed overall mean, higher than 3 as a midpoint, conveys naïve, immature and less sophisticated epistemological beliefs. Conversely, computed overall mean, less than 3, reveals mature, sophisticated and developed epistemological belief.

To further analyze the mean mathematics performance and academic performance in Plane Trigonometry, the scale used was (95 – 100) Excellent; (90 - 94) Very Satisfactory; (85 – 89) Satisfactory; (80 – 84) Fair; (75 – 79) Poor and (Below 75) Very Poor.

Furthermore, the misconceptions were analyzed qualitatively through the assistance of the three (3) teachers teaching Plane Trigonometry. The basis for analysis was the summative test prepared by the researcher for the subject. To determine the significant difference in the epistemological beliefs and academic performance in Plane Trigonometry when grouped according to their profile variables, One-way ANOVA was used. However, Pearson Product Moment Correlation was utilized to investigate the significant relationship between epistemological beliefs and academic performance in Plane Trigonometry, Mathematics performance in 4th year high school and Mathematics performance for the 1st Semester SY 2015 - 2016. Finally, the hypotheses in the study were tested at 0.05 level of significance.

RESULTS AND DISCUSSION

Participants' Profile

Majority or 57.85% of the participants are female; most or 49.04% of them are 17 years of age; and are graduates of Basic Education Curriculum (BEC).

Students' Performance in Mathematics

Result revealed that the participants' mean grade for 4th year high school mathematics and mean grade for 1st Semester college mathematics both have a descriptive interpretation of "fair" with a weighted mean of 79.51. The "fair" performance grade in high school mathematics of the participants implied that they have not met the minimum competencies desired in the subject. Moreover, they have not mastered the basic concepts required in high school mathematics.

Level of students' epistemological beliefs about Mathematics

Result unveiled that the participants hold naïve, immature and less sophisticated epistemological beliefs about Mathematics as reflected by the overall weighted mean which is greater than 3.73. They are more inclined to believe that mathematical knowledge is handed down by authority, absolute, isolated, quick, fixed at birth and exclusive concern of mathematicians.

Significant difference in the participants' epistemological beliefs about Mathematics when grouped according to their profile variables

ANOVA test showed a significant difference in the epistemological beliefs of the participants based on sex and course but not for age and curriculum. The difference in the epistemological beliefs along speed of knowledge and innate ability of the participants based on sex reveals that females tend to be more naïve, immature and less sophisticated in their epistemological belief about Mathematics as compared to males. On the other hand, participants from the College of Agriculture hold naïve and immature belief compared to their counterparts with respect to all dimensions of epistemological beliefs.

Participants' academic performance in Trigonometry

Result indicated that the academic performance of the participants in Plane Trigonometry has a descriptive interpretation of "poor". The highest grade obtained is "excellent" while the lowest is "very poor" with an overall mean of 77.59. The "poor" academic performance of the participants in Plane Trigonometry reveals that they have not obtained the minimum level of the basic competencies required in the course. In short, they have not reached a "satisfactory level" or "mastery" of the basic concepts in the subject. It also conveys that there is much to be done to further improve their competency in this course.

Difference in the participants' academic performance in Plane Trigonometry when grouped according to their profile

ANOVA test revealed that except for sex, there is no significant difference in the academic performance of the participants in Plane Trigonometry when they are grouped according to course, age and high school curriculum. Significantly, females have better academic performance in Plane Trigonometry than the males.

Relationship between the participants' academic performance in Plane Trigonometry and their epistemological beliefs about Mathematics

Pearson-r test implied no significant correlation between the participants' academic performance in Plane Trigonometry and their epistemological beliefs except for certainty of knowledge. On the other hand, there is a significant negative association between participants' epistemological belief along certainty of knowledge and academic performance in Plane Trigonometry. They just rely on what they have learned in the past from their previous mentors on how to solve problems and they do not exert effort to question, challenge and modify what has learned and taught to them.

Relationship between the participants' academic performance in Plane Trigonometry and their Mathematics performance

Pearson-r test indicated a significant correlation between academic performance in Plane Trigonometry and their Mathematics performance. Participants who performed well in their 4th year mathematics and 1st semester college mathematics performed better in their Plane Trigonometry. In short, there is a direct relationship between these variables, that is, students' mathematics performance influences to a great extent their performance in Plane Trigonometry.

Relationship between the participants' fourth year high school mathematics performance and their epistemological beliefs

Pearson-r test showed no correlation between the participants' high school mathematics performance and their epistemological beliefs except for real world applicability. The participants' high school mathematics performance is not influenced by their epistemological beliefs. However, there is a significant relationship between participants' mathematics performance in 4th year high school and their epistemological beliefs along real world applicability.

Relationship between the participants' 1st semester college Mathematics performance and their epistemological beliefs

There is no significant relationship between the participants' 1st semester college mathematics performance and their epistemological beliefs along source of knowledge, certainty of knowledge and structure of knowledge. Meanwhile, there is a negative correlation between participants' epistemological beliefs along speed of knowledge acquisition, innate ability and real world applicability and College Mathematics Performance for 1st semester, SY 2015 –2016.

Students' Misconceptions in Plane Trigonometry relative to trigonometric functions or ratios of acute angles and right triangles

The misconceptions of the participants along trigonometric functions/ratios of acute angles and right triangles are (a) evaluating angle measure using inverse trigonometric function; (b) determining the trigonometric function of an angle that is equal to a given ratio of the sides of a given triangle; (c) evaluating trigonometric function values of an angle using a calculator; and (d) solving equations involving radicals. On the other hand, the three (3) most common misconceptions of the participants along trigonometric function values of special and quadrantal angles are (a) evaluation of exact values of special angles; (b) determining the values of x , y and r from a point (x,y) on the terminal side of the angle; and (c) determining the reference angle.

CONCLUSION

On the basis of the foregoing findings, it can be concluded that first year students of Cagayan State University Piat Campus did not meet the minimum competency and mastery level of basic and tertiary mathematics. Such poor academic performance is principally attributed to some misconceptions about essential concepts, procedures and principles in Mathematics. Significantly, they have less developed epistemological belief, understanding and appreciation of the nature of Mathematics as a discipline. Furthermore, females and those who are enrolled in the College of Agriculture have less understanding of the nature and learning process in mathematical knowledge. Interestingly, although females have less developed epistemological beliefs in Mathematics, they nonetheless, performed better in their Plane Trigonometry subject which explains the absence of correlation between epistemological beliefs and Mathematics performance (mathematics performance in 4th year high school and for first semester SY 2015-2016) as well as academic performance in Plane Trigonometry. It must be noted that academic performance in Plane Trigonometry cannot be attributed to a single factor like epistemological beliefs because there are numerous factors that interplay in one's understanding and mastery of the subject. Finally, the correlates of academic performance in Plane Trigonometry are high school mathematics grade and first semester college mathematics grade. This shows a direct relationship between basic mathematics and college algebra in influencing one's performance in Plane Trigonometry.

RECOMMENDATIONS

Based on the findings and conclusion of the study, the following recommendations are offered:

The researcher may seek support for the endorsement of the College Dean regarding the adoption of the instructional plan as this shall address the misconceptions and difficulties of the participants in Plane Trigonometry.

The researcher may disseminate the result of the study for Mathematics teachers in Piat Campus to be aware of so that they

could help improve the academic performance of the students in College Algebra and Plane Trigonometry through a more effective and meaningful teaching and learning approach. Efforts should be focused on addressing students' misconceptions so that they will improve their mathematics achievement. Specifically, teachers teaching algebra and basic mathematics should lay a strong foundation in these subjects as they predict the success of the students in Plane Trigonometry.

To transcend from the immature, naïve and less sophisticated epistemological belief of the participants, teachers may explore and utilize a more student-centered approach such as discovery learning, manipulative-based learning, reflective learning and inquiry-based learning. In this way, they get to expose students to a deeper, more comprehensive and meaningful understanding of mathematical concepts, procedures, formulas and the like.

Teachers may revisit their approaches, methods and strategies in teaching Plane Trigonometry in order to suit to the learning needs and learning beliefs of the students.

A similar study on epistemological belief may be conducted; with focus on learning style, mathematics attitude, and mathematics anxiety as these may also influence students' mathematics performance.

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