Students' Motivation, Learning Strategies, and Proof Construction Skills in Basic Set Theory: A Correlation Analysis

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Keywords:

Mathematics Education, students' motivation, learning strategies, proof construction skills, qualitative - quantitative methods of research, Philippines

ABSTRACT

The study analyzed and correlated student's motivation, learning strategies and proof construction skills in Basic Set Theory. The respondents of the study were the BS Mathematics fourth year students (N = 215) of the Bulacan State University taking up Real Analysis for the Academic Year 2014-2015. The study adopted the descriptive correlation design. To measure student's proof construction skills, results of the written responses on the Proof Test was analyzed based on teacher – made rubrics. Through the use of the correlation method as a type of quantitative analysis, the researcher explored the existence of significant relationships among the variables mentioned. Among the factors of Motivation, the students posted high level of motivation in Value and Expectancy constructs; however of the Average level only in the Affect construct. The overall learning strategies of the students were described to be of average level with the three factors - Metacognitive Strategies, Non-Informational Resource Management Informational Resource Management falling under the same category. Whereas, cognitive strategies was classified as high. On the proof construction results, students performed poorly considering bulk of their scores are in the lower half of the total range. Analysis showed only students' motivation has significant, positive relationship with students' learning strategies.

INTRODUCTION

Mathematics is an integral part of the education of an individual. For many students, doing mathematics is an ordeal while to the mentors, teaching mathematics is a complicated process. Teachers must create a conducive learning atmosphere to motivate students develop an attitude of appreciation towards mathematical task and value what they are doing. If the students are properly and effectively motivated, they may look upon mathematics as a delightful experience. If challenged and provided with appropriate approaches of instruction, then they are likely to look forward with anticipation to a more prolonged time for math instruction. It is not enough that teachers merely provide the necessary learning experiences to students enabling them to learn mathematics skills. It is also important that they are provided with appropriate learning and teaching strategies suited to their interest, motivations, and skills to address learning distractions. These identified instructional approaches must be based on the actual needs and results of studies.

The National Council of Teachers of Mathematics (NCTM, 2000) through the Principles and Standards for School Mathematics identified the understanding of, and the ability to write mathematical proof as an important skill to be developed among students of mathematics. In fact one of the competency standards expected of a graduate of the BS Mathematics Program is to appreciate the concept and role of proof and reasoning and demonstrate knowledge in reading and writing mathematical proofs (CMO, No. 19, s. 2007). The researcher believed that proof construction helps in the understanding of newly developed concepts as well as in the discovery of new ideas since it relies heavily on making connections between established ideas. Krantz (2007) mentioned that proof could be viewed as a device for establishing the absolute and irrevocable truth of statements in mathematics.

Despite its importance, proof is not regarded by students as a tool in learning and comprehending mathematics. Higgins (2005) observed that students seemed unable to use logical reasoning and showed lack of understanding of proof and its significance in Mathematics. Actual experiences in teaching mathematics has established the idea that demonstrating skills in proving and applying theorems are very critical to students. For most college students specializing in mathematics, the study of proof is impractical and a waste of time. They would always argue that proving has nothing to do with the work they will have after graduation. As a result, students do not pay much attention in constructing proofs during their lessons. Weber (2003) pointed out that several studies showed that many students emerge from proof-oriented courses such as high school geometry, set theory with logic, real analysis, and abstract algebra unable to construct anything beyond very trivial proofs.

Perlas (2008) said that at the end of a full year course in Geometry in which proof writing is studied, about 25% of the students have no competence in writing proofs, another 25% can only do trivial proofs, about 20% can do some with greater complexity, and only 30% master proofs similar to the theorems and exercises in standard textbook. The researcher has the same observations when teaching proof construction in Mathematical Analyses courses.

This dismal performance of our students in proof-oriented courses is disappointing. Probably, learners do not find direct application of proof construction to real world problems considering the long and tedious processes involved in it. In their minds is the stigma the practice may cause to a learner who cannot construct proofs well in front of the class. This researcher believes that there are other factors that serve as external distracters leading to students' poor proof construction skills. One might ask what drives some students to do well in proving and, similarly, what motivates the struggling ones to persevere and hone their proof construction skills despite the challenges they have to deal with to be able to prove completely.

Mathematics educators agreed that motivation and good learning strategies have positive impact upon learning- they stimulate, sustain, and give direction to an activity. Pintrich and De Groot (1990) proposed a motivation model where they asserted that the intensity of an individual's motivation will trigger him or her to execute good or bad learning strategies. The components of motivation in this model are value, expectancy, and affect. Value consists of the goals and beliefs of the students concerning the importance and appreciation of the task; expectancy refers to students' beliefs regarding their ability to do a task; and affect includes the students' emotional reactions to the task. Moreover, the model also showed the direct link between students' motivation and their ability to self-regulate their learning activities (Eccles and Wigfield, 2002). Self-regulated may be regarded as the students use of the various cognitive, metacognitive and resource management strategies. Cognitive strategies involve the use of the students of ways for processing information from texts and lectures to structure new knowledge; metacognitive strategies refer to the use of strategies that will help them plan, regulate and verify their cognitive processes; and resource management strategies include the students' regulatory strategies in controlling available resources (i.e. time and effort) in order to cope with their tasks (Kivinen, 2003).

This model also assumes that motivation and learning strategies are not static traits of the learner; rather, "motivation is dynamic and contextually bound and that learning strategies can be learned and brought under the control of the student" (Duncan and McKeachie, 2005). The main key here is to capture the learner's attention by using a variety of instructional approaches.

The foregoing discussions have shown the need for a study that will guide teachers of mathematics to become models of inquiry and help them establish a learning environment in which students are motivated to improve their learning strategies in proof construction.

METHODOLOGY

The study made used of descriptive correlational design. The goal of this design is to get a picture of the current thoughts, feelings, or behaviors in a given group of people (Stangor, 2013). Descriptive research is summarized using descriptive statistics whereas correlational research designs measure two or more relevant variables and assess a relationship between or among them.

In the present study, the descriptive approach was used to analyze the level of the students' motivation towards Basic Set Theory learning in terms of value, expectancy, and affect as well as the level of the students' learning strategies in terms of cognitive strategies, metacognitive strategies, non-informational resource management, and informational resource management. Furthermore, the proof construction skills of the students were described and interpreted using their written responses in the Proof Test based on a teacher – made rubrics.

A correlation analysis among the three aforementioned variables - the students' motivation, learning strategies, and proof construction skills in Basic Set Theory learning was applied to determine the strength of their possible relationship in the population of interest.

The respondents of the study consists of 215 Fourth Year BS Mathematics students of the university taking up Real Analysis subject for Academic Year 2014-2015. The subject has Basic Set Theory as a preliminary course taken by the students before the major topics. Proof construction is the primary activity done by the students to attain the course objectives.

The instrument used is an improved Taiwan mathematics norm of MSLQ (Liu and Lin, 2010), revised to fit the need of the study. The modified MSLQ instrument contains 101 items, 36 of which are devoted to measuring motivation, and the remaining 65 are for measuring learning strategies.

The first part, the component of motivation, is subcategorized into: Value, Expectancy, and Affect. Whereas, the second part of the questionnaire is subcategorized into: Cognitive Strategies, Meta-cognitive Strategies, Non-informational Resource Management, and Informational Resource Management.

The Proof Tests on Basic Set Theory is composed of 5 teacher- made problems requring students to perform complete proof for each. The items were face and content validated by selected faculty of the BS Mathematics program. Rubrics were developed by the researcher in scoring the responses of the students in the test. The set of criteria presented in the rubric specifies the levels of proof construction skill of the students indicative as well of the observable outcomes expected. The scores were numbered from 0 to 5.

Prior to analyzing the data, the variables of the study were controlled in terms of data entering by using frequencies, minimum and maximum scores. Data cleaning and screening procedure were done for potential data entry errors such as missing values, univariate and multivariate outliers. Checking of normality of the data was also performed. Descriptive statistics was used to describe students' motivation and learning strategies. Now, to see if there are significant relations among motivation, learning strategies, and proof construction skills of students in the subject, Pearson r was applied.

To interpret computed mean values as to the levels of motivation and learning strategy, the following equivalents in Table 1 are used.

RESULTS AND DISCUSSIONS

This section deals with the presentation, analysis and interpretation of results of the study on the motivation, learning strategies, and proof construction skills of 4th year BS Mathematics students toward Basic Set Theory learning.

Level of the students' motivation towards Basic Set Theory learning

Table 2 shows the level of motivation of the students towards Basic Set Theory learning, based on three components – Value, Expectancy, and Affect – measured quantitatively through the mean and standard deviation.

The table shows that the students displayed the highest level of motivation on Expectancy, which registered an overall mean of 3.56 and is interpreted as high level of motivation. This means that the respondents

Table 1. Interpretation on Level of Motivation and Learning Strategies

Likert Scale	MSLQ Instrument Rating	Mean Bracket	Interpretation
5	Strongly Agree	4.51-5.00	Very High Level
4	Agree	3.51-4.50	High Level
3	Normal	2.51-3.50	Average Level
2	Disagree	1.51-2.50	Low Level
1	Strongly Disagree	1.00-1.50	Very Low Level

Table 2. Mean of Factors under Students' Motivation

Level of the Students' Motivation Toward Basic Set Theory in terms of:	Elements	Mean	Standard Deviation	Interpretation
Value	IGO	3.63	0.59	High
	EGO	3.49	0.71	Average
	TV	3.39	0.58	Average
Overall Value		**3.51**	**0.58**	**High**
Expectancy	CBL	3.69	0.61	High
	SE	3.43	0.51	Average
Overall Expectancy		**3.56**	**0.42**	**High**
Affect	**TA**	**3.21**	**0.59**	**Average**
Overall Motivation		**3.42**	**0.53**	**Average**

1.0 – 1.50 – Very Low (VL) *1.51 – 2.50 – Low (L);* *2.51 – 3.50 – Average*
3.51 – 4.50 High (H) *4.51 – 5.00 – Very High(VH)*
IGO = Intrinsic Goal Orientation *EGO = Extrinsic Goal Orientation* *TV = Task Value*
CBL = Control Beliefs in Learning *SE = Self – Efficacy* *TA = Test Anxiety*

of the study who are BS Mathematics students taking Basic Set Theory believe that they can perform the required mathematical tasks and are personally responsible for their performance in the course.

For the two component elements of Expectancy - namely control beliefs in learning and self-efficacy, results showed that students posted high level of motivation in the first element (control beliefs in learning) with a mean score of 3.69. This means that the students believe that their efforts would lead to positive result. However, in Self-efficacy (the other element of Expectancy) their rating is only 3.43. This is interpreted as Average Level of Motivation. The result indicates that their belief in the ability to complete the task is adequately strong, as well as their confidence in their skills to accomplish the mission, say being able to receive exemplary grade in the subject.

On the factor Value, the students got a rating of 3.51, hence showing as well a high level of motivation. This means that many students believe that what they are learning in Basic Set Theory are relevant to the career they will pursue later on in life. They know that passing the subject is essential in completing their course. Moreover, they scored the highest in Intrinsic Goal Orientation, being 3.63. This may mean that they have a relatively strong personal reasons to participate in the learning tasks in Basic Set Theory. These personal reasons could be curiosity, self-development, satisfaction, or personal goal. In the Extrinsic Goal Orientation, the mean is posted at 3.49. It could be interpreted that students posses sufficiently strong outer reasons for learning. This may include such extrinsic factos as money, grades, or praises from parents, teachers and peers . A slightly lower mean of 3.39 was posted by the students in the Task Value. At this component, the respondents can be categorized as having an average level of motivation. This means that they are relatively aware of the applicabilty and usefulness of the instructional materials and exercises used in the lesson.

The component Affect has only one element which is Test Anxiety. Results yield a lower mean of 3.21 for the respondents in this element. Hence, they are at the Average Level in Test Anxiety. This shows that the students are quite anxious whenever they take exam in the subject. This is not surprising since proof construction is part of any examination in the course.

Results of the present study on Expectancy and Task Difficulty (Affect) is related to the findings of Yurt (2015) who found out that students' interest in mathematics, their perceptions of task difficulty and expectancy beliefs towards mathematics were at an average level.

Overall, the students during the Basic Set Theory discussions have an Average Level of Motivation with the mean set at 3.42. This implies that the students are neither positively nor negatively motivated during the period of investigation. Mathematics teachers should look on such result on a positive note since the respondents can still be easily transformed into enthusiastically receptive students of mathematics classes. Effective mathematics teachers should focus attention on the less interested students as well as the motivated ones.

Level of the students' learning strategies towards Basic Set Theory learning

Table 3 displays the status of the students' learning strategies in Basic Set Theory. The overall mean for the category is 3.25, which describes the respondents as having an average learning strategy towards the topic of consideration.

The students posted the highest mean of 3.53 in Cognitive Strategies. Among the elements associated with cognitive strategy namely rehearsal, elaboration and organization, the elements rehearsal and organization got the highest mean values of 3.60 and 3.51 respectively . These scores placed the students under the High Level of Learning Strategy on said elements. The figures imply that the students can identify and state definitions, theorems or propositions and name formulas presented during the lesson. They are also organized in that they can arrange assumptions and consequences into an acceptable level. The element Elaboration has the least mean value of 3.47 placing the students under average level of learning strategy on this element. This shows that they can satisfactorily summarize lesson, take notes, or paraphrase concepts and theorems on readings given.

For the factors, Non-informational Resource Management, Metacognitive Strategies, and Informational Resource Management, results showed the students getting mean scores of 3.31, 3.28, and 2.70, respectively. Collectively for these factors, the students are described as having average level of learning strategies.

For the Non-informational Resource Management , students were categorized as having average level of learning strategy in all the component elements which include Effort Regulation, Time and Study Environment, Peer-learning, and Help-seeking. This means that the students are fairly good in scheduling and managing their time and study habit like attending class regularly, in learning with friends or classmates or engaging in collaborative discussions, and in soliciting help and support from others in order to complete a required task or assignment or even understand a concept given. Moreover, they have an average commitment in completing their goal of learning in a particular required

Table 3. Mean of Factors under Learning Strategies

Level of the Students' Learning Strategies Toward Basic Set Theory in terms of:	Elements	Mean	Standard Deviation	Interpretation
Cognitive Strategies	R	3.60	0.69	High
	E	3.47	0.65	Average
	O	3.51	0.63	High
Overall Cognitve Strategies		**3.53**	**0.66**	**High**
Metacognitive Strategies	CT	3.33	0.62	Average
	SR	3.22	0.60	Average
Overall Metacognitive Strategies		**3.28**	**0.61**	**Average**
Non-Informational Resource Management	ER	3.27	0.60	Average
	TSE	3.32	0.60	Average
	PL	3.41	0.62	Average
	HS	3.25	0.71	Average
Overall Non-Informational Resource Management		**3.31**	**0.63**	**Average**
Informational Resource Management	EBI	2.82	0.90	Average
	CBI	2.58	0.95	Average
Overall Informational Resource Management		**2.70**	**0.92**	**Average**
Overall Learning Strategies		**3.25**	**0.50**	**Average**

1.0 – 1.50 – Very Low (VL) *1.51 – 2.50 – Low (L)* *2.51 – 3.50 – Average*
3.51 – 4.50 High (H) *4.51 – 5.00 – Very High(VH)*
R = Rehearsal *E = Elaboration* *O = Organization*
CT = Critical Thinking *SR = Self-Regulation* *ER = Effort regulation*
TSE = Time and Study Environment *PL = Peer-learning* *HS = Help-seeking*
EBI = Exploratory Behavior on Internet *CBI = Communication Behavior on Internet*

lesson in Basic Set Theory.

In Meta-cognitive Strategies, the mean posted are 3.33 and 3.22 respectively for the elements Critical Thinking and Self-Regulation. Hence, students were described as having average level of learning strategy on both elements. The numbers express their fairly good reflective judgment in analyzing a proof or lesson presented by the teacher in the class.

Surprisingly, the students scored just average in both elements of Informational Resource Management, with a mean of 2.82 in Exploratory Behavior on Internet and a mean of 2.58 in Communication Behavior on Internet. The first mean manifests that the students do not maximize search for information, answers to questions, or help, as part of a personal strategy in acquiring learning outside the classroom. They seldom search for websites or information related to the topic in Basic Set Theory. Considering that the students in this study are mostly graduating students, this could mean that they have not been properly pushed to explore the dynamism of the internet related to the course. Furthermore, on the element - Communication Behavior on Internet, the result shows that the students are not much into the habit sharing learning experiences in the subject via emails, yahoo group, or any social networking sites like Facebook, as specifically cited in the questionnaire. They are also not into posting questions in yahoo answers, blog sites, or tutorial websites. This could be partly attributed to the mentor's failure to provide learning tasks to students that will require them to use the internet and enable them to discover the unlimited potential of the medium. This unrealistically presents a picture that the students of the program are not internet-savvy in relation to mathematics courses. The aforementioned findings imply that teachers should think of measures for students to imbibe the habit of using the e – reference learning materials from the internet to complement their textbooks. Teachers should also be capacitated on this strategy to provide guidance to their students.

The results of this study is somehow related to the study of Khanal (2016) which attempted to find out the difference in preferred learning strategies in mathematics between urban and rural schools in Nepal. In the said study, it was found out that elaboration and organization strategies are more often used by rural students than urban school students whereas peer learning, elaboration, help seeking, and effort management strategies are more often used by urban school students. Moreover, the urban school students easy access to educational resources, technology, and educated family background have enabled them to develop and use effective learning strategies, and achieve high.

Students' Proof Construction Skills in Basic Set Theory

Table 4 is a description of the students in terms of their Proof Construction Skills, as based on their scores in the Proof Test involving items on Basic Set Theory. The table categorizes the performance scores in intervals, with corresponding frequencies and relative percentages.

The results shows positive skewness if plotted into a normal distribution curve. It is evidenced by the bulk of students' scores being in the lower half of the total range. From Table 4, it could be observed that 122 students, equivalent to 56.74 % of the population performed poorly in the Proof Test. Only 6 and 1 among the total number of subjects showed average and above average proof construction skills, respectively. It is disappointing considering that one of the competency standards expected of a graduate of the BS Mathematics program is for the students to appreciate the concept of role of proof and reasoning and demonstrate knowledge in reading and writing mathematical proofs.

This result is supported by the study of Ko Y (2009) on student production of

Table 4. Description and Category of Students Based on their Proof Construction Skills

Performance Score	Frequency	Relative Percentage	Interpretation
1	122	56.74	Poor
2	86	40.00	Below Average
3	6	2.79	Average
4	1	0.47	Above Average
Total	**215**	**100.00**	

Table 5. Correlation between Students' Motivation and Proof Construction Skills

Students' Motivation in Basic Set Theory in relation to:	Pearson Correlation	Sig. (2-tailed)	Interpretation
Proof Construction Skills	-0.105	0.124	Not Significant

proofs and counterexamples which showed that undergraduate mathematics majors had insufficient understandings of continuous functions for determining the validity of a given statement and producing proofs and counterexamples. The findings suggest that more attention should be paid to teaching and learning of proofs and counterexamples as participants showed difficulty in writing these statements.

The Correlation of Students' Motivation and Proof Construction Skills in Basic Set Theory

Results shown in Table 5 indicate that Students' Motivation has negligible relationship with the Proof Construction Skills of the students. That is, not one of the elements of Motivation has significant correlation with the result of the Proof Construction Test.

The Correlation of Student's Learning Strategies and Proof Construction Skills in Basic Set Theory

Analysis of the data in Table 6 indicates that Students' Learning Strategies has no relationship with the Proof Construction Skills of the students. This finding is not consistent with the findings of Pintrich and deGroot (1990) where both motivation and learning strategies supposedly relates with student's learning performance.

In the study of Randy and Corno (2000), they noted that self-regulated learners seek to accomplish academic goals strategically and manage to overcome obstacles using resources.

The Correlation of Student's Motivation and Students' Learning Strategies

Table 7 reveals that Students' Motivation has a significant and strong positive relationship with Students' Learning Strategies. This implies that if the students have good motivation in all components, they would adapt to good learning strategies.

Likewise, if they improve in learning strategies, they become better motivated. If they lag in learning strategies, soon they lose their motivation, or if they are less motivated, they do not exercise good learning strategies as well.

With motivation being positively correlated with learning strategies, then an increase in motivation would imply an increase in the level of learning strategies. Now, considering that motivation has the factor Affect which is about the element Test Anxiety, then one can extend that the higher the students' level of anxiety, the greater will be the required level of strategies from them. Findings of a study undertaken by Rusmono

Table 6. Correlation between Students' Learning Strategies and Proof Construction Skills

Students' Learning Strategies in Basic Set Theory in relation to:	Pearson Correlation	Sig. (2-tailed)	Interpretation
Proof Construction Skills	-0.063	0.361	Not Significant

Table 7. Correlation between Students' Motivation and Learning Strategies in Basic Set Theory

Students' Motivation in Basic Set Theory in relation to:	Pearson Correlation	Sig. (2-tailed)	Interpretation
Learning Strategies	.692	.000	Significant

(2013) support this claim. Group of students learning mathematics with high math anxiety and and learning strategies followed by Problem Based Learning performed better than a group of students who have math anxiety and following Expository learning strategies. To this end, teachers are advised to identify students characteristics i.e. level of motivation, level of anxiety in order to select and implement the appropriate learning strategies for the teaching of mathematics.

In a similar study undertaken by Shih (1998), results pointed out that motivation and learning strategies were the two most important factors in student achievement in Web-based learning. Students were likely to be higher achievers in a Webbased course if they used more learning strategies and were more highly motivated to leam.

Another similar study contrasted motivation and learning strategies of ex-Mathematics and ex-Mathematical Literacy students (Baumgartner,W.L., Spangenberg, E.D.,and Jacobs, G. J., 2018) . This inquiry detected significant differences in motivation and learning strategies between the two groups of students. The intrinsic goal orientation, task value, self-efficacy, effort regulation and test anxiety-handling abilities of ex-Maths students were significantly superior. Moreover, the study supported the more general findings that link motivation and learning strategies as aspects of self-regulated learning (SRL) with academic achievement.

CONCLUSIONS

Among the factors of Motivation, the students posted high level of motivation in value and expectancy constructs; however of average level only in the affect construct. This implies the need of sustaining the value and expectancy levels of motivation among the participants; on the hand, enhancing the affect constructs of motivation in the same group. Despite the perception of the students that they have insufficient skills to perform a given mathematical task, their high level of expectancy will see them through and enable them to see that their efforts will not be futile at the end. Expectedly, the students' level of affect (with the element - test anxiety) is only average. Proof construction just like problem solving posed challenge to students of mathematics.

The overall learning strategies of the students were described to be of average level with the three factors - Metacognitive Strategies, Non-Informational Resource Management Informational Resource Management falling under the same category. Whereas, cognitive strategies were classified as high. This has great mathematical implication on assisting students do problem solving and related tasks. Equipped with strong cognitive strategies, then students sre expected to possess the required mathematical scaffolds that will facilitate teachers to provide students with instructional supports to enable them perform proof constructions.

A great majority of the students in this study did poorly in the Proof Construction Test. The experience of this researcher have shown that undergraduate students often are aware of and able to apply the facts required to prove a statement but still fail to prove it. One can surmise that proof construction is an important mathematical competency but there are serious difficulties encountered by mathematics students regarding their ability to prove.

There are no significant correlations between motivation and proof construction skills and between learning strategies and proof construction, whereas motivation and learning strategies significantly relates with each other. Such outcome means that efforts exerted to enhance the motivation level of students will also improve the level of their learning strategies. Studies on motivation and learning strategies have shown that these variables are predictors of high level cognitions (Stolk, Olin and Harrari,2014). In fact, students' motivation help students to engage in high – order thinking strategies. Proof construction offers students the opportunity to make conjectures, to make connections between established ideas, to generalize and abstract, to verify the truth of a statement and to communicate mathematical knowledge – all skills requiring the use of the higher cognitive domain. Consequently, improved motivation and learning strategies should relate with students' performance in proof construction. However, this result was not supported by the outcomes of this paper.

RECOMMENDATIONS

Mathematics teachers should emphasize to their students the essentiality of mathematics in pursuing one's career in life; hence the need for them to participate in classroom learning tasks and improved their performance in the subject. Further, teachers can tap on both the intrinsic and extrinsic goal orientations of the students for improved motivation leading to better achievement in mathematics. Lastly, teachers should identify strategies that will engage students in proof construction activities.

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