International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Association of Ambiguity Tolerance and Problem-solving Ability of Students in Mathematics

Mabel Buela[a]*, Ma. Nympha Joaquin[b], Nancy Tandang[c], Abriel Bulasag[d]

[a,d]*Assistant Professor 1, University of the Philippines Los Baños, Los Baños, Laguna 4031, Philippines*

[b]*Professor 1, University of the Philippines Diliman, Diliman, Quezon City 1101, Philippines*

[c]*Assistant Professor 6, University of the Philippines Los Baños, Los Baños, Laguna 4031, Philippines*

[a]*Email: msbuela@up.edu.ph*

[b]*Email: mbjoaquin@up.edu.ph*

[c]*Email: natandang@up.edu.ph*

[d]*Email: asbulasag@up.edu.ph*

Abstract

Development of problem-solving ability among students is one of the main goals of mathematics education. This study investigated the association between student ambiguity tolerance and their problem-solving ability in mathematics. It also sought to determine whether or not a student's reaction to unfamiliar or uncertain stimuli influences their ability to solve non-routine word problems. A total of 182 junior high school students participated in this study. Two instruments, namely: McLain Multiple Stimulus Types Ambiguity Tolerance (MSTAT-II) Scale and a problem-solving ability test were considered in this study. Both tests were subjected to validity and reliability analyses. Results showed that ambiguity tolerance and problem-solving ability have a moderate positive association. Further, ambiguity tolerance was found to be a significant determinant of the problem-solving ability in mathematics of a student. A detailed analysis of student solutions and empirical evidences suggest that the use of open-ended problems be employed across various subject matters in mathematics to develop not only problem-solving skills but critical and logical reasoning as well as creativity among students.

Keywords: ambiguity tolerance; non-routine word problems; problem-solving ability.

---

* Corresponding author.

1. Introduction

For many years of studying the classroom, researchers agree that mathematical performance increases with the positive desire of a student to learn mathematics. In the Philippine set-up, students are more accustomed in dealing with routine problems that are usually found in the textbooks [1,2]. This type of problem is content specific and follows multiple steps and a structured solving process. Hence it most often results in a lack of creativity in the teaching and learning of mathematics. According to the National Council of Teachers of Mathematics Standards, much emphasis has been given to problem-solving as a means to solve problems in the area of mathematics [3]. Various studies have been conducted to address problems involving mathematical standards, curriculum, and pedagogies. It has been shown that understanding creativity by learning through ambiguous situations will be helpful in addressing issues related to problem-solving abilities of the students. Researchers affirmed that tolerance for ambiguity positively influences performance and adjustment in cross-cultural settings [4,5,6]. In the traditional set-up and in the current K-12 curriculum, learning ambiguity and accepting the abstract are not being emphasized in the classroom [7]. Most of the time, certain attributes of uncertainty are involved in the daily encounters and in the researches of mathematics around the world. In addition, open-ended views in mathematics are being neglected in the conduct of pedagogical approaches inside a mathematics classroom. In a usual classroom set-up, teachers/ facilitators/educators often do not use open-ended problems in the set of exercises or tasks given to the students. The teaching practices most often than not deal with textbook mathematics problems that are routine, and do not involve engaging activities that will provide opportunities for students to think deeply and perform independently [1]. Comprehensive researches about ambiguity tolerance as a means of evaluating the student's abilities create openness for different points of views in the teaching and learning process [7]. Solving ambiguous problems in Mathematics will provide opportunities for the students to think of different solutions and will make way for their creative juices to flow in generating novel ideas and meaningful answers [8]. According to the authors in [9], ambiguity can be most suitably defined as the lack of necessary information to understand a specific circumstance and come up with comprehensible decisions with expected outcomes. Moreover, tolerance of ambiguity indicates the capacity to live with ambiguity, endure ambiguity, to operate with and within ambiguity [10]. It is also defined to be the tendency of an individual (group) to perceive and process information on ambiguous situations. Individuals with a low - tolerance of ambiguity view ambiguous situation as a threat that causes them to react hastily and avoid such stimuli. On the other hand, individuals with high-tolerance of ambiguity view the situation as an interesting encounter [11]. Ambiguity tolerance is considered to be an intrinsic psychological characteristic of a person [12,13]. An individual with high ambiguity tolerance may contradict positively or tolerate contradiction in his/ her beliefs and understanding [12]. Several studies on the relationship of ambiguity tolerance and foreign language reading and learning have been done since 1990. Some of these showed that the ambiguity tolerance of the students, their self-perceived success and strategy training in reading was significantly correlated [14]. It was also found that majority of the Turkish EFL (English as a Foreign Language) learners has low ambiguity tolerance. Results also showed that ambiguity tolerance and perceived success in foreign language reading have a strong direct relationship which indicates that the more ambiguity tolerant the learner is, the more successful they could be in reading. The role of learner training was emphasized to be significant in improving the ambiguity tolerance of the students [14]. Ambiguity is the perception of inadequate information arising from certain characteristics of a situation. In a situation that demands evaluation or choice, the perception of ambiguity is threatening and presents as a cognitive challenge [15]. More assistance and encouragement from the teachers are needed in language learning by low ambiguity tolerant individuals [16]. This should be particularly evident, especially for challenging topics. Problem solving requires combined creative skills and proficiency of concepts to deal with real-world problems. It has been observed that most of the students encounter difficulties in solving real-world problems. Studies have shown that problem-solving is a higher-order thinking process composed of major intellectual abilities and cognitive processes. It is not just about recalling simple facts or applying well-learned methods. Factors that were deemed significant in the problem-solving performance include intelligence, creativity and originality, spatial ability, verbal ability, working memory, and knowledge, which are all identified as cognitive abilities [17]. Moreover, solving problems involves both analytical and creative skills. Through problem solving, students can understand and develop innovative solutions to problems or challenges that may vary in different contexts. A lot of discussions were made in the past regarding the restrictions involved in solving problems in a mathematics classroom, which resulted in the formulation of standard procedures in teaching how to solve a problem. Nonetheless, the basic idea of the existing problem-solving models has not yet been defined objectively. The skills intended to be learned by the students in problem-solving have been overshadowed by universal standards and considerations. The means to understand the process of deepening, synthesizing, and analyzing problems has been ignored; put aside behind the curriculum [18]. An open-ended problem, according to the authors in [19], operates on having multiple answers. One needs to master both the textbook knowledge and imagine boldly with a sound and active mind. Hence, these questions help students to greatly achieve their creativity, making them smarter and more logical thinkers. Using open-ended questions in a problem-solving ability test, the author in [20] identified mathematical errors, difficulties and thought processes of students in their answers. It was found that the students had difficulty with the basic concepts such as measurement, perimeter, length of one side of a square, linear equation, and ratio and proportion. As shown in this study, students' lack of understanding in these concepts stemmed from any of the following reasons: use of inappropriate mathematical operations; misapprehension of the mathematical language; English language deficiencies; difficulty in translating verbal phrases to mathematical expressions or equations; lack of completeness in the learned concepts; wrong use of data given; defective and incomplete algorithm; computational errors; and some other random responses. Moreover, because of their misconceptions in the lessons learned prior to the conduct of the study, the students were not able to generate or provide correct responses to each question [20]. Bridging ambiguity tolerance as it relates to problem-solving ability implies helping students in handling challenging tasks, cognitive and emotional complexity, and thus enables them to have personal, intellectual and social growth [11]. Students with high ambiguity tolerance attain higher scores on tests, produce unique solutions to open ended problems and perform better in answering various types of puzzles. In addition, ambiguity tolerant students were observed "to deal better with vague language, partial information, tasks with little structure, and multiple perspectives in problem solving" [21:85]. Furthermore, teachers have important roles in helping students cope with ambiguity and use it to their advantage. At the point when the teachers can stress the importance of critical and creative thinking even with encountering ambiguity is a good opportunity for the students to extract their creativity and can participate in solving complex problems [7]. The author in [22] conducted another study on ambiguity tolerance and its relation to the mathematical ability of students from private and public schools. The study determined the moderating effects of gender and school type on the tolerance of ambiguity and mathematical ability. The researcher made use of Problem-Solving Ability Test (PSAT) that includes some ambiguous problems, Reasoning Skill Test and a Likert Scale – Measure of Ambiguity Tolerance (MAT-50) Test. The findings showed that gender and school type did not moderate the effects of ambiguity tolerance on students' reasoning skills and problem-solving ability. However, results showed a significant difference between public and private high schools in their ambiguity tolerance. The researcher also suggested that the difference in the ambiguity tolerance of the students from the two schools can be explained by the diverse experiences and social life of the students. The researcher also emphasized that the complexity of the personal experience and social life brings confusion to the young generation, therefore challenging their abilities to deal with uncertainty. It was also obtained that ambiguity tolerance correlated negatively with problem-solving ability [22]. Studies regarding ambiguity tolerance usually dealt with linguistic applications. But there have been a lot of studies associating language with mathematical skills and processes. Hence, despite the lack of studies directly linking ambiguity tolerance and problem-solving ability, there is enough literature to support its presupposition. The results and deductions from this study will hopefully create an impact on the students, teachers, school administrators, Teacher Education Institutions, and future researchers. This study was conducted in a public (laboratory) school and in a private school in Laguna, Philippines. Students in the Grade 8 level served as respondents for the study. The study focused on select lessons in Intermediate Algebra which includes Basic Mathematical Operations, Order of Operations, Algebraic Expressions, Set of Real Numbers, Exponents, Mathematical Sentences, Factoring, Quadratic Polynomials, and Complex Fractions. This study aimed to determine the association between student ambiguity tolerance and their problem-solving ability in mathematics. It also sought to determine whether or not a student's reaction to unfamiliar or uncertain stimuli influences their ability to solve non-routine word problems.

2. Materials and Methods

This study is a non-experimental, mixed methods research wherein both quantitative and qualitative data collection and analyses were utilized. This employed a one-time testing procedure. The study has a total of 182 respondents from two different schools (private and public) in Laguna, Philippines. All the respondents were in Grade 8. All these students were subjected in the data collection using the prepared instruments. Moreover, a sample of the students was considered and requested to participate in an interview.

2.1. Instruments

Multiple Stimulus Types Ambiguity Tolerance (MSTAT-II) Scale. It is a 5-point Likert scale developed by David L. McLain in 2009 to measure the ambiguity tolerance of individuals, in which the answers were treated as scores. The instrument was used to obtain and classify the ambiguity tolerance of students. It is a 13-item scale with an internal consistency reliability of 0.83. MSTAT-II was a modification of MSTAT-I developed also by McLain in 1993. MSTAT-I is a 22-item scale with an internal consistency reliability of 0.86 which was made with an attempt to redefine ambiguity tolerance and aide in the weaknesses of psychometric measures of ambiguity tolerance. In a review conducted by Furnham & Marks, MSTAT-II scale was recommended over MSTAT-I scale because the former was found to be less comprehensive, and respondents who will take the test will not be cognitively overloaded [6]. Moreover, MSTAT-II scale reduces the positions to specific context and objects not related to ambiguity tolerance [11].

Problem-Solving Ability Test (PSAT). The PSAT is the researchers made test composed of six open-ended problems in Intermediate Algebra. The topics include Basic Mathematical Operations, Order of Operations, Algebraic Expressions, Set of Real Numbers, Exponents, Mathematical Sentences, Factoring, Quadratic Polynomials, and Complex Fractions. All the items were devised to stimulate critical thinking and generate creative mathematical solutions/ answers. This instrument was subjected to content validation of Mathematics experts. Reliability analysis was also conducted using the 31 Grade 9 students, and gave a Cronbach alpha of 0.518. The author in [23] noted that it is necessary to have a reliability coefficient of .70 or higher in an exam done in a classroom. Although the resulting reliability in the pilot test of the PSAT is lower than .70, it does not necessarily mean that obtaining a low reliability will nullify a measurement as a way of drawing substantial references [24]. Cronbach alpha relies on the number of items in a test measurement. If there are 10 or less items in the test, it is projected to have a low reliability. A 12-item test would give a higher contrast [23,25]. Aside from the length of the test, group homogeneity is additionally thought to be an imperative element that will influence the reliability [26]. Since the PSAT was pilot tested with a set containing all Grade 9 students, there might be some similar attributes that affected the homogeneity of the group (i.e. level of mathematical ability and exposure to open-ended questions) resulting to a low reliability of the scores. The reliability would be higher for the group that is heterogeneous as to the characteristic being measured [26].

2.2. Data collection procedure and data analyses

Scheduling of the administration of the two instruments (MSTAT-II and PSAT) was done. The teachers-in-charge of the Math classes of Grade 8 from the two schools were asked about their course outline to ensure homogeneity of the lessons covered. Prior to the administration of the instruments, the students were informed about the objectives and significance of the study and their involvement as the subjects in the study. The students were also ensured the confidentiality of all of the data generated. The MSTAT-II was first administered, followed by PSAT, one week after the other. Each of the instruments was administered simultaneously to the students to avoid leakage that might affect the students' answer during the tests. Appropriate numerical descriptive statistics were generated to summarize the recorded scores of the students. The t-test procedure for independent samples was performed to compare the scores of students from public with those from private schools. The Pearson correlation coefficient was generated to determine the degree of association between ambiguity tolerance and problem-solving ability of students. Moreover, a linear regression analysis was performed to determine if ambiguity tolerance is a significant determinant of the problem solving ability of the students. Moreover, views and opinions of those who were requested to be interviewed were presented in a narrative form.

3. Results

3.1. Ambiguity tolerance of the students

The students from a public (laboratory) school obtained a higher mean score (37.1) of ambiguity tolerance compared to those from a private school with a mean score of 32.7. The t-test analysis showed that indeed the mean ambiguity tolerance scores of students from public school is significantly higher than those from private school (p=<.001) at 5% level of significance.

Table 1: Descriptive statistics and t-test for ambiguity tolerance (AT)

School Type	n	Mean	Standard Deviation	Standard Error of the Mean	t-test
Public (laboratory)	91	37.1	5.31	.57	5.36
Private	91	32.7	5.98	.63	(p=<.001)*

*significant at p<.05

Further comparisons were made between students from public and private schools, with reference to items in the MSTAT-II instrument. Table 2 shows that seven out of 13 items of the MSTAT-II Scale resulted in significant mean score differences between the two schools, In particular, students from public school scored higher than those from private school in the following items: *don't tolerate ambiguous situations well* (p=.002)*; would rather face solving a problem that must be viewed from different perspectives* (p=.003)*; prefer new situations over familiar ones* (p=.025)*; tolerant of ambiguous situations* (p=0.031)*; enjoy tackling problems that are complex enough to be ambiguous* (p=0.002). On the other hand, students from private school scored higher, on the average, for the items which are (1) *try to avoid problems that don't seem to have one 'best' solution* (p=0.009); and (2) *prefer a situation in which there is some ambiguity* (p=<0.001) than their private school counterparts. The results might be due to the highly selective nature of the public (laboratory) school. The laboratory high school of a state university implements a stringent admission program. The school only takes in about 10% of the examinees every year. As part of the mandate of the government for a laboratory school under a state university, only 125 students can be accommodated as incoming Grade 7 students, resulting in tight competition among the examinees. The slots are given to the top 125 students who qualified in the entrance examination. The private school has an admission test as well, but used primarily for their evaluation if a student needs to enroll in remedial classes. The students of the public (laboratory) school usually come from different elementary schools from different regions, mostly from Region IV-CALABARZON, while students from the private school usually come from elementary schools around Laguna area. Hence, the diversity of the students in terms of their socio-economic status and other family-related variables might have influenced the results as well. This merits further investigation for future studies as these variables were not included in the questionnaires. Moreover, the author in [22] suggested that the difference in the ambiguity tolerance of the students from different school types can also be attributed to the diverse experiences and social life of the students. He also emphasized that the complexity of their personal experiences and social life brings confusion to the young generation, thereby challenging their abilities to deal with uncertainty [22]. As students encounter more and more uncertainties over time, the more comfortable they can be in handling those situations [11,15].

Table 2: Mean score and t-test for each item on MSTAT-II scale

	Statement	Mean (A)	Mean (B)	Diff (A-B)	T	P
1	I don't tolerate ambiguous situations well. [a]	2.74	2.19	0.55	3.15	.002
2	I would rather avoid solving a problem that must be viewed from several different perspectives. [a]	2.86	2.36	0.5	2.97	.003
3	I try to avoid situations that are ambiguous. [a]	2.34	2.56	-0.22	-1.48	.14
4	I prefer familiar situations to new ones. [a]	2.12	1.74	0.38	2.26	.025
5	Problems that cannot be considered from just one point of view are a little threatening. [a]	2.57	2.69	-0.12	-.83	.41
6	I avoid situations that are too complicated for me to easily understand. [a]	2.58	2.41	0.17	1.25	.21
7	I am tolerant of ambiguous situations.	3.43	3.07	0.36	2.17	.031
8	I enjoy tackling problems that are complex enough to be ambiguous.	3.42	2.90	0.52	3.18	.002
9	I try to avoid problems that don't seem to have only one "best" solution.[a]	2.87	2.47	0.4	2.65	.009
10	I generally prefer novelty over familiarity.	3.56	3.41	0.15	.98	.33
11	I dislike ambiguous situations. [a]	2.24	2.07	0.17	.92	.36
12	I find it hard to make a choice when the outcome is uncertain. [a]	2.37	2.67	-0.3	-1.59	.11
13	I prefer a situation in which there is some ambiguity.	3.46	2.70	0.76	4.34	<.001*

*p<.05, [a]reverse-scored item, n=91 per school type, A=Public (laboratory), B=Private

3.2. Problem-solving ability of the students

The Problem-solving Ability Test (PSAT) was also administered to students from public (laboratory) and private schools. An inter-rater reliability analysis was employed to check the internal consistency and agreement of the two raters in the scores obtained from PSAT. Inter-rater reliability was tested at a 5% level of significance. A very high inter-rater reliability and agreement among the raters of the scores (Cronbach's α ranges from 0.971 to 1.000; R ranges from 0.944 to 1.000; and ICC ranges from 0.942 to 1.000 with p=<0.001) were obtained from the results. The scores of the students in the PSAT were recorded and summarized in Table 3. The students from public (laboratory) school obtained significantly higher mean PSA scores (8.98) than those from private school (5.44) with a p-value of <0.001. Hence, it can be inferred that students from public (laboratory) outperformed students from private school in terms of problem-solving ability.

Table 3: Descriptive statistics and t-test of the problem-solving ability (PSA) scores

	School Type	n	Mean	Std. Deviation	Std. Error Mean	t-test
PSA	Public (laboratory)	91	8.98	2.84	.30	8.75 (p=<.001)*
	Private	91	5.44	2.61	.27	

*significant at p<.05

Since the items on the PSAT have ambiguous contexts, the ambiguity tolerance of the students might have influenced the result as well. It is worth noting from the previous discussion, that there is also a significant difference between students from public (laboratory) and private schools in their ambiguity tolerance; students from public (laboratory) school has a higher tolerance for ambiguity than students from private school. The phrasing of the open-ended items may be unfamiliar to the students from a private school that resulted in vagueness in comprehending the instructions in the items. Furthermore, students with high ambiguity tolerance obtained higher scores on tests, produced unique solutions to open-ended problems and performed better in answering various types of puzzles [11]. In addition, ambiguity tolerant students were found to deal better with vague language, partial information, tasks with little structure, and multiple perspectives in problem-solving [21].

3.3. Ambiguity tolerance as predictor of problem-solving ability in mathematics

As shown in Table 4, problem-solving ability of a student is positive and moderately associated with ambiguity tolerance with a correlation coefficient of 0.5. This implies that as a student's ambiguity tolerance gets higher, he/she is expected to have a better problem-solving ability. Moreover, ambiguity tolerance can be considered as a significant determinant of a student's problem-solving, as suggested by the constructed model. As revealed in the model, a point increment in the ambiguity tolerance score will yield an increase of 0.27 in the PSAT score. This indicates that the ambiguity tolerance score from MSTAT-II has a significant positive weight on problem-solving ability and that those students with higher MSTAT-II scores are expected to have higher PSAT scores.

Table 4: *Simple linear regression model on problem-solving ability test scores.*

	Coefficient	Std. Error	T	P
Constant	-2.07	1.22	-1.69	.093
Ambiguity Tolerance	.27	.035	7.69	<.001*
R	.50			<.001*
R^2	.25			

*significant at p<.05, n=182

The author in [11] suggested that students with high ambiguity tolerance attain higher scores on tests, produce unique solutions to open ended problems and perform better in answering various types of puzzles [11]. In addition, ambiguity tolerant students were found to deal better with vague language, partial information, tasks with little structure, and multiple perspectives in problem-solving [21]. The results from this study seem to contradict the results obtained by the author in [22] wherein problem-solving ability correlates negatively with ambiguity tolerance. However, the difference could be attributed to the difference in the instruments used in measuring the ambiguity tolerance of the students. Moreover, the sample in the present study came from the set of Grade 8 students who came from a public (laboratory) and a private school, whereas in the study by the author in [22], the sample came from the set of fourth year students from a regular public and a co-educational private high school. Hence, the diversity of the students from the two sets of samples might have affected the contradicting results. Also, the location of the schools and the socio-economic status of the students' family might have affected the results since his study was conducted in a metropolitan area while the present study was conducted in a provincial area. Cultural factors and availability of other resources might have also contributed to the contradicting results. A subsidiary analysis of the misconceptions of the students was also implemented. Hereinafter, the students from a public (laboratory) school were coded as A1, A2, A3, and so on, while students from a private school were coded as B1, B2, B3, and so on. Because of their misconceptions in the lessons learned prior to the conduct of the study, not all students were able to generate or provide correct responses to each question. The researcher used open-ended questions to elicit creative answers and solutions among students. However, since the students were not really accustomed to answering ambiguous open-ended questions, their answers were only limited to their set of experiences and in what had been taught in the classroom. This perception was apparent in the students' remarks when asked to identify any problems in PSAT that did not give enough information and that might be helpful in answering the problems. Of the 182 students, 103 (57%) students answered that they encountered problems that did not give enough information. Here are some remarks of the students regarding the question: "*Yes. It is very confusing. I don't usually encounter this type of problem. I prefer to be given the facts than to have to find it, and I am a slow person."*-Student B72 "*Yes. Just like in number 6. It was very vague about what fraction it would represent, whether q has a greater value or whether it was p which has the greater value, thus it's difficult to deduce which expression has the lowest value.*"-Student A1 *"Yes. They should be more specific and more understandable because of the incomplete/ vague info can lead to different solutions that might be wrong."*-Student B27 The students' remarks reflect their inexperience in answering ambiguous open-ended questions, and hence found it difficult to answer and provide correct solutions. Moreover, some students preferred to be given facts rather than given options or assumptions or cases of possible answers. Furthermore, they were asked which, among the three types of problems they preferred to answer: (a) problems with too many possible answers; (b) problems with a single answer; and (c) problems they are familiar with. Among the 182 students, 24 (13%) students chose problems with numerous possible answers, 48 (26%) students chose problems with a single answer, and 103 (57%) students chose problems they are familiar with. The majority of the students chose the problems which they are familiar with. Here are some reasons why they chose such:

Students who chose problems that they are familiar with:

"*I do not like the vast knowledge of too many possible answers. And it's not adventurous if it has a single* *answer. Unless of course, it's an exam. Therefore, what I like the most is the problems that I'm familiar with but I would also like to solve problems that I'm not familiar with.”* – Student B13 “*I chose problems that I'm familiar with because if I am familiar with a certain topic, I can answer it even if it asks to give many possible answers or a single answer.*”-Student A48 “*I will choose the problems that I am familiar with because it will be easier to comprehend what is really needed and I will be able to find out how to best answer the problem and with ease.”*-Student B32

Students who chose problems a single answer:

“I chose B because you'll only find one answer, so it's easy to make sure that I have the right or wrong answer.”-Student A41 “*It may be a bit hard, but I think it causes less confusion, since there is only one answer to find.”*-Student A61 “*I find it easier than too many answers.”*-Student B42

Students who chose problems with numerous possible answers:

“*Since most problems in life can't be solved with only a single method/ answer.*”-Student A34 “*Because it can give me freedom to think outside the box.”*-Student A35 “*Because many answers could give me a whole array of options to use and hopefully lead me to a right answer.”*-Student B2

From the students' preference on the type of problems, it can be inferred that most students do not take risks in getting the correct answer. Familiarity gives them the advantage of going around the process of problem-solving. Similarly, students who chose problems with a single answer wanted it to be straightforward, with no detours, so that it will be easy to check if they got a right or wrong answer. They found it easier to focus on the problem at hand if they know that they only need to aim for one goal or one answer. Conversely, some students wanted some challenge in having the freedom to think outside the box, having opportunities to explore other options for many possible answers. Some students also thought that having many possible answers can lead to having more chances of getting the correct answer. These findings may explain the results of the ambiguity tolerance test showing that 118 (65%) of students belong to the moderately ambiguity tolerant group (which will be further elaborated in the next discussions on the levels of ambiguity tolerance), indicating that most of the students prefer safe answers. In the study conducted by the authors in [27], the researchers were able to observe how teachers answer mathematical problems. Routine-based approaches were observed in the solutions made by the teachers, having a serious lack of originality on their part. The teacher factor and school environment can influence the academic performance of the students specifically in problem-solving [27,28,29]. Hence, students also presented routine-based approaches in their answers and solutions to the open-ended problems. Although students lacked originality in their answers, it was worth noting that among the components of creativity, fluency was very evident in the answers of the students in both schools. This may be because it is easier to produce many answers than to move from one idea to another and generate novel solutions. High fluidity also suggests high plausibility of doing problem-solving correctly [27]. This result is in agreement with the findings of the author in [30] in a study focusing on the descriptive analysis of the solutions made by students, according to different components of creativity where high fluency was also observed in the answers of the students [30]. The mistakes committed by the students in this study can be attributed to: wrong problem representation and lack of understanding of the conditions presented; wrong use of the information given; lack of completeness in the learned concepts (i.e., definition of an equation versus an expression, definition of a 'term', factoring and simplifying equations, factorable quadratic polynomials, fractions, and complex fractions); computational errors; and problems in linguistics (especially in translating mathematical phrases and expressing in English). These findings suggest that proper interpretations and clarifications of mathematical concepts must be prioritized for every discussion in a mathematics classroom as confirmed also by the author in [2] in a study of clarifying ambiguous problems. It is also proposed that students should be more exposed to open-ended problems in the classroom; may it be in the form of exercises, individual or group activities, projects, among other similar assessment methods, to provide more ways to identify misconceptions of the students in every mathematical concept being studied. Open-ended problems give more emphasis on the real world and daily experiences of the students. Using these kinds of problems will provide an opportunity for students to think critically, and creatively as if solving real life problems involving logic and critical thinking. The students are given opportunities to reveal their conceptual understanding through experiences with open-ended problems [31].

4. Conclusion

This study aimed to determine if ambiguity tolerance is a significant positive determinant of problem-solving ability. Based on the findings, it can be inferred that ambiguity tolerance can be considered as a significant determinant of student's problem-solving ability in mathematics, specifically with the use of open-ended problems. Ambiguity tolerance gave the moderate and positive association with problem-solving ability. The use of ambiguous open-ended problems also provided opportunities for students to think critically and creatively, hence providing meaningful solutions. Moreover, the conceptual understanding of the students can be revealed with the use of open-ended problems in mathematics.

5. Recommendations

In consideration of the results of the analyses, it is recommended that the use of open-ended problems be employed by teachers across various subject matters in Mathematics and across all grade levels so as to encourage critical and logical reasoning and creativity among students. School administrators should initiate extension/ training programs that will equip their faculty/ personnel and other neighboring school facility of ambiguity tolerance, its effects and usability to better enhance approaches and techniques in the teaching and learning process. Moreover, Teacher Education Institutions should create programs that will expose pre-service and in-service teachers to the idea of incorporating ambiguous open-ended problems in their lessons in mathematics. They should also encourage their teachers to have their ambiguity tolerance measured so that they can be equipped with the appropriate tools needed in teaching diverse types of learners.

References

[1]. A. Lee. "Non-routine problem solving heuristics of selected high-performing students in University of the Philippines Rural High School." M.S. thesis, University of the Philippines Los Baños, Philippines,

(2011).

[2]. L. Sibbaluca. (2009). "Clarification of ambiguous problems: Effects on problem solving ability and attitude towards mathematics." Alipato: A Journal of Basic Education. [On-line] 3(3). Available: http://journals.upd.edu.ph/index.php/ali/article/view/1758.

[3]. National Council of Teachers of Mathematics. Curriculum and standards for school mathematics. Reston, VA: Author. (2000)

[4]. T. Jokinen. "Global leadership competencies: A review and discussion." Journal of European Industrial Training, vol. 29, pp.199–216, 2005.

[5]. Y. Yamazaki and D. Kayes. "An experiential approach to cross-cultural learning: A review and integration of competencies for successful expatriate adaptation." Academy of Management Learning & Education, vol. 3, pp. 362–379. 2004.

[6]. A. Furnham and J. Marks. (2013) "Tolerance of ambiguity: A review of the recent literature." Psychology. [On-line]. 4(9), pp. 717-728. Available: http://www.scirp.org/journal/psych.

[7]. R. Eisinger. "Teaching ambiguity." Internet: https://www.insidehighered.com/views/teaching-ambiguity, Feb. 21, 2011 [Dec. 2, 2016].

[8]. R. Tallent. "Being ambiguous: Problem solving through teaching ambiguity in IMC classrooms." Review of Journalism and Mass Communication, vol 4(1), pp.1-18, 2016.

[9]. J. Arquero and D. McLain. "Preliminary validation of the Spanish version of the Multiple Stimulus Types Ambiguity Tolerance Scale (MSTAT-II)." The Spanish Journal of Psychology, 2010.

[10]. K. Stoycheva. "Intolerance, uncertainty, and individual behaviour in ambiguous situations." NIAS. Pp. 63-73, 2011

[11]. D. McLain. "Evidence of the properties of an ambiguity tolerance measure: The Multiple Stimulus Types Ambiguity Tolerance Scale-II (MSTAT-II)." Psychological Reports, vol. 201, pp. 975-988, 2009.

[12]. H. Brown. "Principles of language learning and teaching" 5th ed. White Plains, NY: Pearson Education, 2007

[13]. L. Steenkamp and P. Wessels. "An analysis of the tolerance for ambiguity among accounting students." International Business & Economics Research Journal, vol. 13(2). Canada, 2014.

[14]. I. Erten and E. Topkaya. "Understanding tolerance of ambiguity of EFL learners in reading classes at tertiary level." Novitas-ROYAL, vol.3(1), pp. 29-44, 2009.

[15]. J. Arquero and C. Tejero. "Ambiguity tolerance levels in Spanish accounting students: A comparative study." Revista de Contabilidad-Spanish Accounting Review, vol. 12(1), 2009.

[16]. W. Chu, D. Lin, T. Chen, P. Tsai and C. Wang. (2015). "The relationships between ambiguity tolerance, learning strategies, and learning Chinese as a second language." System. [On-line] 49, pp. 1-16. Available: http://dx.doi.org/10/1016/j.system.2014.10.015.

[17]. A. Bahar and C. Maker. "Exploring the relationship between mathematical creativity and mathematical achievement." Asia-Pacific Journal of Gifted and Talented Education, vol. 3(1), pp. 33-48, 2011.

[18]. B. Sriraman. "Are giftedness & creativity synonyms in mathematics? An analysis of constructs within the professional and school realms." The Journal of Secondary Gifted Education, vol. 17, pp. 20–36, 2005.

[19]. Y. Li and D. Li. "Open-ended questions and creativity education in mathematics." Research in Mathematical Eucation, vol. 13(1), pp. 23-30, 2009.

[20]. M. Lumpas. "Mathematics error, difficulties, and though processes of students as gleaned from the TIMSS." M.A. thesis, University of the Philippines Diliman, Philippines, 1997.

[21]. R. Williams. "Leadership for school reform: Do principal decision-making reflect a collaborative approach?" Canadian Journal of Educational Administration and Policy, vol. 53, pp. 1-7, 2006.

[22]. R. Dianco. "Ambiguity tolerance: relationship to the mathematical ability of public and private school students." M.A. thesis, University of the Philippines Diliman, Philippines, 2014.

[23]. Wells, C.S. & Wollack, J.A. (2003). An instructor's guide to understanding reliability. Retrieved on June 4th, 2010 from the World Wide Web,http//:www.testing.wisc.edu/reliability,

[24]. G. Ferguson and Y. Takane. "Statistical Analysis in Psychology and Education." 6th ed. NY: McGraw-Hill Book Company, 1989.

[25]. J. Pallant. "A step by step guide to data analysis using SPSS for Windows (Version 10)." Open University Press. Philadelphia, 2001.

[26]. B. Thompson. "Understanding reliability and coefficient alpha, really." in Score reliability: Contemporary thinking on reliability issues, B. Thompson (Ed.), Thousand Oaks, CA: Sage, 2003, pp. 3–23.

[27]. B. Kim and J. Lee. "A study on the development of creativity in the secondary mathematics in Korea." Journal of the Korea Society of Mathematical Education, Series D. vol. 5(1),pp. 45-58, 2001.

[28]. S. Habibullah and J. Ashraf. "Factors affecting academic performance of primary school children." Pakistan Journal of Medical Research, vol. 52(2), 2013.

[29]. J. Cheema. "The private-public literacy divide amid educational reform in Qatar: What does PISA tell us?" Int. Res. Educ. 61, pp. 173-189, 2015.

[30]. M. Borja. "Mathematical creativity on students' solutions to open-ended problems." Masters in Teaching, special problem, Philippine Normal University, Philippines, 2011.

[31]. E. Mann. "Creativity: The essence of mathematics." Journal for the Education of the Gifted, vol. 30, pp. 236–262, 2006.