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Abstract Reasoning and Problem-Solving Skills of First Year College Students

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Abstract *– The study ought to discuss the two of the considered most important cognitive processes, the Abstract Reasoning and Problem-Solving Skills. In general, the study hypothesized a statistically significant relationship between the respondents' abstract reasoning ability and problem-solving skills. Moreover, the study also focuses on the categories of problem solving based on Triarchic Theory of human intelligence by Robert J. Sternberg: the Analytical, Practical and Creative Problem Solving and the probability of difference between these three. Findings showed that there is no significant difference between the categories of problem solving. In addition, there are significant differences in the performance of the respondents in abstract reasoning when classified to the college or department they belong. It is also the same with the respondents' performance in analytical, practical, creative and general problem solving. As a final point, there is a significant direct proportion relationship between the respondents' abstract reasoning and problem solving skills.*

Keywords *– Abstract Reasoning, Problem Solving, Analytical, Practical, Creative*

INTRODUCTION

Problem solving is an important cognitive process directed at transforming a given situation into a goal situation when no obvious method of solution is available (Wismath et al., 2015; Jonassen, 2000). Problem solving is not a one-stop-shot approach in finding the answer. Polya provided four steps in problem solving (Polya, 1986); Deek, Turoff & McHugh (1999) proposed a six-stage process in problem solving; Stenberg (2009) identified seven steps; and Shahat et al. (2013) written eight-stage process of solving problems. In the world of mathematics, it is very common to deal with problems. Solving the values of the unknown (x, y, z), finding the measure of the angle in a right triangle, getting the area of an irregular solid, and finding cosine function are some of the theoretical instances requiring problem solving skills of the students. However, studies show that students are lacking of this skill when it comes to application in real life contexts (Incebacak & Ersoy, 2016) particularly those who are non-routine problems (Hewson, 2011). Conversely, students primarily learn to solve only well-structured subject matter problems and similar problems to the ones that they had solved (Yu, et al., 2014). Although there are some initiatives done by researchers to increase the problem-solving skills of the students (Agran, Blanchard, Wehmeyer & Hughes, 2002; Dees, 1991; Ozsoy & Ataman, 2017; Zanzali & Lui, 2000), still, studies concluded that students have low command on this skill (Reddy & Panacharoensawad, 2017). There are several factors affecting problem solving skills of students. These include poor mathematical skills and lacking of understanding the problem (Pimta, Tayraukham, & Nuangchalerm, 2009); attitude towards mathematics, self-esteem teachers' teaching behavior (Isabelo & Silao, 2018); parental involvement (Sophonhiranrak, Suwannatthachote, & Ngudgratoke, 2015); and planning for own approach in solving the problems (Klauer & Phye, 2008). Another important concept in mathematics is the abstract reasoning. Abstract reasoning refers to an individual's ability to recognize patterns and relationships of theoretical or intangible ideas. Abstract reasoning is most closely related to rational thought as opposed to empirical thought (Hulac, 2011). Abstract reasoning has been found significant to academic performance of students (Gomez-Veiga, Vila, Duque, & Garcia, 2018; BillT, n.d.) but no concrete study supports the connection and implication of abstract reasoning to problem solving skills of the students. Since both problem-solving skills and abstract reasoning have found significant in students' performance, specifically in mathematics, this study focuses on the probability of existing relationship between problem-solving skills and abstract reasoning skills of randomly selected first year college students.

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OBJECTIVES OF THE STUDY

The study was conducted to determine the relationship between the respondents' level of abstract reasoning and problem-solving skills. To achieve the objectives of the study, the following question were answered: 2) 1) What is the level of the abstract reasoning of the respondents? 2) What is the performance of the respondents in problem solving in terms of – a) analytical, b) practical, and c) creative? 3) Is there a significant difference between the respondents' performance in problem solving in terms of – a) analytical, b) practical, and c) creative? 4) Is there a significant difference between the respondents' abstract reasoning when classified according to the college they belong? 5) Is there a significant difference between the respondents' performance in problem solving when classified according to the college they belong?

MATERIALS AND METHODS

Descriptive correlational design was employed in this study. In this type of design, the researchers were interested in describing the relationships among variables without seeking to establish casual connections (Stenberg, 1986). A total of 225 first year college students were taken from the population of 512 first year college students in a One State University in the Philippines. The stratified random sampling technique specifically the proportionate stratification approach was utilized in this study. With proportionate stratification, the sample size of each stratum (in this study are the colleges or departments the respondents belong) is proportionate to the population size of the stratum. This means that each stratum has the same sampling fraction.

The data needed was gathered using a validated questionnaire, an online test and a standardize tests. The questionnaire is composed of forty (40) items multiple choice questions that determined the level of Problem-solving Skill of the respondents. Twenty questions for both Analytical and Practical Problem Solving. An online test to measure the Creative Problem Solving of the students was also used. Finally, a standardized test was used to determine the level of Abstract Reasoning of the respondents.

RESULTS AND DISCUSSION

Abstract Reasoning

Table 1 shows the performance of the respondents in abstract reasoning.

Table 1. Level of Abstract Reasoning

Statistics	Value	Interpretation
Mean	9.91	Fairly Satisfactory
Median	10.00	Fairly Satisfactory
Mode	8.00	Fairly Satisfactory
Standard Deviation	4.83	---
Kurtosis	-0.79	---
Skewness	0.04	---

The value of the skewness signifies that the distribution of the scores below and above the mean is approximately symmetrical. On the other hand, the value of the kurtosis displays a more scattered set of scores with respect to the mean. The most frequent scores and the middle scores of the respondents denotes fairly satisfactory in abstract reasoning. The mean signifies that the respondents performed fairly satisfactory. The result conforms to Kusmaryono, et al. (2018) who concluded that abstract reasoning is not reaching 100% as expected in the curriculum. Abstract reasoning of the students is a predictor of mathematics performance of the students (Drager, 2014) and in order to increase the performance of the respondents from fairly satisfactory, the respondents seemed to need more challenging learning tasks that require abstract reasoning and mechanisms as what a study which focused on identifying students' self-reported problems recommended (Basadur, Graen & Wakabayashi, 1990).

Analytical Problem Solving

Table 2 show the respondents' performance in analytical problem solving. The distribution of the scores below and above the mean is approximately symmetrical as the skewness shows. On the other hand, the kurtosis denotes that the distribution of the scores of the respondents are peaked and clustered near to the mean. The most frequent scores and the middle score the respondents in analytical problem is poor while the average score denoted that the respondents performed fairly satisfactory. Similar to Programme for International Student Assessment, as

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discussed by Greiff, Holt & Funke (2013), analytical problem-solving was aligned with several disciplines however, majority of the problems are aligned with mathematics and science. Likewise, Analytical skill is found related to cognitive ability of the students (Foster, 2014). For this reason, the need for improving the analytical problem-solving skill of the students is necessary.

Table 2. Analytical Problem Solving

Statistics	Value	Interpretation
Mean	7.52	Fairly Satisfactory
Median	7.00	Poor
Mode	7.00	Poor
Standard Deviation	2.78	---
Kurtosis	0.44	---
Skewness	0.16	---

Practical Problem Solving

Table 3 presents the performance of the respondents in practical problem solving. The distribution of the scores is moderately skewed to the right, indicating that there are respondents who got extremely high scores than the others. The values of mean, median and mode assessed the performance of the respondents in practical problem solving as fairly satisfactory. This insinuates that first year college students need to connect theoretical foundations of problem-solving skills to the practical application of these skills in real world scenario. Tambychik & Meerah (2010) found that students have experienced difficulties in problem solving due to absence of effectively connecting the information in the problems. This further implies that when applying mathematical concepts into real world problem solving, difficulties arise. This denotes that practical application of problems involving mathematics be given emphasis rather than merely focusing on the abstraction of the concept.

Table 3. Performance in Practical Problem Solving

Statistics	Value	Interpretation
Mean	7.28	Fairly Satisfactory
Median	7.00	Fairly Satisfactory
Mode	5.00	Fairly Satisfactory
Standard Dev.	3.36	---
Kurtosis	0.61	---
Skewness	0.65	---

Creative Problem Solving

Table 4 displays the performance of the respondents in creative problem-solving. The overall weighted mean shows that the respondents are often creative in problem solving. The highest value indicated that the respondents strive to look at problems from different perspectives and general multiple solutions. The lowest value complimented to this and suggested that even the old assumptions are important for the respondents to solve problems. Based on the findings, the first-year college students have high perception on the level of their creative problem-solving skills. Problems experienced by the students, particularly real life, do not always come from the lessons they study. Several of these problems arise from their everyday experience. According to Ritter & Mostert (2017) creative thinking skills could be considered as one of the salient competencies of 21st century which allows people to remain flexible having still the capability on dealing challenges and opportunities in the complexity of fast-changing world.

Table 4. Level of Creative Problem Solving

Indicator	WM	VI
1) Looking out for different ways to approach a problem.	3.49	O
2) When presented with a problem, many different solutions occur to me without much effort.	3.13	S
3) Throwing out old assumptions at the start of the problem solving is being naïve.	3.05	S
4) Considering instincts when formulating a solution to a problem.	3.58	O
5) Developing implementation plan in choosing a solution.	3.49	O
6) Looking for ways to improve the idea to avoid future problems.	3.49	O
7) Taking care to define each problem carefully before trying to solve it.	3.66	O
8)Striving to look at problems from different perspectives and general multiple solutions.	3.27	S
9)Trying to address the political issues and other consequences of the change.	3.22	S
10)Evaluating potential solutions carefully and thoroughly against a predefined standard.	3.32	S
11) Systematically searching for issues that may become problems in the future.	3.25	S

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12) Making it the solution happen no matter what opposition that may face.	3.30	S
13)Finding small problems often become much bigger in scope.	3.31	S
14)Asking lots of different questions about the nature of the problem.	3.49	O
15) Relaxing and focusing on regular duties after solution is implemented.	3.60	O
16)Focusing on keeping current operations running smoothly.	3.34	S
17)Evaluating potential solutions.	3.41	O
18)Having all the information needed to solve the problem.	3.50	O
19)Taking time to think about choosing between options.	3.65	O
20) Making a decision is the end of problem solving process.	3.65	O
Total	**3.41**	**O**

S-Sometimes; O-Often

Difference in the Categories of Problem Solving

Table 5 presents the difference of problem-solving skills when classified as analytical, practical and creative. Since the p-value is greater the alpha level of significance, then there is no significant difference between the respondents' problem-solving skills.

Table 5. Difference in Problem Solving

Problem Solving	N	Median	Average Rank	Z
Analytical	225	107.00	324.6	-1.12
Practical	225	98.00	336.4	-0.01
Creative	222	106.00	348.6	1.14
Overall	672		336.5	
H = 1.71	DF = 2	P = 0.426		
H = 1.71	DF = 2	P = 0.425 (adjust for ties)		

Abstract Reasoning and Respondents' Profile

Table 6 shows the difference between the respondents' abstract reasoning when classified according to the college they belong. The p – value denotes that there is a sufficient evidence of significant difference between the respondents' abstract reasoning. The mean values indicate the performance of the respondents with regards to their abstract reasoning. The higher the value of the mean, the better the performance. Since the mean of the respondents from the College E has the highest value, they have higher abstract reasoning among the other respondents. The results suggest that the college or department which the respondents belong can be an indicator of their abstract reasoning ability.

Table 6. Abstract Reasoning and Respondents' Profile

College/Department	Mean	SD
College E	15.273 A	4.628
College A	10.260 B	4.703
College D	11.056 B	3.888
College B	10.439 B	4.869
College F	9.625 BC	0.518
College C	6.800 C	4.099

Source	DF	SS	MS	F	P
Course	5	803.8	160.8	7.94	0.000
Error	219	4431.3	20.2		
Total	2245	5235.0			
S=2.608	R– Sq = 14.04%		R-Sq(adj) = 12.07%		

(Means that do not share a letter are significantly different)

Analytical Problem Solving and Respondents' Profile

Table 7 shows the difference between the respondents' performance in analytical problem solving when classified according to the college they belong. The p – value indicates a high significance on the difference between the respondents' performance. The mean values indicate the measures of the performance of the respondents in analytical problem solving. The higher the value of the mean, the better the performance. Since the mean of the respondents from the College E has the highest value, they performed better in analytical problem solving among the other respondents. The results suggest that the college or department which the respondents belong can be an indicator of their analytical problem solving.

Table 7. Analytical Problem Solving and Respondents' Profile

College/Department	Mean	SD
College E	11.273^{A}	3.687
College A	7.494^{B}	2.836
College D	7.944^{B}	1.924
College B	7.803^{B}	2.873
College F	6.625^{BC}	0.744
College C	6.244^{C}	2.144

Source	DF	SS	MS	F	P
Course	5	243.12	28.62	7.15	0.000
Error	219	1489.00	6.80		
Total	224	1732.12			
S=2.608	R – Sq = 114.04%		R – Sq (adj) = 12.07%		

(Means that do not share a letter are significantly different)

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Practical Problem Solving and Respondents' Profile

Table 8 shows the difference between the respondents' performance in Practical Problem Solving when classified according to the college they belong. There is significant difference between the performances of the respondents in practical problem solving considering the resulted p – value.

Support in the significant difference of practical problem solving in different fields was shown in the study conducted with respondents from faculty members, graduates and undergraduates of psychology and business (Mayer, 1990). The mean value signifies the performance of the group. Having the highest mean value, the respondents from the College E performed better among the other respondents. The results suggest that the college or department which the respondents belong can be an indicator of their practical problem solving.

Table 8. Practical Problem Solving and Respondents' Profile

College/Department	Mean	SD
College E	13.182^{A}	3.816
College A	6.961^{BC}	3.270
College D	7.056^{BC}	3.208
College B	7.697^{B}	2.966
College F	6.533^{C}	2.519
College C	3.625^{D}	0.518

Source	DF	SS	MS	F	P
Course	5	535.32	107.06	11.80	0.000
Error	219	1986.48	9.07		
Total	224	2521.80			

S=2.608 R–Sq=21.23% R-Sq (adj) =19.43%

(Means that do not share a letter are significantly different)

Creative Problem Solving and Respondents' Profile

Table 9 displays the difference between the respondents' performance in creative problem solving when classified according to the college they belong. Having p – value less than the alpha level of significance, there is a sufficient evidence that there is a significant difference between the performances of the respondents in creative problem solving.

Support was found that unique personal style in creative problem solving can be identified for each individual in which one has a relatively greater or lesser inclination (Mayer, 1990). The median values and average ranks represent the performance of each group. The respondents from the College E got the highest performance rate considering its median value and average rank. As the median value increases, the better the performance of the group. The results suggest that the college or department which the respondents belong can be an indicator of their creative problem solving.

Table 9. Creative Problem Solving and Respondents' Profile

College/Department	Median	Average Rank	Z
College E	3.800^{A}	131.5	1.06
College A	3.500^{A}	122.2	1.79
College D	3.425^{A}	122.6	0.76
College B	3.425^{A}	113.2	1.26
College F	3.300^{AB}	83.0	1.28
College C	2.250^{B}	85.5	2.96
H = 12.39 DF = 5	P = 0.030		

(Medians that do not share a letter are significantly different)

Problem Solving and Respondents' Profile

Table 10 displays the difference between the respondents' overall performance in problem solving when classified according to the college they belong. There is a high significance of difference in the overall performance of the respondents in problem solving based on the comparison of the alpha level of significance and the resulted p – value. The performance of the respondents from College E has the highest median value that signifies its position as the highest rate performance among the other respondents. The results suggest that the college or department which the respondents belong can be an indicator of their overall performance in problem solving.

Table 10. Problem Solving and Respondents' Profile

Course	Median	Average Rank	Z
College E	1.733 A	166.3	2.90
College A	1.400 B	119.0	1.26
College B	1.400 B	117.7	0.93
College D	1.400 BD	121.6	0.69
College C	1.283 CD	80.6	-3.51
College F	1.267 D	56.8	- 2.45
H = 25.82	DF = 5	P = 0.000	

(Medians that do not share a letter are significantly different)

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Correlation of Problem Solving and Abstract Reasoning

Table 11 shows the relationship of the respondents' performance in problem solving and abstract reasoning. The p – value indicates a highly significant relationship between the respondents' performance in problem solving and abstract reasoning. The resulted positive value of r signifies a direct proportional relationship. It implies that the respondents with high performance rate in problem solving relatively showed high performance rate in abstract reasoning and vice versa. The finding of the study confirms that abstract reasoning is necessary in solving problems whether what degree of complexity in the natural world (Datta & Roy, 2015).

Table 11. Problem Solving and Abstract Reasoning

	Analytical Problem Solving	Practical Problem Solving	Creative Problem Solving
Abstract Reasoning	r=0.342	r=0.304	r=0.174
	p=0.000	p=0.000	p=0.009
Pearson correlation of PS and AR = 0.337			
P- value = 0.000			

CONCLUSION AND RECOMMENDATION

Based on the findings of this study, the researchers established the following conclusions: The statistical significance in the difference of the respondents' abstract reasoning implies that the college or department which the first year students decided to be enrolled can be an indicator of their abstract reasoning ability. This can also be applicable and relative to the students' performance in analytical, practical, creative, and in general problem solving. As a final point, the respondents with high performance rate in problem solving relatively showed high performance rate in abstract reasoning (vice versa). With these reasons, it is recommended that the teachers to be aware of these types of cognitive processes that can affect the performance of their students. Moreover, seminars, programs, workshops, or activities that will aid in developing the students' abstract reasoning that will relatively develop their problem solving and vice versa are highly recommended in the colleges or departments identified with the students that showed poor performance in the said cognitive processes.

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