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The Influence of Triarchic Intelligence Model in Mathematics Intervention on the Students' Mathematics Performance

Aniceto B. Naval[1], Laila S. Lomibao[2], Charita A. Luna[3]

University of Science and Technology of Southern Philippines, Lapasan, Cagayan de Oro City 9000, Philippines

Abstract: ***This study endeavors to examine the influence of the triarchic intelligence on students' mathematics performance as embedded in academic intervention through counseling program which focuses on maximizing students' innate abilities known as natural intelligence and compensating their weaknesses through reinforcements. Traditional reinforcement was applied to control group while experimental group underwent triarchic intervention involving analytical, creative, and practical based instructions. Students who were exposed to triarchic intervention showed significant improvements in their mathematical skills and performance. In general, triarchically based intervention was superior against traditional reinforcement.***

Keywords: Triarchic Intelligence, Mathematical Skills, Mathematics Performance

1. Introduction

Students' mathematics performance has become a major challenge to Philippine settings as evidently shown in the deteriorating performance of the Filipino students in the national and international assessment for the last two decades. Even Filipino students with advance curriculum performed least among participating countries in the Asian region. This posed a big challenge to the higher institutions, specifically to the mathematics faculty. Addressing this challenge, many institutions have done intervention programs to help students improve academic achievement especially on mathematics courses. However, results are not effective to a diverse group of students with different level of intelligence. Teachers are confronted with students of different needs but will not alter their style of teaching in accordance with students' differences.

Stenberg [20] said that many students could learn more effectively when they are taught in a way that will match to their mental abilities that will capitalize their strengths and correct their weaknesses. Under this circumstances students will developed their abilities [9]. This intelligence match instruction strategy using triarchic theory of human intelligence is called triarchic teaching which showed positive result on students' academic achievement [17],[21].

Notable researches on human intelligence geared towards explaining its influence in one's life success or failures can be attributed through the efforts of Galton [7], Binet [3], Spearman [18], Vernon [23], Catell [4], Gardner [8], and Stenberg [19]. The results of these researches brought significant impact in educational system and training processes. Hence, cognitive learning theorists such as Piaget [14], Vygotsky [24], Bandura [2], and Lave [12] link their standpoint views emphasizing the importance of learners' intellectual ability in cognitive development.

Intelligence is usually associated to a good school performance because this refers to the higher functions of cognitive processing. Binet and Simon [3] said that intelligence is a matter of problem solving, logical reasoning and spatial judgement. However, there are intellectual abilities that cannot be detected through tests; it can be observed directly to one's ability in assessing situations based on rational reasoning, create practical solutions for non-routine problems, and recognize causal links between facts and ideas very quickly and precisely [10]. It is just a matter of adapting within one's potential strength and gradual developing of weaknesses. In this sense, innate potential abilities will exceed beyond expected output in any IQ tests. Teachers can initiate this by understanding individual differences of the learners [5]. As Kaufman [11] said understanding individual difference helps teachers determine appropriate process of intervention to fit to the students' cognitive ability.

However, relatively little is known regarding integrating triarchic theory of human intelligence in an intervention process through academic counseling program with reinforcements on improving students' academic performance. Hence, this research was initiated to investigate the influence of triarchic intelligence in academic intervention to address the daunting challenge of every mathematics educators on improving students' mathematical performance.

2. Method

The quasi-experimental pretest-posttest design was employed to gather the data and to answer the posed questions in the study. Two intact classes of College Algebra course were randomly chosen and randomly assigned as control group and experimental group. Each of this group underwent interventions given in a form of academic counseling. A total of 56 students taking up computer related courses were the participants in the study. The participants were studying at St. Michael's College of Iligan City, Philippines. Twenty-seven (27) of them were randomly

assigned as control group and the remaining twenty-nine (29) as experimental group.

Students' strongest natural intelligences were determined using Stenberg's Triarchic Intelligence Inventory (STII), while students' mathematics performance was assessed via multiple-choice for achievement scores and open-ended questions for problem solving skills utilizing a validated researchers' made Achievement Test in College Algebra. The STII was adapted and revised based from *Triarchic Theory of Human Intelligence Survey* of Schultz Center for Teaching and Leadership website [16]. The revised instrument is a Likert-scaled inventory consisting of 30 items with 10 items each on analytical, creative, and practical intelligences. Their dominant intelligence was described based from the scoring guide of Shearer's [17] *Multiple Intelligences Developmental Assessment Scales* (MIDAS). This was piloted using a sample of 92 students majoring at different academic disciplines. The reliability estimate of the questionnaire using Cronbach alpha was $\alpha = .90$ which indicates a very high level of internal consistency.

On the other hand, the achievement test is composed of 25 multiple-choice items and 5 open-ended questions for problem solving skills including selected topics from sets and notations, set of real numbers, algebraic expression, special products, and factoring. The students' achievement scores were transmuted and interpreted based on the school's grading system while students' problem solving skills were measured accordingly through a problem solving skills rubrics [6]. The Achievement Test in College Algebra was also piloted using a sample of 51 students majoring at various disciplines in computer studies who have taken already College Algebra course. Using KR-20, the reliability and validity estimate was .74 which indicates good reliability for a teacher made test.

On the first day of class the randomly chosen group of students were given pre-test on achievement test in College Algebra. In the following session, the STII was administered to both groups to evaluate students' most dominant natural abilities. The results were analysed and it served as the springboard for the academic intervention for experimental group. These were done through counseling, monitoring, tutorials, and remedial classes which focuses on their ability patterns while compensating their weaknesses. Meanwhile, control group underwent the existing school intervention program for selective students who received failing grades after prelim examination. The treatment lasted for 10 weeks equivalent for prelim to the end of the midterm periods. After this specified time frame, the post-test was conducted. The results were analyzed through descriptive and ANCOVA (Analysis of Covariance).

3. Results and Discussion

The results of the analysis on the data gather are shown on the following tables.

Table 1: Frequency, Mean, and Standard Deviation of Students' Intelligence Profile

Triarchic Intelligence Profile	Control (n_1=27)				Experimental (n_2=29)			
	F	Mean	DE	SD	*f*	Mean	DE	SD
Analytical	6	37.83	*High*	6.145	3	37.67	*High*	4.163
Creative	7	37.86	*High*	7.175	10	34.6	*High*	5.254
Practical	14	37.07	*High*	5.269	16	33.88	*High*	5.005

Scale: 1 – 9 *Very Low*; 10 – 19 *Low*; 20 – 29 *Moderate*; 30 – 39 *High*; 40 – 50 *Very High*

It can be seen Table 1 that the most dominant triarchic intelligence profile for both control (14 out of 27 or 51.9%) and experimental (16 out of 29 or 55.2%) groups was the practical intelligence. Students belong to control group (M = 37.07, SD = 5.269) appeared to be more practical than experimental group (M = 33.88, SD = 5.005). It can be gleaned also that only few students have analytical intelligence in the experimental group (3 out of 29 or 10.3%) compared to the control group (6 out of 27 or 22.2%) though most of students from experimental group (M = 37.67, SD = 5.005) exhibited similar analytical intelligence level to some analytical students in control group (M = 37.83, SD = 4.163). On the other end, since control group were predominantly practical students, creative students shared almost the same number of analytical students within control group (7 out of 27 or 25.9%). This number of creative students is quite few than the number of creative students in experimental group (10 out 29 or 34.5%), however they are more creative (M = 37.86, SD = 7.175) than the students in experimental group (M = 34.60, SD = 5.254).

Table 2: Mean, Standard Deviations, and Level of Students' Performance in the Achievement Test in College Algebra as Classified in Terms of Their Intelligences

Triarchic Intelligence Profile	Control (n_1=27)						Experimental (n_2=29)					
	Pre-test			Post-test			Pre-test			Post-test		
	Mean	*DE*	*SD*	*Mean*	*DE*	*SD*	*Mean*	*DE*	*SD*	*Mean*	*DE*	*SD*
Analytical	13.5	*(F)*	2.429	18.33	*(S)*	1.966	14.33	*(F)*	2.309	22.67	*(VS)*	0.577
Creative	7.86	*(P)*	1.676	9.57	*(P)*	2.07	7.1	*(P)*	2.378	13.2	*(F)*	4.022
Practical	8.14	*(P)*	3.035	11.79	*(P)*	3.62	7.62	*(P)*	3.862	15.13	*(F)*	3.649
Over-all Mean	9.26	*(P)*	3.426	12.67	*(P)*	4.323	8.14	*(P)*	3.852	15.24	*(F)*	4.445

Scale: Below 13 *Poor (P)*; 13 – 15 *Fair (F)*; 16 – 18 *Satisfactory (S)*; 19 – 22 *Very Satisfactory (VS)*; 23 – 25 *Excellent (E)*

Table 2 shows the comparison between the groups' pre-test and post-test results of the achievement test in College Algebra as classified according to their most dominant nature of intelligence. As revealed, analytical students in experimental group got a little higher pre-test mean score (M = 14.33, SD = 2.309) than control group (M = 13.50, SD = 2.429) though their performances were categorized on the same level as "fair". Creative and practical students under

control group performed a little bit better than the experimental group. Moreover, over-all results indicate that control group has a better performance in pre-test (M = 9.26, SD = 3.426) against the experimental group (M = 8.14, SD = 3.852). However, it can be observed that analytical students in both groups got the highest pre-test mean score among others. This result conforms to the theory of Stenberg (1999) that analytical students are generally recognized as smart and tend to score well on any conventional cognitive test whereby they can have good grades academically.

Great improvements were exhibited by the experimental group (M = 15.24, SD = 4.445) against the control group (M = 12.67, SD = 4.323) in the over-all post-test mean score of the achievement test which indicate a mean score net performance of 7.41 and 3.41 respectively. Furthermore, analytical, creative, and practical students under experimental group showed a great leap of improvements against their counterpart students whose interventions solely based from the school's existing academic advising program.

To determine the influenced of the triarchic intelligence embedded in the academic counseling intervention further analysis was conducted using one-way ANCOVA unequal n. The result is shown in Table 3.

Table 3: Summary Table of One-Way Analysis of Covariance (ANCOVA) on the Achievement Scores of the Students as Influenced by the Academic Counseling Programs

Source of Variation	Sum of Squares	df	Mean Square	F-ratio	p-value
Treatment	178.803	1	178.803	22.899	0.001*
Error	413.840	53	7.808		
Total	12108.000	54			

* Significant at the 0.05 level

The result of the analysis yielded an F-ratio of 22.90 which revealed that there exist a significant difference between the mean scores of control (M = 12.67, SD = 4.323) and experimental (M = 15.24, SD = 4.445) groups in the post-test, $F(1, 53) = 22.899$, $p<.001$ at 0.05 level of significance. This allows the researchers to reject the null hypothesis. This implies that the students who were exposed to triarchic intervention performed much better than students whose intervention was based from the school's existing academic advising program. This implies further that the intervention based on students' ability is most appropriate to help students improve mathematics achievement. This result reiterated the study of Ahmed, et al. [1] that integrating lesson with multiple intelligences had increased the level of motivation among students which led better academic performance. In fact, utilizing the students' innate intelligence predicted a substantial amount of overall academic performance [13].

Table 4: Mean, Standard Deviations, and Level of Students' Problem Solving Skills in College Algebra as Classified in Terms of Their Intelligences

Triarchic Intelligence Profile	Control (n_1=27)						Experimental (n_2=29)					
	Pre-test			Post-test			Pre-test			Post-test		
	Mean	*DE*	*SD*	*Mean*	*DE*	*SD*	*Mean*	*DE*	*SD*	*Mean*	*DE*	*SD*
Analytical	6	*(Dv)*	6.723	18.67	*(P)*	5.955	8.67	*(Dv)*	5.859	23.33	*(Ds)*	2.082
Creative	1.57	*(L)*	1.902	4.43	*(L)*	5.711	1.5	*(L)*	2.506	11.9	*(C)*	2.767
Practical	1.43	*(L)*	2.593	9	*(Dv)*	6.939	2.94	*(L)*	4.449	13.94	*(C)*	3.214
Over-all Mean	2.48	*(L)*	4.07	9.96	*(Dv)*	8.041	3.03	*(L)*	4.395	14.21	*(C)*	4.378

Scale: Below 6 *Limited (L)*; 6 – 10 *Developing (Dv)*; 11 – 15 *Competent (C)*; 16 – 20 *Proficient (P)*; 21 – 25 *Distinguished (Ds)*

Table 4 shows that both analytical students in control group (M = 6.00, SD = 6.723) and experimental group (M = 8.67, SD = 5.859) got the highest mean score in problem solving pre-test. Although analytical students in experimental group got a little bit higher mean score than the students in control group but they fall on the same category on "developing" skills. Creative and practical students in both groups were classified as having with "limited" skills in problem solving. Over-all results indicate that experimental group performed a little bit better (M = 3.03, SD = 4.395) than control group (M = 2.48, SD = 4.070) though on the same premise their problem solving skills were "limited".

After the intervention was fully implemented the post-test of problem solving skills was administered. Results showed that analytical students from control group showed improvements from "developing" to "proficient" skills (M = 18.67, SD = 5.955) however, their counterpart from the experimental groups showed great improvements from "developing" to "distinguished" skills (M = 23.33, SD = 2.082). Great disparity of improvements were exhibited by creative students in experimental group from "limited" to "competent" problem solver (M = 11. 90, SD = 2.767) against the students in control group who only improved their mean scores (M = 4.43, SD = 5.711) but still categorized as "limited". Practical students in both groups showed improvements also, control group improved from "limited" to "developing" (M = 9.00, SD = 6.939); but the practical students from experimental group surpasses this outcome from "limited" to "competent". In general, most of the students in experimental group improved their skills in problem solving from limited to competent skills (M = 14.21, SD = 4.378) while students in control group showed sporadic improvements from limited to developing skills (M = 9.96, SD = 8.041). Over-all, the net mean score performance of the experimental group and control group in problem solving can be given as 11.18 and 7.48 respectively.

To determine whether there is significant influence of the intervention considering the triarchic intelligence of the students, the analysis of covariance (ANCOVA) was done. The result is shown in Table 5.

Table 5: Summary Table of One-way Analysis of Covariance (ANCOVA) on the Problem Solving Skills of the Students as Influenced by the Academic Counseling Programs

Source of Variation	Sum of Squares	df	Mean Square	F-ratio	p-value
Treatment	204.087	1	204.087	6.475	.014*
Error	1670.394	53	31.517		
Total	10751	56			

* Significant at the 0.05 level

The analysis yielded an F-ratio of 6.47 with the probability of .014 which is significant at .05 level. This led to the rejection of the null hypothesis. This means that the mean scores in problem solving of the experimental group is significantly higher than the control group with the mean score of 9.96 and a standard deviation of 8.041. This indicates that the interventions given in experimental group is more effective than the intervention in the control group. This implies that when interventions are done based from their natural ability, students have better assimilation of problem solving processes. These findings conform to the study of Rabanos and Torres [15] that if metacognitive thinking skills development based from the students' innate ability is incorporated into teacher training processes and into teaching-learning processes students' learning improves.

4. Conclusion

This study tried to address on how students' achievement and problem solving skills in College Algebra be influenced by their most dominant nature of intelligence utilizing the Stenberg's [19] triarchic model of human intelligence. While most of the researches showed the effectiveness of this theory in matching students ability patterns in classroom instructions and assessments using triarchic teaching model, in this study it showed another dimension using students' natural abilities in making intervention. The study has shown that students' mathematical skills and performance were influenced by their most dominant natural intelligence. Creative and practical students who were exposed to academic intervention which focuses on their innate abilities while compensating their weaknesses through reinforcements showed significant improvements in both achievement and problem solving skills compared to their counterpart students whose reinforcement is conventional. Problem solving skills of the students with analytical intelligence showed significant improvements in either way through triarchic intervention or by traditional method. Nonetheless students who underwent triarchic intervention clearly do better than those who were exposed to traditional method of intervention. In general, triarchically based intervention was superior against traditional reinforcement. The study implies that any teaching and learning activity employing the triarchic intelligence model will always enhance students' mathematics performance.

5. Recommendation

Based on the analysis and findings, the researchers recommend the following:

1) Mathematics educators should evaluate the natural capabilities of their students specially when handling larege class. They should alter their style of teaching, pedagogies, strategies, materials, and classrooms activities in accordance to the students' strenght, capabilities, and limitations.
2) Students should be exposed intensively to the classroom activities and experiences that match their natural ability while compensating their weaknesses through reinforcements.
3) School administrators, Deans, or Department Heads should evaluate their existing intervention programs on addressing students' performance in Mathematics if these interventions are still effective to the group of students with different level of intelligence.

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Author Profile

Aniceto B. Naval received the B.S. Mathematics degree from Holy Name University of Tagbilaran City, Bohol, Philippines in 2001, Master of Mathematics degree from Mindanao State University- Iligan Institute of Technology (MSU-IIT), Iligan City, Philippines in 2009, and PhD (candidate) in Mathematical Sciences major in Mathematics Education at the University of Science and Technology of Southern Philippines (USTP), Cagayan de Oro City, Philippines.