International Journal of Research Studies in Education
2022 Volume 11 Number 12, 89-102

Role of arithmetic principles and operations in understanding students' mathematics performance

Raza, Jose Mari ✉
Dapa National High School, Department of Education Siargao Division, Philippines (*josemari.raza@deped.gov.ph*)

ISSN: 2243-7703
Online ISSN: 2243-7711

Received: 27 May 2022 **Revised**: 12 June 2022 **Accepted**: 30 June 2022
Available Online: 30 June 2022 **DOI**: 10.5861/ijrse.2022.326

OPEN ACCESS

Abstract

The main purpose of this study was to assess the Junior High School Students' arithmetic principles and operations understanding in Siargao Division. Also, to further seek its role to their mathematics performance. The participants of this study were 295 randomly selected municipal and 182 barangay junior high school students across all grade levels of the Municipality of Dapa during the school year 2019-2020. The study utilized a descriptive-correlational study design. The instrument used was localized with consent from Dr. Terry Tin-Yau Wong (2017). Then validated by content experts and has a 0.976 intra-class correlation coefficient value for its reliability. Based on the findings, it was found out that the students have low mastery level on arithmetic principles and operations. Despite having an average of satisfactory rating on their mathematics achievement. Also, students' performance across grade levels in Operation Application and Relation to Operand Task do not significantly vary. However, Grade 7 and 8 students' performance in Commutativity and Associativity Judgement Task statistically differ from those of higher grade levels. Moreover, only Grade 7 and Grade 9 students significantly vary in Operation Mastery. This study has unraveled the relationship between the extent of students' arithmetic principles and operation understanding to their mathematics performance. A model was crafted as well on the predictability of the former variable to the latter variable abovementioned.

Keywords: arithmetic principles, arithmetic operation understanding, student performance, operation application, relation to operand, commutativity and associativity judgement

Role of arithmetic principles and operations in understanding students' mathematics performance

1. Introduction

Mathematics is one of the few subjects that is consistently being taught from elementary level to high school level in some countries. The mastery of the mathematical skills is related to a better educational attainment, psychological well-being and financial status (Ritchie & Bates, 2013). However, it is considered to be one of the most challenging subject students have ever to face in their learning endeavor (United Nations Educational, Scientific and Cultural Organization elaborated on their study entitled Challenges in Basic Mathematics Education, 2012). Furthermore, Program for International Student Assessment (PISA) had recently released the 2018 15-year-old-students' assessment results last December 2019 and it was found out that Philippines got the second-lowest score in mathematics and science. In addition, there has been a downward trajectory of students' mathematics proficiency in the National Achievement Test 2013 for the entire high schools in the Philippines which only mounted to a mean percentage score (MPS) of 46.37% and a few years back during the school year 2004-2005 when the MPS was 50.70% (National Education Testing and Research Center, 2013). Thus, evaluation of the few basic principles and concepts in the said discipline has to be done to make sure it is not being overlooked by authorities (e.g teachers).

Accordingly, one of the fundamental concepts in mathematics in the secondary level is the arithmetic principles and operations on integers. The common notion about the understanding of arithmetic operations focuses on how the mastery of its rules and regularities (Prather & Alibali, 2009). However, in this paper, understanding is look at as a three-legged stool comprises of procedural understanding, conceptual understanding and application. This is inclined with the principle of the common core state standards initiate of the National Council of Teachers in Mathematics.

Unfortunately, there is lack of effort made to explore the role of students' arithmetic understanding on signed numbers in their mathematics' achievement which the previous study of Wong, (2017) unable to capture. Moreover, most of the studies conducted regarding students' mathematics learning were in Western context, hence Asian context remains largely unexplored (Torbeyns et al., 2015). Thus, it gives birth to the conduct of this current study which was done in the Philippines along with its 6^{th} year implementation of the Enhanced Basic Education Curriculum which will at the same time provide a unique opportunity to study high school students' mathematics learning in an understudied context.

2. Review of Related Literature

This part presents the review of related literature and studies that have important contributions to this study regarding the role of students' arithmetic operation understanding on integers to their mathematics performance.

2.1 Definition of Understanding

A part from the structure of the revised Bloom's Taxonomy by Anderson and Krathwohl (2016), a couple of important ideas were given emphasis: the factual, conceptual, procedural and the newly added metacognition knowledge. Wherein, the procedural and conceptual knowledge play a vital role in determining the students' understanding in mathematics competencies especially on arithmetic operations on signed numbers and its fundamental properties. Since, those relate to the three-legged stool model of building students' understanding adopted by the National Council of Teachers in Mathematics (2015) to its common core state standards for mathematics.

Operationally, conceptual understanding is defined as possessing the knowledge of classifications, generalizations, models, theories, principles or structures relevant to a particular disciplinary area. This means that students understand why and how things are done, the reasons behind every single step of the solution and not relying on the likeliness of the examples given. While procedural understanding is defined as possession of knowledge pertains to information or knowledge that aid students to perform specific task in a discipline or subject area. This also means that students are able to perform tasks in a systematic way. Lastly, application understanding means able to apply those conceptual and procedural tasks in a specific real-life-scenario.

2.2 Understanding of Arithmetic Principles

Wong (2017) argued that there is a relative less understanding about how children perceived arithmetic operations on natural numbers, let alone integers. Arithmetic operation understanding pertains to the learners' sense about the four fundamental arithmetic operations (addition, subtraction, multiplication and division), like in what situation they should use a specific operator and the basic underlying principles behind its usage instead of merely performing calculations. This means that, when a child is asked to buy 8 pieces of cupcakes worth Php 4.00 each, then he/she has to multiply the amount and quantity to be purchased to determine the total cost s/he has to pay. Also, if he/she knows that either way s/he multiplies Php 4.00 x 8 pieces or 8 pieces x Php4.00 then s/he would get the same result not just they know that 4x8=32. Prather and Alibali (2009) highlighted that the focus on some literatures on understanding of arithmetic operations is on how people understand various rules and principles of arithmetic operations.

Moreover, the arithmetic principles include commutativity (e.g., order of operand is irrelevant, e.g., 5+8=8+5 and (-4)*(6)=(6)*(-4))and associativity (e.g., order of operand is irrelevant as well, e.g.,4+(9+2)=(4+9)+2 or 3*(2*4)=(3*2)*4). Furthermore, relations of operands with respect to its operation e.g., addition or multiplication of positive numbers will lead to the increase of numerical values, while adding zero to any number does not change the value of the number and multiplying zero to any number will make that numerical value zero, etc. whereas subtracting and dividing sometimes result in the opposite. Also, direction of effect (the change of value in the operands) would affect the resulting value as well, e.g. sum or product.

On top of those mentioned, arithmetic understanding refers to the capability to utilize specific rules in every distinct operation on integers (e.g., what happens when positive and negative numbers are to be added, subtracted, multiplied or divided). Despite the fact that children as early as 5 years old, they already realized that the order of addends in small natural numbers do not matter and it will give the same result either way it is operated, e.g., 5+4=4+5 (Farrington et al., 2010). But, the complete mastery of far advanced arithmetic principles, such as relation to operands, direction of effect and involving signed numbers, is not achieved even during adulthood (Siegler & Lortie-Forgues, 2015).

On the other hand, the ability to relate symbolic numbers onto non-symbolic numerosity representation in the underlying arithmetic principles is known to be predictive of children's mathematical skills (Chen & Li, 2014; Schneider et. al., 2017). As a matter of fact, such skills mediate the relation between non-symbolic numerical representation and one's mathematical competence (Libertus et al., 2016). However, in the current study, the use of non-symbolic numerical representation would be used as concept representation to determine students' understanding on commutativity. Thus, improving students' understanding on non-symbolic numerical comparison and non-symbolic arithmetic tasks improves their symbolic arithmetic competence and their mathematics performance as a whole (Hyde et al., 2014).

2.3 Understanding of Arithmetic Operations

On the other hand, aside from the understanding of the fundamental arithmetic principles, the understanding of arithmetic operation like determining when and where a specific operation is to be used in certain problems on top of its merely computational concept should be achieved (e.g., Michael earns Php600/day while Kenneth earns Php3000/week. Both of them work in six working days a week, who earns better and by how much?). For solving this kind of word problems, one should be able to immediately grasp the idea of what operation/s is/are to be performed in order to work with the problem efficiently and effectively. Choosing the incorrect operation/s will immediately lead to the wrong answer (Lewis & Mayer, 1987).

Furthermore, there has been a limited empirical study made to examine the relation between students' level of arithmetic operation understanding and their mathematics learning performance and most of these studies mainly focused on their arithmetic principles understanding (Wong, 2017). However, contradictory findings emerged, where Canobi et al. (2003) observed significant relations between students' understanding on arithmetic principles and various mathematical outcomes (e.g., more flexible utilization in solving mathematical problems) and higher problem accuracy (Dowker, 2014) but other studies failed to discern identical results (Prather, 2012; Watchorn et al., 2014; Siegler & Lortie-Forgues, 2015) where they laid out the inconsistent association of the mentioned variables at the secondary and tertiary level students.

In the current study, the main target is within the four fundamental arithmetic operations (FAO) namely; addition, subtraction, multiplication and division and its applications through solving word problems. Because these FAO are extremely related to individual's daily living. We use it in the market to purchase goods, to pay bills and many more, although there are still more uses of FAO than anyone can imagine. In Philippine K-12 Curriculum, it is consistently embedded in every grade level mathematics with its increasing level of complexity. Thus, this only shows that numerical or arithmetic understanding and arithmetic skills are two of the most essential aspects to be considered mastering by the students in order to significantly enhance their mathematics competence or performance in general (Torbeyns et al., 2015).

3. Theoretical and Conceptual Framework

3.1 Three-Legged Stool Model

This study is anchored on the three-legged stool model of building understanding of the National Council of Teachers in Mathematics (NCTM) applied to their common core state standards in mathematics. Which is focused on establishing conceptual, procedural and application understanding to the students in order to perform great at any mathematics concepts not merely focusing on the computational skills which computers are capable of doing it now for them but way more beyond it. Hence, this is deemed relevant to this study since in order to determine the student's level of understanding on arithmetic principles and its operation, it has to be specifically dissected into those 3 legs of stool. It is comprised of procedural understanding, conceptual understanding and application understanding for students to be able to achieve something in mathematics.

Explicitly, one of the six Principles of the NCTM is learning, where they expect students learn mathematics with understanding, actively building new knowledge from experience and prior knowledge in order to meet content and process standards in the specific field of number and operations in all grade levels. Hence, with the guidance of this three-legged stool model of building understanding, students' potential in mathematics will be unlocked which has a significant implication to their mathematics performance as a whole.

3.2 Association of Arithmetic Principles and Operations Understanding to Mathematics Performance

Torbeyns et al. (2015) discussed that on top of fractional understanding, numerical or arithmetic understanding which includes its principles and operations are considered vital to uplift students' general mathematics competence or performance. It was in parallel with the findings of Wong (2017) about the unique contribution of arithmetic principles and operations understanding to students' mathematics achievement. Despite some inconsistent association of those mentioned variables to secondary and tertiary students' s performance in mathematics found out by Lortie-Forgues, (2015), the researcher is interested to look into the relationships of the students' understanding of those fundamental concepts to their mathematics performance with the aid of the three-legged stool model of understanding by NCTM (2000).

3.3 Instrument

A modified research instrument is used to measure students' conceptual, procedural and application understanding. The first part of the research instrument aimed to measure students' conceptual understanding on arithmetic principles which is the commutativity and associativity judgement task. The participants were given a couple of non-symbolic tasks which they determined whether it was true or false base from their understanding of the said arithmetic principles (AP). Shapes instead of numeric representation are given to avoid the participants into performing computations to verify their answer which could become a tremendous confounding factor to determining their familiarity of the principles, the same style was used by Canobi et al. (2002) and Patel and Canobi (2010). While the second part aimed to assess their understanding of the relation to operand principle. Here, students would choose what operation/s are applicable to meet the specific condition asked in each statement like for example, "If I want to increase the value of a number, I can transform it by (+, -, x, ÷) 5" then students will encircle the specific operations in which in this it is "+" and "x". Moreover, the third part aimed to measure their procedural and conceptual understanding on the AO on signed numbers. They are tasked to determine which operation to be used in order to achieved what is asked in the problem, e.g "What operation to be used for -10 and -2 to obtain the maximum value?" in which the answer is multiplication since it yields to 20 compare to the quotient 10. This requires series of procedures and conceptual understanding to come up with the correct answer to the problem. Lastly, the fourth part aimed to measure their conceptual, procedural application understanding with the given real-life scenarios involving arithmetic operations.

Thus, those measured independent variables were to be correlated to their mathematical performance to verify if the aforementioned model of building understanding holds to its purpose.

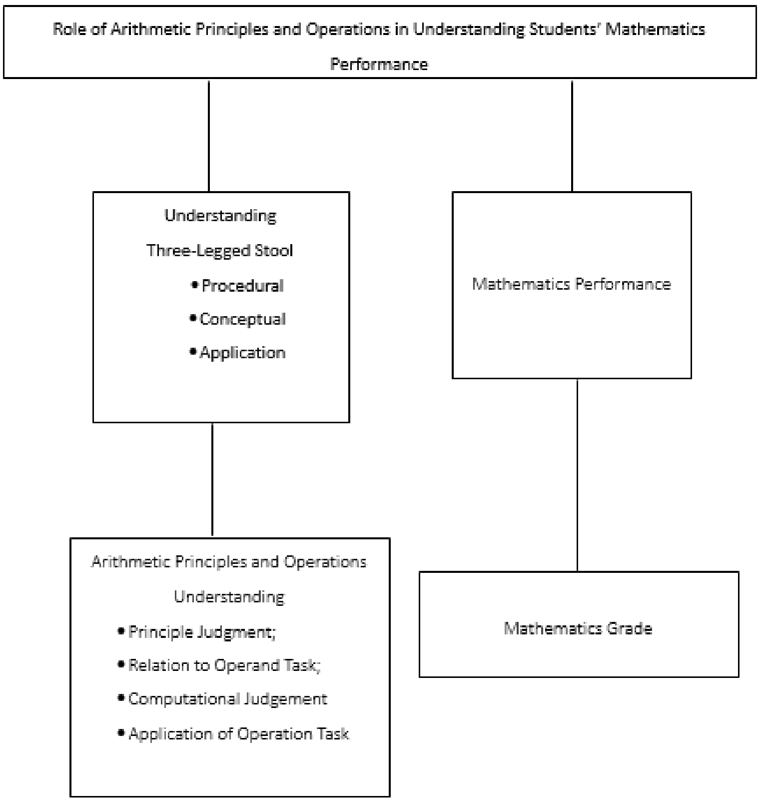

Figure 1. Research Paradigm

3.4 Statement of the Problem

This study aimed to determine the role of students' arithmetic principles understanding such as commutativity and associativity (addition and multiplication) and operations understanding to their mathematics performance. Specifically, this study seeks answers to the following:

- What is the Mathematics Performance of the participants?
- To what extent is the arithmetic operation understanding of participants in terms of principle judgement, relation to operand task, computational judgement, and application of operation task in word problem?
- Is there significant difference between the arithmetic operation understandings of the participants when grouped according to their grade level?
- Is there significant relationship between students' mathematics performance and arithmetic operation understandings?
- Can students' arithmetic operation understanding estimate their mathematics performance?

3.5 Hypotheses

Statements 1 and 2 are hypotheses free. At 0.05 level of significance, it is hypothesized that:

H_{o1}: There is no significant difference between the arithmetic operation understandings of the participants when grouped according to their grade level.

H_{o2}: There is no significant relationship between students' mathematics performance and arithmetic operation understandings.

H_{o3}: The students' arithmetic operation understanding cannot estimate their mathematics performance.

3.6 Significance of the Study

The findings to this study are expected to benefit the following:

Division Mathematics Coordinator/Supervisor: They may be able to assess the current competence of the education in their respective divisions as students' performance may reflect to the kind of quality they offer. Thus, interventions or programs might be a necessity to reinforce teachers if it is seen fit.

Mathematics Teachers: they may be able to grasp a much deeper understanding to the level of proficiency of the students' understanding in fundamental concepts such as arithmetic principles and arithmetic operations and its relation to students' mathematics performance.

Students: They may be able to reflect among themselves as to how far they have mastered or familiarized themselves to these basic concepts in mathematics which are extremely significant in dealing with further mathematics studies.

Future Researchers: They can use this as a reference for further or off-short studies

3.7 Scope and Limitation of the Study

The scope and limitations of the study in terms of context, participants, time and place were as follows:

Focus: The focus of this study is to examine the current level of arithmetic principles and operations understanding of the students in both public and private high schools of the Division of Siargao. Also, it would see to it if students' understanding of such fundamental concepts can estimate their mathematics performance.

Participants: The participants of this study were randomly selected through multistage random sampling from 16 high schools in the mainland of Siargao. There were two strata to be looked into, such as the area where the school is situated (municipality high school or barangay high school) and the grade levels of the participants (from grade 7 to 10).

Place and Time: This was conducted within the mainland of Siargao Islands. The timeframe for this study covered from January to March 2020.

3.8 Definition of Terms

The following terms are defined operationally or conceptual to provide better understanding of the study:

Arithmetic Principles **-**is defined as general rules that capture regularities within a arithmetic such as commutativity and associativity for addition and multiplication for integers.

Arithmetic Principles and Operation Understanding – the capability of an individual to perform precisely such general rules and applications in the domain of arithmetic principles and operations.

Arithmetic Operations **–** the four fundamental operations such as addition, subtraction, multiplication and division.

Application of Operation **–** refers to the situation in real-life where the fundamental arithmetic operations are used.

Arithmetic Principles **–** refer to commutativity and associativity for addition and multiplication.

*Computational Judgement***-** refers to student's ability to choose which operation best suited to be used to meet the required condition of a certain problem.

Non-Symbolic Numerical/Concept Representation **–** figures that are used to represent values e.g., dots, polygons etc.

Principle Judgement **–** refers to the student's ability to determine whether a specific principle such as commutativity or associativity holds to the given equation or not.

Symbolic Numerical Representation **–** digits like but not limited to Roman Numerals and Hindu Arabics.

Relation to operand **–** refers to the influence of the operation to the operand when it is performed.

4. Research Design

This study employed a descriptive - correlational research design according to M.L Patten (2002). Descriptive research design is deemed appropriate in describing the participants demographic profile characteristics as well as the students' arithmetic operation understandings. On the other hand, a mix of correlational research design is deemed suited for assessing the possible relationship between students' arithmetic operation understanding and their mathematics performance.

Research Participants **-** The participants of this study were taken after the researcher has done a simple random sampling technique from all of the municipalities in the mainland of Siargao Islands. After the municipality was identified, two schools were automatically chosen since those are the only municipal high school and barangay high school in that certain municipality. For the chosen municipal high school, one section in every grade level was randomly selected since there were a number of sections in each grade level comprising of a total of 295 students. On the other hand, since there was only single section per grade level in barangay high school, all junior high school students who were present at the time of the conduct of the study were taken as samples which totaled to 142 students.

Distribution of Participants by Grade Level

Grade Level	Frequency	Percent
Grade 7	111	25.4
Grade 8	101	23.1
Grade 9	118	27.0
Grade 10	107	24.5
Total	437	100.0

Generally, 111 grade 7 students, 101 grade 8 students, 118 grade 9 students and 107 grade 10 students in both municipal high school and barangay high school.

Research Instrument - In the current study, the 1st, 2nd and 4th part of the intended research questionnaire is paralleled with the developed questionnaire of Wong (2017) while the 3rd part was developed by the researcher to further assess the students' computational skills which would come handy in their mathematics endeavors. Also, a little enrichment of the 4th part which was taken from the previous work of Wong, students were asked to solve those items displaying their procedural mathematics understanding. Samples were taken from secondary grade levels through multistage sampling technique. It shall be noted as well that the author of the questionnaire to be used had given the current researcher to modify the content as to the units of measurement and characters according to the local norm without compromising its context. The content of this revised test questionnaire was validated by experts prior to the conduct of the study. Its reliability was tested as well through intra-class correlation coefficient after gathering the scores of a small amount of non-participants junior high school students for the pilot testing using the test-retest method. The average measures was statistically significant at 0.05 level of significance which yearned 0.976 intra-class correlation coefficient value which means highly reliable. This table below contains the parameters for interpreting the students' academic performance in mathematics as to the prescribed quantitative and qualitative description of the Department of Education Philippines.

Parameters

Grading Scale	Qualitative Description	Remarks
90-100	Outstanding	Passed
85-89	Very Satisfactory	Passed
80-84	Satisfactory	Passed
75 - 79	Fairly Satisfactory	Passed
Below 75	Did not meet expectations	Passed

Ethics and Data Gathering Procedure - The researcher submitted a formal letter of request to the Schools Division Superintendent of the Division of Siargao asking approval to conduct the study. With regard to the utilization of the adopted questionnaire, the current researcher had sought permission and was approved by the original researcher Dr. Wong Terry Tin-Yau. The municipality of Dapa where the research samples were taken was randomly selected by the researcher. One section per grade level which totaled to 142 junior high school students in Union National High School were considered as participants. However, since Dapa National High School has 2756 junior high school students consisting multiple sections per grade level, hence the researcher randomly selected two sections per grade level which summed up to 295 in order to meet the computed sample size using the Cochran's formula. Orientation to the participants prior to responding to this study was taken care of and was dealt discretely with complete concordance to the secrecy and confidentiality of the responses.

5. Results and discussion

The table displayed the distribution of students' grade point average in mathematics during the conduct of the study. The students from all grade levels have satisfactory performance in mathematics represented by the computed means which place within the range of 80-84. The Grade 9 students' mean GPA was the highest at

84.53 with the SD=4.152, while the lowest was Grade 8 students' mean GPA which was at 83.28.

Table 1

Students' mathematics grade point average

Grade Level	N	Mean	Std. Deviation	Qualitative Description
Grade 7	111	83.80	4.208	Satisfactory
Grade 8	101	83.28	3.669	Satisfactory
Grade 9	118	84.53	4.152	Satisfactory
Grade 10	107	83.94	4.047	Satisfactory

On the other hand, Table 2 showed the results of all high school students' poor mean percentage score which has an implication of low mastery in four measured variables of the study. Grade 7, 8 and 10 obtained below 50% of the items correctly while the Grade 9 students barely hit the 50% mark. Where they obtained a general percentage score of 53% and performed worst at Operation Application where they only got 42% general mean percentage score. While in Principle (Commutativity and Associativity) Judgement Task and Operation Mastery both are at 47.5% general percentage score. Hence, students' conceptual (Principle Judgement Task and Relation to Operand), procedural (Operation Mastery and Operation Application Tasks) and application (Operation Application Task) understanding are below average which could be a factor to poor performance in mathematics national assessment.

Table 2

The extent of the students' arithmetic principles and operation understanding

Variables	Grade Levels	N	Mean	Percentage Score	Qualitative Description
Commutativity and Associativity Judgement Task	Grade 7	111	3.43	0.429	Low Mastery
	Grade 8	101	3.40	0.425	Low Mastery
	Grade 9	118	4.14	0.518	Low Mastery
	Grade 10	107	4.17	0.521	Low Mastery
	Total	437	3.80	0.475	Low Mastery
Relation to Operand Task	Grade 7	111	3.61	0.516	Low Mastery
	Grade 8	101	3.53	0.505	Low Mastery
	Grade 9	118	3.84	0.548	Low Mastery
	Grade 10	107	3.82	0.546	Low Mastery
	Total	437	3.71	0.530	Low Mastery
Operation Mastery	Grade 7	111	4.02	0.446	Low Mastery
	Grade 8	101	4.11	0.457	Low Mastery
	Grade 9	118	4.50	0.500	Low Mastery
	Grade 10	107	4.44	0.493	Low Mastery
	Total	437	4.27	0.475	Low Mastery
Operation Application	Grade 7	111	2.78	0.398	Low Mastery
	Grade 8	101	2.82	0.403	Low Mastery
	Grade 9	118	3.05	0.436	Low Mastery
	Grade 10	107	3.05	0.435	Low Mastery
	Total	437	2.93	0.418	Low Mastery
TOTAL	Grade 7	111	13.85	0.447	Low Mastery
	Grade 8	101	13.86	0.447	Low Mastery
	Grade 9	118	15.53	0.501	Low Mastery
	Grade 10	107	15.48	0.499	Low Mastery
	Total	437	14.70	0.474	Low Mastery

This joints in to the 2018 National Achievement Test Results where Grade 10 students garnered 44.59 MPS. This means that Grade 10 students averaged 4 correct answers out of 10 items in the test which falls under the "low mastery" level in NAT. Seemingly, for the third straight year in 2018, the Grade 6 students who are the Grade 8 this time continued a downward trajectory in their NAT results. The national average mean percentage score was only at 37.44, considered to be the weakest in history of the standardized examination of the Department of Education (DepEd).

On the other hand, Table 3 depicted the results of the mean difference of the students' arithmetic principles and operations understanding when grouped according to where their school is situated. The junior high school students' understanding from barangay high school and municipal high school perform similarly since statistical results failed to establish a significant difference from their compared means.

Table 3

Junior HS students in urban and rural areas arithmetic principles and operations understanding means

Measured Variables	p-value	Interpretation	Decision
Commutativity and Associativity Judgement Task	.480	Not Significant	Failed to Reject Ho
Relation to Operand Task	.667	Not Significant	Failed to Reject Ho
Operation Mastery	.193	Not Significant	Failed to Reject Ho
Operation Application	.160	Not Significant	Failed to Reject Ho

It can be gleaned in the table above that the p values of the measured variables were greater than 0.05. Specifically, in Commutativity and Associativity Judgement Task the p=0.480, while of the Relation to Operand Task, the p=0.667. Also, in the Operation Mastery and Operation Application, the p values obtained were 0.193 and 0.160 respectively. This implies that, there is not enough statistical evidence to show that students in barangay (rural area) and municipal (urban) national high school significantly varies in arithmetic principles and operation understanding. Hence, students in both areas perform similarly in these measured domains. Thus, hypothesis was failed to be rejected.

Table 4

Difference on students' arithmetic principles and operations understanding across all grade levels means

Measured Variables	p-value	Interpretation	Decision
Commutativity and Associativity Judgement Task	.000	Significant	Reject Ho
Relation to Operand Task	.097	Not Significant	Failed to Reject Ho
Operation Mastery	.012	Significant	Reject Ho
Operation Application	.218	Not Significant	Failed to Reject Ho

On the flip side, Table 4 contained the results on the compared means of the participants when they are grouped according to their grade levels. It depicted those students from different grade levels significantly differ in their test scores in Commutativity and Associativity Judgement Task as well as in the Operation Mastery since the p-values acquired are less than 0.05. Hence, the null hypothesis is rejected. However, in Relation to Operand Task and Operation Application, students across all grade levels do not statically vary. This means that in these measured domains, students' understanding is quite comparable to one another wherein they have low mastery level despite these domains being taught since the late elementary level until high school.

Explicitly, Table 5 illustrated where grade levels differ in Commutativity and Associativity Judgement Task and in the Operation Mastery.

Table 5

Specific differences in commutativity and associativity judgement task and operation mastery across grade levels

	Grade Levels		Mean Diff.	p-value	Interpretation	Decision
Commutativity and Associativity Judgement Task	Grade 7	Grade 8	.036	.598	Not Significant	Failed to Reject Ho
		Grade 9	-.712*	.009	Significant	Reject Ho
		Grade 10	-.736*	.006	Significant	Reject Ho
	Grade 8	Grade 9	-.748*	.002	Significant	Reject Ho
		Grade 10	-.772*	.002	Significant	Reject Ho
	Grade 9	Grade 10	-.024	.919	Not Significant	Failed to Reject Ho

Operation Mastery	Grade 7	Grade 8	-.091	.878	Not Significant	Failed to Reject Ho
		Grade 9	-.482*	.029	Significant	Reject Ho
		Grade 10	-.421	.085	Not Significant	Failed to Reject Ho
	Grade 8	Grade 9	-.391	.125	Not Significant	Failed to Reject Ho
		Grade 10	-.330	.268	Not Significant	Failed to Reject Ho
	Grade 9	Grade 10	.061	.906	Not Significant	Failed to Reject Ho

It has clear indications that the Grade 7 and 8 students significantly differ from those of Grade 9 and 10 in terms of familiarity on Commutativity and Associativity Judgement. Whilst, only Grade 7 and Grade 9 students statistically differ in their scores on Operation Mastery indicated by those p-values less than 0.05. Thus, the null hypothesis was being rejected.

Explicitly, Grade 9 and 10 performed better than Grade 7 and 8 since their main difference is negative. This means that Grade 7 and 8 have lesser scores in Commutativity and Associativity Judgement Task and Operation Mastery compare to the two higher grade levels.

Table 6 held the statistical results to whether the students' Arithmetic Principles and Operations Understanding relate to their Mathematics Achievement in school across grade levels. It is shown that there is statistical evidence of strong significant relationship between the extent of students' Arithmetic Principles and Operations Understanding and their Mathematics Performance indicated by its p value which is less than .05 and r-value of .885 which means strong positive linear relation between the two variables.

Table 6

Relationship between the arithmetic principles and operation understanding and their mathematics performance

Independent Variable	Dependent Variable	r-value	p-value	Interpretation	Decision
Students' Arithmetic Principles and Operation Understanding	Students' Mathematics Performance	.885**	.00	Sig	Reject Ho

This implied that, those students have lower mastery level the more they struggle in the subject. In contrary, those students who have higher mastery level of the said domains, the better their performance is in mathematics discipline. This affirmed to the findings of Sari and Olkun (2019) about the strong relationship of the students' arithmetic performance and their mathematics performance even in early years of education. Thus, students who have better understanding on its concepts, procedures and its application yield better performance in mathematics as a whole.

On the other hand, Table 7 depicted the results of simple linear regression calculation to predict the performance of the students in mathematics through GPA based on their extent of Arithmetic Principles and Operations Understanding, b=0.89, t(435) = 229.436 p<0.001. A significant regression equation was found F(1, 435) = 1572.38 p=.000[b] with an R^2 of 0.78. Which are statistically significant. Hence, the null hypothesis is rejected. This meant that 78.3% of the variance of the of the students' mathematics performance can be explained by their level Arithmetic Principles and Operations Understanding. Furthermore, it is shown on the table above that the equation of the line that predicts students' mathematics performance can be modelled through y=.810x + 471.993. Which implies that, in every one-point increase of the mean of the students' arithmetic principles and operations understanding there is an equivalent increase of .810 on the mean of the students' mathematics performance. Furthermore, this is in congruence with Wong T. (2017) findings, where he found out a model as well that indicated these measured variables being marginally significant predictors to students' general mathematics performance.

Table 7

Regression model of arithmetic principles and operations understanding as the predictor of performance

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	5587.68	1	5587.68	1572.38	$.000^b$
Residual	1545.84	435	3.554		
Total	7133.52	436			

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	71.993	.314		229.436	0.000
TOTAL	.810	.020	.885	39.653	1.53E-146

R Square = 0.783299361462422, Adjusted R Square = 0.78280119907498

6. Summary, conclusions and recommendations

Summary **-** The study determined the level of understanding on arithmetic principles and operations of the junior high school students in Siargao Division and its possible relation to their academic performance in mathematics. It has found out that the academic performance of the students across grade levels do not significantly vary and they are at satisfactory level. Furthermore, their conceptual, procedural and application understanding on arithmetic principles and its operations were measured using the modified questionnaire from Wong (2017) and the results are quite poor. In all parts of the questionnaire, students across grade levels managed to only get more or less 50% of all items correctly. On the other hand, it was confirmed in the study that there is a strong significant relationship between students' conceptual, procedural and application understanding on arithmetic principles and its application to their mathematics performance as a whole. Thus, a linear model y=.810x + 471.993 was crafted to predict the students' mathematics performance by its level of understanding on the said matter.

Findings **-** After all the necessary data of the study were treated accordingly, the salient findings of the study are as follows:

1. The academic performance in mathematics of the students across all grade levels are satisfactory.
2. However, the extent of the students' arithmetic principles and operations understanding was found to be significantly low, more specifically on their application understanding where they only got 41% correct answers in the test given. Also, their conceptual and procedural understanding are significantly low where they only got 47% of the items correctly. Also, they barely got 50% correct answers in the relation to operand task.
3. There is no significant difference on students' procedural and application understanding across grade levels. However, Grade 7 students' conceptual understanding significantly vary to those of Grade 9 and 10 students.
4. There is a strong significant relationship between students' arithmetic principles and operation understanding to their academic performance in mathematics.
5. The predictability level of students' arithmetic principles and operation understanding to their mathematics performance can actually be modelled through this linear equation through y=.810x + 471.993.

Conclusions

1. Junior high school students' mathematics performance is satisfactory.

2. Students across grade levels in Junior High School have not mastered the fundamentals of arithmetic and its application.
3. There is almost none to a little amount of difference on students' arithmetic principles and operation understanding across junior high school grade levels.
4. Students' arithmetic principles and operations understanding have significant association to their mathematics performance.

Recommendations

1. Students' should enhance their conceptual, procedural and application understanding on arithmetic principles and its operations.
2. Students should be exposed and engaged more into the application of arithmetic principles and operations since they performed the poorest in that content area.
3. Students in higher grade levels should take more time revisiting and/or mastering the fundamentals of mathematics like the arithmetic principles and its operations since their skills/mastery barely differ to those of lower grade levels.
4. For further exploration, students' actual results from National Achievement Test should be included as variable to further enhance the result of the study. Also, any deemed fundamental concepts that may play a role to students' mathematics performance is highly recommended to be looked into.

7. References

Canobi, K. H., Reeve, R. A., & Pattison, P. E. (2002). Young children's understanding of addition concepts. *Educational Psychology, 22*, 513–532.

Challenges in basic mathematics education UNESCO. (2012). Retrieved from https://www.academia.edu/4166750/CHALLENGES_IN_BASIC_MATHEMATICS_EDUCATION_UNESCO

Chen, Q., & Li, J. (2014). Association between individual differences in non-symbolic number acuity and math performance: A meta-analysis. *Acta Psychologica, 148*, 163–172.

DepEd sets conduct of 2013 NAT in March | GOVPH. (2013, January 18). Retrieved from https://www.officialgazette.gov.ph/2013/01/18/deped-sets-conduct-of-2013-nat-in-march/

Dowker, A. (2014). Young children's use of derived fact strategies for addition and subtraction. *Frontiers in Human Neuroscience, 7*. https://doi.org/10.3389/fnhum.2013.00924.

Farrington-Flint, L., Canobi, K. H., Wood, C., & Faulkner, D. (2010). Children's patterns of reasoning about reading and addition concepts. *British Journal of Developmental Psychology, 28*(2), 427–448.

Foote, M. Q., Earnest, D., & Mukhopadhyay, S. (2014). *Implementing the common core state standards through mathematical problem solving*.

Hyde, D. C., Khanum, S., & Spelke, E. S. (2014). Brief non-symbolic, approximate number practice enhances subsequent exact symbolic arithmetic in children. *Cognition, 131*, 92–107.

Lewis, A. B., & Mayer, R. E. (1987). Students' miscomprehension of relational statements in arithmetic word problems. *Journal of Educational Psychology, 79*, 363–371.

Libertus, M. E., Odic, D., Feigenson, L., & Halberda, J. (2016). The precision of mapping between number words and the approximate number system predicts children's formal math abilities. *Journal of Experimental Child Psychology, 150*, 207–226.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics.* Reston, VA: Author.

Patel, P., & Canobi, K. H. (2010). The role of number words in preschoolers' addition concepts and problem-solving procedures. *Educational Psychology, 30*, 107–124.

Patten, M. L. (2002). *Understanding research methods*. Pyrczak Publishing, U.S.A.

Publications - PISA. (n.d.). Retrieved from https://www.oecd.org/pisa/publications/pisa-2018-results.htm

Prather, R. W. (2012). Implicit learning of arithmetic regularities is facilitated by proximal contrast. *PLoS ONE, 7*(10), e48868.

Prather, R. W., & Alibali, M. W. (2009). The development of arithmetic principle knowledge: How do we know what learners know? *Developmental Review, 29*, 221–248.

Principles, Standards, and Expectations. (n.d.). Retrieved from https://www.nctm.org/Standards-and-Positions/Principles-and-Standards/Principles,-Standards,-and-Expectations/

Ritchie, S. J., & Bates, T. C. (2013). Enduring links from childhood mathematics and reading achievement to adult socioeconomic status. *Psychological Science, 24*, 1301–1308.

Sari, M., & Olkun, S. (2019). *The relationship between place value understanding, arithmetic performance and mathematics achievement*.

Schneider, M., Beeres, K., Coban, L., Merz, S., Schmidt, S.S., Stricker, J., & De Smedt, B. (2017). Associations of non-symbolic and symbolic numerical magnitude processing with mathematical competence: A meta-analysis. *Developmental Science.* https://doi.org/10.1111/desc.12372.

Siegler, R. S., & Lortie-Forgues, H. (2015). Conceptual knowledge of fraction arithmetic. *Journal of Educational Psychology, 107*, 909–918.

Torbeyns, J., Schneider, M., Xin, Z., & Siegler, R. S. (2015). Bridging the gap: Fraction understanding is central to mathematics achievement in students from three different continents. *Learning and Instruction, 37*, 5–13.

Watchorn, R. P. D., Bisanz, J., Fast, L., LeFevre, J.-A., Skwarchuk, S.-L., & Smith-Chant, B. L. (2014). Development of mathematical knowledge in young children: Attentional skill and the use of inversion. *Journal of Cognition and Development, 15*, 161–180.

Wilson, L. O. (2016). Anderson and Krathwohl Bloom's taxonomy revised understanding the new version of Bloom's Taxonomy. Retrieved from http://www0.sun.ac.za/ctlresources/wp-content/uploads/2018/11/Anderson-and-Krathwohl.-2001.-Extract-from-A-taxonomy-for-learning-teaching-and-assessing-a-revised-Blooms-Taxonomy.pdf

Wong, T. T. (2017). The unique and shared contributions of arithmetic operation understanding and numerical magnitude representation to children's mathematics achievement. *Journal of Experimental Child Psychology*, *164*, 68-86. https://doi.org/10.1016/j.jecp.2017.07.007

ZigZag Weekly ONLINE. (n.d.). Grade 6 NAT nears 'very low mastery' level. https://www.zigzagweekly.net/grade-6-nat-nears-very-low-mastery-level/