

# Scientific Reasoning Abilities and Physics Performance of High School Students in a State University

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#### ABSTRACT

This study measured the scientific reasoning ability and physics performance of fourth year high school students. The researchers used descriptive-correlational research design in this study. Based from the results and analysis made by the researcher, it was found out that majority of the respondents have formal level of reasoning abilities; student-respondents' reasoning abilities was significantly related with their sex, but not with their fathers' education and mothers' education; and there was significant difference in academic performance in physics transitional thinkers and rigorous formal thinkers but not between concrete and transitional thinkers; concrete and formal thinkers; concrete and rigorous thinkers; and transitional and formal thinkers.

**Keywords**: high school students, physics performance, physics education, scientific reasoning, science education

## INTRODUCTION

One of the major function of education system is to have programs and curriculum that will allow learners to grow holistically. This will make sure that students are provided with adequate knowledge and skills in facing classroom and real-world tasks and problems. According to United Nations Educational, Scientific, and Cultural Organization (UNESCO), the 21st century is an age of booming educational diversification and market-based education where students need to be capacitated with world class skills and knowledge.

On the other hand, there is an apprehension that the current century made the students faced tremendous bulk of information due to information explosion. Toulmin (2000) argue that the knowledge explosion requires caution and careful information sorting with regards to relevant and fake news. Hence, he suggested that learners of this century must have reasoning skills that will allow them to sort relevant information to irrelevant ones.

However, gaining reasoning skills is labor-intensive to students. It requires that students have attained the formal stage of development advocated by Piaget. Researchers around the globe will agree that learning is a continuous process and needs time for it to occur. That means to attain formal level of learning entails successive failures and learning through the educational



failures. Learning happens due to various factors and influences like the thinking skills of students.

Therefore, it is a must to know scientific reasoning skills of high school students and know how their reasoning skills affect their academic performance. It is vital to learn about their reasoning skills before attaining college so that remedy can be made. In this way it is hoped that students learn effectively by utilizing the level of their reasoning skills on how they learn. On the onset applying these reasoning skills in the societal perspective. Moreover, Paul and Elder (2006) offer list of reasoning skills which starts by giving hypothesis and testing it to have sound and justifiable conclusion.Moreover, Toulmin (2000) highlights the necessities required for scientific reasoning to occur that is scrutinizing the claim through observation and testing, analyzing the evidences offered, and judgment through merits.

Hence, reasoning skills would students to grasp the highest reasoning skill in order to sort out false information from not. This will allows students to formulate defensible decisions on difficult situations. Acido (2010) argue that in every learning activity and personal set-up, students are expected to offer a stand and make decisions to solve certain conflicts and issues. Hence, the 21st century requires the students to present vivid premise, balanced evidence for justification, and reasoning skills which in fact students did not realize its importance. Therefore making, reasoning skills are very vital in this current generation to with the upheaval of fake news. This will allow them to create important decisions not to accept data from an erroneous source.

According to education.stateuniversity.com, the ability of a person to speak and reason out is a key ingredient on how a person learn new knowledge and experience. It is from a person's reasoning skills which will measure his/her ability to learn, assess, take and nullify a particular position and claim.

Despite the topic being not new, the study is still meaty and fresh especially understanding the reasoning skills of 21<sup>st</sup> century students and what differences they have from the 19<sup>th</sup> and 20<sup>th</sup> century students. Pacala (2018) argued that studying reasoningskills of 21<sup>st</sup> century learners will be very vital information in the teaching and learning process inside the classroom. These skills will help teachers adjust their activities to the reasoning skills of the students and eventually help them progress their reasoning skills. These research interventions and findings have the capacity to make remediation of educational failures and points of improvement with respect to scientific understanding and reasoning. Hence, this study has ventured into such field.

In an article of Saloma (2010) on "Content Learning and Scientific Reasoning" posted on science column of Philippine Star Website it emphasized the lack of scientific tradition in Philippine Society because of the fact that the researcher population density in the Philippine is low, with only one researcher for every 8000 Filipinos in 2005 compared to Thailand and Indonesia with 2500 in 2004 and 2011.

The failure of the Philippines to produce high number of quality researchers may lead to incapacity of the country to compete in the global arena. Understanding of students reasoning skills may able to help in this problem. Looking into students' reasoning skills will allow educators and administrators to see potential people who have the ability for high caliber researchers.



The purpose of the present study is to investigate the reasoning abilities of fourth year high school students in five forms of reasoning abilities (control of variables, proportional, probabilistic, correlational, and combinatorial reasoning) and to determine whether students' reasoning abilities contribute to the prediction of their grade point average in physics.

#### Statement of the problem

This study determined the reasoning abilities and physics performance of fourth year high school students of Samar State University, Catbalogan City for school year 2013-2014.Specifically, this study sought answers to the following questions: what is the profile of the respondents in terms of sex andparents' educational attainment; what are the reasoning abilities of the respondents based on Piagetian perspective along concrete, transitional, formal and rigorous formal; is there a significant relationship between respondents' reasoning abilities and profile variates; what is the academic performance in physics of the student-respondents; is there a significant relationship between student-respondents' reasoning abilities and academic performance in physics; is there a significant difference in academic performance of the respondents grouped according to reasoning abilities?

#### Hypotheses

The following hypotheses were tested in this study: there is no significant relationship between student-respondents' reasoning abilities and profile variates; there is no significant relationship between student-respondents' reasoning abilities and academic performance in physics; there is no significant difference in academic performance of the respondents grouped according to sex; and there is no significant difference in academic performance of the respondents grouped according to reasoning abilities.

#### METHODOLOGY

#### **Research Design**

The study utilized descriptive-correlation design solving the research questions. This design was used in order to determine the relationship between the physics performance of the students and their scientific reasoning abilities. The variables involved are profile variates of student-respondents, reasoning ability and academic performance in physics which were determined using a questionnaire. The study employed statistical tools such as frequency count, percentage, mean, standard deviation, weighted mean, Pearson r, Fisher's t-test and t-test for independent samples.

#### Participants

The research utilized all fourth year high school students of the Laboratory High School of the College of Education, Samar State University, Catbalogan City was involved in the study. There were 40 students involved in this research.

#### Instrumentation

*Questionnaire*. This composed of three parts. Part I solicited personal information from the student-respondents such sex, parents' educational attainment and grades in physics. Part II consisted of 10 paired items which was used to determine the reasoning abilities of student-



respondents. Said instrument is labeled Test of Logical Thinking (TOLT) borrowed from (Valanides, 1996). Permission from the author was secured. The instrument is a paper-andpencil test where the items are distributed according to six different subscales or modes of logical thinking abilities: Proportional reasoning –1 and 2 (2 items), Controlling variables –3 and 4 (2 items), Probabilistic reasoning –5 and 6 (2 items), Correlational reasoning –7 and 8 (2 items), and Combinatorial reasoning –9 and 10 (2 items). Test scores range from 0-1, 2-3, 4-7, and 8-10 and will be used as a basis for classifying the student-respondents as concrete, transitional, formal, and rigorous formal, respectively.

*Grading Sheet.* The grades came from the grade of periodical exams from first grading period to fourth grading period of the student-respondents in physics which served as their academic performance in said subject. The grades were categorized as: Developing (D) (75-79); Approaching Proficiency (AP) (80-84); Proficient (P) (85-89); and Advanced (A) (90 and above).

#### **RESULTS AND DISCUSSION**

*Sex.* Table 1 shows the sex distribution of the respondents. *Table 1* 

#### Sex Distributions of Respondents

Sex Distributions of Hesponu	ciitis	
Sex	Frequency	Percent
Male	16	40
Female	24	60
Total	40	100

Based on the table, 24 students or 60% of the respondents are female while on the other hand 16 or 40% are males.

*Parents' Educational Attainment*. Table 2 reflects the distribution of parents according to their educational attainment.

#### Table 2

#### **Educational Attainment of the Respondents' Parents**

Educational Attainment	Father		Mother		Total	Donoont
Educational Attainment	f	%	f	%	Totai	rercent
High school level	1	2.5	1	2.5	2	2.5
High school graduate	3	7.5			3	3.8
College level	4	10.0	2	5.0	6	7.5
College graduate	26	65.0	31	77.5	57	71.1
MA/MS/MAT/MAEd units	5	12.5	2	5.0	7	8.8
MA/MS/MAT/MAEd			3	75	13	38
Graduate			5	1.0	15	2.0
PhD/Ed.D/DA graduate	1	2.5	1	2.5	2	2.5
Total	40	100	40	100	80	100

Of the total number of parents, 57 or 71.1% are college graduate consist of 26 fathers and 31 mothers. Seven or 8.8% have earned MA/MS/MAT/MAEd units made up of five fathers and



two mothers. The lowest educational attainment is high school level by two or 21.5% of the parents which consist of one father and one mother while the highest educational attainment is PhD/Ed. D/DA graduate composed of one father and one mother.

#### **Reasoning abilities of the respondents**

#### Table 3

#### **Reasoning Abilities of the Respondents**

Sex	Frequency	Percent
Concrete	8	20.0
Transitional	6	15.0
Formal	20	50.0
Rigorous formal	6	15.0
Total	40	100

As can be gleaned from the table, 20 or 50.0% of the respondents are in the formal level. Eight or 20.0% are still in the concrete level while six or 15.0% are in the transitional level. And finally, six or 15.0% are in the rigorous formal level. This implies that the respondents are at formal operational thinking stage. The result is similar to the study of Kanazawa (2010) by which he reported that senior high school students are formal thinkers.

#### Relationship between respondents' reasoning abilities and profile variates

As can be gleaned from the table, respondents' reasoning abilities and sex obtained a Pearson r of 0.446 with p-value of 0.004. The p value is lower compared to the 0.05 significance level which means a significant relationship exists between reasoning abilities and sex. Hence, the hypothesis "there is no significant relationship between reasoning abilities and sex" is rejected. This is due to the fact that female scored high reasoning abilities than male respondents in this study which implies that female are more formal thinkers than male respondents. Kanazawa (2010) supported this result. He reported that if you compare boys and girls at the same chronological age, girls on average are more formal thinkers than boys.

#### Table 4

## **Relationship between Reasoning Abilities and Profile Variates**

Profile	r <sub>xy</sub>	p-value	<b>Evaluation/Decision</b>
Sex	0.446	0.004	S/Reject H <sub>o</sub>
Fathers' education	0.224	0.164	NS/Accept H <sub>o</sub>
Mothers' education	0.140	0.387	NS/Accept H <sub>o</sub>

On the other hand, reasoning abilities and the other profile variates obtained the following Pearson r values and p values: 0.224 and 0.164 for fathers' education; and 0.140 and 0.387 for mother's education. The p values are higher than the stipulated 0.05 significance level which indicate no significant relationships between paired variables. So, the hypotheses "there are no significant relationships between respondents' reasoning abilities and fathers' education; and mothers' education" is accepted. This implies that parent's educational



background did not affect the respondent's scientific reasoning abilities. There is a Filipino saying that "poverty is not a hindrance to success" which was reported true in this research since parent's educational background, a significant related variable to family's income, is not related to scientific reasoning abilities of the fourth year high school students.

#### Academic performance in physics of the respondents

Table 5

#### Academic Performance of the Respondents

Academic Performance	frequency	Percent
veloping (D) (75-79%)	5	12.5
proaching Proficiency (AP) (80-84%)	26	65.0
oficient (P) (85-89%)	8	20.0
vanced (A) (90% and above)	1	2.5
Total	40	100
Mean	82.6 (AP)	
SD	3.30	
Vanced (A) (90% and above) Total Mean SD	1 40 82.6 (AP) 3.30	

About 26 or 65.0% of the respondents are approaching the proficiency level and 8 or 20.0% are the proficient level. Five or 12.5% of the respondents are in the developing level while one or 2.5 is at the advance level. As a whole the respondents' academic performance are at the approaching proficiency level as supported by a grand mean of 82.6.

## Relationship between respondents' reasoning abilities and academic performance

Table 6

## Relationship between reasoning abilities and academic performance in physics

Variables	r <sub>xy</sub>	p-value	<b>Evaluation/Decision</b>
Reasoning abilities vs Academic Performance	0.385	0.014	S/Reject H <sub>o</sub>

As shown in the table, the reasoning abilities and academic performance of the respondents obtained an r value of 0.385 with p-value of 0.014. The p-value is lower compared to the 0.05 significance level which means a significant relationship exists between reasoning ability and academic performance. So, the hypothesis "there is no significant relationship between reasoning abilities and academic performance in physics" is rejected. This implies that students with higher performance in Physics have higher scientific reasoning abilities and vice versa.

## Comparison of academic performance of the respondents according to sex

As reflected in the table, the computed t value of 0.931and p-value of 0.128 were obtained. The p-value obtained is lower than the 0.05 significance level interpreted as no significant difference between male and female-respondents with regards to their academic performance in Physics which lead to the acceptance of the hypothesis "there is no significant difference



inacademic performance in Physics between male- and female-respondents". This implies that

Table 7

#### Difference in academic performance according to sex

Sex	n	Mean	SD	t-comp	p-value	<b>Evaluation/Decision</b>
Male	16	81.63	3.423	0.021	0 1 2 9	NS/A acout H
Female	24	83.25	3.110	0.931	0.128	NS/Accept H <sub>o</sub>

both male respondents and female respondents have similar performance in Physics. There is no distinction in Physics performance as to their sex which is a known fact as far as Aina (2013) is concerned in her study on gender performance in Physics in colleges of education in Nigeria. As far as Nobel Prize is concerned there are female laureate in Physics as well as male like the renowned Physicist and Chemist Marie Curie who was awarded the Nobel Prize in 1903 and 1907.

#### Comparison on physics performance according to reasoning abilities

#### Table 8

Comparison of physics performance of the respondents according to reasoning abilities

Source of Variation	SS	df	MS	F	p- value	Evaluate/Decision
Between Groups	93.017	3	31.006	3.376	0.029	S/Reject Ho
Within Groups	330.583	36	9.183			
Total	423.600	39				-

The ANOVA table reflects a calculated F-ratio of 3.376 with a p-value of 0.029. Since the p-value is lower than the 0.05 significance level imply significant differences in academic performance. The hypothesis "there is no significant difference in academic performance according to reasoning abilities" is rejected. The result implies that students whose scientific reasoning is higher can achieved greater in physics. This can be attributed to daily simple to complex tasks in physics classes.

#### Academic performance according to reasoning abilities

As reflected in Table 9 above, the result of the Scheffe's test reveals a significant relationship in academic performance between transitional thinkers and rigorous formal thinkers in connection to their reasoning abilities. This means that transitional thinkers who acquired high Physics Academic Performance have same performance with the rigorous formal thinkers in relation to their scientific reasoning abilities.



## Table 9

Posteriori Test in comparing the academic performance according to reasoning abilities
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Pair	Difference in Means	p-value	<b>Evaluation/Decision</b>
Concrete-Transitional	1.000	0.945	Not Significant/Accept Ho
Concrete-Formal	-1.250	0.808	Not Significant/Accept Ho
Concrete-Rigorous formal	-4.167	0.110	Not Significant/Accept Ho
Transitional-Formal	-2.250	0.477	Not Significant/Accept Ho
Transitional-Rigorous formal	-5.167	0.048	Significant/Reject Ho
Formal-Rigorous formal	-2.917	0.251	Not Significant/Accept Ho

# CONCLUSION

Majority of the respondents, at the formal level of reasoning abilities, and whose parents were college graduates. Respondents' reasoning abilities was significantly related with their sex, but not with their fathers' education; and mothers' education. The respondents' academic performance in Physics was at the approaching proficiency level. Reasoning abilities and academic performance were significantly related. There was no significant difference in academic performance in Physics between male and female-respondents. There was significant difference in academic performance in Physics between male and female-respondents. There was formal thinkers, but not between concrete and transitional thinkers; concrete and formal thinkers; are indicator of physics success.

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