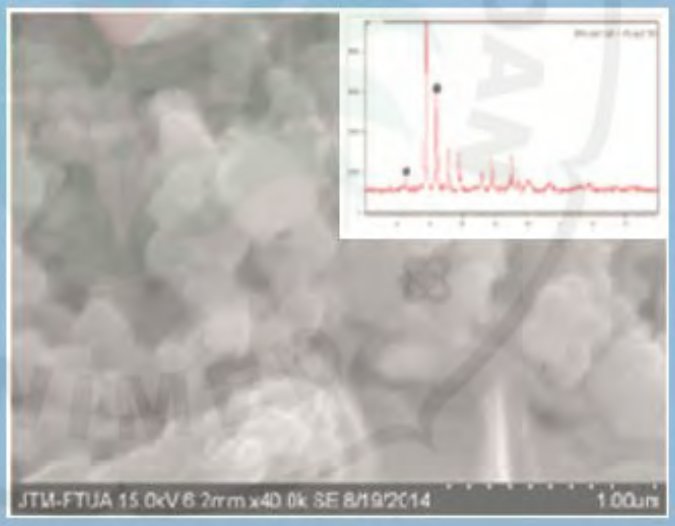
ISBN: 978-602-294-116-3
Published: 12 May 2016

UNUD

HFI

PROCEEDING
THE 4th INTERNATIONAL CONFERENCE ON THEORETICAL AND APPLIED PHYSICS (ICTAP) 2014

Bali, Indonesia
16 - 17 October 2014



Editors :
Ni Nyoman Rupiasih, Wayan Gede Suharta and Hery Suyanto
Udayana University, Bali, Indonesia

All Papers have been peer reviewed.

Copyright © 2016, by Udayana University Press. All rights reserved.
Printed by: Udayana University Press, Jl. P.B. Sudirman, Denpasar, Bali, Indonesia 80114

ISBN: 978-602-294-116-3
Published: 12 May 2016

PROCEEDING
THE 4th INTERNATIONAL CONFERENCE ON THEORETICAL AND APPLIED PHYSICS (ICTAP) 2014

Bali, Indonesia
16-17 October 2014

Editors:
Ni Nyoman Rupiasih, Wayan Gede Suharta and Hery Suyanto
Udayana University, Bali, Indonesia

Cover Design: I Ketut Putra
Udayana University, Bali, Indonesia

Sponsoring Organizations
Indonesian Physical Society – IPS
Indonesian Physical Society – Bali Branch

All papers have been peer reviewed

Copyright © 2016 by Udayana University Press. All rights reserved.
Printed by: Udayana University Press, Jl. P.B. Sudirman, Denpasar, Bali, Indonesia 80114

PREFACE

The *4th International Conference on Theoretical and Applied Physics* (*ICTAP*) 2014 was held in Bali, Indonesia on October 16-17, 2014. It is an international conference covering a wide subject in the field of theoretical and applied physics. This Conference was organized by the Department of Physics, Udayana University (UNUD) and Indonesian Physical Society (HFI). Many people have unreservedly and enthusiastically participated in the planning and preparation of this conference, including the Organizing and Scientific Committees, the speakers, the conference officer, students, etc. Thank you all for your positive attitude and fantastic support. Thanks to all invited speakers: Prof. Dr. Yusaku Fujii (Gunma University, Japan), Prof. Jakrapong Kaewkhao, Ph.D (Nakhon Pathom Rajabhat University, Thailand), Prof. Dr. Hong Joo Kim (Kyungpook National University, Republic of Korea) and Prof. Dr. Ing Mitra Djamal (ITB) that you have accepted our invitation. The financial support from Udayana University is gratefully acknowledged. ICTAP 2014 is aimed at providing the much needed forum of scientific communication and interaction among distinguished scientists working in the field of physics and related fields.

This event was also designed to offer the opportunity of making direct contact for the young Indonesian scientists and students with well-known scientists abroad and thereby fostering the existing research collaborations and extending international research networking for the future.

More than 106 authors from 6 countries have submitted their work in the conference. ICTAP 2014 finally accepted 57 original research papers after a peer review process. During the conference, 14 parallel sessions were held in order to advance and contribute to specific research area in physics.

Finally, special thanks to you, the delegates, for supplying the input needed for successful scientific conferences. We wholeheartedly welcome you and hope you find ICTAP 2014 as successful and rewarding as we envision it to be.

Denpasar, 12 May 2016

Editors

Ni Nyoman Rupiasih, Ph.D.
Dr. Wayan Gede Suharta
Dr. Hery Suyanto

Table of Contents

The Relationship between Formal Thinking Abilities and Problem-Solving Skills in Kinematics Topic

Sondang R. Manurung[1, a)]

[1]*Departement of Physics Educational*
[a)]*State University of Medan*

Email: sondangrina@gmail.com

Abstract. The main purpose of the study was to investigate the relationship between formal thinking students' ability level and their competence in problem solving task in physics. The population was all student prospective teacher students of the first grade in physics education program. A relationship was thought to exist since both sets of skills strongly emphasize conducting fair experiments as well as other abilities. Pencil and paper measures of formal operational and problem solving skill achievement in the kinematics topic were given to 36 students. Resulting correlations showed a moderate relationship between achievements on the two measurements. Factor analysis data corroborate the correlation evidence. One potential inference to be drawn from these results is that problem solving skill teaching might be influenced formal thinking ability.

Keywords: formal thinkng ability, problem solving skill, kinematics, education prospective
PACS: 00-01.Communication, education, history, and philosophy

INTRODUCTION

Low level of performance and poor achievement of students in their education is the concern of the government, teachers, parents, and the general public. Problems may arise after the graduation of the students, by the time they will start their careers. Many efforts were already been done by the Government of Republic of Indonesia, through the Ministry of Education, to improve the performance and achievement of the students in the field of science. These efforts showed the concern of the government and the educator in motivating the students to reach a certain objectives of science education. The main objective of science education is to develop individuals to have scientific literacy and becomes a qualified human resource. The main focus for the educators is to develop the scientific ability of the students in problem solving, both inside and outside the classroom [1]. The problem solving ability is one main part in education, which increases the ability for abstraction, conceptual thinking, and generalization [2].

Learning process of science requires high level of reasoning ability, especially formal reasoning thinking. There is a direct relation between formal thinking and integrated science process such as the ability to identify and control variables, and the ability to construct hypothesis [3]. Strong formal reasoning ability is expressed as a predictor of skill attainment process [4]. There are five aspects of the operation of formal reasoning, namely: proportional reasoning, control of variables, probability reasoning, correlation reasoning, and combinatorial reasoning. The fifth aspect has been identified as an important ability in order to achieve success in science and mathematics [5]. Based on the importance, some authors suggest that the development of formal reasoning ability is a key priority in science education [1]; [6]; [7]. In fact, proportional reasoning, for example, is very important in many aspects of the science of quantitative reasoning without access to a proportional understanding of the derivation and the use of a large number of functional relationships in science is not achieved. However, most of the elementary grade students do not have the ability to think like this. [8]. Lawson found a substantial correlation between formal reasoning and achievement in biology [6]. Similarly, Chandran, Treagust and Topin showed that formal reasoning ability and prior

knowledge was a significant predictor of performance on chemical calculations, laboratory applications, and contents of chemical knowledge [9]. Piaget showed that, there are four stages of growth of logical thinking from infancy to adolescence, these are; sensory-motor (age 0-2 years), preoperational (age 2-7 years), concrete operational (ages 7-11 years), and formal operational (age 11-16 years), representing a progressive organization and reorganization of experience to form mental structures which is able to accommodate new material and use it [10]. Problem solving is a complex process and it is important to solve the problems of everyday life and learn physics. Hayes defines the process of solving the problem as follows: "Every time there is a gap between where you are now and where you want, and you do not know how to find a way to cross that gap means you have a problem" [11]. Martinez described problem solving as "the process of moving towards the goal when the path to that goal is uncertain" [12]. Problem solving ability of a student is not only depended on the level of maturity, but also determined from the problems they themselves experienced [13]. The strategy refers to the five-step problem solving include: (a) Focus the problem), (b) Describe the physics, (c) Plan the solution, (d) Execute the plan, and (e) Evaluate the solution. Problem solving can be done in writing individual and group discussions.

METHODOLOGY

This research was conducted in one of the Physics education program in North Sumatra for the first year students. The number of research subjects was 36 students with 26 women and 10 men. Data were collected through two research instruments, namely logical thinking test (TOLT) [4]. developed by Tobin and Capie was translated and adapted into Turkish by Geban, Askar, and Ozkan, and the reliability was found to be 0.81 [15] has been translated into Bahasa Indonesia by Sumarmo having reliability of 0.66 [16] by using ANATES software ver. 4.0.9, the test results obtained from the validity and reliability tests of 0.67 and 0.80. and the ather is test of problem solving in kinematics, in the form of an essay test consisting 2 questions. The questions of the test were thus tested, and its reliability was proven. Collected data were analyzed and getting of description of data is shown in the form of frequency, percentage, mean, standard deviation. Analysis of the data and the results are presented with particular reference to the research hypothesis: formal thinking skills affect the ability of solving the problem. The hypothesis was tested using simple regression analysis. In regression model, formal thinking ability is used as the independent variable, while the problem-solving ability as the dependent variable.

RESEARCH RESULTS

The test scores of formal thinking ability test and problem solving skills test are shown in Table 1.

TABLE 1. Statistical Result of Formal Logical Thinking Test (TOLT).

	Number of valid data	Mean	Standard Deviation	Maximum	Minimum
Dependent variable (Problem solving skills)	36	13.57	2.95	7.00	18.00
Independent variable (Formal thinking ability)	36	6.58	1.68	4.00	18.00

From the above statistics, the scores of independent variables (formal thinking abilities) show the mean and standard deviation of 6.5833 and 1.67971. On the other hand, the dependent variable (problem solving skills) has the mean of 13.750 and the standard deviation of 2.95079. The minimum value for the independent variable is 4 and the maximum value is 10. For dependent variable, the minimum is 7 and the maximum is 18.

The description data of ability of formal thinking is shown in Table 2. Combinatorial is the hardest test section, as indicated by the smallest mean score of tested aspects, 0.6667. Meanwhile, the easiest is proportional reasoning and control of variables, indicated by the mean score of 1.8056.

The frequency distribution of variable data in formal thinking ability and problem solving skills are shown in Table 3 and 4. Most students are in the early stages of formal thinking skills (29 students). Only 7 students at the final stage of formal thought, and still there is one student in the transition phase. All can be seen In Table 3.

In Table 4, it is shown that as many as 47.2 % of students scored below average approximately, by 27.8 % of students got a score around the average, and as much as 52.87% of students scored above average.

TABLE 2. Description Data of Aspects in Formal Thinking Abilities.

	Proportional ability	Ability to control variable	Probability	Correlation	Combination
Number of valid data	36	36	36	36	36
Mean	1.8056	1.8056	1.2222	1.1667	0.6667
Standard Deviation	0.40139	0.52478	0.89797	0.91026	0.79282
Maximum	1.00	0.00	0.00	0.00	0.00
Minimum	2.00	2.00	2.00	2.00	2.00

TABLE 3. Frequency Distribution of Variable Data in Formal Thinking Ability

Score	Number of person	Valid percent	Cumulative Percent
4.00	1	2.8	2.8
5.00	10	27.8	30.6
6.00	11	30.6	61.1
7.00	5	13.9	75.0
8.00	2	5.6	80.6
9.00	4	11.1	91.7
10.00	3	8.3	100
Total	36	100	

TABLE 4. Frequency Distribution of Variable Data in Problem Solving Skills

Score	Number of person	Percent	Valid percent	Cumulative Percent
7.00	1	2.8	2.8	2.8
8.00	1	2.8	2.8	5.6
10.00	5	13.9	13.9	19.4
12.00	5	13.9	13.9	33.3
13.00	5	13.9	13.9	47.2
15.00	12	33.3	33.3	80.6
17.00	1	2.8	2.8	83.3
18.00	6	16.7	16.7	100
Total	36	100	100	

Test of Hypothesis

The relationship between formal thinking abilities (X) with problem solving skills (Y) was examined. From the calculation results obtained by simple regression analysis, a regression toward $b = 10$ and a constant $a = 0.569$ was obtained, resulting a regression equation: $y = 0.569\,x + 10$.

To determine the significance and the linearity of the regression, ANAVA F-test was conducted, based on tests of problem solving skills and formal thinking ability as a predictor (independent variable/IV), as shown in Table 5.

TABLE 5. ANAVA Analysis on the Score of Problem Solving.

Source	Type II Sum of Squares	Mean Square	F	Df	P	Conclusion
IV: Ability of Formal Thinking	76.652	12.775	2.624	6	0.017	Significant
Error	228.098			29		
Total	7111	7.865		36		
Error Correction	304.750			35		

$R^2 = 0.252$ (*adjusted* $R^2 = 0.097$).

ANAVA calculations showed that the problem solving ability of formal thinking can be a significant predictor in determining the problem solving skills. The results of the calculations indicated that the ability to think formally is proved to be a good predictor to determine the problem solving scores, $F(6.29) = 2.624$, $p = 0.017$, because of $F_{calculation} < F_{table}$ for 5 % error level, or $2.624 < 6.296$. Thus, the use of a linear regression is confirmed.

The relationship between formal thinking abilities (X) and problem solving skills (Y) from the calculation of the correlation coefficient of 0.324 is shown in Table 6. From the result in Table 6, N denotes the number of observations / sample of 36, whereas the correlation indicated by the number 0.324, which means that the magnitude of the correlation between the variables of formal thinking with problem solving variable is equal to 0.324. Meanwhile, the number of sig. (2-tailed) is 0.054. This value is greater than the critical threshold α of 0.01 that will means that there is no relationship between the two variables at a significance level of 0.01.

TABLE 6. Correlation Calculation between Test of Formal Thinking and Problem Solving.

		Formal Thinking	Problem Solving
Formal Thinking	Pearson Correlation	1	0.324
	Sig. (2-tailed)	**0**	0.054
	N	36	36

Based on the criteria of degree of difficulty, the correlation coefficient of 0.324 lies in the medium category (moderate).

DISCUSSION AND CONCLUSIONS

A high percentage (77.8 %) of the sample is in the early stages of formal reasoning, the final stage of formal reasoning by 19.4 %, and by 2.7 % in the transition phase. Classification of subjects in a stage of cognitive development is derived directly from the theory of Piaget. In other words, the need to classify subjects in a stage of cognitive development is not fully justified from the results of this study because the basic premise of Piaget's theory that formal reasoning is common in integrated mode and intellectual function not confirmed. Similarly, the test scores for the problem solving skills are as much as 47.2 % of students scored below average approximately, by 27.8 % of students got a score around the average, and as much as 52.87 % of students scored above the mean average. The research results also show that the correlation between formal thinking skills and problem solving abilities is 0.32; thus in the medium category. If we consider the value of the coefficient of determination of 10.5 %, the positive relationship was contributed mainly by the variable formal thinking skills to students' ability to solve problems. In other words, the average value of 10.5 % problem solving ability is determined by the value of the given formal thinking skills, through the equation $y = 0.569\ x + 10$. That is, the higher the formal thinking skills of students, the more it will affect the growth of problem solving skills. This is supported by Gabel et al DeCarcer and Lawson, who said that the development of formal reasoning ability is a key priority in science education, which can improve science process skills and understanding of concepts [17];[7]. This is evidenced by the research by Diniwati, Padilla which stated that there is a significant relationship between students' formal thinking skills with the ability to provide an overview of microscopic acid-base concept [18] [19]. Furthermore, Padilla proposed three strong arguments which emphasized the need and importance of science process skills activities in the classroom learning [20].

REFERENCES

1. Karslı, F., Şahin Ç. & Ayas, A. (2009). A study on science and technology course teachers'ideas about the scientific process skills. Procedia Social and Behavioral Sciences, 1(1), 890–895.
2. Maloney, D. (1994). "Research in Problem Solving: Physics." In Handbook of Research on the Teaching and Learning of Science, D. Gabel (Ed.), MacMillan.
3. Krajcik,].S. Bl Hanet, RE. (1987): Proportional Reasoning and Achievement in High School Chemistry. School Science and Mathematics 87(1): 25-32.
4. Tobin, K., & Capie, W. (1980). The development and validation of a group test of logical thinking. Paper presented at the annual meeting of the American Educational Research Association,Boston.
5. Bitner, B.L. (1991). Formal operational reasoning modes: Predictors of critical thinking abilities and grades assigned by teachers in science and mathematics for students in grades nine through twelve. *Journal of Research in Science Teaching*, 28, 275-285.
6. DeCarcer Gabel, & Slaver, 1978; DeCarcer, I. A., Gabel, D. L., & Staver, J. R. (1978). Implications of Piagetian research for high school science teaching: A review of literature. Science Education, 62, 571-583.
7. Lawson, 1982. Lawson, (1982), Lawson, A.E. (1982). Formal reasoning, achievement, and intelligence: An issue of importance. Science Education, 66, 77-83.
8. Garnett dan Tobin, 1984). Garnett, J. B. and Tobin, K. (1984). Reasoning patterns of preservice elementary and middle school science teachers. Science Education, 68, 621-631.
9. Chandran, S., Treagust, D., & Tobin, K. (1987). The role of cognitive factors in chemistry achievement. Journal of Research in Science Teaching, 24, 145-160.
10. Piaget (1972). Intellectual evolution from adolescence to adulthood. Human Development, 15, 1-12.
11. Hayes, J.R. (1989). The complete problem solver (2nd ed.), Hillsdale NJ; Lawrence .
12. Martinez, M. E. (1998). What is problem solving? Phi Delta Kappan, 79, 605-609.

13. Gerace, W. J. (2001) "Problem Solving and Conceptual Understanding", dalam S. Franklin, J., Marx & K. Cummings (Eds) Proceedings of the 2001 Physics Education Research Conference, 33 -45. New York: PERC Publishing, 33.
14. Heller, P & Hollabaugh, M (1992b). "Teaching Problem Solving Through Cooperative Grouping: Designing Problems and Structuring Groups". American Journal of Physics, 60 (7). 637-644.
15. Geban, Ö., Aşkar, P. and Özkan, İ. (1992). Effects of computer simulated experiment and problem solving approaches on students' learning outcomes at the high school level. Journal of Educational Research, 86, 5-10.
16. Diniwati, Anisa. 2011. Hubungan Antara Kemampuan Berpikir Formal Dengan Kemampuan Memberikan Gambaran Mikroskopis Konsep Asam Basa pada Siswa Kelas XI SMA Negeri 1 Gorontalo. Skripsi. Jurusan Pendidikan Kimia FMIPA Universitas Negeri Gorontalo.
17. Haryanto Haryanto Zeni, 2012, Tahap perkembangan intelektual siswa SMP dan SMA dalam kaitannya dengan pembelajaran fisika: kajian berdasarkan teori perkembangan intelektual Jean Piaget, (Disertasi), Bandung: UPI.
18. Lawson, A.E. (1985). A review of research on formal reasoning and science teaching. Journal of Research in Science Teaching, 22, 569-617.
19. Padilla, M. J., Okey, J. R., & Dillashaw, F. G. (1983). The relationship between science process skills and formal thinking abilities. Journal of Research in Science Teaching, 20,239-246. Journal of Research in Science Teaching.
20. Padilla, M. J. (1990). The science process skills. "Research Matters. To the Science Teacher."National Association for Research in Science Teaching, No. 9004.

UNIMED
THE Character Building UNIVERSITY