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PROCEEDING

INTERNATIONAL CONFERENCE ON RESEARCH, IMPLEMENTATION AND EDUCATION OF MATHEMATICS AND SCIENCES 2014

ICRIEMS 2014

Yogyakarta, 18-20 May 2014

Global Trends and Issues on Mathematics and Sciences and the Education

PROCEEDING

Conference Proceedings

INTERNATIONAL CONFERENCE ON RESEARCH, IMPLEMENTATION AND EDUCATION OF MATHEMATICS AND SCIENCES (ICRIEMS) 2014

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Global Trends and Issues
on Mathematics and Science
and The Education

Faculty of Mathematics and Natural Sciences
Yogyakarta State University

ICRIEMS 2014 : Global Trends and Issues on Mathematics and Science and The Education

- Mathematics & Mathematics Education
- Physics & Physics Education
- Chemistry & Chemistry Education
- Biology & Biology Education
- Science Education

Preface

Bless upon God Almighty such that this proceeding on International Conference on Research, Implementation, and Education of Mathematics and Sciences (ICRIEMS) 2014 may be compiled according to the schedule provided by the organizing committee. All of the articles in this proceeding are obtained by selection process by the reviwer team and already ben presented in the Conference on 18 – 20 May 2014 in the Faculty of Mathematics and Natural Sciences, Yogyakarta State University. This proceeding consists of 344 parallel papers, and comprises 9 fields, that is mathematics, mathematics education, physics, physics education, chemistry, chemistry education, biology, biology education, and science education.

The theme of ICRIEMS 2014 is 'Global Trends and Issues of Mathematics and Science and the Education'. The main articles in this conference are given by five keynote speakers, which are Prof. Dean Zollman (Physics Department, Kansas State University), Prof. David F. Treagust (Center of Education, Curtin University), Prof. Dr. Amy Cutter-Mackenzie (School of Education, Southern Cross University, Australia), Prof. Tran Vui (Hue University, Vietnam), and Asst. Prof. Dr. Duangjai Nacapricha (Faculty of Science, Mahidol University). The conference is also supported by the LPTK (Lembaga Pendidikan Tenaga Kependidikan) Forum from Faculty of Mathematics and Sciences that consists of 12 universities all over Indonesia. Each member of the Forum contributed one invited speakers, such that there are an additional 10 invited speakers presenting in the forum. Besides the keynote and invited speakers, there are also 344 parallel articles that presented the latest research results in the field of mathematics and sciences, and the education. These parallel session speakers come from researchers from Indonesia and abroad, including Malaysia and Australia.

Hopefully, this proceeding may contribute in disseminating research results and studies in the field of Mathematics and Sciences and the Education such that they are accessible by many people and useful for the Nation Building.

Yogyakarta, June 2014

The Editor Team

Forewords from The Head of Committee

Assalamu'alaikum wa Rahmatullahi wa Barakatuh
May God bless upon us.

Your excellency The president of UNY Prof. Dr. Rochmat Wahab, M. Pd., M.A., ladies and gentlemen, good morning and welcome to State University Yogyakarta. This seminar entitled International Conference on Research, Implementation, and Education of Mathematics and Science (ICRIEMS): global trends and issues on mathematics and science and the education is organized by the Faculty of Mathematics and Science, State University of Yogyakarta working together with 12 members of the Association of the Faculty of Math and Sciences from Teacher Education Program (LPTK). This seminar is also dedicated to the golden aniversary of UNY; 1 among 90 academic activities dedicated to the aniversary.

Ladies and gentlemen, on behalf of the committee of this conference, I would like to express highest appreciation and gratitudes to the keynote speakers, including:

1. Prof. David F. Treagust (Center of Science Education Curtin University)
2. Prof. Dean Zollman (Physics Dept, Kansas University, US)
3. Dr. Amy Cutter-Mackenzie (School of Education, Southern Cross University, Australia)
4. Asst. Prof. Dr. Duangjai Nacapricha (Faculty of Science , Mahidol University)
5. Prof. Tran Vui (College of Education, Hue University, Hue City, Vietnam)

Secondly, I would like also to give sincere thanks and gratitudes to the speakers from 10 College of Educations, including:

1. Universitas Negeri Surabaya (UNESA): Prof. Dr. Muchlas Samani, and 33 speakers
2. Universitas Negeri Jakarta (UNJ): Prof. Dr. Gerardus Pola, and 7 speaker
3. Universitas Pendidikan Indonesia (UPI): Dr. Hary Firman, and
4. Universitas Negeri Malang (UM): Prof. Effendi, Ph.D
5. Universitas Negeri Padang (UNP): Prof. Tjeerd Plomp
6. Universitas Negeri Semarang (UNNES): Prof. Dr. Supriyadi Rustad

7. Universitas Pendidikan Singaraja (UNDIKSA): Prof. Dr. I Nengah Suparta, M.Si
8. Universitas Negeri Makasar (UNM): Oslan Junaidi, Ph.D
9. Universitas Negeri Gorontalo (UNG): Prof. Dr. Sarson Pomalto, M.Pd
10. Universitas Negeri Yogyakarta (UNY): Dr. Jaslin Ikhsan

Next, I also would like to thanks to our special guests and speakers from:
1. Universitas Pendidikan Sultan Indris (UPSI), Malaysia
2. University of Mahidol, Thailand
3. University of Malaysia in Trengganu

Next, I would like to thanks and welcome to 379 speakers from the entire Indonesia and all participants registered in this seminar.

Ladies and gentlemen, recently the number of research and publication on mathematics and science and the education is vulnarable. It is nescessary for us to organise, to share, and to publish the results of the research in this conference. I hope the conference will bear fruitful results and promote networking and future collaborations for all participants from diverse background of expertise, intitutions, and countries to promote science, mathematics, and the education.

Finally, I am delighted to thank the committee members who have been working very hard to ensure the succes of the conference.

Please enjoy the conference and enjoy Yogyakarta, the city of education, tourism, and culture. Thank you very much.

Assalamu'alaikum wa rahmatullahi wa barrakatuh

Dr. Slamet Suyanto, M. Ed.

Forewords from The Dean of Faculty of Mathematics and Natural Sciences, Yogyakarta State University

Assalamu'alaikum warahmatullahi wabarakatuh

May peace and God's blessings be upon us all.

On behalf of the Organizing Committee, first of all allow me to extend my warmest greeting and welcome to the International Conference on Research, Implementation, and Education of Mathematics and Sciences 2014, held in Yogyakarta State University, one of the qualified education universities in Indonesia.

To celebrate the 50th Commemoration of Yogyakarta State University, our faculty, in collaboration with Forum of MIPA LPTK, has the opportunity to conduct International Conference on Research, Implementation, and Education of Mathematics and Sciences 2014. This conference proudly presents five keynote speeches by five fabulous speakers: Prof. Dean Zollman, Prof. David F. Treagust, Prof. Dr. Amy Cutter-Mackenzie, Prof. Tran Vui, and Asst. Prof. Dr. Duangjai Nacapricha, around 380 parallel speakers with 344 orally presented articles.

Distinguished guest, ladies and gentlemen,

The independence of a country is impossible to gain if the education does not become the priority and it is not supported with the development of technology. We all know that the technology development could be achieved if it is supported by the improvement of firm fundamental knowledge. The empowerment of fundamental knowledge could not be separated from research which is related to the development of technology and the learning process in school and universities.

This conference is aimed to pull together researchers, educators, policy makers, and practitioners to share their critical thinking and research outcomes. Therefore, we are able to understand and examine the development of fundamental principle, knowledge, and technology. By perceiving the matters and condition in research and education field of mathematics and sciences, we could take a part in conducting qualified education to reach out the real independence of our nation.

Distinguished guest, ladies, and gentlemen

This conference will be far from success and we could not accomplish what we do without the support from various parties. So let me extend my deepest gratitude and highest appreciation to all committee members. I would also like to thank each of participants for

attending our conference and bringing your expertise to our gathering. Should you find any inconveniences and shortcomings, please accept my sincere apologies.

To conclude, let me wish you fruitful discussion and a very pleasant stay in Yogyakarta.

Wa'alaikumsalam warahmatullahi wabarakatuh

Dr. Hartono

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THE DEVELOPMENT OF PHYSICS ESSAY TEST FOR HIGHER ORDER THINKING SKILLS IN JUNIOR HIGH SCHOOL

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Abstract

This research has been done to develop an instrument for measuring junior high school students' physics higher order thinking skills (PhysETHOTSS) and to obtain the characteristics of the PhysETHOTS. The instrument blue print has been developed based on the aspects and sub-aspects of higher order thinking skills, then it was used to develop the items. The instrument consisting of 24 items were validated by physics educational measurement experts. The validated instrument was tried out on students of junior high school (SMPN 1 Sewon). The polytomous data were analyzed according to the partial credit model (PCM). The results show that the 24 items of PhysETHOTS were fit to the PCM, the reliability of the test was 0.75, the items' difficulty indexes ranged from -1.22 to 0.34. Therefore, the PhysETHOTS is qualified for the measurement of junior high school students' physics higher order thinking skills.

Keywords: *instrument development, physics essay test of higher order thinking skills, polytomous, and PCM*

INTRODUCTION

Today the world is in an era of globalization that needs quite tight competition. In this era the competition is quite tight, the competition of human resources (HR). The quality of the nation's human resources is determined by the education level of the nation. Improving the quality of education can begin from improving the learning quality. Improving the learning quality can begin by setting appropriate learning objectives.

One of the aims Science learning in junior high school so that learners have the ability to develop reasoning skills in the analysis of inductive and deductive thinking using concepts and principles of physics to explain the events of nature and solving problems both qualitatively and quantitatively (BSNP, 2006: 160). Thus, through the study of physics students are expected to develop themselves in thinking. Learners are required not only have the ability of lower order thinking, but the higher order thinking skills (HOTS). With regard to the higher order thinking skills, the fact remains that the Indonesia physics achievement as measured on the reasoning aspect is ranked 40^{th} of 42 countries (TIMSS & PIRLS International Study Center, 2012:48). Thus, the physics achievement of Indonesian high school students that requires of HOTS in the international level is low. The low physics achievement can be caused by an improper learning process or assessment model. In this case, only assessment will be discussed, because proper assessment can encourage students to learn higher order thinking skills.

Based on Piaget's development theory, the formal operational stage is a stage of children beginning from eleven years old. At this stage the children have begun to develop the ability to manipulate abstract concepts through the use of propositions and hypotheses (Piaget, 2005: 122 and Reedal, 2010:7). The junior high school students are between 12 to 15 years, so that higher order thinking skills of junior high school students have been established.

The revised Bloom's taxonomy divide the cognitive aspect into lower order thinking skills (LOTS) and higher order thinking skills (HOTS). LOTS include the ability to remember, understand, and apply, while the HOTS include the ability to analyze, evaluate, and create

(Anderson and Krathwohl, 2001:30). Bloom's taxonomy has been applied in the education. Bloom's taxonomy is still used in many curricula and teaching materials (Brookhart, 2010: 39; Schraw and Robinson, 2011: 158-159). Thus the HOTS in physics includes physics abilities, i.e. analyzing, evaluating, and creating.

According to Brookhart (2010:5) higher order thinking skills (HOTS): (1) high-order thinking is at the top of Bloom's cognitive taxonomy, (2) The purpose behind teaching cognitive taxonomy to equip learners to transfer knowledge, (3) able to think meaning that learners are able to apply the knowledge and skills they developed while studying in a new context. In this case the term "new" is a concept application that has not been thought of before by learners, this means that the universal is not necessarily something new. Higher-lorder thinking means the ability of learners to connect learning with other things that have never been taught.

To monitor the process, progress, and improvement of students' learning outcomes on an ongoing basis, the necessary assessment. Educational assessment is the process of information collecting and processing to determine the achievement of students' learning outcomes (Regulation of the Minister of National Education, No. 20, 2007). Assessment can be done orally or in writing. Written assessment is conducted by a written test. There are two forms of the written tests, namely selecting and supplying the answers. Written test by selecting answers include: multiple choice, two- choice (true - false, yes - no), matching, and cause and effect.

Keep in mind that the evaluation model also effects the thinking skills of students. According to van den Berg (2008:15) that the curriculum has a rich potential for developing higher-order thinking skills of learners. Teachers have to plan well and engage learners in activities that encourage and develop the higher order thinking. Assessment can be implemented to bring students in improving their higher order thinking skills. This is supported by the other opinions, higher-order thinking questions that encourage students to think deeply about the subject matter (Barnett & Francis, 2012 : 209). Based on this argument means that the assessment, test of higher-order thinking skills, provide stimulation of students to develop high order thinking skills as well.

Nitko and Brookhart (2011:223) describe that the basic provisions of the assessment is the ability to use higher order thinking tasks that require the use of knowledge and skills in new situations. Must use new materials to assess the higher order thinking skills. One way done use sets of items that depend on the context .

There are disadvantages of multiple choice test, namely: (1) students chances to guess the answer is still quite large and (2) the students' thinking process cannot be seen exactly (Sujana, 1990:49). Therefore, essay test is good alternative test.

Assessment are based on the stages can be completed examinees. Although only just completed the initial stage, the examinees had to get the value. The highest value of course obtained when the examinee has completed all phases of the exam in point. The assessment procedure is the same with how individuals respond to the items in the psychological scale. For example, an item that provides four categories of response of 'never', 'rarely', 'often', and 'always ' analogous to the completion stage. Just about to finish the first stage is analogous to the category of 'never', while when it comes to the final stage, analogous to the category of 'always'. This assumption was later developed into a partial credit model (PCM). When it is assumed that a partial credit item then follow the pattern of higher ability individuals are expected to have higher scores than individuals who have a low ability (Widhiarsa, 2010: 6). According to Wright & Masters, PCM is also appropriate to analyze the response to the measurement of critical thinking and conceptual understanding in science (Linden & Hambleton, 1997: 101-102)

Based on the above, of various types of written test, essay test is a good one to explore the physics higher order thinking skills in junior high school. To measure higher-order thinking skills is used test that called Physics Essay Test for Higher Order Thinking (PhysETHOTS). So that we need to develop of physics essay test for higher order thinking skills (PhysETHOTS). Based on the description in the future, the goal is : (1) to develop an instrument for measuring junior high school students' physics higher order thinking skills (PhysETHOTS); and (2) to obtain the characteristics of the PhysETHOTS

RESEARCH METHOD

This research is the development research with quantitative approach. This instrument development research was done with the modified of the Wilson Model and Antonio Oriondo Model.

The test instrument development used a modified form of the Wilson and Antonio Oriondo model, consisting of: (1) the design of the test and (2) the test tryout. The test design phase included: (1) the determination of objective tests, (2) the determination of competency to be tested, (3) the determination of the tested material, (4) the preparation of test blue print, (5) the writting of items based on the principles of HOT test development, (6) the preparation the scoring guidelines, (7) test validation and (8) the repairing the items and assembling the test, The stages of the development of the test are presented in Figure 1. The try out included: (1) the establishment of try out subjects and (2) the implementation of the tryout.

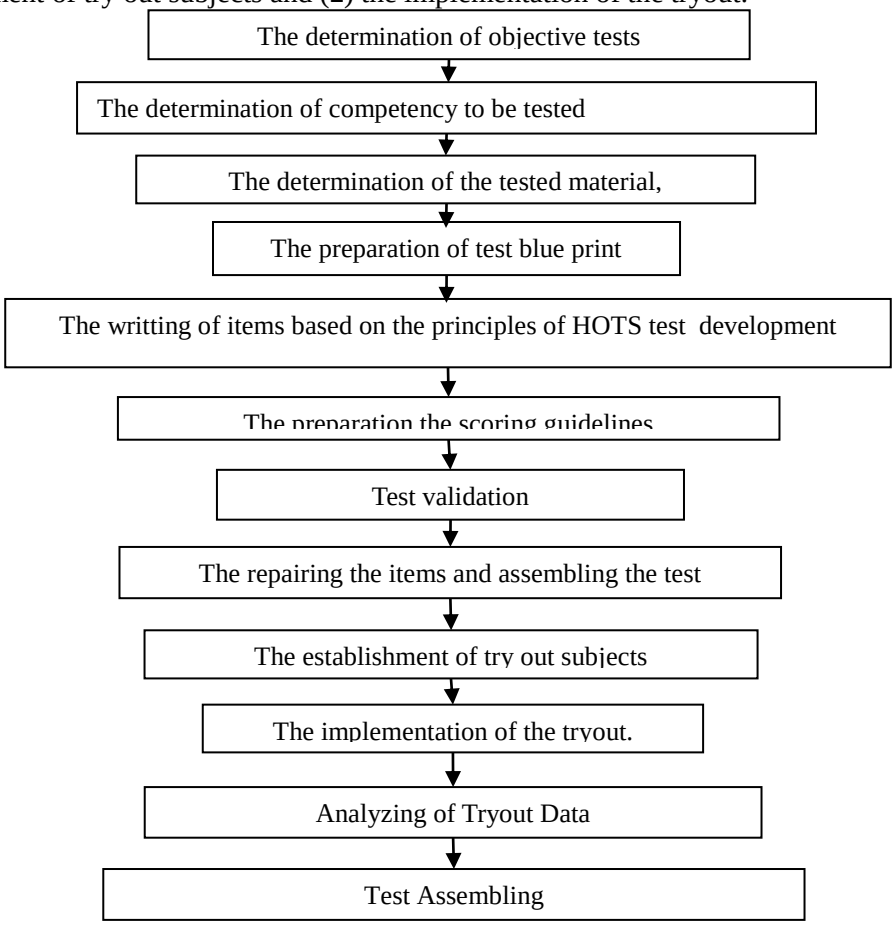

Figure 1. Steps of The Instrumen Development

Related to the sample number, according to some measurement experts IRT analysis requires 200 to 1000 people (Seon, 2009: 3). Reckase (2000) concluded that the minimum sample size for estimating the three parameters, which include discrimination, the difficulty index, and pseudoguessing, is 300 (Haladyna, 2004: 206). So with the PCM model of 1PL, the students for the tryout subjects as many as 100 are more than enough.

RESULT AND DISCUSSION

Result of The Test developed

The PhyTHOTS instrument consisted of 24 items, The test included sub physics matter: force, Newton's law, work and energy, simple machines, pressure, vibrations and waves, sound, light, and optical instruments and sub-aspect of HOTS: analyze, evaluate, and create. The items distribution is presented on Table 1. The PhyETHOTS was validated by experts judgment.

Description of the Physics instruments higher order thinking skills (PhysETHOTS) in JHS validation has been done then do the next step is try out. Tests conducted on 100 students in grade VII of SMP N 1 Sewon. The response of students then assessed and given a score on respondents (examinee). Score of the students are coded in note pad for analysis preparation.

Table 1. Distribution of Item PhyETHOTS in Grade VII of Junior High School

Dimension Kognitive Category	**Kognitive Process**	**Kompetency Standard and Physics Matter**								
		5. Understanding the role of work, force, and energy in daily life					6. Understanding the concept and application of vibration, waves and optics in daily technology products			
		Force	Newton's law	Work and energy	Simple machines	Pressure	Vibrations and waves	Sound	Light	Optical instrument
Analyze	Differenting	1					15	18		
	Organizing		4			12				23
	Attributing			7	10				21	
Evaluate	Checking	2		8				19		
	Critiquing		5			13	16			
Create	Generating			9	11				22	
	Planning	3	6				17			
	Producing					14		20		24

Goodness of fit of Instrument

Testing for goodness of fit for the overall test and each item is carried out. Testing goodness of fit the fit for the overall test developed Adam Khoo (1996:30) based on the mean value of INFIT Mean Square (Mean INFITMNSQ) and its standard deviation or average values INFIT t (Mean INFIT t) and its standard deviation. If the average INFIT MNSQ approximately 1 and 0.0 standard deviation or mean INFIT t close to 0 and standard deviation 1.0, then the

overall fit test with PCM. The INFITMNSQ is 1.01 (about 1) and a standard deviation is 0.13 (approximately 0.0), therefore the overall test fits with 1 PL PCM model.

Testing for goodness of fit Item and testee is determined that an item or testee is fit by models with boundary MNSQ INFIT range of 0.77 to 1.30. The MNSQ INFIT values of items between 0.78 to 1.27. Thus, 24 items are fit with PCM model.

Reliability

Based on the analysis, the reliability of the instrument (test) is estimated at 0.75. Reliability value is qualified as good instrument.

Item Characteristic Curva (ICC)

The characteristics of the item indicated by the curves characteristic of the item (ICC) and the index of difficulty. Based on the analysis, there were obtained item characteristic curves (ICCs) as many as 24 pieces. Figure 2 presented the characteristic curve item 1, that means: (1) score of 1 is largely for very low ability students ($\theta = -3$), (2) score 2 mostly to moderate ability students ($\theta = 0$), (3) score 3 mostly for high ability students ($\theta = 1$), (4) a score of 4 and 5 mostly for very high ability students ($\theta = 3$). The items' difficulty index from the small to the large ones sequential categories 1, 2, 3, and 4.

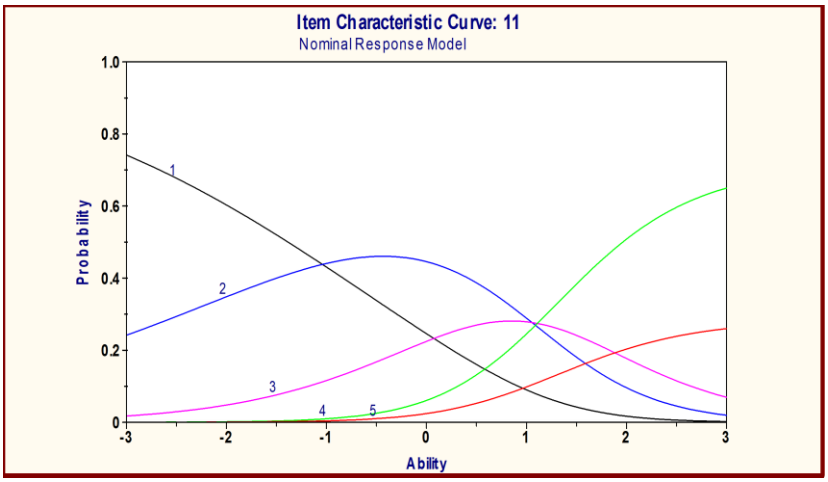

Figure 2. Item Characteristic Curve 11

The Difficulty Index

The items' difficulty index were from -1.22 to 0.34 with an average of 0 and a standard deviation of 0.35. So that based on difficulty ($-2.0 < b < 2.0$), all of 24 items were good. For more details, please see diagram distribution of items according to index difficulty and subaspek aspects of the instrument in Figure 3. Based on Figure 3, the order of item difficulty index of each aspect is analyzing, evaluating, and creating.

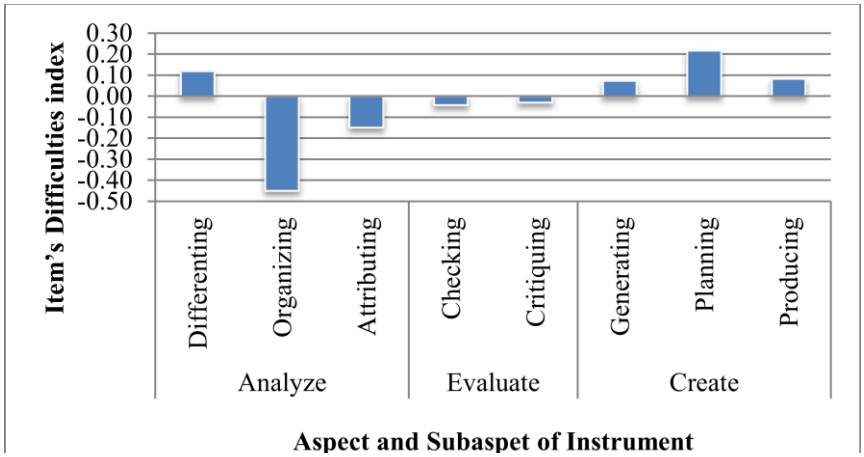

Figure 3. Item's difficulty Index of Each Aspect and Subaspect Instruments

Information Function and SEM

Based on the data analysis, it was obtained information and standard error of measurment (SEM). Based Functions information and SEM presented Figure 4, the test is suitable for the students that whose ability (θ) is high, ie $1 \leq \theta \leq 2.8$. This is consistent with the purpose of the developed instrument to measure Physics higher-order thinking skills.

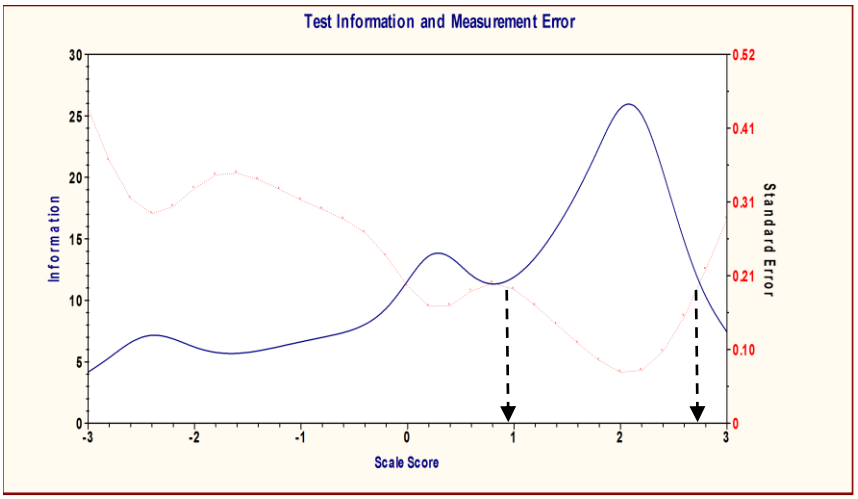

Figure 4. Information Function and SEM

Discussion

PhysETHOTS reliability is 0.75 that mean the test is good. It is said to be good, if the test has a reliability coefficient of more than 0.65 (Mchrens & Lehman (1991: 263). In addition, the information function is relatively for high ability between 1.0 to 28. This means that this instrument has high strength and reliable because it is composed of items that have high information function (Hambleton and Swaminathan, 1985: 94). Based on the reliability coefficient, the test information functions, and parameter estimation, this means PhysETHOTS

realiabel and has high stability.

Content validity of the test has been proven by expert judgment. Empirically verified the validity of the goodness of fit of the partial credit model (PCM). Based on Table 2, the average value and the standard deviation INFIT MNSQ 1.01 each (about 1) and 0.13 (about 0) , then the fit test with 1 PL PCM. This means that the test empirically valid. This is supported by all the items have a value between 0.78 INFIT MNSQ up with 1.27 which lies between the limits of receipt of the item using INFIT MNSQ or fit according to the model (between 0.77 to 1.30) means that all items fit many as 24 items of all. This is caused by several things, among others: (1) the items were developed according to the procedure correct item development instruments, (2) the items were developed from indicators derived from aspects of high order thinking skills and materials physics, (3) test which consists of 24 items that has tested the content validity by expert judgment, and (4) the respondents (students) were tested in earnest in doing because it involves supervisors of their physics teacher.

According to Hambleton & Swaminathan (1985:36), the item's difficulty index are good if they varied between 2.00 to 2.00. Items whose difficulty index of -2.00 indicates this is very easy, while the difficulty index of 2.00 means that the item is very difficult. Thus, based on the item's difficulty index the instruments (from -1.22 to 0.34) are good.

CONCLUSION AND SUGESSTION

Conclusion

Based on the analysis, the conclusions are as follows:

1. PhysETHOTS instrument was developed on junior high school students' abilities to analyze, evaluate, and create and on sub physics matter: force, Newton's law, work and energy, simple machines, pressure, vibrations and waves, sound, light, and optical instruments. The PhysETHOTS instrument is essay test that consisted of 24 items.
2. Characteristic of PhysETHOTS are:
   a. PhysETHOTS has content validity provided by expert judgment and empirical evidence has been getting fit with Partial Credit Model (PCM) based on polytomous data five categories.
   b. All items of PhysETHOTS on the criteria well as the difficulty index is in the range between 2.00 to 2.00.
   c. PhysETHOTS reliability is qualified
   d. Based on the information function and SEM, PhysETHOTS is very appropriately used to measure students' higher order thinking skills physics of 1.0 to 2.8.

Sugesstion

Based on the analysis, it are recommended:

1. Teachers can implement physics tests of high order thinking skills in junior high school.
2. Training for the development of physics test of higher order thinking skills is required for teachers.
3. Further research can be done using the data analysis by generalized partial polytomus credit model (GPCM 3PL).

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Certificate

Ref: 1643/UN34.13/PS/2014

This is to certify that

Dr. Edi Istiyono, M.Si.

has participated in

INTERNATIONAL CONFERENCE ON RESEARCH, IMPLEMENTATION, AND EDUCATION OF MATHEMATICS AND SCIENCES 2014 (ICRIEMS 2014)

organized by Faculty of Mathematics and Natural Sciences, Yogyakarta State University
on May 18-21, 2014

as a: **PRESENTER**

With the paper entitled

"THE DEVELOPMENT OF PHYSICS ESSAY TEST FOR HIGHER ORDER THINKING SKILLS IN JUNIOR HIGH SCHOOL"

Yogyakarta, May 21, 2014
Chairperson

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