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EDUCATION OF MATHEMATICS AND
SCIENCES 2014



PROCEEDING

ICRIEMS 2014

Yogyakarta, 18-20 May 2014

*Global Trends and Issues
on Mathematics and Sciences
and the Education*

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on Mathematics and Science
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Faculty of Mathematics and Natural Sciences
Yogyakarta State University

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

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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 reviewer team and already been 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.

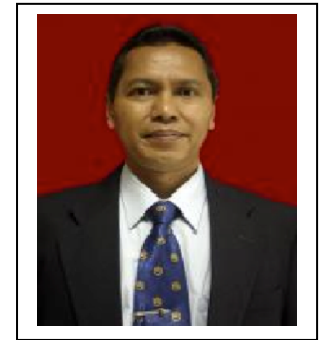
Yogyakarta, June 2014

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 anniversary of UNY; 1 among 90 academic activities dedicated to the anniversary.



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

Table of Content

	Page
Front Cover	i
Editorial Board and Reviewers	ii
Preface	iii
Forewords From The Head of Committee	iv
Forewords From The Dean of Faculty	vi
Table of Content	ix
 Plenary Session	
Using Dynamic Visual Representations To Discover Possible Solutions In Solving Real-Life Open-Ended Problems <i>Prof. Tran Vui</i>	I-1
 Parallel Session	
MATHEMATICS	
01 On Counting Sequences And Some Research Questions <i>I Nengah Suparta</i>	M-1
02 Probability Density Function of M/G/1 Queues under (0,k) Control Policies: A Special Case <i>Isnandar Slamet, Ritu Gupta, Narasimaha R. Achuthan</i>	M-11
03 C[<i>a, b</i>]-Valued Measure And Some Of Its Properties <i>Firdaus Ubaidillah , Soeparna Darmawijaya , Ch. Rini Indrati</i>	M-19
04 Applied Discriminant Analysis in Market Research <i>Hery Tri Sutanto</i>	M-27
05 Characteristic Of Group Of Matrix 3x3 Modulo P, P A Prime Number <i>Ibnu Hadi, Yudi Mahatma</i>	M-35
06 The Properties Of Group Of 3×3 Matrices Over Integers Modulo Prime Number <i>Ibnu Hadi, Yudi Mahatma</i>	M-41
07 Random Effect Model And Generalized Estimating Equations For Binary Panel Response <i>Jaka Nugraha</i>	M-47

- 08 **The Properties of Ordered Bilinear Form Semigroup
in Term of Fuzzy Quasi-Ideals** M-55
Karyati, Dhoriva Urwatul Wutsqa
- 09 **Systems Of Interval Min-Plus Linear Equations And Its Application
On Shortest Path Problem With Interval Travel Times** M-63
M. Andy Rudhito and D. Arif Budi Prasetyo
- 10 **Some Properties Of Primitive ϑ –Henstock Of Integrable Function
In Locally Compact Metric Space Of Vector Valued Function** M-71
Manuهارawati
- 11 **Learning Gauss-Jordan Elimination Using Ms Excel** M-79
Meifry Manuhutu
- 12 **Linear Matrix Inequality Based Proportional Integral Derivative
Control For High Order Plant** M-83
M. Khairudin
- 13 **Bayesian With Full Conditional Posterior Distribution Approach
For Solution Of Complex Models** M-91
Pudji Ismartini
- 14 **Optimal Control Analyze And Equilibrium Existence Of Seir
Epidemic Model With Bilinear Incidence And Time Delay In State
And Control Variables** M-97
Rubono Setiawan
- 15 **Selection Of The Best Univariate Normality Test On The Category
Of Moments Using Monte Carlo Simulation** M-103
Sugiyanto and Etik Zukhronah
- 16 **Additive Main Effect and Multiplicative Interaction on Fixed Model
of Two Factors Design** M-111
Suwardi Annas and Selfi Dian Purtanti
- 17 **Gram-Schmidt Super Orthogonalization Process For Super Linear
Algebra** M-117
Syarif Abdullah, Siti Na'imah
- 18 **Solving A System Of Fourth Order Ordinary Differential Equations
By Using Diagonalization Matrix** M-123
Tjang Daniel Chandra

- | | | |
|------------------------------|---|-------|
| 19 | A Model For Determining An Optimal Labor Contract Under Profit Sharing System
<i>Umi Mahmudah, L. Muhamad Safih</i> | M-131 |
| 20 | Application of Fourier series In Microtremor Analysis, Case Study On Disaster Risk Management Worth Mining Region In Blitar districts, East Java
<i>Yogi Wiratomo, D. Parwatiningtyas, D. Marlina, Erlin Windia</i> | M-137 |
| 21 | Application Of Neuro Fuzzy Model For Forecasting Consumer Price Index In Yogyakarta
<i>Agus Maman Abadi</i> | M-145 |
| 22 | Applicating Cvd Algorithm On Edge-Coloring Of Special Graphs
<i>Nur Insani</i> | M-151 |
| 23 | Series " H154M " As A Unit Area Of The Region Between The Lines And Curves
<i>Hisyam Hidayatullah</i> | M-157 |
| 24 | Symmetry Of Limit Cycles On A Liénard-Type Dynamical System
<i>Kus Prihantoso Krisnawan</i> | M-177 |
| MATHEMATICS EDUCATION | | |
| 01 | Connectedness Dimension Of Productive Pedagogies In Students' Understandingto Concepts Of Differential Calculus
<i>Abadi , Atik Wintarti, and Faradillah Hariyani</i> | ME-1 |
| 02 | Just Questioning in Teaching Mathematics
<i>Abdul Haris Rosyidi</i> | ME-7 |
| 03 | Problem Based And Metacognitive Learning To Improve Mathematical Reflective Thinking Skills
<i>Abdul Muin and Lia Kurniawati</i> | ME-13 |
| 04 | The Achievement of Mathematical Connection Skills Based on Cognitive Level through Means Ends Analysis (MEA) Strategy of Learning
<i>Abdul Muin, Citra Permata, Afidah</i> | ME-21 |
| 05 | Teaching Problem Solving In Mathematics Learning: Reflection From Pisa And TIMSS Results Of The Students Of Indonesia
<i>Abdul Rahman, M. Darwis M., S. Asyari, I. Kautsar Qadry</i> | ME-33 |

- 06 **Improving Senior High School Student's Mathematical Communication Abilities And Mathematical Disposition By Using Model-Eliciting Activities** ME-41
Adi Asmara
- 07 **Intoverted Primary School Students' Creativity In Mathematics Problem Solving Based On Gender Differences** ME-47
Adri Nofrianto
- 08 **The Profile Of Primary School Students' Conceptual Understanding Of Equivalent Fractions Based On Kolb's Learning Styles** ME-55
Agnita Siska Pramasyahsari
- 09 **Development of Interactive Learning Media Based Lectora Inspire in Discrete Method Course** ME-65
Alfensi Faruk
- 10 **Experimentation Stad With Ctl To Material Of Phytagoras Teorema Was Inspected From The Temperament Of Student In Class VIII SMP N 3 Pengasih Kulon Progo The Academic Year 2013/2014** ME-73
Ambar Widuri, A.A Sudjadi, Sri Adi Widodo
- 11 **Improving Mathematical Representation Skill By Using Pace Model** ME-79
Andri Suryana
- 12 **Mathematics Self-Concept And Anxiety With Different Achievement In Calculus Problem Solving** ME_85
Angga Hidayat
- 13 **The Development Of Technology Application Based Mathematics Learning Tools On Real Numbers Operations At The Vocational School Of Technology And Engineering** ME-91
Anggita Maharani
- 14 **Efforts To Improve Students' Mathematical Literacy In Mathematics Learning** ME-99
Anik Yuliani
- 15 **Practicability And Effectivity Of Koncama Model In Geometry Learning** ME-105
Asdar dan Jeranah
- 16 **The Profile Of Junior High School Students' Reasoning In Solving Mathematics Open-Ended Problem According To Reflective-Impulsive Cognitive Styles** ME-113
Ayu Faradillah

- 17 **Mental Computation Strategies By 5th Graders According To Object-Spatial-Verbal Cognitive Style** ME-121
Chusnul Khotimah Galatea
- 18 **A Comparison Of Students Self-Belief And Mathematics Achievement In The Asian Countries: Finding From The Third International Mathematics And Science Study (TIMSS)** ME-127
Desi Rahmatina
- 19 **Efforts to Improve Student Learning Ourcomes by Using Cooperative Learning Type of Student Teams Achievement Division (STAD)** ME-135
Dori Lukman Hakim
- 20 **Keeping Mathematical Assessment Process On Track** ME-143
Edy Bambang Irawan
- 21 **Enhancing the Students' Ability of Reasoning on Aspects to Formulate the Counter Example through Problem Solving Strategies** ME-149
Make an Organized List
Kadir and Muhamad Faozan Afandi
- 22 **Mathematical Communication and Problem Solving Ability of 8th Grade Students after Involving Model Eliciting Activities (MEA) Strategy** ME-157
Endang Wahyuningrum
- 23 **Developing a Teaching Kit on Pythagorean Theorem with Computer-Assisted Media** ME-165
Erni Ayda
- 24 **The Implementation Of Curriculum 2013 In The Teaching Of Mathematics And Its Effect Tostudents' mastery Of Essentialmathematics Concept In Senior High School** ME-173
Euis Eti Rohaeti
- 25 **Analyzing Mathematical Literacy Of Junior High School Students In West Sumatra** ME-179
Ahmad Fauzan
- 26 **Efforts To Improve Student Learning Outcomes And Activities With Realistic Mathematics Education (RME)** ME-187
Fina Nurmita

- 27 **Multidimensional Reliability Estimation In Instrument Of Students' Satisfaction As An Internal Costumer** ME-195
Gaguk Margono
- 28 **Improving Students' Mathematics Reasoning And Emotional Intelligence Through Meas (Model-Eliciting Activities) Instruction** ME-205
Hamidah
- 29 **Education Quality Improvement in Indonesia** ME-213
Hamzah Upu
- 30 **Constructivism Versus Cognitive Load Theory: In Search For An Effective Mathematics Teaching** ME-221
Hamzah Upu, Bustang
- 31 **Teacher Readiness In Implenting Curriculum 2013 A Case Study On Mathematics Teachers In West Nusa Tenggara Province** ME-229
Hapipi
- 32 **Internalization Of Multiplication And Division Concepts In A Neo-Piagetian Perspective** ME-237
Helti Lygia Mampouw, Agung Lukito, St. Suwarsono
- 33 **Analysis Of Students' Mathematical Self-Esteem** ME-249
Heni Pujiastuti
- 34 **The Effects Of Cooperative Learning Structures And Prior Knowledge Toward The Learning Outcomes Of Understanding And Application Of Physics Concepts For The Students Of Mathematics Education Department** ME-255
Heny Sulistyaningrum and Tanti Nawangsari
- 35 **The Identification Of Difficulties In Problems Solving Of Mathematics Teachers In Junior High School Of Nusa Tenggara Timur And Maluku Utara** ME-263
Heri Retnawati, Dhoriva Urwatul Wutsqo, Endang Listyani, Kartiko Rachman Y.P.
- 36 **Improving Students' Metaphorical Thinking Ability Of Mathematic In Senior High School Through Scientific Approach In The 2013 Curriculum** ME-275
Heris Hendriana

- 37 **Cognitive Profile Of Subject 1 About Philosophy, Principles And Characteristics Of Realistic Mathematics Education Before And After Studying The Realistic Mathematics Education Learning Resource** ME-281
Hongki Julie, St. Suwarsono, and Dwi Juniati
- 38 **Student's Difficulties In Solving Problem Of Real Analysis** ME-289
Jackson Pasini Mairing
- 39 **The Comparison Of Mathematical Understanding And Connection Through Cognitive Conflict Of Piaget And Hasweh** ME-299
Jarnawi Afgani Dahlan, Ade Rohayati
- 40 **Analyzing Students' Strategy In Pattern Generalization** ME-307
Junaidah Wildani
- 41 **Problem Solving Learning Approach Using Search, Solve, Create And Share (Sscs) Model And The Student's Mathematical Logical Thinking Skills** ME-315
Lia Kurniawati, Bunga Siti Fatimah
- 42 **Islamic Values In Mathematics Learning** ME-323
Masduki, Rita P Khotimah, Sri Sutarni
- 43 **Environment Education In Mathematics Classroom: As An Effort To Develop The Critical Thinking Skills And For Environmental Sustainability Concerning** ME-331
Mhmd Habibi
- 44 **The Influence Of Pmri To Develop Mathematical Communication Skills Fourth Grade Students Of SDN 01 Koto Timur** ME-341
Mira Amelia Amri, Novyta
- 45 **Learning Model Experimentation Of Think Pair Share (TPS) Of Assessment For Learning (AFI) Based Through Peer Assessment On The Linear Programming Subject** ME-349
Muhammad Noor Kholid
- 46 **Learning Model Experimentation Of Student Team Achievement Division (STAD) And Think Pair Share (TPS) Of Assessment For Learning (AFI) Based** ME-355
Muhammad Noor Kholid, Yoga Muh. Muklis, Ummi Khasanah

- 47 **The Profile Of Teacher' Questions On Mathematics Lessons In Ix Class Students With Visual Impairment SMPLB YKAB Surakarta** ME-363
Naning Sutriningsih, Suherman, Siti Khoiriyah
- 48 **The Profile Of Students' Lateral Thinking In Solving Mathematics Open-Ended Problem In Terms Of Learning Style Differences** ME-369
Nicky Dwi Puspaningtyas
- 49 **Students' Ability Of Smp To Solve Problems Mathematiclly Creative Thinking** ME-375
Nila Kesumawati
- 50 **Some Attempts To Improve The Quality Of Teaching-Learning Processes Of Engineering Mathematics** ME-383
Nur Kholis
- 51 **The Process of Deductive Thinking at 8th Grade Students with High Math Skill in Completing Geometric Proof** ME-391
Pipit Firmanti
- 52 **Analysis Of Mathematics Teaching Based On The Students Characteristics** ME-399
Rina Oktaviyanthi
- 53 **The Construction Of The Early-Childhood Teachers' Creative Process Assessment** ME-409
Risky Setiawan
- 54 **Micro Teaching And Self Efficacy Toward Mathematics Students In Mathematics Program Of FKIP UMB** ME-419
Risnanosanti
- 55 **The Development Of Realistic Mathematics Education-Based Blog At Linear Algebra Course In UIN Suska Riau** ME-427
Risnawati, Annisa Kurniati, Elviza Regita
- 56 **The Effect Of Problem Based Instruction (PBI) Learning With Using Aptitude Treatment Interaction (ATI) Approach Towards Math Problem Solving Ability** ME-433
Risnawati
- 57 **Implementation Of Cooperative Learning With Talking Chips Technique On Solids Material** ME-439
Rizky Oktaviana E.P.

- 58 **The Implementation Of Contextual Mini Laboratory Approach To Improve The Mathematical Understanding Of Students In Marginal School Palm Plantation Area Koto Gasib Subdistric, Siak Regency** ME-445
Shatta Saragih
- 59 **Tangram Game Activities, Helping The Students Difficulty In Understanding The Concept Of Area Conservation Paper Title** ME-453
Shofan Fiangga
- 60 **Proving Process And Types Of Proof** ME-461
Silvia Dwi Anggraini
- 61 **Error Analysis Of Guardians Student In Understanding The Problem Of Divergence** ME-467
Sri Adi Widodo
- 62 **High Order Thingking Skills And Self Regulated Learning Of Junior High School Student In Bandar Lampung City** ME-473
Sri Hastuti Noer
- 63 **Cognitive Processes of Elementary School Students in Mathematical Investigation based on Gender Difference** ME-479
Sri Subarinah, I Ketut Budayasa, Agung Lukito
- 64 **The Development Of A Virtual Mathematics Teaching Aid Based On Cognitive Load Theory** ME-487
Sugiman, R. Rosnawati, Endah Retnowati, Ilham Rizkianto
- 65 **Conjecturing Via Analogical Reasoning to Explore Critical Thinking** ME-495
Supratman
- 66 **Developing Teacher Performances to Improving Students Creative Thinking Capabilities in Mathematics** ME-509
Tatag Yuli Eko Siswono
- 67 **Bilingual in Calculus Class,Introducing Strategy to Conduct Bilingual Classroom in Mathematics** ME-517
Tutuk Narfanti
- 68 **The Profile Of Students' Metacognition In Learning Through Realistic Mathematics Education** ME-525
Usman Mulbar

- 69 **The Implementation Of Meas Instruction To Students' Mathematics Problem Solving And Connecting Ability** ME-535
Wahyu Hidayat
- 70 **Design Of Mathematic Learning Based On Cognitive Style** ME-543
Warli, Mu'jizatin Fadiana
- 71 **The Use Of Local Context In Designing Learning Activities For Mathematics Teaching In Elementary School** ME-553
Yenita Roza, Syarifah Nur Siregar, Titi Solfitri
- 72 **The Influence of Blended Learning, Learning Styles Against Understanding Math Concepts** ME-561
Yunia Mulyani Azis & Sussy Susanti
- 73 **The Development Of Digital Assessment Bloom As Assessment Tools In Junior High School** ME-571
Yurizka Melia Sari
- 74 **Student Perceptions, Principal Assesment, And Observations Of Teacher Performance** ME-577
Zetriuslita, Gadis Arniyati Athar
- 75 **An Analysis Of Difficulties On Mathematical Model Interpretation Of Junior High School Students On The Materials Of Two-Variable Linear Equation System** ME-583
Didi Suhaedi, Tia Purniati
- 76 **The Metacognitive Reflection Ability To Arrange The Strategy of Mathematical Problem Solving** ME-589
Georgina Maria Tinungki
- PHYSICS**
- 01 **Analysis and Synthesis of Sound of Gong Ageng of Kagungan Dalem Gongso Kanjeng Kyai Guntur Sari** P-1
Ahmad Fauji, Agus Purwanto
- 02 **Power Spectrum of Large Gong (Gong Ageng) Kagungan Dalem Gongso Kanjeng Kyai Guntur Sari** P-7
Dhara Nurani, Agus Purwanto, Sumarna
- 03 **Computation to Obtain the Spread Out Bragg Peak (SOBP) for Proton Radiotherapy on Model of Thyroid Cancer** P-13
Eko Sulistya, Kusminarto, Arief Hermanto

- 04 **Modeling of Reactive Magnetron Sputtering in Tialn Film Deposition: Analysis of Pump Speed and Target Current Effect** P-19
Esmar Budi
- 05 **Young Lunar Crescent Visibility Prediction on Telescopic-Based Visual Observation** P-29
Judhistira Aria Utama
- 06 **“Joko Tingkir” for Decision Making on Real Time Tsunami Warning System** P-33
Madlazim, Supriyono, Masturyono, Thomas Hardy, Karyono
- 07 **The Study of Harmony on Triad Key C in C Major** P-39
Mega Rusitha, Agus Purwanto
- 08 **The Effect of Reducing Na₂O and Increasing PbO on Optical and Physical Properties of TZPBN:Er Glasses** P-45
M. N. R. Jauhariyah, Ahmad Marzuki, Cari
- 09 **QCL Based Integrated Cavity Output Spectroscopy for Gas Detection** P-55
R. Widiatmono, J. Mandon, F.J.M. Harren, Kusminarto, M.A.J. Wasono, Mitrayana
- 10 **The Development of Titania Solar Cells by Insertion of Conductive Material as an Alternative Third Generation Solar Cells** P-65
Rita Prasetyowati
- 11 **The Patterns of The Sound Intensity Distribution of Midrange Loudspeaker** P-69
Septiana Nur Laely, Agus Purwanto
- 12 **Analysis of Waste Sand at Diamonds Mining Cempaka Banjarbaru** P-75
Mustika Wati, Sri Hartini
- 13 **Simulation on Power Spectrum Density (PSD) of an Optically Trapped Particle** P-79
Sugeng Riyanto, Shahrul Kadri Ayop, Wan Nor Suhaila Wan Aziz
- 14 **Re-evaluation of Hilaal Visibility Criteria in Indonesia by Using Indonesia and International Observational Data** P-87
T. B. Ramadhan, T. Djamaluddin, J. A. Utama
- 15 **The Development of Universal Mass Balance** P-93
Wan Nor Suhaila Wan Aziz, Shahrul Kadri Ayop, Mohamad Azrul Amat, Mohd Helmy Hashim, Rosly Jaafar

- 16 **Testing Microcrystalline Celulose using Spectrometer and Polarized Light Microscope** P-99
Harsojo, Dedi Mardiansyah, Harini Sosiati
- 17 **An Example of System Which Can Be Used to Explicitly Show The Symmetry Between the Electric and Magnetic Fields** P-107
Arief Hermanto
- 18 **The Effect of Tellurium Atomic Fraction On The Crystal Structure And Chemical Composition of Pb (Se_{1-X}, Te_X) Semiconductor Materials Prepared Using Bridgman Technique** P-113
Ariswan and Denny Darmawan

PHYSICS EDUCATION

- 01 **The effectiveness Using of Contextual Teaching Material Integrating Mathematics, Natural Science, Disasters and Character Base on ICT in Physics Learning High School Grade XI** PE-1
Akmam, Harman A, Asrizal, Dea. S, Widya. F
- 02 **Improving The Result of Physics Study of The students on Particle Dynamics Topic by Using Contextual Teaching and Learning (Classroom Action Research at class X Science 2 at Public High School (SMAN 68) Jakarta-Indonesia)** PE-13
Anida Nurafifah, Slamet Siswoyo, Vina Serevina
- 03 **Efforts to Improve the Students Learning Outcomes at Particle Dynamic Topic by Using Inquiry Method, Constructivism and Learning Community in class X 5 SMAN 68 Jakarta** PE-23
Annisa Nor Fitria, Hasan, Vina Serevina
- 04 **Development of Blended Learning Model for Improving Students Competence in the Engineering Physics Learning** PE-35
Usmeldi
- 05 **Development of Teaching Aid of Electrometer in Physics Learning** PE-45
Dr. Esmar Budi, M.Si, Hadi Nasbey, S.Pd, M.Si, Dio Sudiarto
- 06 **Development Of An Android Application In The Form Of A Simulation Lab To Explain Properties Of An Ideal Gas** PE-49
A.Nugraha
- 07 **Treating Fourier series as vector: a concept simplification for teaching Fourier series** PE-59
Johannes V.D. Wirjawan

- 08 **Mapping of Profesional, Pedagogical, Social, and Personal Competence of Senior High School Physics Teachers in Yogyakarta Special Region** PE-65
Jumadi, Zuhdan Kun Prasetyo, Insih Wilujeng
- 09 **The Development of Physics Based on Problem Based Learning for Gifted-Talented Students at Islamic Senior High School of Amanatul Ummah Grade XI** PE-77
Mukhayyarotin Niswati Rodliyatul Jauhariyah, Sarwanto, Suparmi
- 10 **Reasoning-Based Diagnostic Test to Identify Learning Difficulties and Misconceptions of Work and Energy Among Senior High School Students** PE-89
Mundilarto, Zuhdan Kun Prasetya, Suyoso, Wiwi Diah Ratnasari
- 11 **Improving The Result of Physics Study of The Students on Circular Motion Topic by Using Project Based Learning (Classroom Action Research at class X Science 3 at Public High School (SMAN 68) Jakarta-Indonesia)** PE-97
Umi Nurhasanah, Herwin Sinaga, Vina Serevina
- 12 **Student's Self-Confidence to Understanding The Physics Concepts Through Computer Simulation Animation** PE-107
Wahyu Hari Kristiyanto, Prabowo, Soeparman Kardi
- 13 **The Comparation Study of Laboratory Experiment and Computer Simulation Methods in Increasing Students' Cognitive Achievement and Science Process Skills on The Topic of Linear Motion** PE-113
Yosaphat Sumardi, Dyah Uswatun Khasanah, Titin Marseta Dyah Utami, Novia Istikhomah
- 14 **The Development of Physics Essay Test for Higher Order Thinking Skills in Junior High School** PE-121
Edi Istiyono
- 15 **Performance of Diploma of Science Students at Upsi in Force Concept Inventory** PE-129
Nur Solehah Rahim and Shahrul Kadri Ayop
- 16 **The Estimation of Inquiry Performance Test Items of High School Physics Subject with Quest Program** PE-137
Supahar
- 17 **Analyzing Physics Items of UN, TIMSS, and PISA Based on Higher-Order Thingking and Scientific Literacy** PE-147
Wasis

- 18 **Improving The Student Learning Outcomes of Physics Subject at Circular Motion Topic by Using discovery Method (Classroom Action Research at class ten (X-1) at Public High School (SMAN 68) Jakarta-Indonesia)** PE-155
Muhammad Elizar Utomo, Heny Kuspianto, Vina Serevina
- 19 **The Measurement of Lecturers' Teaching Quality and Academic Atmosphere in International Class Program of FMIPA UNM Makassar** PE-167
Kaharuddin Arafah
- 20 **Increasing Student's Attention In Physics Learning With Computer Interactive Enhancing Attention of Physics Student Learning of Interactive Computer Help with Instruction-Assisted** PE-175
Festiyed
- 21 **Development of Evaluation Model of Physics Experiment Exam for Secondary Level** PE-182
Setiya Utari, Harun Imansyah, Winny Liliawati, Arif Hidayat

BIOLOGY

- 01 **Scale Morphology of Cuning Fish (*Caesio Cuning* Bloch, 1971) (Caesionidae) Using Dekstop Scanning Electron Microscope** B-1
Abdul Razak
- 02 **Growth of Local Rice Genotypes Planted Center Paddy Production in West Sumatera** B-11
Azwir Anhar
- 03 **Optimization of PCR Conditions for Amplify Microsatellite Loci in Cotton (*Gossypium Hirsutum*) DNA** B-21
Dede Nuraida
- 04 **Factors Associated with Higher Uptake for HIV Testing among Indirect Female Sex Workers (FSWs) in Yogyakarta Indonesia** B-27
Dhesi Ari Astuti
- 05 **Recent Development Of Carotenoids Encapsulation Technology** B-33
Dian Marlina
- 06 **Antimicrobial Activity of Extracelullar Protein from Six Isolates of Thermophilic Bacteria** B-41
Evy Yulianti
- 07 **The Impact of Circumcision Towards Women** B-51
Farida Kartini

- 08 **Pseudomonad Fluorescent Preservation Using Tapioca and Rice Flour Carrier and The Addition of Glycerol Stabilizer** B-61
Linda Advinda
- 09 **Inhibitory Power Test Medicinal Plants Against Methicillin Resistant Bacterial Growth Strains of Staphylococcus Aureus (MRSA)** B-67
Mades Fifendy
- 10 **Microalgae Biomass Production and Nitrate Removal from Landfill Leachate** B-73
Norjan Yusof
- 11 **The Effect of Skim Milk Addition in Cep-2 Diluent on Motility and Viability of Limousin Bull Sperm during Storage at Refrigerator** B-83
Nur Ducha
- 12 **Cage Temperature in Relation to The Width of Beak Opening of Gelatik Jawa (*Padda oryzivora*)** B-89
Nur Kuswanti
- 13 **Feasible Options to Reduce Greenhouse Gases Emission From Agriculture and Its Effect to Microbial Communities in Indonesia** B-95
Oslan Jumadi
- 14 **Morphogenetic Effects of Several Plant Growth Regulators (PGR) on In Vitro Development of Binahong (*Anredera cordifolia* L.) Leaf** B-103
Paramita Cahyaningrum Kuswandi
- 15 **Composition and Structure of Mangrove Associates Vegetation in Kwandang Coastal Area North Gorontalo Region and Mananggu Coastal Area Boalemo Region** B-109
Abubakar Sidik Katili
- 16 **Inventory The Waterbird Species which Accumulate Mercury from Mining Waste in Coastal Area North Gorontalo Regency, Indonesia** B-117
Ramli Utina
- 17 **Regeneration in Vertebrates : A Research Model to Study Angiogenesis** B-127
Rizka Apriani Putri
- 18 **Cellular Distributions of Chloride and Hidrogen Peroxide In Mesophyll and Bundle Sheath Cells of Maize Exposed to Salinity Stress** B-133

Rusdi Hasan

- 19 **Turgo Society's Environment Wisdom in Managing Natural Resources and Environment** B-143
Suhartini
- 20 **Menstrual Cycle and History of Infectious Diseases Related to Anemia in Adolescent Women** B-151
Sulistyaningsih
- 21 **Swiftlet Bird (*Aerodramus fuciphagus*) Affinity Analysis in Java and Kalimantan Based on Morphometry** B-159
Sunu Kuntjoro
- 22 **Phytochemical Analysis of Manggong Bamboo Leaf Extract** B-165
Supriyatin
- 23 **Cadmium and Lead Content in Aquatic Ecosystem, Brackiswater Ponds and Fish in Areas Affected LAPINDO Mud** B-169
Tarzan Purnomo
- 24 **Epyphitic Cyanobacteria on Pneumatophore *Avicennia marina* in Mangrove Ecosystem of Cagar Alam Pulau Dua (CAPD) Serang, Banten** B-177
Tika Khusnul Fatimahsari
- 25 **Contens of Phenolic Compounds of *Pluchea Indica* Leaves Extract from Some Altitude Habitat** B-183
Yuliani
- 26 **Follicle Stimulating Hormone Receptor Ser680asn Polymorphism in Women with Polycystic Ovary** B-189
Yuni Ahda
- 27 **The Role of Mychorhizae, Rhizobium, and Phosphate Soluble Bacteria to Increase Plant Tolerance Grown on High Saline Soil** B-195
Yuni Sri Rahayu

BIOLOGY EDUCATION

- | | | |
|----|--|-------|
| 01 | The Development of Inquiry Based Vertebrate Zoology Practicum Guidance to Increase Cognitive and Skill Process of Biology Students
<i>Andi Asmawati Azis</i> | BE-1 |
| 02 | The Relationship Between Teachers' Attitude of Sex Education among Adolescents and the Implementation of Sex Education at School
<i>Anjarwati</i> | BE-9 |
| 03 | The Comparison of Water Management Knowledge and Water Conservation Attitude on Farmers at Gunung Kidul Regency
<i>Diana Vivanti</i> | BE-19 |
| 04 | Development of Project-Based Worksheets of Pharmacognosy to Train Critical and Creative Thinking in Biology Students
<i>Evie Ratnasari</i> | BE-27 |
| 05 | Improving Communication Ability and Learning Achievement in Biology Learning Strategy Using Jigsaw
<i>Fitri Arsih</i> | BE-35 |
| 06 | Implication Of Problem Based Instruction (PBI) Toward Student's Ability in Solving of Environmental Pollution Problems
<i>Iis Sugiati</i> | BE-43 |
| 07 | Efforts to Promote Critical Thinking through Cooperative Learning Type Think Talk Write Assignment Based on Basic Genetics
<i>Imas Cintamulya</i> | BE-51 |
| 08 | Related Knowledge Of Diarrhea In Infants With ASI Exclusive Breastfeeding Behavior In West Java
<i>Mia Nurkanti</i> | BE-57 |
| 09 | Correlation Analysis Between Discriminancy Power and Validity of Item Tests
<i>Muhyiatul Fadilah</i> | BE-63 |
| 10 | Development and Validation of Physical Classroom Learning Environment Instrument (PCLI) for Secondary School in Malaysia
<i>Nurul Jannah Binti Amirul</i> | BE-69 |

- | | | |
|----|--|--------|
| 11 | Increasing Student's Activities and Learning Achievement in General Biology Course Using Reading, Questioning, and Answering Method
<i>Rahmawati D</i> | BE-77 |
| 12 | Learning Activators to Energize Self-Study Using Computer-Assisted Module (CAM)
<i>Shakinaz Desa</i> | BE-83 |
| 13 | Web Based Learning Media Development in Cardiovascular System Human Anatomy and Physiology Subject
<i>Sri Rahayu</i> | BE-91 |
| 14 | Factors That Influence The Effectiveness of Process and Result Research in Students' Accomplishment
<i>Suciati</i> | BE-97 |
| 15 | Inculcating Awareness on Biodiversity Using Project-Based Learning
<i>Syakirah Samsudin</i> | BE-103 |
| 16 | Environmental Care Attitude Formation in Biology Student Programming Environmental Science Course Method Through Project Task Method
<i>Winarsih</i> | BE-111 |
| 17 | The Implication of Islamic Character Education and Minangkabau Culture to Biological Learning Achivement
<i>Yosi Laila Rahmi</i> | BE-119 |
| 18 | Developing Learning Outcome Based on The Indonesian Qualification Framework Level Six for Biology Education
<i>Zuhdan Kun Prasetyo</i> | BE-127 |
| 19 | Analysis of Student's Misconceptions on Basic Science Concept Through CRI (Certainly of Response Index), Clinical Interview and Concepts Map
<i>Zulfiani</i> | BE-135 |
| 20 | Increasing ISTE Program Student's Activities Using Video on Writing and Retelling
<i>Zulyusri</i> | BE-147 |
| 21 | The Development of Teaching Material Internalization Models on Topic Human Reproductive System Tocultivate Moral Sensitivity And Discipline
<i>Raharjo</i> | BE-155 |

CHEMISTRY

- 01 **The Effects Of Micro- And Nanohydroxyapatite Application In Metal Contaminated Soil On Metal Accumulation In Ipomoea Aquatica And Soil Metal Bioavailability** C-1
Azlan Kamari, Norjan Yusuf, Che Fauziah Ishak, Esther Phillip, and Galuh Yuliani
- 02 **Chromium Extraction from Soil by Using Green Mustard (*Brassica juncea*)** C-9
Tri Santoso, Baharuddin Hamzah, Irwan Said, Ririen Hardani
- 03 **Biosorption of Technical Direct Dyes by Activated Sludge** C-17
Dewi Yuanita Lestari and Endang Widjajanti LFX
- 04 **Effect Activation of Chemical and Physical to Structure and Activated Carbon Quality from Charcoal Obtained Bypyrolysis of Coconut Shell** C-23
Djefry Tani, Bambang Setiaji, Wega Trisunaryanti, Akhmad Syoufian
- 05 **Effects of Calcination Temperatures on Synthesis of LiMn_2O_4 by Polymer Matrix-Based Alkaline Deposition Method** C-35
Dyah Purwaningsih, Hari Sutrisno, Dewi Yuanita Lestari
- 06 **Silver Nanoparticle Impregnated on The Composite of Bacterial Cellulose-Chitosan-Glycerol as Antibacterial Material** C-43
Eli Rohaeti, Endang Widjajanti LFX, and Anna Rakhmawati
- 07 **Determination of Glycemic Score of Processed Food from Whole Wheat (*Triticum aestivum* L.) Flour Dewata's Variety in Terms of Amylose Content and Starch Digestibility** C-55
Febrine Pentadini, Silvia Andini, Sri Hartini, Anik Tri Haryani
- 08 **Characterization of Quinoline and Quinoline Conjugated Metal as The Base Material of Photodetector** C-63
I Gusti Made Sanjaya, Dian Novita and Aldo Swaztyznt Saputra
- 09 **Study On Population Of From *D. Melanogaster* Katul Media Fermented *Sacharomyces Cerevisae* As Swiflet Woof** C-71
Ignatius R. S. Santoso
- 10 **Preparation and Mechanistic Study of ZnO/Zeolite as Catalyst in 1-Pentanol Dehydration** C-79
Is Fatimah

- 11 **Effect of Pyrolysis Temperature and Distillation on Character of Coconut Shell Liquid Smoke** C-87
Johny Zeth Lombok, Bambang Setiaji, Wega Trisunaryanti, Karna Wijaya
- 12 **Characterization Chemical Compound Based Pyrolysis Process from Cacao Wastes** C-97
Mohammad Wijaya.M
- 13 **Preparation and Characterization of Poly(ϵ -Caprolactone) Microparticle Blends Containing Propranolol HCl and Carbamazepine** C-103
Muhaimin, Burkhard Dickenhorst, Roland Bodmeier
- 14 **Production and Characterization of Anti Fim-C *Salmonella typhi* Native Protein Antibody in Ddy Mice** C-111
Muktiningsih Nurjayadi, Umar Hasan, Dea Apriyani, Fera Kurnia Dewi, Irma Ratna Kartika, Fernita Puspasari, Dessy Natalia
- 15 **Synthesis of Star Poly(4-Vinylpyridine) Architecture by Nitroxide Mediated Polymerisation** C-119
Nurulsaidah Abdul Rahim, Fabrice Audouin, Johannes G Vos, Andrea Heise
- 16 **Antifungal Potential Test of Glycoside Compound from Root Woolf of *Pterospermum subpeltatum* C. B. ROB** C-127
Pince Salempa, Alfian Noor, Nunuk Hariani, Sudding, Muharram
- 17 **Test Method Verification of Fe and SiO₂ in Industrial Water by Uv-Vis Spectrophotometry at Pt Krakatau Steel** C-133
Reni Banowati Istiningrum, Intan Permatasari, Idrus Bambang Iryanto
- 18 **Chalcones: The Promising Compounds to Provide New Ways for Cancer Treatment** C-141
Retno Arianingrum
- 19 **Electrocoagulation of Detergent Wastewater Using Aluminium Wire Netting Electrode (Awne)** C-151
Riyanto and Afifah Hidayatillah
- 20 **Characterization K₃PO₄/NaZSM-5 Using Xrd and Ftir as a Catalyst to Produce Biodiesel** C-159
Samik, Ratna Edianti, and Didik Prasetyoko

- 21 **Adsorption Rate Constant and Capacities of Lead(Ii) Removal from Synthetic Wastewater Using Chitosan Silica** C-165
Sari Edi Cahyaningrum and Dina kartika
- 22 **Intervention Effect of Liquid Smoke of Pyrolysis Result of Coconut Shell on Profile of pH Fillet of *Lates Calcarifer*** C-171
Sofia Satriani Krisen, Bambang Setiaji, Wega Trisunaryanti, Harno Dwi Pranowo
- 23 **Phytochemical of *Kaempferia* Plant and Bioprospecting for Cancer Treatment** C-179
Sri Atun
- 24 **Study of Acid Catalysis for Condensationof 4-Hydroxybenzaldehyde With Acetone** C-187
Sri Handayani
- 25 **Isolation and Identification Secondary Metabolites Compound Ethyl Acetate : N-Hexane (4 : 6) Fraction of Gulma Siam Leaves (*Chromolaena odorata* L.)** C-195
Sudding
- 26 **Review of Applications Nanoparticles of TiO₂ and ZnO in Sunscreen** C-203
Sulistiyani
- 27 **A QM/MM Simulation Method Applied to The Solution of Zr⁴⁺ in Liquid Ammonia** C-213
Suwardi, Harno D. Pranowo dan Ria Armunanto
- 28 **Comparative Study of Methods in The Synthesis of Magnetite (Fe₃O₄)** C-221
Suyanta, Eko Sri Kunarti, Muhamad Muzakir, Citra Pertiwi and Dian Pertiwi
- 29 **Chemical Constituents of Indonesian Silver Fern (*Pityrogramma calomelanos*) and Their Citotoxicity** C-229
Suyatno, Nurul Hidajati, Khoriyah Umami, and Ika Purnama Sari
- 30 **Chitosan and N-ALKYL Chitosan as A Heterogeneous Base Catalyst in The Transesterification Reaction of Used Cooking Oil** C-237
Tatang Shabur Julianto and Restu Ayu Mumpuni
- 31 **Study on Growth of Carbon Crystal from Charcoal Obtained by Pyrolysis of Coconut Shell** C-243
Meytij Jeanne Rampe, Bambang Setiaji, Wega Trisunaryanti, Triyono

- 32 **Phenolic Compounds from Chloroform Extract of *Xylocarpus Moluccensis* Stem Bark (Meliaceae)** C-251
Tukiran, Nurul Hidayati, Nurul Aini, and Yunita Dwi Setyorahayu
- 33 **Preparation of Chitin from Shrimp Shells by Papain Latex (*Carica Papaya*)** C-259
Yuli Rohyami, Reni Banowati Istiningrum, Ida Sulistyanningrum
- 34 **Characterization of Cu(Ii) Complexes of 4-Methylbenzenesulfonylhydrazone and The Potential as Reagent for Phenolic Compound Detection** C-267
Yusnita Juahir, Norlaili Abu Bakar, Wan Rusmawati Wan Mahamod, Saripah Salbiah Syed Abdul Azziz, Rozita Yahaya, Wong Chee Fah

CHEMISTRY EDUCATION

- 01 **A Brief Review of The Complexities of Teaching and Learning Chemical Equilibrium With Specific Reference to Malaysia** CE-1
A.L. Chandrasegaran, David F. Treagust, Mauro Mocerino, Mihye Won & Mageswary Karpudewan
- 02 **The 1st Year Chemistry Undergraduate Students' Understanding in Naming Simple Compounds** CE-9
Habiddin
- 03 **The Use of Hybrid Multimodal Learning on Chemistry at Senior High School to Improve Students' Motivation** CE-19
Hesty Parbuntari and Jaslin Ikhsan
- 04 **The Use of Ict-Based Media in Web-Based Collaborative Assistance of Hybrid Learning on Chemical Kinetic to Improve Students' Academic Performance** CE-27
Jaslin Ikhsan
- 05 **Development of Online Learning using Moodle Version 2.5.3 (Case Study at Secondary Schools, Jakarta)** CE-39
Maria Paristiowati and Amanda Franciska
- 06 **Improving The Learning Process of Polifunctional Compound Topic by Using Jigsaw Cooperative Learning with Multi Learning Resources** CE-47
Mitarlis, Sri Hidayati Syarief, Nurul Hidayati, Suyatno and Tukiran

- 07 **Implementation of Jigsaw Model with Lesson-Study-Based on Strategy And Method of Chemistry Instruction Subject (Smpk)** CE-55
Muhammad Danial
- 08 **The Influence of Constructivism Approach in Direct Learning Towards Students' Metacognitive Awareness and Learning Outcomes in The Topic of Solubility and Solubility Product** CE-63
Muharram, St. Hayatun Nur Abu, and Jusniar
- 09 **The Use of Web-Based Assistance in Multimodal Chemistry Learning at Senior High School to Improve Students' Motivation** CE-71
Nuke Ajeng Prabawati and Jaslin Ikhsan
- 10 **The Development of Inorganic Chemistry Learning Model Based on Portfolio Assessment** CE-79
Ramlawati and Melati Masri
- 11 **The Development of Android Mobile Game as Senior High School Learning Media on Rate Reaction and Chemical Equilibrium** CE-85
Resti Yektyastuti, Jaslin Ikhsan2, Rr. Lis Permana Sari
- 12 **Implementation of Guided-Inquiry to Promote Students' Metacognitive Self Regulation in Xi Grade** CE-91
Rusly Hidayah, Fitria Dwi Lestari
- 13 **Improving Students' Critical Thinking and Character Skill Through Chemsistry Lecture** CE-97
Sri Poedjiastoeti
- 14 **Misconception Prevention of Senior High School Students on Chemistry Concepts Using Several Inquiry-Based Learning Models** CE-105
Suyono
- 15 **The Development of Android-Based Mobile Learning Media as Chemistry Learning for Senior High School on Acid Base, Buffer Solution, and Salt Hydrolysis** CE-113
Yogo Dwi Prasetyo, Jaslin Ikhsan, and Rr. Lis Permana Sari
- 16 **Engaging Students in Social Emotional Learning: The Role of Dilemma Stories in Chemistry Learning** CE-123
Yuli Rahmawati, Nurbaity, and Marheni

SCIENCE EDUCATION

- 01 **Influence of Frequency Natural Grasshoppers Sound to Leaf Chlorophyll Content Teak (*Tectona grandis*) and Peanut (*Arachis hypogaea*) as Natural Science Learning Resources** S-1
Asri Widowati, Juli Astono, Agus Purwanto
- 02 **The Efforts To Improve Teacher Ability Of State Elementary School Jetis 1 Of Yogyakarta In Developing A Scientific Writing Through A Collaborative Approach** S-9
Astuti Wijayanti, Aris Munandar
- 03 **The Development Of “Cerdas” Learning Model Based On Gardner’s Theory Of Multiple Intelligences In Natural Science** S-23
Atiek Winarti
- 04 **Integrated Science Smp/Mts Based On The Local Potential In Yogyakarta Special District** S-33
Insih Wilujeng
- 05 **An Effective Curriculum Units For Running Inquiry Based Science Learning Activities In Schools: A Success Story** S-41
Kandi
- 06 **The Identification Of Multiple Intelligences Of 8th Grade Students Of Junior High School** S-51
Kartika Gita Septiana¹, Jaslin Ikhsan²
- 07 **Learning Science Oriented Pedagogy For Sustainability To Build The Concern For The Environment** S-59
Susilowati
- 08 **The Impact Of Structured Designed Multimedia And Commercial Learning Media Towards The Learning Outcomes Of Student Who Have Low Motor Ability In Learning Breastroke Swimming Technique** S-65
Syahrastani
- 09 **Effect Of Globalization On Learning Science In The District Smpn Of Bantul** S-71
Yuni Wibowo , Asri Widowati , Purwanthy Widhi H.
- 10 **Contributions Of The Certification Aspects To The Performances Of Natural Science Teachers In Junior High Schools In The Regency Of Hulu Sungai Selatan, The Province Of Kalimantan Selatan** S-85
Syubhan Annur

- 11 **Project Approach In Science: An Exploratory Case Study**
Mohd Halim Marzuki and Sophia Md Yassin S-89
- 12 **Assessment Of Tofu Carbon Footprint In Banyumas, Indonesia -
Towards 'Greener' Tofu** S-97
Sidharta Sahirman, Ardiansyah

**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 40th 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-order 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 writing of items based on the principles of HOTS 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.

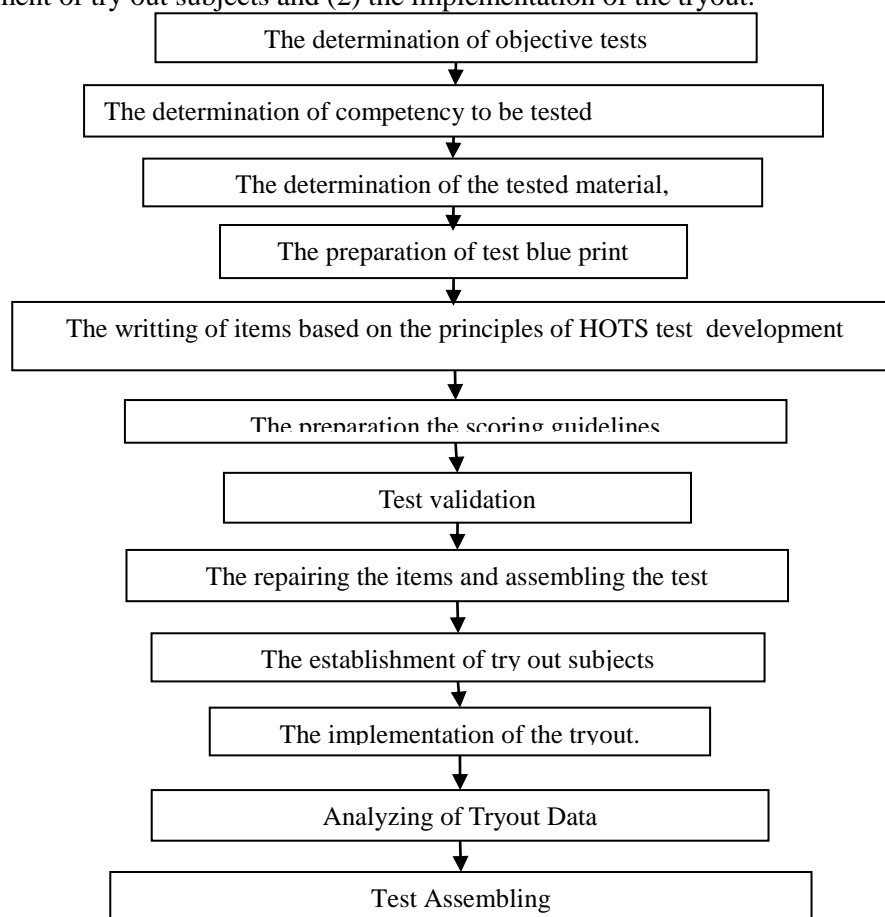


Figure 1. Steps of The Instrumen Development

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.

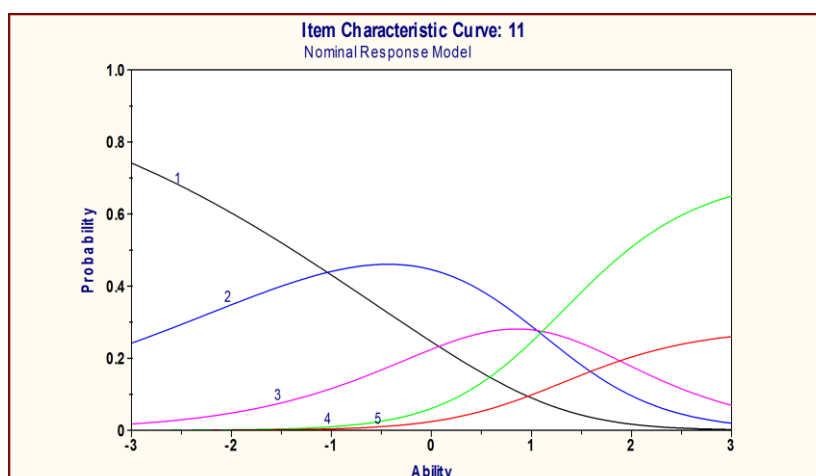


Figure 2. Item Characteristic Curve 11

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.

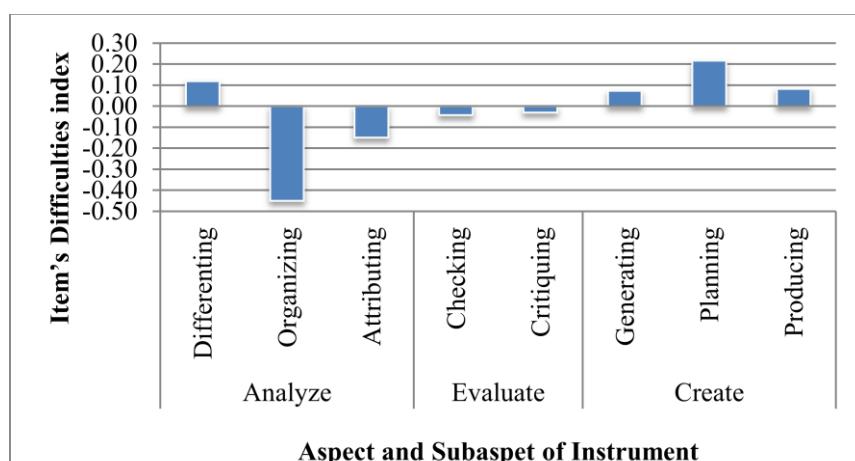


Figure 3. Item's difficulty Index of Each Aspect and Subaspet Instruments

Information Function and SEM

Based on the data analysis, it was obtained information and standard error of measurement (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.

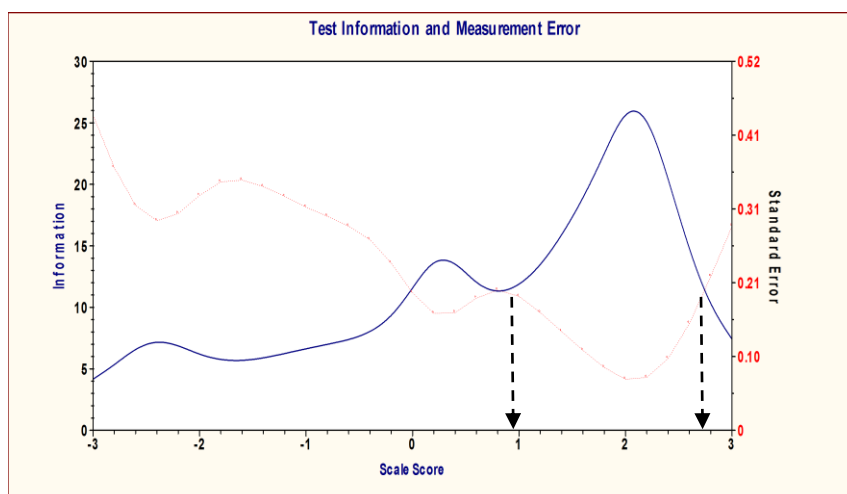


Figure 4. Information Function and SEM

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

reliabel 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



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(ICRIEMS 2014)**

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as a: **PRESENTER**

With the paper entitled

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

Rector,



Prof. Dr. Rochmat Wahab, M.Pd., M.A.

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Yogyakarta, May 21, 2014
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