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RESEARCH, IMPLEMENTATION AND
EDUCATION OF MATHEMATICS AND
SCIENCES 2014



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ICRIEMS 2014

Yogyakarta, 18-20 May 2014

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

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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.

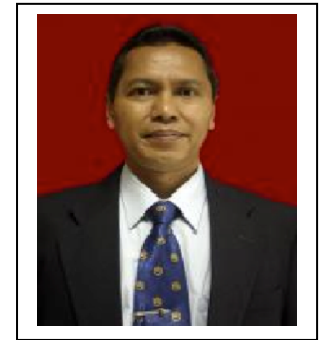
Yogyakarta, June 2014

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 vulnerable. 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

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

- | | | |
|----|---|-------|
| 19 | A Model For Determining An Optimal Labor Contract Under Profit Sharing System
<i>Umi Mahmudah, L. Muhamad Safiih</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
<i>Adi Asmara</i> | ME-41 |
| 07 | Intoverted Primary School Students' Creativity In Mathematics Problem Solving Based On Gender Differences
<i>Adri Nofrianto</i> | ME-47 |
| 08 | The Profile Of Primary School Students' Conceptual Understanding Of Equivalent Fractions Based On Kolb's Learning Styles
<i>Agnita Siska Pramasdyahsari</i> | ME-55 |
| 09 | Development of Interactive Learning Media Based Lectora Inspire in Discrete Method Course
<i>Alfensi Faruk</i> | ME-65 |
| 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
<i>Ambar Widuri, A.A Sudjadi, Sri Adi Widodo</i> | ME-73 |
| 11 | Improving Mathematical Representation Skill By Using Pace Model
<i>Andri Suryana</i> | ME-79 |
| 12 | Mathematics Self-Concept And Anxiety With Different Achievement In Calculus Problem Solving
<i>Angga Hidayat</i> | ME_85 |
| 13 | The Development Of Technology Application Based Mathematics Learning Tools On Real Numbers Operations At The Vocational School Of Technology And Engineering
<i>Anggita Maharani</i> | ME-91 |
| 14 | Efforts To Improve Students' Mathematical Literacy In Mathematics Learning
<i>Anik Yuliani</i> | ME-99 |
| 15 | Practicability And Effectivity Of Konkama Model In Geometry Learning
<i>Asdar dan Jeranah</i> | ME-105 |
| 16 | The Profile Of Junior High School Students' Reasoning In Solving Mathematics Open-Ended Problem According To Reflective-Impulsive Cognitive Styles
<i>Ayu Faradillah</i> | ME-113 |

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

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

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

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

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

- | | | |
|----|---|--------|
| 69 | The Implementation Of Meas Instruction To Students' Mathematics Problem Solving And Connecting Ability
<i>Wahyu Hidayat</i> | ME-535 |
| 70 | Design Of Mathematic Learning Based On Cognitive Style
<i>Warli, Mu'jizatin Fadiana</i> | ME-543 |
| 71 | The Use Of Local Context In Designing Learning Activities For Mathematics Teaching In Elementary School
<i>Yenita Roza, Syarifah Nur Siregar, Titi Solfitri</i> | ME-553 |
| 72 | The Influence of Blended Learning, Learning Styles Against Understanding Math Concepts
<i>Yunia Mulyani Azis & Sussy Susanti</i> | ME-561 |
| 73 | The Development Of Digital Assessment Bloom As Assessment Tools In Junior High School
<i>Yurizka Melia Sari</i> | ME-571 |
| 74 | Student Perceptions, Principal Assesment, And Observations Of Teacher Performance
<i>Zetriuslita, Gadis Arniyati Athar</i> | ME-577 |
| 75 | An Analysis Of Difficulties On Mathematical Model Interpretation Of Junior High School Students On The Materials Of Two-Variable Linear Equation System
<i>Didi Suhaedi, Tia Purniati</i> | ME-583 |
| 76 | The Metacognitive Reflection Ability To Arrange The Strategy of Mathematical Problem Solving
<i>Georgina Maria Tinungki</i> | ME-589 |

PHYSICS

- | | | |
|----|---|------|
| 01 | Analysis and Synthesis of Sound of Gong Ageng of Kagungan Dalem Gongso Kanjeng Kyai Guntur Sari
<i>Ahmad Fauji, Agus Purwanto</i> | P-1 |
| 02 | Power Spectrum of Large Gong (Gong Ageng) Kagungan Dalem Gongso Kanjeng Kyai Guntur Sari
<i>Dhara Nurani, Agus Purwanto, Sumarna</i> | P-7 |
| 03 | Computation to Obtain the Spread Out Bragg Peak (SOBP) for Proton Radiotherapy on Model of Thyroid Cancer
<i>Eko Sulistya, Kusminarto, Arief Hermanto</i> | P-13 |

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

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

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
<i>Akmam, Harman A, Asrizal, Dea. S, Widya. F</i> | PE-1 |
| 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)
<i>Anida Nurafifah, Slamet Siswoyo, Vina Serevina</i> | PE-13 |
| 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
<i>Annisa Nor Fitria, Hasan, Vina Serevina</i> | PE-23 |
| 04 | Development of Blended Learning Model for Improving Students Competence in the Engineering Physics Learning
<i>Usmeldi</i> | PE-35 |
| 05 | Development of Teaching Aid of Electrometer in Physics Learning
<i>Dr. Esmar Budi, M.Si, Hadi Nasbey, S.Pd, M.Si, Dio Sudiarto</i> | PE-45 |
| 06 | Development Of An Android Application In The Form Of A Simulation Lab To Explain Properties Of An Ideal Gas
<i>A.Nugraha</i> | PE-49 |
| 07 | Treating Fourier series as vector: a concept simplification for teaching Fourier series
<i>Johannes V.D. Wirjawan</i> | PE-59 |

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

- | | | |
|----|---|--------|
| 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 |
| | <i>Muhammad Elizar Utomo, Heny Kuspianto, Vina Serevina</i> | |
| 19 | The Measurement of Lecturers' Teaching Quality and Academic Atmosphere in International Class Program of FMIPA UNM Makassar | PE-167 |
| | <i>Kaharuddin Arafah</i> | |
| 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 |
| | <i>Festiyed</i> | |
| 21 | Development of Evaluation Model of Physics Experiment Exam for Secondary Level | PE-182 |
| | <i>Setiya Utari, Harun Imansyah, Winny Liliawati, Arif Hidayat</i> | |

BIOLOGY

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

- | | | |
|----|---|-------|
| 08 | Pseudomonad Fluorescent Preservation Using Tapioca and Rice Flour Carrier and The Addition of Glycerol Stabilizer
<i>Linda Advinda</i> | B-61 |
| 09 | Inhibitory Power Test Medicinal Plants Against Methicillin Resistant Bacterial Growth Strains of Staphylococcus Aureus (MRSA)
<i>Mades Fifendy</i> | B-67 |
| 10 | Microalgae Biomass Production and Nitrate Removal from Landfill Leachate
<i>Norjan Yusof</i> | B-73 |
| 11 | The Effect of Skim Milk Addition in Cep-2 Diluent on Motility and Viability of Limousin Bull Sperm during Storage at Refrigerator
<i>Nur Ducha</i> | B-83 |
| 12 | Cage Temperature in Relation to The Width of Beak Opening of Gelatik Jawa (<i>Padda oryzivora</i>)
<i>Nur Kuswanti</i> | B-89 |
| 13 | Feasible Options to Reduce Greenhouse Gases Emission From Agriculture and Its Effect to Microbial Communities in Indonesia
<i>Oslan Jumadi</i> | B-95 |
| 14 | Morphogenetic Effects of Several Plant Growth Regulators (PGR) on In Vitro Development of Binahong (<i>Anredera cordifolia</i> L.) Leaf
<i>Paramita Cahyaningrum Kuswandi</i> | B-103 |
| 15 | Composition and Structure of Mangrove Associates Vegetation in Kwandang Coastal Area North Gorontalo Region and Mananggu Coastal Area Boalemo Region
<i>Abubakar Sidik Katili</i> | B-109 |
| 16 | Inventory The Waterbird Species which Accumulate Mercury from Mining Waste in Coastal Area North Gorontalo Regency, Indonesia
<i>Ramli Utina</i> | B-117 |
| 17 | Regeneration in Vertebrates : A Research Model to Study Angiogenesis
<i>Rizka Apriani Putri</i> | B-127 |
| 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
<i>Suhartini</i> | B-143 |
| 20 | Menstrual Cycle and History of Infectious Diseases Related to Anemia in Adolescent Women
<i>Sulistyaningsih</i> | B-151 |
| 21 | Swiftlet Bird (<i>Aerodramus fuciphagus</i>) Affinity Analysis in Java and Kalimantan Based on Morphometry
<i>Sunu Kuntjoro</i> | B-159 |
| 22 | Phytochemical Analysis of Manggong Bamboo Leaf Extract
<i>Supriyatin</i> | B-165 |
| 23 | Cadmium and Lead Content in Aquatic Ecosystem, Brackiswater Ponds and Fish in Areas Affected LAPINDO Mud
<i>Tarzan Purnomo</i> | B-169 |
| 24 | Epyphitic Cyanobacteria on Pneumatophore <i>Avicennia marina</i> in Mangrove Ecosystem of Cagar Alam Pulau Dua (CAPD) Serang, Banten
<i>Tika Khusnul Fatimahsari</i> | B-177 |
| 25 | Contens of Phenolic Compounds of <i>Pluchea Indica</i> Leaves Extract from Some Altitude Habitat
<i>Yuliani</i> | B-183 |
| 26 | Follicle Stimulating Hormone Receptor Ser680asn Polymorphism in Women with Polycystic Ovary
<i>Yuni Ahda</i> | B-189 |
| 27 | The Role of Mychorhizae, Rhizobium, and Phosphate Soluble Bacteria to Increase Plant Tolerance Grown on High Saline Soil
<i>Yuni Sri Rahayu</i> | B-195 |

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

- 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 Woof 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 Ediati, and Didik Prasetyoko

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

- 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 Syarieff, Nurul Hidayati, Suyatno and Tukiran

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

SCIENCE EDUCATION

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

- | | | |
|----|--|------|
| 11 | Project Approach In Science: An Exploratory Case Study
<i>Mohd Halim Marzuki and Sophia Md Yassin</i> | S-89 |
| 12 | Assessment Of Tofu Carbon Footprint In Banyumas, Indonesia -
Towards ‘Greener’ Tofu
<i>Sidharta Sahirman, Ardiansyah</i> | S-97 |

SYSTEMS OF INTERVAL MIN-PLUS LINEAR EQUATIONS AND ITS APPLICATION ON SHORTEST PATH PROBLEM WITH INTERVAL TRAVEL TIMES

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Abstract

The travel times in a network are seldom precisely known, and then could be represented into the interval of real number, that is called interval travel times. This paper discusses the solution of the iterative systems of interval min-plus linear equations its application on shortest path problem with interval travel times. The finding shows that the iterative systems of interval min-plus linear equations, with coefficient matrix is semi-definite, has a maximum interval solution. Moreover, if coefficient matrix is definite, then the interval solution is unique. The networks with interval travel time can be represented as a matrix over interval min-plus algebra. The networks dynamics can be represented as an iterative system of interval min-plus linear equations. From the solution of the system, can be determined interval earliest starting times for each point can be traversed. Furthermore, we can determine the interval fastest time to traverse the network. Finally, we can determine the shortest path interval with interval travel times by determining the shortest path with crisp travel times.

Key words: Min-Plus Algebra, Linear System, Shortest Path, Interval.

INTRODUCTION

Let $\mathbf{R}_\varepsilon := \mathbf{R} \cup \{\varepsilon\}$ with \mathbf{R} the set of all real numbers and $\varepsilon := \infty$. In \mathbf{R}_ε defined two operations : $\forall a, b \in \mathbf{R}_\varepsilon$, $a \oplus b := \min(a, b)$ and $a \otimes b := a + b$. We can show that $(\mathbf{R}_\varepsilon, \oplus, \otimes)$ is a commutative idempotent semiring with neutral element $\varepsilon = \infty$ and unity element $e = 0$. Moreover, $(\mathbf{R}_\varepsilon, \oplus, \otimes)$ is a semifield, that is $(\mathbf{R}_\varepsilon, \oplus, \otimes)$ is a commutative semiring, where for every $a \in \mathbf{R}$ there exist $-a$ such that $a \otimes (-a) = 0$. Thus, $(\mathbf{R}_\varepsilon, \oplus, \otimes)$ is a *min-plus algebra*, and is written as \mathbf{R}_{\min} . One can define $x^{\otimes 0} := 0$, $x^{\otimes k} := x \otimes x^{\otimes k-1}$, $\varepsilon^{\otimes 0} := 0$ and $\varepsilon^{\otimes k} := \varepsilon$, for $k = 1, 2, \dots$. The operations \oplus and \otimes in \mathbf{R}_{\min} can be extend to the matrices operations in $\mathbf{R}_{\min}^{m \times n}$, with $\mathbf{R}_{\min}^{m \times n} := \{A = (A_{ij}) \mid A_{ij} \in \mathbf{R}_{\min}, \text{ for } i = 1, 2, \dots, m \text{ and } j = 1, 2, \dots, n\}$, the set of all matrices over max-plus algebra. Specifically, for $A, B \in \mathbf{R}_{\min}^{n \times n}$ we define $(A \oplus B)_{ij} = A_{ij} \oplus B_{ij}$ and $(A \otimes B)_{ij} = \bigoplus_{k=1}^n A_{ik} \otimes B_{kj}$. We also define matrix $E \in \mathbf{R}_{\min}^{n \times n}$, $(E)_{ij} := \begin{cases} 0, & \text{if } i = j \\ \varepsilon, & \text{if } i \neq j \end{cases}$ and $\varepsilon \in \mathbf{R}_{\min}^{m \times n}$, $(\varepsilon)_{ij} := \varepsilon$ for every i and j . For any matrices $A \in \mathbf{R}_{\min}^{n \times n}$, one can define $A^{\otimes 0} = E_n$ and $A^{\otimes k} = A \otimes A^{\otimes k-1}$ for $k = 1, 2, \dots$. For any weighted, directed graph $\mathcal{G} = (\mathcal{V}, \mathcal{A})$ we can define a matrix $A \in$

$\mathbf{R}_{\min}^{n \times n}$, $A_{ij} = \begin{cases} w(j, i), & \text{if } (j, i) \in \mathcal{A} \\ \varepsilon, & \text{if } (j, i) \notin \mathcal{A}. \end{cases}$, called the *weight-matrix* of graph G .

A matrix $A \in \mathbf{R}_{\min}^{n \times n}$ is said to be *semi-definite* if all of circuit in $\mathcal{G}(A)$ have nonnegative weight, and it is said *definite* if all of circuit in $\mathcal{G}(A)$ have positive weight. We can show that if any matrices A is semi-definite, then $\forall p \geq n$, $A^{\otimes p} \preceq_m E \oplus A \oplus \dots \oplus A^{\otimes n-1}$. So, we can define $A^* := E \oplus A \oplus \dots \oplus A^{\otimes n} \oplus A^{\otimes n+1} \oplus \dots$. Define $\mathbf{R}_{\min}^n := \{ \mathbf{x} = [x_1, x_2, \dots, x_n]^T \mid x_i \in \mathbf{R}_{\min}, i = 1, 2, \dots, n \}$. Notice that we can be seen \mathbf{R}_{\min}^n as $\mathbf{R}_{\min}^{n \times 1}$. The elements of \mathbf{R}_{\max}^n is called *vector* over \mathbf{R}_{\min} . In general, min-plus algebra is analogous to max-plus algebra. Further details about max-plus algebra, matrix and graph can be found in Baccelli *et.al* (2001) and Rudhito (2003).

The existence and uniqueness of the solution of the iterative system of min-plus linear equation and its application to determine the shortest path in the with crisp (real) travel times had been discussed in Rudhito (2013). The followings are some result in brief. Let $A \in \mathbf{R}_{\min}^{n \times n}$ and $\mathbf{b} \in \mathbf{R}_{\min}^{n \times 1}$. If A is semi-definite, then $\mathbf{x}^* = A^* \otimes \mathbf{b}$ is a solution of system $\mathbf{x} = A \otimes \mathbf{x} \oplus \mathbf{b}$. Moreover, if A is definite, then the system has a unique solution. A *one-way path network* S with crisp activity times, is a directed, strongly connected, acyclic, crisp weighted graph $S = (\mathcal{V}, \mathcal{A})$, with $V = \{1, 2, \dots, n\}$ such that if $(i, j) \in \mathcal{A}$, then $i < j$. In this network, point represent *crosspathway*, arc expresses a *pathway*, while the weight of the arc represent *travel time*, so that the weights in the network is always positive. Let x_i^e is *earliest starting times* for point i can be traversed and $\mathbf{x}^e = [x_1^e, x_2^e, \dots, x_n^e]^T$. For the network with crisp travel times, with n nodes and A the weight matrix of graph of the networks, then

$$\mathbf{x}^e = (E \oplus A \oplus \dots \oplus A^{\otimes n-1}) \otimes \mathbf{b}^e = A^* \otimes \mathbf{b}^e$$

with $\mathbf{b}^e = [0, \varepsilon, \dots, \varepsilon]^T$. Furthermore, x_n^e is the *fastest times to traverse* the network. Let x_i^l is *latest times left* point i and $\mathbf{x}^l = [x_1^l, x_2^l, \dots, x_n^l]$. For the network above, vector

$$\mathbf{x}^l = -((A^T)^* \otimes \mathbf{b}^l)$$

with $\mathbf{b}^l = [\varepsilon, \varepsilon, \dots, -x_n^e]^T$. Define, a pathway $(i, j) \in \mathcal{A}$ in the one-way path network S is called *shortest pathway* if $x_i^e = x_i^l$ dan $x_j^e = x_j^l$. Define, A path $p \in P$ in the one-way path network S is called *shortest path* if all pathways belonging to p are shortest pathway. From this definition, we can show that a path $p \in P$ is a shortest path if and only if p has minimum weight, that is equal to x_n^e . Also, a pathway is a shortest pathway if and only if it belonging to a shortest path.

DISCUSSION

We discusses the solution of the iterative systems of interval min-plus linear equations its application on shortest path problem with interval travel times. The discussion begins by reviewing some basic concepts of interval min-plus algebra and matrices over interval min-plus algebra. Definition and concepts in the min-plus algebra analogous to the concepts in the max-plus algebra which can be seen in Rudhito (2011).

The (closed) interval \mathbf{x} in \mathbf{R}_{\min} is a subset of \mathbf{R}_{\min} of the form

$$\mathbf{x} = [\underline{\mathbf{x}}, \bar{\mathbf{x}}] = \{ \mathbf{x} \in \mathbf{R}_{\min} \mid \underline{\mathbf{x}} \preceq_m \mathbf{x} \preceq_m \bar{\mathbf{x}} \}.$$

The interval x in \mathbf{R}_{\min} is called *min-plus interval*, which is in short is called *interval*. Define

$$\mathbf{I}(\mathbf{R})_{\varepsilon} := \{ x = [\underline{x}, \bar{x}] \mid \underline{x}, \bar{x} \in \mathbf{R}, \varepsilon \prec_m \underline{x} \preceq_m \bar{x} \} \cup \{ \varepsilon \}, \text{ where } \varepsilon := [\varepsilon, \varepsilon].$$

In the $\mathbf{I}(\mathbf{R})_{\varepsilon}$, define operation \oplus and \otimes as

$$x \oplus y = [\underline{x} \oplus \underline{y}, \bar{x} \oplus \bar{y}] \text{ and } x \otimes y = [\underline{x} \otimes \underline{y}, \bar{x} \otimes \bar{y}], \forall x, y \in \mathbf{I}(\mathbf{R})_{\varepsilon}.$$

Since $(\mathbf{R}_{\varepsilon}, \oplus, \otimes)$ is an idempotent semiring and it has no zero divisors, with neutral element ε , we can show that $\mathbf{I}(\mathbf{R})_{\varepsilon}$ is closed with respect to the operation \oplus and \otimes . Moreover, $(\mathbf{I}(\mathbf{R})_{\varepsilon}, \oplus, \otimes)$ is a comutative idempotent semiring with neutral element $\varepsilon = [\varepsilon, \varepsilon]$ and unity element $0 = [0, 0]$. This comutative idempotent semiring $(\mathbf{I}(\mathbf{R})_{\varepsilon}, \oplus, \otimes)$ is called *interval min-plus algebra* which is written as $\mathbf{I}(\mathbf{R})_{\min}$.

Define $\mathbf{I}(\mathbf{R})_{\min}^{m \times n} := \{ A = (A_{ij}) \mid A_{ij} \in \mathbf{I}(\mathbf{R})_{\min}, \text{ for } i = 1, 2, \dots, m \text{ and } j = 1, 2, \dots, n \}$. The element of $\mathbf{I}(\mathbf{R})_{\min}^{m \times n}$ are called *matrices over interval min-plus algebra*. Furthermore, this matrices are called *interval matrices*. The operations \oplus and \otimes in $\mathbf{I}(\mathbf{R})_{\min}$ can be extended to the matrices operations of in $\mathbf{I}(\mathbf{R})_{\min}^{m \times n}$. Specifically, for $A, B \in \mathbf{I}(\mathbf{R})_{\min}^{n \times n}$ and $\alpha \in \mathbf{I}(\mathbf{R})_{\min}$ we define

$$(\alpha \otimes A)_{ij} = \alpha \otimes A_{ij}, (A \oplus B)_{ij} = A_{ij} \oplus B_{ij} \text{ and } (A \otimes B)_{ij} = \bigoplus_{k=1}^n A_{ik} \otimes B_{kj}.$$

Matrices $A, B \in \mathbf{I}(\mathbf{R})_{\min}^{m \times n}$ are *equal* if $A_{ij} = B_{ij}$, that is if $\underline{A}_{ij} = \underline{B}_{ij}$ and $\bar{A}_{ij} = \bar{B}_{ij}$ for every i and j . We can show that $(\mathbf{I}(\mathbf{R})_{\min}^{n \times n}, \oplus, \otimes)$ is a idempotent semiring with neutral element is matrix ε , with $(\varepsilon)_{ij} := \varepsilon$ for every i and j , and unity element is matrix E , with $(E)_{ij} := \begin{cases} 0, & \text{if } i = j \\ \varepsilon, & \text{if } i \neq j \end{cases}$. We can also show that $\mathbf{I}(\mathbf{R})_{\min}^{m \times n}$ is a semi-module over $\mathbf{I}(\mathbf{R})_{\min}$.

For any matrix $A \in \mathbf{I}(\mathbf{R})_{\min}^{m \times n}$, define the matrices $\underline{A} = (\underline{A}_{ij}) \in \mathbf{R}_{\min}^{m \times n}$ and $\bar{A} = (\bar{A}_{ij}) \in \mathbf{R}_{\min}^{m \times n}$, which is called *lower bound matrices* and *upper bound matrices* of A , respectively. Define *matrices interval* of A , that is

$$[\underline{A}, \bar{A}] = \{ A \in \mathbf{I}(\mathbf{R})_{\min}^{m \times n} \mid \underline{A} \preceq_m A \preceq_m \bar{A} \} \text{ and } \mathbf{I}(\mathbf{R}_{\min}^{m \times n})^* = \{ [\underline{A}, \bar{A}] \mid A \in \mathbf{I}(\mathbf{R})_{\min}^{m \times n} \}.$$

Specifically, for $[\underline{A}, \bar{A}], [\underline{B}, \bar{B}] \in \mathbf{I}(\mathbf{R}_{\min}^{m \times n})^*$ and $\alpha \in \mathbf{I}(\mathbf{R})_{\min}$ we define

$$\begin{aligned} \alpha \otimes [\underline{A}, \bar{A}] &= [\underline{\alpha} \otimes \underline{A}, \bar{\alpha} \otimes \bar{A}], [\underline{A}, \bar{A}] \oplus [\underline{B}, \bar{B}] = [\underline{A} \oplus \underline{B}, \bar{A} \oplus \bar{B}] \\ \text{and } [\underline{A}, \bar{A}] \otimes [\underline{B}, \bar{B}] &= [\underline{A} \otimes \underline{B}, \bar{A} \otimes \bar{B}]. \end{aligned}$$

The matrices interval $[\underline{A}, \bar{A}]$ and $[\underline{B}, \bar{B}] \in \mathbf{I}(\mathbf{R}_{\min}^{m \times n})^*$ are *equal* if $\underline{A} = \underline{B}$ and $\bar{A} = \bar{B}$. We can show that $(\mathbf{I}(\mathbf{R}_{\min}^{n \times n})^*, \oplus, \otimes)$ is an idempotent semiring with neutral element matrix interval $[\varepsilon, \varepsilon]$ and the unity element is matrix interval $[E, E]$. We can also show that $\mathbf{I}(\mathbf{R}_{\min}^{n \times n})^*$ is a semimodule over $\mathbf{I}(\mathbf{R})_{\min}$.

The semiring $(\mathbf{I}(\mathbf{R}_{\min}^{n \times n})^*, \oplus, \otimes)$ is isomorphic with semiring $(\mathbf{I}(\mathbf{R}_{\min}^{n \times n})^*, \oplus, \otimes)$. We can define a mapping f , where $f(A) = [\underline{A}, \bar{A}]$, $\forall A \in \mathbf{I}(\mathbf{R})_{\min}^{n \times n}$. Also, the semimodule $\mathbf{I}(\mathbf{R})_{\min}^{n \times n}$ is isomorphic with semimodule $\mathbf{I}(\mathbf{R}_{\min}^{n \times n})^*$. So, for every matrices interval $A \in \mathbf{I}(\mathbf{R}_{\min}^{n \times n})^*$ we can determine matrices interval $[\underline{A}, \bar{A}] \in \mathbf{I}(\mathbf{R}_{\min}^{n \times n})^*$. Conversely, for every $[\underline{A}, \bar{A}] \in \mathbf{I}(\mathbf{R}_{\min}^{n \times n})^*$, then

$\underline{A}, \bar{A} \in \mathbf{R}_{\min}^{n \times n}$, such that $[\underline{A}_{ij}, \bar{A}_{ij}] \in \mathbf{I}(\mathbf{R})_{\min}$, $\forall i$ and j . The matrix interval $[\underline{A}, \bar{A}]$ is called *matrix interval associated with the interval matrix A* and which is written $A \approx [\underline{A}, \bar{A}]$. So we have $\alpha \otimes A \approx [\alpha \otimes \underline{A}, \alpha \otimes \bar{A}]$, $A \oplus B \approx [\underline{A} \oplus \underline{B}, \bar{A} \oplus \bar{B}]$ and $A \otimes B \approx [\underline{A} \otimes \underline{B}, \bar{A} \otimes \bar{B}]$.

We define for any interval matrices $A \in \mathbf{I}(\mathbf{R})_{\min}^{n \times n}$, where $A \approx [\underline{A}, \bar{A}]$, is said to be *semi-definite (definite)* if every matrices $A \in [\underline{A}, \bar{A}]$ is semi-definite (definite). We can show that interval matrices $A \in \mathbf{I}(\mathbf{R})_{\max}^{n \times n}$, where $A \approx [\underline{A}, \bar{A}]$ is semi-definite (definite) if and only if $\bar{A} \in \mathbf{R}_{\max}^{n \times n}$ semi-definite (definite).

Define $\mathbf{I}(\mathbf{R})_{\min}^n := \{ \mathbf{x} = [x_1, x_2, \dots, x_n]^T \mid x_i \in \mathbf{I}(\mathbf{R})_{\min}, i = 1, 2, \dots, n \}$. The set $\mathbf{I}(\mathbf{R})_{\min}^n$ can be seen as set $\mathbf{I}(\mathbf{R})_{\min}^{n \times 1}$. The Elements of $\mathbf{I}(\mathbf{R})_{\min}^n$ is called *interval vector over $\mathbf{I}(\mathbf{R})_{\min}$* . The interval vector \mathbf{x} associated with *vector interval* $[\underline{\mathbf{x}}, \bar{\mathbf{x}}]$, that is $\mathbf{x} \approx [\underline{\mathbf{x}}, \bar{\mathbf{x}}]$.

Definition 1. Let $A \in \mathbf{I}(\mathbf{R})_{\min}^{n \times n}$ and $\mathbf{b} \in \mathbf{I}(\mathbf{R})_{\min}^n$. A interval vector $\mathbf{x}^* \in \mathbf{I}(\mathbf{R})_{\min}^n$ is called *interval solution of iterative system of interval min-plus linear equations* $\mathbf{x} = A \otimes \mathbf{x} \oplus \mathbf{b}$ if \mathbf{x}^* satisfy the system.

Theorem 1. Let $A \in \mathbf{I}(\mathbf{R})_{\max}^{n \times n}$ and $\mathbf{b} \in \mathbf{I}(\mathbf{R})_{\min}^{n \times 1}$. If A is semi-definite, then interval vector $\mathbf{x}^* \approx [\underline{A}^* \otimes \underline{\mathbf{b}}, \bar{A}^* \otimes \bar{\mathbf{b}}]$, is an interval solution of system $\mathbf{x} = A \otimes \mathbf{x} \oplus \mathbf{b}$. Moreover, if A is definite, then interval solution is unique.

Proof. Proof is analogous to the case of max-plus algebra as seen in the Rudhito (2011)

Next will be discussed the *earliest starting times interval* for point i can be traversed. The discussion is analogous to the case of (crisp) travel time (Rudhito, 2013), using the interval min-plus algebra approach.

Let $ES_i = x_i^e$ is *earliest starting times interval* for point i can be traversed, with $x_i^e = [\underline{x}_i^e, \bar{x}_i^e]$.

$$A_{ij} = \begin{cases} \text{interval travel time from point } j \text{ to point } i & \text{if } (j, i) \in \mathcal{A} \\ \varepsilon (= [+ \infty, + \infty]) & \text{if } (j, i) \notin \mathcal{A} \end{cases}.$$

We assume that $x_i^e = 0 = [0, 0]$ and with interval min-plus algebra notation we have

$$x_i^e = \begin{cases} 0 & \text{if } i = 1 \\ \bigoplus_{1 \leq j \leq n} (A_{ij} \otimes x_j^e) & \text{if } i > 1 \end{cases}. \quad (1)$$

Let A is the interval weight matrix of the interval-valued weighted graph of the networks, $\mathbf{x}^e = [x_1^e, x_2^e, \dots, x_n^e]^T$ dan $\mathbf{b}^e = [0, \varepsilon, \dots, \varepsilon]^T$, then equation (1) can be written in an iterative system of interval max-plus linear equations

$$\mathbf{x}^e = A \otimes \mathbf{x}^e \oplus \mathbf{b}^e \quad (2)$$

Since the project networks is acyclic directed graph, then there are no circuit, so according to the result in Rudhito(2011), A is definite. And then according to Theorem 1,

$$\mathbf{x}^e = A^* \otimes \mathbf{b}^e \approx [\underline{A}^* \otimes \underline{\mathbf{b}}^e, \bar{A}^* \otimes \bar{\mathbf{b}}^e]$$

$$= [(\underline{E} \oplus \underline{A} \oplus \dots \oplus \underline{A}^{\otimes n-1}) \otimes \underline{\mathbf{b}}^e, (\bar{E} \oplus \bar{A} \oplus \dots \oplus \bar{A}^{\otimes n-1}) \otimes \bar{\mathbf{b}}^e]$$

is a unique solution of the system (2), that is the vector of earliest starting times interval for point i can be traversed.

Notice that \mathbf{x}_n^e is the *fastest times interval to traverse* the network. We summarize the description above in the Theorem 2.

Teorema 2. Given a one-way path network network with interval travel times, with n node and A is the weight matrix of the interval-valued weighted graph of networks. The interval vector of earliest starting times interval for point i can be traversed is given by

$$\mathbf{x}^e \approx [(\underline{E} \oplus \underline{A} \oplus \dots \oplus \underline{A}^{\otimes n-1}) \otimes \underline{\mathbf{b}}^e, (\bar{E} \oplus \bar{A} \oplus \dots \oplus \bar{A}^{\otimes n-1}) \otimes \bar{\mathbf{b}}^e]$$

with $\mathbf{b}^e = [0, \varepsilon, \dots, \varepsilon]^T$. Furthermore, \mathbf{x}_n^e is the *fastest times interval to traverse* the network.

Bukti: (see description above) . ■

Example 1 Consider the project network in Figure 1.

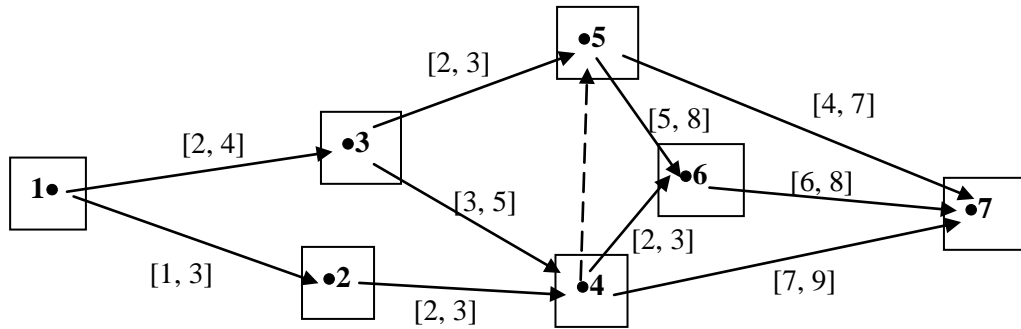


Figure 1. A one-way path network network with interval travel times

We have

$$A = \begin{bmatrix} \varepsilon, & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon \\ [1,3] & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon \\ [2,4] & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon \\ \varepsilon & [2,3] & [3,5] & \varepsilon & \varepsilon & \varepsilon & \varepsilon \\ \varepsilon & \varepsilon & [2,3] & [0,0] & \varepsilon & \varepsilon & \varepsilon \\ \varepsilon & \varepsilon & \varepsilon & [2,3] & [4,7] & \varepsilon & \varepsilon \\ \varepsilon & \varepsilon & \varepsilon & [7,9] & [5,8] & [6,8] & \varepsilon \end{bmatrix}.$$

Using MATLAB computer program, we have

$$\underline{A}^* = \begin{bmatrix} 0 & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon \\ 1 & 0 & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon \\ 2 & \varepsilon & 0 & \varepsilon & \varepsilon & \varepsilon & \varepsilon \\ 3 & 2 & 3 & 0 & \varepsilon & \varepsilon & \varepsilon \\ 3 & 2 & 2 & 0 & 0 & \varepsilon & \varepsilon \\ 5 & 4 & 5 & 2 & 4 & 0 & \varepsilon \\ 8 & 7 & 7 & 5 & 5 & 6 & 0 \end{bmatrix}, \bar{A}^* = \begin{bmatrix} 0 & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon \\ 3 & 0 & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon \\ 4 & \varepsilon & 0 & \varepsilon & \varepsilon & \varepsilon & \varepsilon \\ 6 & 3 & 5 & 0 & \varepsilon & \varepsilon & \varepsilon \\ 6 & 3 & 3 & 0 & 0 & \varepsilon & \varepsilon \\ 9 & 6 & 8 & 3 & 7 & 0 & \varepsilon \\ 14 & 11 & 11 & 8 & 8 & 8 & 0 \end{bmatrix},$$

$$\underline{x}^e = [0, 1, 2, 3, 3, 5, 8]^T \text{ dan } \bar{x}^e = [0, 3, 4, 6, 6, 9, 14]^T.$$

So the vector of earliest starting times interval for point i can be traversed is

$\underline{x}^e = [[0, 0], [1, 3], [2, 4], [3, 6], [3, 6], [5, 9], [8, 14]]^T$ and the fastest times interval to traverse the network $x_n^e = [16, 25]$.

Next given shortest path interval definition and theorem that gives way determination. Definitions and results is a modification of the definition of critical path-interval and theorem to determine the critical path method-interval, as discussed in Chanas and Zielinski (2001) and Rudhito (2011). We also give some examples for illustration.

Definition 2. A path $p \in P$ is called an *interval-shortest path* in S if there exist a set of travel times $A_{ij} \in [\underline{A}_{ij}, \bar{A}_{ij}]$, $(i, j) \in \mathcal{A}$, such that p is shortest path, after replacing the interval travel times A_{ij} with the travel time A_{ij} .

Definisi 3. A pathway $(k, l) \in \mathcal{A}$ is called an *interval-shortest pathway* in S if there exist a set of travel times $A_{ij} \in [\underline{A}_{ij}, \bar{A}_{ij}]$, $(i, j) \in \mathcal{A}$, such that (k, l) is shortest pathway, after replacing the interval travel times A_{ij} with the travel time A_{ij} .

The following theorem is given which relates the interval-shortest path and interval-shortest pathway.

Teorema 3. If path $p \in P$ is an interval-shortest path, then all pathways in the p are interval-shortest pathway.

Proof : Let path $p \in P$ is an interval shortest path, then according to Definition 2, there exist a set of times $A_{ij} \in [\underline{A}_{ij}, \bar{A}_{ij}]$, $(i, j) \in \mathcal{A}$, such that p is shortest path, after replacing the interval travel times A_{ij} with the travel time A_{ij} . Next, according to the definition of shortest path above, all pathways in p are shortest pathways for a set of travel times $A_{ij} \in [\underline{A}_{ij}, \bar{A}_{ij}]$, $(i, j) \in \mathcal{A}$. Thus according to Definicion 3, all pathways in p are interval-shorstest pathways. ■

The following theorem is given a necessary and sufficient condition a path is an interval-shortest path.

Teorema 4. A path $p \in P$ is an *interval-shortest path* in S if and only if p is a shortest path, with interval travel times $A_{ij} \in [\underline{A}_{ij}, \bar{A}_{ij}]$, $(i, j) \in \mathcal{A}$, have been replace with travel times A_{ij} which is determined by the following formula

$$A_{ij} = \begin{cases} \bar{A}_{ij} & \text{jika } (i, j) \notin p \\ \underline{A}_{ij} & \text{jika } (i, j) \in p \end{cases} \quad (3)$$

Bukti : \Rightarrow : Let p is an interval-shortest path, then according to Definition 2, there exist a set of travel times A_{ij} , $A_{ij} \in [\underline{A}_{ij}, \bar{A}_{ij}]$, $(i, j) \in \mathcal{A}$, such that p is shortest pathway, after replacing the interval travel times A_{ij} with travel times A_{ij} , $(i, j) \in \mathcal{A}$. If the travel times for all pathway is located at p is reduced from A_{ij} to \underline{A}_{ij} and for all pathway is not located p is increased from A_{ij} to \bar{A}_{ij} , then p is a path with minimum weight in S for new travel time formation. Thus path p is a shortest path.

\Leftarrow : Since path p a shortest path with a set of travel times $A_{ij} \in [\underline{A}_{ij}, \bar{A}_{ij}]$, which is determined by the formula (9), then according to Definition 2, path p is an interval-shortest path. ■

Example 2. We consider the network in Example 1. We will determine all interval-shortest path in this network. For path $1 \rightarrow 3 \rightarrow 5 \rightarrow 7$, by applying formula (9), we have weight

$$\begin{bmatrix} \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon \\ 3 & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon \\ 2 & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon & \varepsilon \\ \varepsilon & 3 & 5 & \varepsilon & \varepsilon & \varepsilon & \varepsilon \\ \varepsilon & \varepsilon & 2 & 0 & \varepsilon & \varepsilon & \varepsilon \\ \varepsilon & \varepsilon & \varepsilon & 3 & 8 & \varepsilon & \varepsilon \\ \varepsilon & \varepsilon & \varepsilon & 9 & 4 & 8 & \varepsilon \end{bmatrix}.$$

Using MATLAB computer program, we have a shortest path $1 \rightarrow 3 \rightarrow 5 \rightarrow 7$ with minimum weight of path is 8. Thus $1 \rightarrow 3 \rightarrow 5 \rightarrow 7$ is an interval-shortest path. The results of the calculations for all possible path in the network are given in Table 1 below.

Tabel 1 Calculation results of all path

No	Path p	Weight Interval p	Shortest-path p^* (with formula (9))	Weight of p^*	Conclusion
1	$1 \rightarrow 3 \rightarrow 5 \rightarrow 7$	[8, 14]	$1 \rightarrow 3 \rightarrow 5 \rightarrow 7$,	8	Interval-shortest
2	$1 \rightarrow 3 \rightarrow 5 \rightarrow 6 \rightarrow 7$	[15, 23]	$1 \rightarrow 3 \rightarrow 5 \rightarrow 7$	11	Not interval-shortest
3	$1 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 7$	[9, 16]	$1 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 7$ $1 \rightarrow 3 \rightarrow 5 \rightarrow 7$	9	Interval-shortest
4	$1 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 6 \rightarrow 7$	[16, 25]	$1 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 7$ $1 \rightarrow 3 \rightarrow 5 \rightarrow 7$	12	Not interval-shortest
5	$1 \rightarrow 3 \rightarrow 4 \rightarrow 6 \rightarrow 7$	[13, 20]	$1 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 7$ $1 \rightarrow 3 \rightarrow 5 \rightarrow 7$	12	Not interval-shortest
6	$1 \rightarrow 3 \rightarrow 4 \rightarrow 7$	[12, 18]	$1 \rightarrow 3 \rightarrow 4 \rightarrow 5 \rightarrow 7$ $1 \rightarrow 3 \rightarrow 4 \rightarrow 7$ $1 \rightarrow 3 \rightarrow 5 \rightarrow 7$	12	Interval-shortest

7	$1 \rightarrow 2 \rightarrow 4 \rightarrow 5 \rightarrow 7$	[7, 13]	$1 \rightarrow 2 \rightarrow 4 \rightarrow 5 \rightarrow 7$	7	Interval-shortest
8	$1 \rightarrow 2 \rightarrow 4 \rightarrow 5 \rightarrow 6 \rightarrow 7$	[14, 22]	$1 \rightarrow 2 \rightarrow 4 \rightarrow 5 \rightarrow 7$	10	Not interval-shortest
9	$1 \rightarrow 2 \rightarrow 4 \rightarrow 6 \rightarrow 7$	[11, 17]	$1 \rightarrow 2 \rightarrow 4 \rightarrow 5 \rightarrow 7$	10	Not interval-shortest
10	$1 \rightarrow 2 \rightarrow 4 \rightarrow 7$	[10, 15]	$1 \rightarrow 2 \rightarrow 4 \rightarrow 5 \rightarrow 7$ $1 \rightarrow 2 \rightarrow 4 \rightarrow 7$	10	Interval-shortest

REFERENCES

1. F. Bacelli, *et al.*, *Synchronization and Linearity*, John Wiley & Sons, New York, 2001.
2. S. Chanas, S., P. Zielinski, P., Critical path analysis in the network with fuzzy activity times. *Fuzzy Sets and Systems*. **122**. 195–204., 2001.
3. M. A. Rudhito, *Sistem Linear Max-Plus Waktu-Invariant*, Tesis: Program Pascasarjana Universitas Gadjah Mada, Yogyakarta, 2003.
4. M. A. Rudhito, *Aljabar Max-Plus Bilangan Kabur dan Penerapannya pada Masalah Penjadwalan dan Jaringan Antrian Kabur*. Disertasi: Program Pascasarjana Universitas Gadjah Mada. Yogyakarta., 2011.
5. M. A. Rudhito, Sistem Persamaan Linear Min-Plus dan Penerapannya pada Masalah Lintasan Terpendek. *Prosiding Seminar Nasional Matematika dan Pendidikan Matematika. Jurusan Pendidikan Matematika FMIPA UNY*, Yogyakarta, 9 November 2013. pp: MA-29 – MA-34.