

# MSCEIS 2019

Proceedings of the 7th Mathematics, Science, and  
Computer Science Education International Seminar

Bandung, West Java, Indonesia

12 October 2019

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Lala Septem Riza

Eka Cahya Prima

Toni Hadibarata

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# **Proceedings of the 7<sup>th</sup> Mathematics, Science, and Computer Science Education International Seminar (MSCEIS)**

12 October 2019, Bandung, West Java, Indonesia

*MSCEIS 2019*

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## Preface

We are delighted to introduce the proceedings of the first edition of the 2019 European Alliance for Innovation (EAI) for 7<sup>th</sup> Mathematics, Science, and Computer Science Education International Seminar (MSCEIS). An annual conference was held by many domestic and overseas universities. It was held by the Faculty of Mathematics and Natural Science Education, Universitas Pendidikan Indonesia (UPI) and the collaboration with 12 University associated in Asosiasi MIPA LPTK Indonesia (AMLI) consisting of Universitas Negeri Semarang (UNNES), Universitas Pendidikan Indonesia (UPI), Universitas Negeri Yogyakarta (UNY), Universitas Negeri Malang (UM), Universitas Negeri Jakarta (UNJ), Universitas Negeri Medan (UNIMED), Universitas Negeri Padang (UNP), Universitas Negeri Manado (UNIMA), Universitas Negeri Makassar (UNM), Universitas Pendidikan Ganesha (UNDHIKSA), Universitas Negeri Gorontalo (UNG), and Universitas Negeri Surabaya (UNESA). In this year, MSCEIS 2019 takes the following theme: ***"Mathematics, Science, and Computer Science Education for Addressing Challenges and Implementations of Revolution-Industry 4.0"*** held on October 12, 2019 in Bandung, West Java, Indonesia.

The number of accepted papers is 211. Especially, there are four keynote speakers and thirteen invited speakers come from Japan, Australia, Thailand, Indonesia, for plenary and parallel sessions, respectively.

We would like to thank all of those who helped and supported MSCEIS 2019. Each individual and institution's support was very important for the success of this seminar. Specifically, we would like to acknowledge the advisory board, scientific committee, and organizing committee for their valuable advice, help, suggestion, and support in the organization and helpful peer-reviewing process of the papers. We would also extend our best gratitude to keynote speakers for their valuable contribution to sharing ideas and knowledge in the MSCEIS 2019.

We sincerely hope that MSCEIS 2019 will be a forum for excellent discussions for improving the quality of research and development relating to mathematics, science, and computer science education. We also hope that this forum will put forward new ideas and promote collaborative researches among participants. We believe that the proceedings can serve not only as an essential research source progress but also other new products and processes for better science and technology.

Chairman,

Dr. Lala Septem Riza and Dr. Eka Cahya Prima

# Contents

## MATHEMATICS EDUCATION

A Rasch Model Analysis of Mathematical Understanding of Prospective Mathematics Teachers in The Conic Concept <i>Eyus Sudihartinih, Tia Purniati, Ade Rohayati</i>	1
Students' Understanding in Learning Fraction with Multiple Representations <i>S. Widodo, T. Ikhwanudin</i>	9
Developing Mathematical Problem Posing Ability of Prospective Mathematics Teachers for Enhancing their Professionalism <i>Wahidah Halimahnur, Yaya S. Kusumah</i>	15
Contributions of Self-Regulated Learning, Disposition Mathematically and Habits of Mind Against Mathematical Problem Solving Ability Students <i>Nurul Afifah Hasibuan, Nurjanah Nurjanah</i>	24
Two Parts of Reflective abstraction: For New Problem Solving and Mathematical Concept <i>Risnina Wafiqoh, Yaya Sukjaya Kusumah, Dadang Juandi</i>	30
The Enhancement of Mathematical Creative Thinking and Logical Thinking Ability, and Student Habits of Mind in Junior High School Through ASSURE Learning Model <i>Nosep Sumiarto, Endang Cahya M. A., B. A. P. Martadiputra</i>	39
The Use of Realistic Mathematics Education Theory for Designing an Algebra Learning Sequence: The Case of Linear Equations in One Variable <i>Dian Usdiyana, Al Jupri, Ririn Sispiyati</i>	48
Error Analysis in Solving the Rational and Irrational Inequalities <i>Yunia Bani Pratiwi, Rizky Rosjanuardi</i>	53
Design an Algebra Learning Sequence Based on Realistic Mathematics Education Theory: The Case of Linear Equation in One Variable using Balance-Scales Model <i>Ririn Sispiyati, Al Jupri, Dian Usdiyana</i>	61
Analysis of Student's Mathematical Reflective Thinking Ability in Number Pattern <i>F. Apendi, S. Prabawanto</i>	65
Didactic Transposition On The Concept Of Central Angle And Circumferential Angle In Junior High School <i>Winarji Winarji, Turmudi Turmudi</i>	71
Students Creative Mathematical Thinking Abilities In Triangles and Rectangles <i>Sry Rita Puspitasari, Wahyudin Wahyudin</i>	79
Analysis of Instruments and Students' Abilities in Material Number Patterns Using the Rasch Model <i>Tia Purniati, Turmudi Turmudi, Maya Evayanti, Didi Suhaedi</i>	86

Procedural Knowledge Versus Conceptual Knowledge of Fraction : An Indonesian Junior High School Case Study <i>W. Ramadianti, N. Priatna, Kusnandi Kusnandi</i>	94
Mathematical Abstraction Abilities of Hight School Students in Term of Cognitive Style <i>Anna Rachmadyana Harry, Endang Cahya M. A., Al Jupri</i>	100
Effectiveness of Constructivism Based Learning Models Against Students Mathematical Creative Thinking Abilities in Indonesia; A Meta-Analysis Study <i>Maximus Tamur, Dadang Juandi</i>	107
Teacher Knowledge to Overcome Student Errors in Pythagorean Theorem Proof : A Study Based on Didactic Mathematical Knowledge Framework <i>Rudi Rudi, Didi Suryadi, Rizky Rozjanuardi</i>	115
Students' Proportional Reasoning Ability in Junior High School Using Collaborative Problem Solving <i>Nunu Nurhayati, Yaya S. Kusumah</i>	123
The Effect of GeoGebra-Based Learning on Students Spatial Ability and Motivation <i>V. N. Yulian, Wahyudin Wahyudin, Lela Anggrayani</i>	130
Application of Problem Based Learning Approaches with Probing-Prompting Techniques to Improve Students' Adaptive Reasoning Capabilities <i>Nia Gardenia, Tatang Herman, Andri Rahadyan, Taufiqulloh Dahlan</i>	138
Developing of Teaching Materials for Statistics Method Using Hybrid Learning in Industry Challenges 4.0 <i>Sowanto Sowanto, A. Dimiyati, Andang Andang, Mutmainnah Mutmainnah</i>	144
How is the quality of 11th grade midterm exam in Indonesia? Is it important? <i>Ibrohim Aji Kusuma, Heri Retnawati</i>	152
Didactical Design of Circle Equation and Tangent of Circle Analytic Geometry Learning <i>Nanang Diana, Didi Suryadi, Jarnawi Afgani Dahlan</i>	161
Developing a Test for Testing Students' Mathematics Competency as Prospective Secondary School Mathematics Teachers <i>Awi Awi, Syahrullah Asyari, Muhammad Darwis M., Sahlan Sidjara, Ikhbariaty Kautsar Qadry</i>	169
Identification of Student' Critical Thinking Ability in Solving Open Ended Mathematics Problem Viewed From Cognitive Styles <i>Masriyah Masriyah, Khofidhotur Rofiah, Umi Hanifah</i>	177
Using GeoMaSchool To Link Between Creativity and Performance for Students In Higher Education <i>Nasrullah Pemu, Asdar Ahmad, Jeranah Tajuddin</i>	184
A Comparison between Generative Learning and Conventional Learning Model on Students' Mathematical Literacy in the 21st century <i>Ellis Salsabila, Wardani Rahayu, Selly Anastassia Amellia Kharis, Agustiani Putri</i>	194
Analysis of Student's Performance Index Using Confirmatory Analysis <i>Nonong Amalita, Dina Fitria, Rafi Oktriatama</i>	201



Achievement of Pedagogical Competency, Professional Competency, and Self-Efficacy In-service Mathematics Teachers, Through Pedagogical Problem Solving Cycle <i>Dadang Juandi</i>	209
How to Apply Metacognitive Strategies in Collaborative Learning Setting? <i>Muntazhimah Muntazhimah, Turmudi Turmudi, S Prabawanto</i>	216
The Effect of Learning Hands-on Activity Media on the Mathematical Reasoning Ability of Junior High School Students <i>Nurjanah Nurjanah, J A Dahlan, Y Wibisono</i>	223
The Impact of Learning Model Based on 2013 Curriculum Towards Contextual Problem Solving Skill <i>Sehatta Saragih, Zulkarnain Zulkarnain, Sahrin Nisa</i>	231
Application of the Scientific Approach Using Guided Inquiry to View the Ability of Critical Thinking Students <i>Reni Dwi Susanti</i>	238
Realistic Mathematics Education: A Learning Innovation in Enhancing Students' Algebraic Thinking Ability <i>Didi Suhaedi</i>	245
Engineering Students' Participations and Creativity Towards Flipped Classroom Method: A Case Study <i>Siti Khoiruli Ummah</i>	253
Learning Design for Topic Two Variable Linear Equation Systems for Students of Machinery and Automotive Engineering Techniques Programs at Vocational High School <i>Armianti Armianti, Roli Mazendra</i>	268
<b>MATHEMATICS</b>	
Influence of Discovery Learning Supported by Solar System Scope Application on Students' Curiosity: The Case of Teaching Solar System <i>Atika Zahara, Selly Feranie, Nanang Winarno</i>	275
Several Properties of Discrete Orlicz Spaces <i>Pradipta Swiantana Prayoga, Siti Fatimah, Al Azhary Masta</i>	283
Comparison Between Convex and Quasiconvex Functions on $\mathbb{R}$ With Development <i>Encum Sumiaty, Endang Dedy, Sofihara Al Hazmy, Andryana Juanda</i>	292
On Cyclically Ordered Groups and Theirs Direct Product <i>Sumanang Muhtar Gozali, Rizky Rosjanuardi, Isnje Yusnitha</i>	299
Holder's inequality in Discrete Morrey spaces <i>Al Azhary Masta, Indra Rukmana, Muhammad Taqiyuddin, Siti Fatimah</i>	303
Staggered Numerical Modeling for Investigating the Effectiveness of Embankment and Vegetation on the Reduction of Wave Run-up <i>Iryanto Iryanto, Muhamad Mustamiin, Munengsih Sari Bunga, Ikha Magdalena, Novry Erwina</i>	308
The metric dimensions of bridge graphs for some classes of graphs <i>Amrullah Amrullah, Syahrul A, Turmuzi M, Baidowi Baidowi, Nani K</i>	316

Analytical Study and Numerical Solutions of Bird Flu Epidemic Model with Vaccination <i>Arrival Rince Putri, Mahdhivan Syafwan</i>	324
Analysis and Simulation of SEIRS model for Hepatitis B <i>Syafruddin Side, Muhammad Abdy, Wahidah Sanusi</i>	331
k-Means and GIS for Mapping Natural Disaster Prone Areas in Indonesia <i>Suwardi Annas, Zulkifli Rais</i>	340
Joint Modeling of Wet Condition Characteristics of Makassar City <i>Wahidah Sanusi, Sahlan Sidjara, Sudarmin Sudarmin, Muhammad Abdy</i>	347
A Note on Generalized Holder's Inequality in P-summable Sequence Spaces <i>Al Azhary Masta, Siti Fatimah, Eka Rahma Kurniasi, Rajab Vebrian, Iis Juniati Lathifah</i>	355
Risk of Death for Low Birth Weight Babies Using Cox Regression <i>Dewi Murni, Yenni Kurniawati, Rosi Ramayanti</i>	360
<b>CHEMISTRY EDUCATION</b>	
First Year Conception of Students in the Concept of Atom and Periodic System Elements <i>Bertha Yonata, Dian Novita, Utiya Azizah, Mitarlis Mitarlis</i>	369
Implementation of Innovative Learning Material With Project to Improve Students Performance in The Teaching of Complexometry Titration <i>Rafidah Almira Samosir, Jecky Bukit, Manihar Situmorang, Murniaty Simorangkir</i>	375
The Development of Innovative Learning Material with Project and Multimedia for Redox Titration <i>Rohazmy Rizki, Habib Hernando, Manihar Situmorang, Simson Tarigan</i>	385
The Validity of Problem-Solving Based Teaching Materials for The Exploration of Conceptual Change and Metacognitive Skills <i>Utiya Azizah, Harun Nasrudin, Mitarlis Mitarlis</i>	394
The study of traditional food HACCP through project-based learning in food chemistry course <i>Nova Kurnia, Liliasari Liliasari, Dede Robiatul Adawiyah, Florentina Maria Titin Supriyanti</i>	402
Profile of Misconception in Senior High School Students on the Concept of Acid-Base Strength <i>Wiwi Siswaningsih, Nahadi Nahadi, Vina Chandratika</i>	409
Development and Validation of Specific Chemistry Teaching Mode for Environmental Sustainability <i>Army Auliah, Muharram Muharram</i>	418
<b>CHEMISTRY</b>	
The Design of Sensitive, Selective and Reproducible Biosensor With Enzyme Immobilisation For Analytical Applications <i>Manihar Situmorang, Isnaini Nurwahyuni</i>	426

Total Phenol, Flavonoid Levels and IC50 in Local Grape ( <i>Vitis vinifera</i> L) Skin Waste Wine <i>Siti Maryam</i>	435
Chemical Water Types of Unconfined Groundwater in Southern Bandung <i>Wilda Naily, Hendarmawan Hendarmawan</i>	441
Study of Methylene Blue Degradation Using Mediated Electrochemical Oxidation With Ce (IV) Ions: Effect of Supporting Electrolyte, Ce (III) Concentration, and Oxidation Potential <i>Ummu Rokhima, Henry Setiyanto, Muhammad Ali Zulfikar, Vienna Saraswati, Nandang Mufti</i>	448
Molecularly Imprinted Polymer as a Sorbent for Alpha Mangostin <i>Neena Zakia, Handajaya Rusli, M Ali Zulfikar, M Bachri Amran</i>	457
Characterization and Application of N-doped Carbon Nanodots from Molasses Produced by Microwave-Assisted Extraction Method for Photocatalytic Degradation of Methylene Blue <i>Mentik Hulupi, Haryadi Haryadi, Muahamd Ariq Al Badar, Ahya Sularasa</i>	463
Modification of Carbon Paste Electrode with Molecularly Imprinted Poly(Glutamic Acid) for Determination of Rhodamine: A Preliminary Study <i>Henry Setiyanto, Ferizal Ferizal, Muhammad Yudhistira Azis, Muhammad Ali Zulfikar, Vienna Saraswati, Nandang Mufti</i>	474
Modification of Carbon Paste Electrode with Ag Nanoparticle for Voltammetric Determination of Phenol <i>Tri Sulistyorini, Henry Setiyanto, Muhammad Ali Zulfikar, Vienna Saraswati, Nandang Mufti</i>	481
The Activity of PVDF-TiO <sub>2</sub> /ZnO/CoO Nanofiber Photocatalyst for Degradation of Humic Acid Solution <i>Siti Oryza Sativa, Muhammad Ali Zulfikar, Ervin Tri Suryandari, Muhammad Nasir</i>	489
Speciation of Lead (Pb) and Cadmium (Cd) in Agricultural Soil of Pancasari Village as A Vegetables Central Area of Bali, Indonesia <i>I Dewa Ketut Sastrawidana</i>	496
Optimization test of ipomoea batatas l. leaf extract as a flocculent in water treatment for practicum in chemical analysis of environment course <i>Hana Rohana, Cahyo Puji Asmoro</i>	506
The Effect of Steaming on The Color and Amount of Anthocyanin of Purple Sweet Potato Flour <i>Ai Mahmudatussa'adah, Rita Patriasih, Rijanti Rahayu Maulani, Karpin Karpin</i>	513
Adsorption-Desorption Properties of Ammonium Ion on Zeolite Bottom Ash in Aqueous Solution <i>Galuh Yuliani, Widya Liswanti, Rahmadhita Murida, Siska Mutiara, Agus Setiabudi</i>	520
Determination of Antioxidant Activity and Physico-Chemicals Characteristics of Fortified Yogurt Powder by Super Red Dragon ( <i>Hylocereus Polyrhizus</i> ) Fruit Peel Powder <i>Florentina Supriyanti, Zackiyah Zackiyah, Fiona Finandia</i>	528

## PHYSICS EDUCATION

QR-Code Assisted Learning Book: Scientific-Based Physical Learning Solution <i>Fauzi Bakri, Sarah Salsabila, Dewi Mulyati</i>	537
Development of Standardized Online Test to Assess the Students 21st Century Skills <i>Setiya Utari, Jessie Manopo, Selly Feranie, Eka Cahya Prima, Bambang Heru Iswanto</i>	542
The Effect of Problem Based Learning (PBL) towards Critical Thinking Used Computer Simulation <i>Mariati Simanjuntak, Chatarina Purba, Berta Panggabean, Azmi Mustafa, Juniar Hutahaean</i>	550
Exploration of Students' Problem-Solving Skills in Physics-Based on Expert and Novice Categories <i>Nehru Nehru, Wawan Kurniawan, Cicyn Riantoni</i>	558
The physics of Gravitrans: "Leisure or outdoor learning?" <i>N Suprpto, H Mubarok</i>	566
Module Equipped with Augmented Reality Technology: An Easy Way to Understand Concepts and Phenomena of Quantum <i>Fauzi Bakri, A Handjoko Permana, Shelma Nur Chaeranti, Dewi Mulyati</i>	574
Development and Validation of Critical Thinking Skills Instruments of Physics Subjects <i>Khaeruddin Khaeruddin, Bunga Dara Amin</i>	583
Pedagogical Content Knowledge Ability in Reflecting Project-Based Learning on Physics Concepts <i>S Efwinda, MN Mannan</i>	588
Simulation of Gas Speed Measurement for Investigating Maxwell Distribution <i>Tugiyo Aminoto, Rahma Dani, Neneng Lestari, Cicyn Riantoni</i>	595
Development of Science Literacy Instruments in the Direct Current <i>Dony Susandi, ED Jannati, A Rachmat, I Kaniawati, P Siahaan</i>	603
Physics Textbook Enriched Augmented Reality: Easy Way to Understand The Physical Concept <i>Dewi Mulyati, Diniar Hikayah Baiti, Fauzi Bakri, Handjoko Permana</i>	607
Implementing Project-Based Learning to Improve Students' Creative Disposition, Creativity and Understanding in Learning Light and Optics <i>Indah Laelasari Efendi, Eka Cahya Prima</i>	613
Using Rasch Model Analysis to Analyze Students' Scientific Literacy on Heat and Temperature <i>Amalia Suci Lestari, Achmad Samsudin</i>	619
Didactic Design Based on Student Responses to Practice Scientific Literacy with Using Marzano Learning Dimensions and Reading Infusion on Momentum Content <i>Setiya Utari, Rattila Arinal Haque, Saeful Karim, Duden Saefuzaman, Muhammad Gina Nugraha, Eka Cahya Prima</i>	627

Enhancing Creative Problem Solving Skills using LEGO® Mindstorm EV3 in STEM Based Learning <i>Alfiansah Sandion Prakoso, Nurazizah Nurazizah, Anti Haryanti, Salman Al-Farizi, Lilik Hasanah, Irma Rahma Suwarma</i>	635
GOTO Telescope Motion Control System Right Ascension and Declination Direction with Three Modes of Speed Using Microcontroller ATmega2560 <i>I H Kurniawan, M Irfan, A Aminudin</i>	641
The Profile Analysis of Problem-Solving Skills on Work and Energy Material Using "Multiple-Ways of Rosengrant" <i>V Vidyawati, P Sinaga, L Hasanah</i>	646
Feasibility of Web-based Teaching Materials that Accommodate Multiple Intelligences on Global Warming Materials <i>Winny Liliawati, Taufik Ramlan Ramalis, Annida Meida Zulika</i>	654
The Impact of Model Based Learning (MBL) in Improving Students' Understanding in Heat and Heat Transfer Concept <i>Mutia Hariza Lubis, Ika Mustika Sari, Parlindungan Sinaga</i>	661
How do pre-service physics teachers see sustainability issues? A case at an Islamic University in Indonesia <i>Dindin Nasrudin, Agus Setiawan, Dadi Rusdiana</i>	666
The Development of Model-Based Learning in Introductory Physics: The effectiveness of improving Students Understanding in Heat and Heat Transfer <i>Ika Mustika Sari, Saeful Karim, Duden Saepuzaman, Taufik R Ramalis, Dadi Rusdiana</i>	672
Scientific or Not? Mapping Category of Students' Written Argument <i>S Siswanto, S Y Anci, Y Yusiran, H Hartono, B Subali, E Trisnowati</i>	680
The Influence of STEM-Integrated 7E Learning Cycle on Students' Creative Thinking Skills in The Topic of Temperature and Heat <i>Parno Parno, Lia Yuliati, Edi Supriana, Ahmad Taufiq, Marlina Binti Ali, Anula Ning Widarti, Umi Azizah</i>	686
Pre-Class Tutorial (PCT) to Improve Understanding of Prospective Physics Teacher Concepts in Basic Physics Course <i>D Saepuzaman, S Karim, S Feranie, I M Sari, S P Sriyansyah</i>	694
Application of a Guided Inquiry Model to Improve the Learning Outcomes of Class XI Physics Students <i>Vina Serevina, Nada Yolanda, Virgiana Tinura</i>	704
<b>PHYSICS</b>	
Peak Ground Acceleration on Bedrock using Probability Seismic Hazard Analysis Methods in Bandung City <i>Anggun Mayang Sari, Afnindar Fakhurrozi, Arifan Jaya Syahbana</i>	714
The Effect Of Temperature To 3D Change Rock Structure On Caprock Of The Area Of Geothermal Potential In Kadidia - Sigi, Central Sulawesi <i>I Assidiq, A Nadhira, S Feranie, F D E Latief</i>	721

Modeling of Tunneling Current in Bilayer Armchair Graphene Nanoribbon-Tunneling Field Effect Transistor by Using Airy Wave Function Approach <i>Shofi Dhiya 'Ulhaq, Muhammad Fulki Fadhillah, Amelia Fadhillah, Intan Anjaningsih, Andhy Setiawan, Endi Suhendi</i>	728
Modeling of Tunneling Current of A Bilayer Armchair Graphene Nanoribbon-Based P-N Junction Diode using Airy Wave-Function <i>A. Fadhillah, I. Anjaningsih, S. D. Ulhaq, M. F. Fadhillah, Waslaluiddin Waslaluiddin, E. Suhendi</i>	735
The Sensitivity of Attenuation Impact to Bedrock PGA Based on PSHA Analysis, Case Study: Yogyakarta Special Region, Indonesia <i>A J Syahbana, K Sugianti, M Irsyam, Hendriyawan Hendriyawan, M Asrurifak</i>	743
Seismic Hazard Analysis of Maumere, Flores: a Review of the Earthquake Sources <i>Lina Handayani</i>	753
Synthesis And Characterization of Nanoparticles CaCO <sub>3</sub> /MgO as Antibacterial <i>Zahrotul Jannah, Lydia Rohmawati, Woro Setyarsih</i>	760
Thermal Distribution Analysis Of Heating System For Optimization Of Co <sub>2</sub> Gas Sensor Detection <i>Dwi Putri Desti Utami, Aldi Rijaldi, Amalia Nurfitriani, Gulistan Amalia Rahman, Siti Inna Zainab, Rossie Wiedya Nusantara, Yuyu Rahmat Tayubi, Ahmad Aminudin, Mimin Iryanti</i>	768
The Automatic Detection of Near-Earth Asteroids in Co-orbital State with Terrestrial Planets by Implementing Motif Discovery Algorithm <i>Judhistira Aria Utama, Lala Septem Riza, Muhammad Naufal Fazanadi, Taufiq Hidayat</i>	776
Bluino: Blind Arduino Sensor to Assist Students with Visual Impairment <i>Rossy Andini Herindra Putri, Annisa Fadhila Nur Fikriah, Diana Ayu Latifah, Shafa Rihadatul Aisy, Eliyawati Eliyawati, Eka Cahya Prima</i>	781
Analysis of Physical and Electrical Properties on Peat Soils in Longan Plantations in West Kalimantan Region <i>Gulistan Amalia Rahman, Mimin Iryanti, Siti Inna Zainab, Aldi Rijaldi, Dwi Putri Desti Utami, Amalia Nurfitriani, Ahmad Aminudin, Yuyu Rahmat Tayubi, Rossie Wiedya Nusantara</i>	788
Graphene/SiO <sub>2</sub> Nanocomposite From Natural Material <i>Munasir Munasir, Mahdalysa Dayu</i>	795
Uniaxial Mechanical Pressure Effect To The Pore Structure Deformation of an Altered Breccia Rock <i>A Nadhira, I Assidiq, S Feranie, F D E Latief</i>	803
The Biomass Coal Fermented (BCF) Briquette as an Alternative Fuel <i>Dyah Marganingrum, Lenny Marilyn Estiaty, Chandra Irawan, Hidawati Hidawati</i>	811
<b>BIOLOGY EDUCATION</b>	
Effectiveness of Learning Material by ICT-Based Guided Inquiry Model to Train Critical Thinking Skill and Science Literacy <i>Sifak Indana, Rudiana Agustini, Yuni Sri Rahayu</i>	820

The Course of Biology Learning Methodology: Are Concept-Based Learning and Drill Method Effective in Enhancing Higher-Order Thinking Skills of Students? <i>Lufri Lufri, Relsas Yogica, Arief Muttaqin, Rahmadhani Fitri</i>	827
The Effectiveness of Modified Free Inquiry Strategies to Enhance Mastery of Molecular Biology Concepts <i>Evi Suryanti, Any Fitriani, Sri Redjeki, Riandi Riandi</i>	832
A comparison of learning the digestion process with comic strips and endoscopic video: the effects on student's achievement and its contributing factors <i>Ikmanda Nugraha, Lilit Rusyati, Rika Rafikah Agustin</i>	840
Students' Biological-Mathematical Attitude in Quantitative Literacy-Based Learning on the Topic of Ecosystem <i>Eni Nuraeni, Soesy Asiah Soesilawaty, Irvan Permana, Sofi Rahmania</i>	847
The Implementation of Learning Materials Based on Local Wisdom of Agricultural in Binjai to Improve the Students Problem Solving Abilities <i>Findi Septiani, Siti Sriyati, Amprasto Amprasto</i>	853
The Development of Ethnobotany Based Local Wisdom Learning Materials to Improve Environmental Literacy and Creative Thinking Skills <i>Defita Permata Sari, Siti Sriyati, Rini Solihat</i>	861
The Achievement of 21st-Century Students' Plant Literacy Through Field Trip Implementation <i>S Diana, AN Alfiah, F Rizkamariana, A Amprasto, AR Wulan</i>	867
Enhancing Students' Problem Solving Ability through Teaching Material based on Tumpek Wariga as Local Wisdom in Bali <i>Kadek Sera Harlistya Udayani, Siti Sriyati</i>	874
<b>BIOLOGY</b>	
Analysis of community needs around the Mallawa Resort in Bantimurung Bulusaraung National Park for Conservation of Natural Orchids <i>St. Fatmah Hiola, Gufran Darma Dirawan</i>	883
Application of Cycle 5E Learning Model in Photosynthesis Discussion to improve Skills of Science Processes Airmadidi State High School Students <i>Meity N Tanor, Arrijani Arrijani, Debby J.J. Rayer</i>	887
Feed Conditions Preference for type Ant ( <i>Oecophyla smaragdina</i> ) In Morphometric Swiftlet ( <i>Aerodramus fuciphagus</i> ) <i>Sunu Kuntjoro, Fida Rachmadiarti, Herlina Fitri Hidajati</i>	896
Effectiveness of <i>Ludwigia adscendens</i> and <i>Ludwigia grandiflora</i> as Cadmium (Cd) Phytoremediator <i>Fida Rachmadiarti, Marátus Sholikhah</i>	902
Study of Soya Addition in Tris Base Extender on the Quality of Senduro Goat Spermatozoa and Membrane Integrity on Storage Temperature 4-5°C <i>Nur Ducha, Widowati Budijastuti, Nur Kuswanti</i>	909
Antibacterial Activity of <i>Lannea coromandelica</i> Extract <i>Hartati Hartati, Syamsuddin Syamsuddin, Hilda Karim, Halifah Pagarra</i>	915

Effect of Sea Surface Temperature and Chemical Parameters on the Metal Zn Contents in Inshore and Offshore Water of Blanakan Coast, West Java, Indonesia <i>Noverita Dian Takarina</i>	920
The Capability of Black Soldier Fly, <i>Hermetia Illuncens</i> , to Consume Some Weeds in Vegetable Field <i>Y Sanjaya, Suhara Suhara, M. Nurjhani, M Halimah</i>	927
Population Estimation and Habitat Characteristics <i>Rhacophorus reinwardtii</i> in the Secondary Forest Ranca Upas Ciwidey <i>Hernawati Hernawati, Tina Safaria Nilawati, Kemas Muhammad Abiyyu Ilham Malik</i>	931
The Use of Degenerate Primer to Isolation and Designing Housekeeping Gene of Eel Fish ( <i>Anguilla bicolor</i> ) <i>Diah Kusumawaty, Tina Yulianti, Hernawati Hernawati</i>	941
<b>CHEMISTRY SCIENCE EDUCATION</b>	
Development of Student Attendance Reporting System Using WhatsApp Gateway with Android-Based Broadcasting Method <i>Enjang Ali Nurdin, Wahyudin Wahyudin, Deni Martin</i>	949
Requirement Engineering Method for Alignment of Information Technology (IT) Utilization with Education Business Strategy <i>Budi Laksono Putro, Heri Sutarno, Rizky Rachman Judhie Putra, Della Ilona Suryana Putri</i>	957
TPS-Based Interactive Multimedia to Improve Learning Effectiveness <i>Wildan Juliardi, Rasim Rasim, Eka Fitrajaya Rahman, Munir Munir</i>	966
Detector Similarity Answers Between Students on Essay Digital Exam System <i>Regi Ismayana Pratama, Munir Munir, Rani Megasari</i>	973
Using Animated Multimedia in Computer and Basic Network Subject <i>Wahyudin Wahyudin, Munir Munir, Muhamad Nursalman, Yaya Wihardi, Enjang Ali Nurdin, Herbert Herbert</i>	982
Development of Mobile Learning Framework for Vegetable Farming in Indonesia <i>Erlangga Erlangga</i>	993
A Cooperative Script Learning Method Application Assisted By Interactive Multimedia To Improve Students' Cognitive Aspect Of 10th Grade At Vocational High School <i>Munir Munir, Donni Triosa</i>	1001
Development of Three Dimensional Based Learning Media Barcode for Basic School <i>Ria Triayomi, Theresia Widyastuti</i>	1009
Lgate-S: Simulation Media for Learning Logic Gate <i>Harsa Wara Prabawa, Erni Nuraeni, Rizky Rachman Judhie, Jajang Kusnendar</i>	1017
Logic and Computer Educational Game for non-IT Vocational Students <i>Annisa Larasati, Harsa Wara Prabawa, Jajang Kusnendar</i>	1025



Instilling Healthy Lifestyle Behaviour into Prospective Physical Education Teachers through 30 Day Fitness Challenge Application <i>T Muhtar, T Supriyadi, A Suherman</i>	1032
2 Dimensions Interactive Media Learning of Good Behavior for Children Elementary School <i>Chaerur Rozikin, Jajam Haerul Jaman, Iqbal Alexander Gumelar</i>	1038
<b>COMPUTER SCIENCE</b>	
Web-Based Literacy Information Systems as Strategies to Improve Society Reading Interest <i>Ricky Firmansyah, Nanang Hunaifi, Dinda Amalia</i>	1046
An Android-based on House sales Monitoring System in Housing Area <i>Chaerur Rozikin, Ultach Enri</i>	1054
Kinect Based Motion Capture for 3D Character Animation <i>Yaya Wihardi, Eka Fitrajaya Rahman, Fadhil Farras H.N.</i>	1062
Developing an Assessment Model of E-Government Software Assets for Maintenance Recommendations: A Case Study in BKD Bandung <i>Rizqia Lestika Atimi, Bayu Hendradjaya, Wikan Danar Sunindyo</i>	1067
Deep Learning-Based Complaint Classification for Indonesia Telecommunication Company's Call Center <i>Shinta Devi Lukitasari, Fadhil Hidayat</i>	1078
Facial Expression Recognition on The Classroom Environments <i>Wawan Setiawan, Yaya Wihardi, Enjun Junateti, Naufan Rusyda Faikar</i>	1089
Neural Networks Classification for Breast Cancer Analysis <i>Paquita Putri, Intan Nurma Yulita</i>	1094
Securing an Event-Based Smart Meter System to Prevent Pricing Cyberattack: A Preliminary Research <i>Desti Nirwana Mozef, Fadhil Hidayat</i>	1101
Hybrid Trust-based Defense Mechanisms Against Sybil Attack in Vehicular Ad-hoc Networks <i>Agria Rhamdhan, Fadhil Hidayat</i>	1111
Web-Based Orphanage Fundraising Information System <i>Phitsa Mauliana, Ricky Firmansyah, Ai Surtika Dewi</i>	1119
Sentiment Analysis of the Body-Shaming Beauty Vlog Comments <i>Jajam Haerul Jaman, Hannie Hannie, Martina Sari Simatupang</i>	1128
Social Influence Data Analytic For Supply Chain Management in Fashion Industry <i>Puspita Nurul Sabrina, Fajri Rakhmat Umbara, Herdi Ashaury</i>	1138
An Integration of National Identity towards Single Identity Number with Blockchain <i>Rana Zaini Fathiyana, Fadhil Hidayat, Budi Rahardjo</i>	1147
A Study Review of Common Big Data Architecture for Small-medium Enterprise <i>Ridwan Fadjar Septian, Fajri Abdillah, Tajhul Faijin Aliyudin</i>	1156

The Artificial Neural Networks (ANN) for Batik Detection Based on Textural Features <i>Anita Ahmad Kasim, Muhammad Bakri, Anindita Septiarini</i>	1168
Predicting Fetal Condition from Cardiotocography Results Using the Random Forest Method <i>Syifa Fauziyah Nurul Islam, Intan Nurma Yulita</i>	1177
Breast Cancer Classification: Comparison of Bayesian Networks, Multilayer Perceptron, and Boosting Method <i>Intan Nurma Yulita, Shofiyyah Nadhiroh</i>	1185
Decision-Making Framework for Validation of Data Collection Process in a Survey with GPS Data <i>You Ari Faeni, Fadhil Hidayat</i>	1192
Code Comment Assessment Development for Basic Programming Subject using Online Judge <i>Rosa Ariani Sukamto, Rani Megasari, Erna Piantari, M Nabillah Fihira Rischa</i>	1204
Student's Skills Competency Test Prediction Using C4.5 Algorithm <i>Ultach Enri, Jajam Haerul Jaman, Muhammad Rizky Ananda</i>	1209
Objective Quality Assessment of Multi-Resolution Video based on H.264/AVC and H.265/HEVC Encoding <i>Adhi Rizal, Aries Suharso, Panji Abujabbar, Munir Munir</i>	1217
Implementation of Rivest Chiper Cryptography (RC6) with One Time Password (OTP) and Two Central Facilities Protocol in Complaint Service System <i>Muhamad Nursalman, Eddy Prasetyo Nugroho, Ferryan Reynaldi Akbar Nur</i>	1227
Tactical Dashboard Design for Study Program in University <i>Erna Piantari, Rani Megasari, Kevin Adriansyah Hidayat</i>	1236
Multi Criteria Evaluation for Vocational School Zone Based on Geographic Information System <i>I Widianingsih, I M Purwaamijaya, R M Masri</i>	1246
Analysis and Design of N-Ram Digital Games for problem-based solving for Early Childhood Geometry Learning <i>Taufik Ridwan, Endang Hidayat</i>	1254
Garbage Bank in Elementary Schools for The Clean Life and Love the Environment Education <i>Budi Laksono Putro, Waslaluddin Waslaluddin, Rizky Rachman Judhie Putra, Heri Sutarno</i>	1263
The Implementation of Project Based Learning to Improve Student Creativity and Learning Outcomes <i>Enjang Ali Nurdin, Wahyudin Wahyudin</i>	1271
A Comparative Study of Blindhide and Filterfirst Algorithm in Digital Images for Steganography Techniques <i>Purwantoro Purwantoro, Garno Garno, Munir Munir, Ari Suntia</i>	1276
Land Suitability Evaluation Using a GIS-Based Logic Scoring of Preference Method <i>R M Masri</i>	1292

Land Suitability Evaluation for Housing and Residential Based on GIS, Satellite Imagery and DTM <i>I M Purwaamijaya</i>	1299
Implementation of CM-SPADE Algorithm In Building Denial of Service Detection System Model Using Snort <i>Eddy Prasetyo Nugroho, Rani Megasari, Enjun Junaeti, Samekto Rinekso Pribadi</i>	1309
Online Information System for Archiving Documents And Letters Requests at The Sub-District Level <i>Nanang Hunaifi, Agung Baitul Hikmah, Maxsi Ary</i>	1319
<b>INTEGRATED SCIENCE EDUCATION</b>	
The Implementation of Education for Sustainable Development in Adiwiyata School <i>Yosi Nurira Adriyanto, Dwi Nowo Martono, Nadiroh Nadiroh, Tri Edhi Budhi Soesilo</i>	1331
Development of Engage, Research, and Present (ERP) Instructional Model to Promote HOTS and 21st Century Moral Values: A Fuzzy Delphy Method <i>S Haryati, S Sukarno, S Siswanto, Ahmad Muhlisin, C W Anggraeni, W W W Brata</i>	1339
Designing Physics Experiment and Assessment of Inquiry-Based Laboratory to Exercise Higher Order Thinking Skills <i>Setiya Utari, Eka Cahya Prima</i>	1346
Analyzing The Student Experiment Psychomotor Abilities <i>Ahmad Yani, Fifi Eka Safitri, Usman Usman, Ahmad Dahlan</i>	1354
Students' Environmental Awareness in Learning Environmental Pollution Using Instagram-mediated SAMR Model <i>Handina Handina, Diana Rochintaniawati, Ikmanda Nugraha</i>	1361
Stellarium as An Interactive Multimedia to Enhance Students' Understanding and Motivation in Learning Solar System <i>Risma Marina, Eka Cahya Prima</i>	1372
Assessing Students' Creative Disposition and Creative Product in Learning Newton Law <i>Melli Indah Suciani, Eka Cahya Prima</i>	1380
Engineering Course Model on STEM Education for Middle School Curriculum Setting in Indonesia <i>Setiya Utari, Eka Cahya Prima, Irma Rahma Suwarma, Andi Suhandi</i>	1388
Preparing The Subject-Specific Pedagogy using REACT Strategy for Improving Higher-Order Thinking Skills <i>Eka Indaryani, Dwi Sulisworo, Suparwoto Suparwoto, Moh Toifur</i>	1393
Gender Differences in The Attribution of Creative Thinking: Experimental Evidence using STEM-based E-Module <i>Lilit Rusyati, Diana Rochintaniawati, Rika R Agustin, Yayan Sanjaya, Ivaldy G. Deandra</i>	1402
The Teachers' Scientific Competence Profile Based on Higher Order Thinking Skills (HOTS) Perspective <i>Eka Danti Agustiani, Nuryani Y Rustaman, Ana Ratna Wulan</i>	1407

The analysis of PPG Students' Mistake in Learning Daring Process <i>Ferry Ferdianto, Jajo Firman Raharjo, Sumar Hendayana, Asep Supriatna, Arif Hidayat</i>	1414
STEM Learning on Electricity using Arduino-Protoboard Experiment to Improve 8th Grade Students' STEM Literacy <i>Kallin Patridhina Manika, Eka Cahya Prima</i>	1423
The Profile of Students Creative Thinking Skill in Designing Optical Instruments Prototype <i>Salman Alfarisi, Irma Rahma S, Lilik Hasanah</i>	1431
The Development of 'E-Layer' Android Mobile Application as Interactive Multimedia in Earth Layer Topics for Junior High School <i>Eksa Nursafira Sunarya, Eka Cahya Prima, Yaya Wihardi</i>	1437
Using Self-Regulated Learning to Promote Students' Metacognitive Awareness in Learning Electricity <i>Miftah Bahari, Ari Widodo, Nanang Winarno</i>	1445
Blended Learning on Students' Motivation: The Case of Teaching Solar System <i>Vania Zhafirah, Agus Fany Chandra Wijaya, Nanang Winarno</i>	1453
SOLAR WALK ADS+: Explore Space as A Multimedia to Improve Students' Understanding and Believe in Learning Solar System <i>Renita Novitasari, Hayat Sholihin, Eka Cahya Prima</i>	1461
'Shake It Up' as Android Mobile Learning Application based on Earthquake Mitigation for Junior High School Students <i>Gita Sukmawati, Eka Cahya Prima, Eliyawati Eliyawati</i>	1469
'Electree' as Android Mobile Learning Application based on Arduino Projects for Junior High School Students <i>Darul Agustiana Ma'rifah, Eka Cahya Prima</i>	1476
Designing Inquiry-based Laboratory on Concave Eyeglasses Experiment to exercise Student's Science Inquiry Skills <i>Setiya Utari, Eka Cahya Prima</i>	1484
Pre-Service Science Teachers' Understanding of Chemical Multiple Representations <i>E Eliyawati, Rika Rafikah Agustin, Rossy Andini</i>	1491
Identifying Argumentation Skills Using Three Tier Test on Pre-service Physics and Biology Teachers <i>E Suryani, Y Yusiran, O Hairullah, S Siswanto, N Nurfathurrahmah, Ariyansyah Ariyansyah</i>	1499
Predicting Teachers' Familiarity on High Order Thinking Skills through Common Keywords in Science Learning: A Preliminary Study <i>Erman Erman, Nur Wakhidah</i>	1505
The Validity and Reliability of Science Virtual Test on Levels of Organization and Cell Transport Topic (SVT-LOCT) to Assess Students' Science Process Skills <i>Wafa Hanifah, Nuryani Rustaman, Lilit Rusyati</i>	1511
Android Based Application Fawless (Food Assist Wasteless) As Innovative Solution On Reducing Food Waste <i>Putri Sekar Melati, Sulistinayah Suwaka Putri, Rossy Andini Herindra Putri, Lilit Rusyati</i>	1521

Predictions of Students' Thinking for The Learning of System of Linear Equations in Two Variables <i>Al Jupri, Dian Usdiyana, Ririn Sispiyati</i>	1529
Creativity Development in Science and Technology Education <i>Janchai Yingprayoon</i>	1536
The Efficient Multiplier GF(28) is Formed by The NAYK Algorithm <i>Muhamad Nursalman, Arif Sasongko</i>	1545
The Didactical Design of Properties of Triangles based on Pecle Traditional Games in Primary School <i>Epon Nur'aeni, Fitri Rohmayati, Muhammad Rijal Wahid Muharram, Oyon Haki Pranata, Hodidjah Hodidjah, Ika Fitri Apriani</i>	1556
Correlation Between Learning Outcomes Modeling Problem Solving Learning with Learning Outcomes of Preparation of Lesson Plant Prospective Biology Teachers <i>R. P. Puspitawati, A. Basri</i>	1566
An Architecture of E-Marketplace Platform for Agribusiness in Indonesia <i>Erna Piantari, Herdi Ashaury, Enjun Junaeti, Venkata Harsha Nagalla</i>	1573
Generalized Hlder's inequality in Orlicz sequence spaces <i>Siti Fatimah, Al Azhary Masta, Ifronika Ifronika, Risnina Wafiqoh, Putri Cahyani Agustine</i>	1580
Teaching Simulator Development Based on Finite State Machine and Big Five Personality <i>Wawan Setiawan, Siti Fatimah, Enjun Junaeti, Jajang Kusnendar, Rasim Rasim, M. Eagan Ramadhan, Ria Anggraeni, Joy M. Suba, Edwin D. Torres, Maynard Jay S. Galang</i>	1584
The Development of High School Physics Teaching Material Based on STEM to Facilitate the Development of 21th Century Learning Skills <i>D. Yulianti, Wiyanto Wiyanto, A. Rusilowati, S. E. Nugroho</i>	1592
Implementation of Interactive Multimedia and Kit with Writing-to-Learn Strategy on the Chemistry in Daily Life Topic for Junior High School with Disabilities <i>Sukarmin Sukarmin, Sri Poedjiastoeti, Dian Novita, Achmad Lutfi, Luky Susanti</i>	1600
A Modified Lax-Friedrichs Method for the Shallow Water Equations <i>Kartika Yulianti, Rini Marwati, Suci Permatahati</i>	1608
Hypnoteaching and Hypnolearning in Mathematics Education <i>Hamzah Upi, Ja'faruddin Ja'faruddin</i>	1614
Development of Plant Tissues Atlas for Instructional Media at Senior High School <i>Ardi Ardi, Yudi Agustira Rahmatullah</i>	1620

# k-Means and GIS for Mapping Natural Disaster Prone Areas in Indonesia

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**Abstract.** The number of natural disasters in Indonesia is very high frequency. However, the data collected based on natural disasters has complex structures. One of the efforts to make prevention design is grouping the areas of natural disasters based on their similarities. The proposed methods are k-means to cluster areas and Geographical Information System (GIS) to improve visualization of yielded clusters. This result showed that the best cluster was seven clusters based on root mean square standard deviation (RMSD). Although k-means obtained the best number of clusters, however, it was difficult to present the clusters of natural disaster areas in a map. Therefore, the GIS method can be a useful tool to improve the visualization of k-means.

**Keywords:** GIS, k-means, Natural disaster, RMSD

## 1 Introduction

Indonesia is one of the countries with a very high frequency of disasters caused by either natural factors or human factors. A disaster is an event that threatens and disrupts people's lives, resulting in the loss of human lives, environmental damage, loss of property, and the psychological impact. A natural disaster is any catastrophic event that is caused by nature, such as earthquakes, volcanic eruptions, floods, hurricanes, and landslides. United Nations Office for Disaster Risk Reduction (UNISDR) published that Indonesia has a very high risk of disaster [1].

We need the effort to take precautions so that casualties and damage in terms of materials as well as in the environment can be minimized. One of the efforts is determining disaster-prone areas. However, these efforts have not been maximal because the determination of the area was only based on the potential damage of the regions, and also the data released has not provided detailed information about the kinds of high-potential natural disasters of these areas.

In order to maximize the handling and prevention of disasters in Indonesia, this study aimed to predict group/cluster of areas and map the risk areas based on the number of natural disasters occur. One of the grouping methods proposed in this study is the k-means method. The advantage of the k-means method is the ability to cluster the data that are large and have very fast outliers [2]. This method uses a similarity measure to classify the object. This similarity can be translated into the concept of distance. Two objects are said to be similar if the distance between the two objects is closed. The higher the value of the distance, the higher the value of dissimilarity [3].

The algorithm of k-means can be summarized by selecting the closest distance to the center, followed by calculating a new center based on the grouping. This is done until there is no change of group members [4]. After the grouping results obtained, then the next step is the determination of the best groups by using Roots means square deviation methods (RMSD) [5]. It is required to get optimum grouping. Optimum grouping result is obtained if the group is not overlapping with each other [3].

Although k-means can analyze data well, this method is not able to provide detailed information related to disaster-prone areas. To overcome this drawback, optimum grouping yielded by k-means then is applied to the Geographical Information System (GIS) to map the types of disasters that are used as an identifier variable of a disaster area. GIS method is a computer-based information system used to process and store data or geographic information. This software was chosen because it can gather information quickly and easily to access, the data can be accessed and without space and time [6]. The results of the merger of k-means and GIS will produce the clustering and mapping of the types of disasters optimally so that the specific disaster-prone areas in Indonesia could be easily identified [7].

## 2 Method

### 2.1 Data

The data used in this research is the data of natural disasters that occurred in 362 districts in Indonesia in 2016. The types of natural disasters used as an identifier variable are landslides, floods, flash floods, earthquakes, tidal waves of the sea, wind quail/typhoons, volcanic eruptions, and forest fires. The data source of this natural disaster is issued by [8].

### 2.2 k-Means Algorithm

k-means are included in partitioning clustering which means as every single data must be included in a particular cluster and enable each data included in the particular cluster in a stage of the process, at a later stage switch to another cluster [9]. k-means separating the data into k separated areas, where k is a positive integer [10]. Two objects are said to be similar if the distance between the two objects closes [11]. The higher the value of the distance, the higher the value of dissimilarity [12]. Below are the steps of the k-means algorithm:

1. Determine the initial cluster centroids.
2. Calculate the distance to the cluster centroids using Euclidean distance.
3. Determine distance with a center cluster with the use equation (1) euclidean distance.

$$D_{(i,j)} = \sqrt{(x_{1i} - x_{1j})^2 + (x_{2i} - x_{2j})^2 + \dots + (x_{ki} - x_{kj})^2} \quad (1)$$

where  $D_{(i,j)}$  is a distance of data  $i$  to center of cluster  $j$ ,  $x_{ki}$  is data point  $i$  in attribute data  $k$  and  $x_{kj}$  is centroid  $j$  in attribute  $k$ .

4. Cluster data, the smaller the distance of cluster centroid, the higher the similarity of the data.
5. Determine new cluster centroids, with the calculation as shown on equation (2).

$$Z_c = \frac{1}{n} \sum_{i=1}^n X_i \quad i = 1, 2, 3, \dots, n \quad (2)$$

6. Do all steps until the result is convergent [13].
7. Calculate roots mean square deviation (RMSD) to measure the differences between population and sample values predicted by a model or an estimator and the values actually observed. The RMSD represents the sample standard deviation of equation (3)

$$RMSD(\theta) = \sqrt{MSE(\theta)} = \sqrt{E((\theta - \hat{\theta})^2)} \quad (3)$$

the differences between predicted values and observed values these individual differences are called residuals when the calculation is performed over the data sample that was used for estimation and are called prediction errors when computed out of sample [5]. The RMSD is a good measure of accuracy, but only to compare forecasting errors of different models for a particular variable and not between variables, as it is scale-dependent [14].

### 2.3 Mapping with GIS

GIS is a computer-based information system used to process and store data or geographic information [6]. According to [15] most of the data will be handled in GIS spatial data, geographic data-oriented. According to [16] This data has a specific coordinate system as a reference base and has two different important parts from other data, that is location information (spatial) and descriptive information (attributes) which is described below: The location information (spatial), corresponds to a coordinate either geographic coordinates (latitude and longitude) or the XYZ coordinates, including datum and projection information. Descriptive information (attributes) or non-spatial information, is a location that has some information related to it. The examples are types of vegetation, population, area, zip code, etc. [17].

## 3 Result and Discussion

The first procedure of the k-means algorithm begins with determining the number of clusters, then determines the center of groups randomly, and then find the distance to each data center, and determine of the members of clusters based on the minimum distance between the center and data points [9]. In this study, the number of groups was set as 3, 4, 5 6, and 7. The result of clustering with 3 clusters was gained by 5 iterations. The clustering process was repeated with 4 clusters and gained as much as 4 to 10 iterations. Clustering was repeated again with 5 clusters and gained as much as 5 to 8 iterations. The clustering process was repeated with 6 clusters obtained up to 5 iterations and the last clustering process was repeated with 7 iterations obtained 7 clusters. After clusters were obtained, then proceed with finding the value of RMSD of each number of clusters to determine where the optimum number of clusters. According to [5] cluster validation study used is RMSD, concluding that RMSD is done to calculate the differences in all grouping results, the two RMSDs are used to see normalized and



decomposition pairs of similarity matrices to determine the top Eigen and the third optimum grouping is determined by the lowest RMSD. Based on the research in Table 1 we can see that the smallest value of RMSD is 0.96 happened when the number cluster was 7 so that the optimum group was obtained.

**Table 1.** RMSD Values. The RMSD value for cluster.

Number of clusters	RMSD
3	1.39
4	1.28
5	1.12
6	1.06
7	0.96

The number of members for each cluster can be seen in Table 2. It can be considered that the smallest group is Cluster 4 and Cluster 6 with one district followed by Cluster 2, Cluster 3, and Cluster 5 with the number of members respectively 4, 6, and 9 districts. Conversely, Cluster 1 has the highest number of members which is 61 districts followed by Cluster 7 which has 280 districts. This variance indicates that the characteristics and the frequency of natural disasters of each cluster are heterogeneous.

**Table 2.** Clusters. The cluster of natural disaster-prone areas.

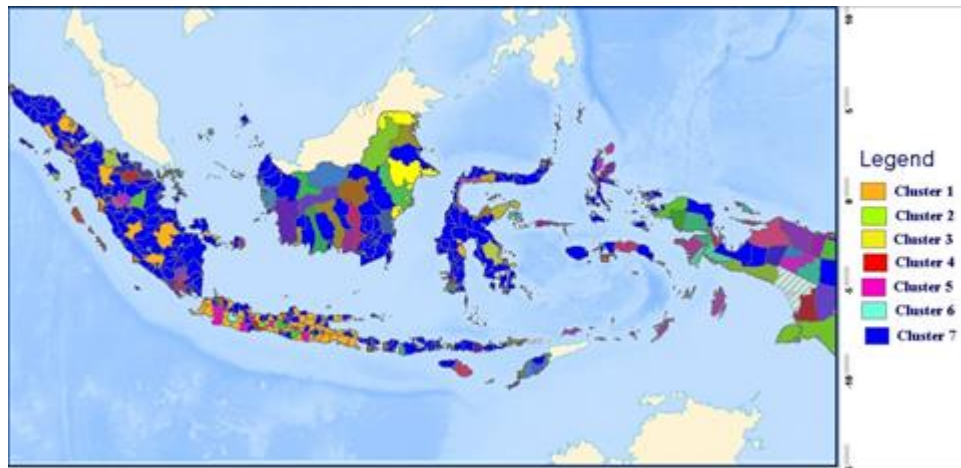
Number of clusters	Number of districts	Percentage
1	61	16.85
2	4	1.10
3	6	1.65
4	1	0.28
5	9	2.49
6	1	0.28
7	280	77.35
Total	362	100.00

After obtaining the optimum number of the cluster with k-means, the mapping of disaster-prone areas using the GIS application was applied. It was used since the k-means method was not able to display the natural disaster regions in a biplot display. The combination of the k-means grouping and the GIS mapping were expected to provide useful information and simplify the interpretation of the research findings. The results of this study are in line with the research conducted by [5], their research concluded that k-means is capable of rapidly grouping areas with ecological and environmental conditions similar to large data. The area identified using remote sensing so that it was clearly seen areas that had different ecological conditions and environments.

The mapping of natural disaster according to the regional clusters can be seen in **Figure 1**. Each cluster was given a unique code of color which is different from others. The relationship between the mean value and the natural disaster districts can be well interpreted showed in Table 3 and **Figure 1**.

**Table 3.** Clusters. The cluster of natural disaster-prone areas.

Variables	Mean scores of each cluster						
	1	2	3	4	5	6	7
Flood	5.29	6.75	1.50	21	4.89	28	1.15
Flood and landslide	0.19	1.00	0.00	1	0.89	0	0.18
High water wave and abrasion	0.13	0.00	0.17	2	0.22	0	0.03
Earthquake	0.05	0.00	0.00	0	0.00	0	0.06
Forest Fire	0.15	0.00	21.67	0	0.00	0	0.13
Explosive mountain	0.00	0.00	0.00	0	0.00	0	0.03
Whirling wind	4.26	19.75	0.67	50	4.89	1	0.86
Landslide	2.57	26.25	4.17	26	19.89	13	0.45



**Fig. 1.** Map of Indonesia's natural disaster in 2016.

Based on Table 3 and **Figure 1**, it can be seen that Cluster 1 is very prone to the flood, whirling wind, and landslide since it has the highest number of disasters compared to the others. Conversely, the number of abrasions, earthquakes, and forest fires is lower than in other groups.

Cluster 2 is very prone to flood and landslide based on the number of disasters, which is more significant than other clusters. However, the whirling wind should be on alert since its number is the second-highest among the groups. Cluster 3 is very prone to an earthquake because the number of disasters is higher than in others. However, the tidal wave/abrasion and landslide disaster must also be monitored due to the number of those natural disasters is high in this group. The areas in this group have never experienced a catastrophic eruption of volcanic eruptions, floods, landslides and earthquakes.

Cluster 4 can be an area where the number of natural disasters can be categorized as moderate because the number of natural disaster events is not the highest and not the lowest among other clusters. However, the floods, the whirlwind/hurricane and the drought should be put on alert for this group. Cluster 5 must be aware of flood, flood and landslide, tidal/abrasion, forest/land fire, and landslide due to the number of incidents that occurred in 2016, but the earthquake and volcanic eruption never occurred in this Cluster.

Cluster 6 is the riskiest areas affected by floods and landslides because the number of disasters in this group is very high. But for other natural disasters did not occur during the year 2016. Cluster 7 is the riskiest area of earthquakes and volcanic eruptions due to the number of disasters in this Group which is very high. But for other natural disasters, they are just simply put on alert due to the number of natural disaster events is low compared with those of other groups.

## 4 Conclusion

This research has applied k-means and GIS in grouping and mapping disaster-prone areas based on the districts that have happened in Indonesia. The use of k-means is based on 8 types of disasters that are used as characteristic variables. The result of grouping with the k-means method was obtained by 7 clusters as the optimum group with the smallest RMSD value from the other group. Based on the average value of every cluster for each variable, it can be concluded that the most frequent natural disasters in almost all clusters of areas are floods, followed by whirling wind and landslides. Forest fire, flood and landslide disasters, tidal waves/abrasion occur in moderate category except in areas of Cluster 7 which is categorized as low. On the other hand, the flood occurred most frequently in the area of Cluster 6. The highest number of whirling winds is in Cluster 4. The interesting fact from the findings of this study is that although the accuracy of the clustering results can be given by k-means this method is not able to map the conflict-prone types according to the type of disaster. This deficiency can be overcome by applying GIS to the result of k-means. The GIS has featured a map of the district's group that exacerbates the risk of natural disasters. The GIS application can be used as a tool to improve grouping by using k-means. A combination of k-means and GIS can help interpret the characteristics of Indonesia's natural disasters.

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