



Proceedings

“ The Global challenges on the development
and the education of mathematics and science “

3rd ICRIEMMS

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3rd ICRIEMMS

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“ The Global challenges on the development
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Preface

Bless upon God Almighty such that this proceeding on 3rd International Conference on Research, Implementation, and Education of Mathematics and Sciences (ICRIEMS) 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 have already been presented in the Conference on 16 – 17 May 2016 in the Faculty of Mathematics and Natural Sciences, Yogyakarta State University. This proceeding comprises 9 fields, that is mathematics, mathematics education, physics, physics education, chemistry, chemistry education, biology, biology education, and science education.

The theme of this 3rd ICRIEMS is '*The Global Challenges on The Development and The Education of Mathematics and Science*'. The main articles in this conference are given by six keynote speakers, which are Prof. Allen Price, Ph.D (Emmanuel College Boston USA), Ana R. Otero, Ph.D (Emmanuel College Boston USA), Dr. Michiel Doorman (Utrecht University, Netherlands), Prof. Dr. Marsigit, M.A (Yogyakarta State University), Asst. Prof. Dr. Warakorn Limbut (Prince of Songkla University, Thailand), and Prof. Dr. Rosly Jaafar (Universiti Pendidikan Sutan Idris, Malaysia). Besides the keynote and invited speakers, there are also 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.

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, May 2016

The Editor Team

Forewords From The Head Of Committee

Assalamu'alaikum warahmatullahi wabarakatuh

May peace and God's blessings be upon us all

First of all, allow me to thanks to God, Allah SWT, who has been giving us blessing and mercies so we can join this conference. Ladies and Gentlemen, it is my great honor to welcome you to Indonesia, a unique country which has more than 17,000 islands, more than 1,300 ethnic groups, and more than 700 local languages, and I am also very happy to welcome you to Yogyakarta, the city of education, culture, tourism, and a miniature of Indonesia. We wish you be happy and comfortable in attending the conference in this city.

The third International Conference on Research, Implementation, and Education of Mathematics and Science (ICRIEMS 3rd) 2016 is organized by the Faculty of Mathematics and Science, State University of Yogyakarta. In this year, theme of the conference is : The Global Challenges on The Development and The Education of Mathematics and Science. This conference are dedicated to the 52nd anniversary of Yogyakarta State University and to face challenges of Asean Economic Community in 2016.

This conference facilitates academics, researchers and educators to publish and disseminate their research in the fields of pure, application and education of Science and Mathematics. Furthermore, the purposes of the conference are to establish interaction, communication, and cooperation among academics, researchers and educators at an international level.

On behalf of the committee of this conference, I would like to express our highest appreciation and gratitude to the keynote speakers, including:

1. Allen Price, Ph.D. (Associate Professor of Emmanuel College, Boston USA)
2. Ana R. Otero, Ph.D. (Emmanuel College, Boston USA)
3. Dr. L.M. (Michiel) Doorman (Associate Professor of Utrecht University, Netherland)
4. Prof. Dr. Marsigit, MA. (FMIPA, Universitas Negeri Yogyakarta)
5. Asst. Prof. Dr. Warakorn Limbut (Faculty of Science, Prince of Songkla University, Thailand)
6. Prof. Dr. Rosly Jaafar (Faculty of Physics, Universiti Pendidikan Sultan Idris, Malaysia)

Furthermore, we inform you that the papers presented in this conference are about 200 papers from 302 applicants, who come from various countries and various provinces throughout Indonesia. Therefore, I would like to give my appreciation and many thanks to the presenters and participants who have been actively involved in this seminar.

Finally, I would like to thank the committee members who have been working very hard since half a year ago to ensure the success of the conference. However, if you find any shortcomings and inconveniences in this conference, please forgive us. We would very

happy to receive your suggestions for improvement in the next conference. Thank you very much.

Wassalamu'alaikum warohmatullahi wabarakatuh.

Yogyakarta, May 2016

Dr. Warsono, M.Si.

**Forewords From The Dean Of Faculty Of Mathematics And Sciences,
Yogyakarta State University**

Assalamu'alaikum warahmatullahi wabarakatuh. My greetings for all of you. 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, the third to be held by the Faculty of Mathematics and Science, State University of Yogyakarta, one of the excellent and qualified education universities in Indonesia. This conference is also celebrate the 52th Anniversary of State University of Yogyakarta.

This conference proudly presents keynote speeches by six excellent academics, these are: Allen Price, Ph.D., Ana R. Otero, Ph.D., Dr. Michiel Doorman, Prof. Dr. Marsigit, MA., Asst. Prof. Dr. Warakorn Limbut, and Prof. Dr. Rosly Jaafar, and around 200 regular speakers.

The advancement of a nation will be achieved if education becomes a priority and firmly supported by the development of technology. Furthermore, the development of technology could be obtained if it is supported by the improvement of basic knowledge such as mathematics, physics, chemistry, and biology. The empowerment of this fundamental knowledge may be achieved by conducting research which is then implemented in developing the technology and the learning process in schools and universities.

This international conference is aimed to gather researchers, educators, policy makers, and practitioners to share their critical thinking and research outcomes. Moreover, through this conference it is expected that we keep updated with new knowledge upon recent innovative issues and findings on the development and the education of mathematics and science, which is in accord with the theme of the conference this year. All material of the conference which are compiled in the abstract book and proceedings can be useful for our reference in the near future.

This conference will be far from success and could not be accomplished without the support from various parties. So let me extend my deepest gratitude and highest appreciation to all committee members who have done an excellent job in organizing this conference. I would also like to thank each of the participants for attending our conference and bringing with you your expertise to our gathering. Should you find any inconveniences and shortcomings, please accept our sincere apologies.

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

Wa'alaikumsalam warahmatullahi wabarakatuh

Yogyakarta, May 2016
Dean Faculty of Mathematics and Science
Yogyakarta State University

Dr. Hartono, M.Si.

**$\langle a, b; a^p, b^q, aba^{-1}b^{-1} \rangle$ And $\langle t; t^{pa} \rangle$ Using Tietze Transformation
Methods**

Yanita

MATHEMATICS EDUCATION

- | | | |
|----|---|---------|
| 01 | Literatur Study: The Relationship Of Mathematics Problem Solving And Students' Higher Order Thinking Skills
<i>Adri Nofrianto, Mira Amelia Amri, Elfa Rafulta</i> | ME – 1 |
| 02 | A Study Of Reflective-Preservice Mathematics Teacher's Reflective Thinking In Solving Geometrical Problem
<i>Agustan S., Dwi Juniati, Tatag Yuli Eko Siswono</i> | ME – 7 |
| 03 | A Study Of Late Formal-Junior School Student's Geometric Thought In Understanding The Relationship Between Quadrilateral
<i>Agustan S.</i> | ME – 15 |
| 04 | Adaptive Reasoning And Strategic Competence In Solving Mathematical Problem: A Case Study Of Male-Field Independent (Fi) Student
<i>Andi Syukriani, Dwi Juniati, Tatag Yuli Eko Siswono</i> | ME – 21 |
| 05 | The Characteristics Of Students' Refractive Thinkingabout Data
<i>Anton Prayitno</i> | ME – 29 |
| 06 | Effectiveness Of Tps And Sgd With Scientific Approach In Terms Of Problem-Solving And Self-Confidence
<i>Anwar Rifa'i, Himmawati Puji Lestari</i> | ME – 39 |
| 07 | The Characteristics Of Teachers' Contingent Dominant Scaffolding In Teaching And Learning Mathematics
<i>Anwar, Ipong Yuwono, Edy Bambang Irawan, Abdur Rahman Asari</i> | ME – 47 |
| 08 | Effectiveness Problem Based Learning And Scientific Approach To Improve Higher Order Thinking Skills
<i>Arini Ulfah Hidayati, Heri Retnawati</i> | ME – 55 |
| 09 | The Excellence Of Realistic Mathematic Education Based On Gardner's Multiple Intelligences Theory Through Mathematical Connection Ability
<i>Aris Kartikasari, Rita Suryani</i> | ME – 61 |
| 10 | Characterization Of Mathematical Connections In Calculus
<i>Arjudin, Akbar Sutawidjaja, Edy Bambang Irawan, Cholis Sa'dijah</i> | ME – 67 |
| 11 | The Effect Of Problem Based Learning To Mathematical Reasoning Abilities Of High School Students, Topic: Series And Sequence
<i>Azmi Yanianti, Fitriani</i> | ME – 73 |

- 12 **Developing Reasoning Ability And Curiosity Of Students Toward Mathematics Through Problem Based-Learning** ME – 79
Bukhori, Heri Retnawati
- 13 **The Development Of Module Of Learning Quadrilateral Based On Van Hiele Theories** ME – 85
Deshinta P.A.D. Argaswari, Budi Usodo, Ikrar Pramudya
- 14 **The Role Of Productive Struggle To Enhance Learning Mathematics With Understanding** ME – 95
Dian Permatasari
- 15 **Didactical Design Research of Mathematical Communication about Concept of Cuboid Volume in Elementary School** ME - 101
Hj. Epon Nur'aeni, Muhammad Rijal Wahid Muharram
- 16 **The Characterization Of Mathematics Students' Metacognition Process In Solving Mathematical Problems** ME – 105
Dwi Purnomo, Toto Nusantara, Subanji, Swasono Rahardjo
- 17 **Students' Anxiety Facing Computer Based Test (CBT) System Of National Examination** ME – 113
Eny Sulistyarningsih
- 18 **Increasing Higher Order Thinking Skill To Build Student's Character By Using Mathematical Reasoning** ME – 119
Evvy Lusyana, Magdalena Wangge
- 19 **Fostering Student's Higher-Order Thinking Skill Through Problem-Based Learning In Calculus** ME – 127
Hasan Djidu, Jailani
- 20 **The Student' Models For The Meaning And Procedure Of Multiply Two Fractions** ME – 131
Hongki Julie
- 21 **Hypnoteaching Method To Foster Self - Belief Of Primary School Students In Learning Math** ME – 139
Imaludin Agus, Ayu Arfiana
- 22 **Analyze Of The Creative Thinking Level Of Students Junior High School Viewed From Mathematics Anxiety** ME – 145
Isnaeni Umi Machromah, Budi Usodo
- 23 **The Technique and Validation of Composing the Attitude Assessment Instrument for Junior High School Mathematics Learning Based on Curriculum 2013** ME – 151
Kana Hidayati

- 24 **The Role of Metacognitive in Problem Solving: A Case in Logarithm** ME – 157
Masduki, Heri Kusuma
- 25 **Developing Mathematics Instructional Package with POGIL that is Oriented to The Competences in Curriculum 2013** ME – 163
Mega Eriska Rosaria Purnomo, Agus Maman Abadi
- 26 **The Development of Interactive Learning Media to Explore The Students' Mathematical Creative Thinking Ability** ME – 173
Nani Ratnaningsih
- 27 **Guided Discovery: A Method to Minimize The Tendency of Students' Rote-Learning Behavior in Studying Trigonometry** ME – 181
Naufal Ishartono
- 28 **The Effect Of CTL Approach With Talking-Chips Setting On Mathematical Communication Of Junior High School's Students** ME – 191
Nina Agustyaningrum
- 29 **Developing A Mathematics Instructional Model Based On Child Friendly, Innovative , Creative and Realistics (CFICR) At Junior High School** ME – 197
Nining Setyaningsih, Sri Rejeki
- 30 **Role Of Scaffolding Toward Enhancing Understanding Of Low-Achieving Students (LAS) In Mathematics Learning** ME – 203
Pika Merliza, Uke Ralmugiz, Arsyil Waritsman
- 31 **Developing Students' Mathematical Reasoning Through Learning Mathematics with Analogical Reasoning** ME – 209
Retno Kusuma Ningrum, Nurul Husnah Mustikasari
- 32 **Undergraduate Student's High Order Mathematical Thinking Abilities Through Lesson Study Activities** ME – 217
Risnanosanti
- 33 **Analysis of Statistical Reasoning Process of Senior High School Students on the Size of Central Tendency (The Case Study For Student's Low Math Ability)** ME – 225
Rosidah
- 34 **Facilitating Students From Inadequacy Concept in Constructing Proof to Formal Proof** ME – 233
Syamsuri, Purwanto, Subanji, Santi Irawaty
- 35 **Adaptive Reasoning Junior High School Students In Mathematics Problem Solving** ME – 239
Teguh Wibowo

- 36 **Active Learning Optimization to Improve Students Critical and Creative Mathematical Thinking** ME – 245
Tri Rahmah Silviani, Atik Lutfi Ulin Ni'mah
- 37 **Metacognition Students In Problem Solving** ME – 253
Ummu Sholihah
- 38 **Developing Mathematics Learning Material Based On CTL For Senior High School, Topic: Series and Sequence** ME – 257
Venti Indiani, Dyah Purboningsih
- 39 **Teachers' Perception Towards ICT in Mathematics Class: A case study in Yogyakarta Secondary Schools** ME – 263
Wahyu Setyaningrum
- 40 **Ethnomathematics in Marriage Tradition in Adonara Island-East Flores** ME – 269
Wara Sabon Dominikus, Toto Nusantara
- 41 **Abstraction Measurement of Students in Constructing Proof Algebra Problems** ME – 275
Warli, Edy Nurfalalah
- 42 **An Analysis of Student's Error in Solving PISA Problems** ME – 285
Yurizka Melia Sari, Erik Valentino
- 43 **Integrating Technology in Inquiry Based Learning** ME – 293
Aprilia Dwi Handayani
- 44 **Characterization of Spontaneous Examples Based on Teacher and Student Thinking Interaction in Mathematics Learning** ME – 299
Baharullah, Purwanto, Subanji, Edy Bambang
- 45 **An Analysis of Problems on Eight Grade of Mathematics Textbook Based on PISA's Framework** ME – 305
Budi Murtiyasa, Sri Rejeki, Sarlita Murdaningsih
- 46 **The Use of Problem Based Learning to Improve Higher Order Thinking Skills in Junior Secondary School** ME – 309
Dita Puspitawedana, Jailani
- 47 **Integrating Maratib Qira'ah Al-Qur'an and Marzano's Taxonomy to Provides Learning Objectives in Mathematics** ME – 315
Kusaeri and Dwi Prasetyo Pribadi
- 48 **Probabilistic Thinking of Elementary School Students in Solving Contextual and Non Contextual Probability Tasks** ME – 323
Dwi Ivayana Sari, I Ketut Budayasa, Dwi Juniati

- 49 **Students' competence Development on Learning Fractal Geometry by Experiments Using ICT Tool** ME – 331
Dwi Juniati, I Ketut Budayasa
- 50 **Creative Problem Solving to Improve Students' Higher Order Thinking Skills in Mathematics Instructions** ME – 339
Ezi Apino, Heri Retnawati
- 51 **Effect Size Of Pakem Model Implementation In Mathematic Learning On Improving Student's Problem-Solving Mastery On Function Material At Junior High School** ME – 347
Fauzan Jafri
- 52 **Improving Students' Logical Thinking Mathematic Skill Through Learning Cycle 5E and Discovery Learning** ME – 351
Gida Kadarisma
- 53 **Multiple Mathematical Representation Profile of Grade VIII Based on Multiple Intelligences** ME – 357
Hestu Wilujeng, Yenni
- 54 **Critical Thinking Skills Development Through Interactive Mathematical Learning Media** ME – 363
Hetty Patmawati
- 55 **Development of Measurement Model Construct Student Persistence of the Open Learning University (UT)** ME – 367
Isfarudi
- 56 **Mathematical Algorithm on Conventional Computerized Adaptive Testing** ME – 377
Iwan Suhardi
- 57 **The Development of Students Worksheet Using GeoGebra Assisted Problem-Based Learning and Its Effect on Ability of Mathematical Discovery of Junior High Students** ME – 385
Joko Suratno
- 58 **Building Student's Honesty Through Contextual Mathematics Learning** ME – 395
Lokana Firda Amrina, Novalinda Puspita Ayu, Nurfarahin Fani
- 59 **Teacher's Pedagogical Content Knowledge Concerned To Students Knowledge On Quadratic Function** ME – 399
Ma'rufi
- 60 **Actualization Pedagogical Content Knowledge (PCK) of Novice Teachers in Learning Practice at Systems of Linear Equations of Two Variables (SPLDV)** ME – 407

Maryono, Akbar Sutawidjaja, Subanji, Santi Irawati

- | | | |
|----|---|----------|
| 61 | Effectiveness of Cooperative Learning Approach (Snowball Throwing) in Logics Instruction at AMIKOM Mataram
<i>Muhamad Galang Isnawan, Teguh Rizali Zahroni</i> | ME – 415 |
| 62 | Prospective Teachers' Structure Patterns of Awareness and Regulated Thinking During Solving Problems In Algebra
<i>Muhammad Baidawi, Akbar Sutawidjaja, Edy Bambang Irawan, I Made Sulandra</i> | ME – 419 |
| 63 | Authentic Assessment On Mathematics Education Research Methodology Course Based Group Discussion
<i>Muhammad Ilyas</i> | ME – 427 |
| 64 | Pre-service Teacher Interpretations of Students' Mathematical Understanding
<i>Mujiyem Sapti, Purwanto, Sri Mulyati, Edy Bambang Irawan</i> | ME – 435 |
| 65 | Development Interactive Learning Media to Excavate Ability Mathematical Creative Thinking Students
<i>Nani Ratnaningsih</i> | ME – 443 |
| 66 | Improve Analytical Thinking Skill and Mathematical Representation of The Students Through Math Problem Solving
<i>Novika Sukmaningthias, Aida Rukmana Hadi</i> | ME - 449 |
| 67 | Development of SMP Student Mathematical Inductive Reasoning and Beliefs With Guided Inquiry Learning
<i>Nurmuludin</i> | ME - 455 |
| 68 | Van Hiele Theory to Improve Higher Order Thinking Skills in Geometry
<i>Oktaviana Mutia Dewi , Heri Retnawati</i> | ME – 463 |
| 69 | The Implementation Of Contextual Teaching And Learning In Differential Equations
<i>Rita Pramujiyanti Khotimah, Masduki</i> | ME – 467 |
| 70 | Analogy Reasoning Ability Students' In Solving Algebra Problem Based On Sternberg Theory
<i>Siti Lailiyah</i> | ME – 475 |
| 71 | Accomplishing Mathematics Problems Using <i>Outside The Box</i> Thinking Phase
<i>Sri Hariyani, Ipung Yuwono, Cholis Sa'dijah, Swasono</i> | ME – 481 |
| 72 | Student's Self-Efficacy In Mathematics
<i>Sri Hastuti Noer</i> | ME – 487 |

- | | | |
|----|--|----------|
| 73 | Autistic Gesture in Recognizing Geometrical Shape
<i>Sriyanti Mustafa</i> | ME – 493 |
| 74 | The Effectiveness Of Teaching Materials Integrated Local Culture Aspect Of <i>Massenrempulu</i> In Mathematic Learning
<i>Sulvianti</i> | ME – 499 |
| 75 | Effectiveness of Cooperative Learning Approach (Snowball Throwing) in Logics Instruction at AMIKOM Mataram
<i>Muhamad Galang Isnawan, Teguh Rizali Zahroni</i> | ME – 509 |
| 76 | “ELIP – MARC” Activities Via TPS of Cooperative Learning to Improve Student’s Mathematical Reasoning
<i>Wisulah</i> | ME – 513 |
| 77 | Improving students’ Mathematical Literacy Skills Through Mathematical Process Skills Approach
<i>Indrie Noor Aini</i> | ME – 523 |
| 78 | Measuring Religiosity and Other Affective Domain with Likert and Inventory Scales in Teaching and Learning Mathematics
<i>Dewi Mardhiyana, Jailani</i> | ME – 531 |
| 79 | Analysis of Students’ Ability on Mathematical Problem Solving in the Course of Mathematical Physics Through Inquiry Approach
<i>Syarifah Fadillah, Wahyudi, Dwi. Fajar Saputri</i> | ME - 541 |

PHYSICS

- | | | |
|----|--|------|
| 01 | Numerical Study of Material Carrier Car on a Belt Conveyor Using the Totally Asymmetric Simple Exclusion Processes with Parallel Updating and Periodic Boundary Condition
<i>Anggraeni Kumala Dewi, Steffannie Natalia Asturida Hariyono, Wipsar Sunu Brams Dwandaru</i> | P-1 |
| 02 | Peak Ground Acceleration For Kulon Progo Regency Based On Microtremor Measurements
<i>Bambang Ruwanto, Lian Karlina Saputri, Denny Darmawan, Yosaphat Sumardi, Nugroho Budi Wibowo</i> | P-9 |
| 03 | The Effect of Alum Layer in The Construction Of Biosand Filter As A Method To Manage The Laundry Wastewater
<i>Dyah Kurniawati Agustika, Muhammad Anshori</i> | P-11 |
| 04 | The Accuracy Of Ore Reserves Estimation
<i>Eddy Winarno, Gunawan Nusanto, Peter Eka Rosadi</i> | P-17 |

Accomplishing Mathematics Problems Using *Outside The Box* Thinking Phase

Sri Hariyani M.Pd, Prof. Dr. Ipung Yuwono M.S. M.Sc,
Prof. Dr. Cholis Sa'dijah M.Pd. M.A, Dr. Swasono M.Si.

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Abstract – Completion of math assignment is an important part of learning mathematics. However, in practice, students often do it in a way that is not creative (monotone). In other words, students are not able to think outside the box. This research described the process of students' thinking outside the box when they completed a math assignment using outside the box thinking phase. Outside the box thinking phase in this research included exploration, idea generated and justification. This research is important for educators to make thinking *outside the box* as the information input about the characteristics of students' thinking. The research instruments that had been validated by expert *validator* were given to the subject of research to be completed. To obtain accurate data, the subjects of the research accomplished it using think aloud technique. The subject of research explored the problem to get an idea of the problem situation. In this case the subject used logical reasoning in order to obtain an idea of different solution. The research subjects used fractions to strengthen the mathematical argument. The conceptual component of cognitive function happened was analyzing-integrating. Analyzing-integrating is the cognitive functions related to the quantity of a concept.

Keywords: *mathematical assignment, phase, outside the box thinking*

I. INTRODUCTION

Mathematical tasks completion does not stop at just getting the result but it also needs to pay attention to the process of accomplishing them that brings creativity of students. "Working on mathematical tasks may influence not only the mathematical content that is learned [1]". Creative behavior of students can be seen from the way the students argue/mathematical reasoning toward the completion of the math task generated. In generating different ideas on task completion, the students are given the opportunity to explore creatively so it is expected later the student will have autonomy and trust and they no longer use the standard thinking pattern (commonly thinking), that is pattern of thinking that only uses the basic algorithm skill.

"Reference [2] says creative thinking as *"out of the box thinking"* or *"outside the box thinking"*, which is a way of thinking "out" of the natural way of thinking (*get out of our own box*). "Mental *"box"* is defined as the restriction created by people for themselves. The human brain has an efficient way of working. In other words the brain develops thinking patterns that recur every day, so it evolves into a "monotonous (*default*)" mental. Therefore, when brain faces a decision or a challenge, then it will easily estimate the limits of perspective that can be done. It means "monotonous" mental sometimes affects all activities undertaken. The existence of "monotonous" mental sometimes create a zone of "happy (comfortable)" which leads to a reluctance to upgrade their quality.

"Reference [3] describes the definition of *"thinking outside the box is generally associated with innovation and problem solving in business and management"*." Thinking *outside the box* is a term used to denote the level of thinking that is higher, that is, when the quality of task solution or completion idea is substandard and the solution has not been found. "Thinking outside the box (thinking out of the box or thinking beyond the box) is a metaphor that means to think differently, unconventionally, or from a new perspective. This phrase often refers to novel or creative thinking" [4]. Thinking *outside the box* associates with a willingness to get out of a happy (comfort) condition (zone) psychologically, open new perspectives toward the task, and the willingness (challenged) to explore. Therefore, this research is intended to describe the phases of thinking outside the box students in solving mathematical tasks. Stages or phases of thinking *outside the box* show the characteristics of the students to think outside the box to produce a different solution.

This research is important to know the characteristics of thinking *outside the box* in solving mathematical tasks through the behavior that can be observed. The activity of students' thinking *outside the box* is a thinking orientation that is "potentially" in the future. This is because thinking *outside the box* is a part of creativity, and creativity itself is a part of self-actualization at the highest level of Maslow's hierarchy of human needs. In addition, the research of thinking outside the box can be a contribution to enrich the knowledge of the thinking process, especially in mathematics.

II. LITERATURE REVIEW

Creativity based on the investment theory [5] contains six interrelated components namely intellectual abilities, knowledge, styles of thinking, personality, motivation and environment. Intellectual skills include (a) synthetic ability that is the ability to see the problem in a new way, out of the boundaries of conventional thinking; (b) analytical ability that is the ability to distinguish useful ideas which could be studied further than the idea that is less potential; and (c) practical-contextual ability that is the ability to convince others about the value of the ideas obtained. To be creative, one must generate new ideas, analyze the idea and present them to others.

"Creativity is the ability to bring ideas or works of art that are new, surprising and valuable" [6]. "Creativity involves the generation of ideas or products that are original, valuable or useful" [7]. Creativity associates with interesting and unimaginable previously new ideas. "For many there is an echo here of the intuition that "thinking outside the box" can be more creative than "thinking inside the box" [8]. It requires a more creative style of thinking that is thinking outside the box.

Thinking outside the box is different from lateral thinking [3]. Thinking outside the box is a linear way of thinking while lateral thinking does not create a new idea in a linear way but it finds in the "deviant" way. To be able to think outside the box, one must leave the comfortable zone psychologically (common routines), be opened with a new perspective toward a task, and bold (interested) in facing challenges. In addition, people who think outside the box should discard the character rigid, high personal egoism, and be able to manage emotions well.

Various models of problem solving are proposed by several researchers, including [9] with his famous completion stages that are widely used by other researchers. They are understanding the problem, devising a plan, carrying out the plan, and looking back. Problem solving in thinking outside the box is the problem solving that does not restrict students to explore the problem and to use the right strategy (uncommon ways) to produce different solutions. Thinking outside the box in solving mathematical tasks are through three phases or stages namely exploration, ideas generated and justification. Exploration phase has two criteria namely problem exploration and interpretation (mathematical interpretation). In interpreting a math assignment, students use the prerequisite knowledge previously possessed. The phase of ideas formation (ideas generated) contains two criteria, namely conjecture and representation. In making conjecture, the resulted solution strategy is different solutions strategy while justification phase contains the criteria namely justification. Justification toward the solution of mathematical tasks is reviewed through the logic and accuracy of students in completing the tasks. The process of settlement which is logical and right shows the understanding depth of the mathematical concepts that have been taught.

III. RESEARCH METHODS

This research is a qualitative research using Grounded Theory Approach. The purpose of grounded theory approach is data theorization that is the research does not start from a theory or to test the theory, but it starts from the data towards a theory. Based on the schedule agreed upon, the researcher gave a math assignment or task to the research subjects to be completed. The researcher used think alouds technique, the researcher observed the research subjects when completing the math assignment, and recorded all the activities of research subjects by using a digital camera. The observation result was not only in the form mathematical tasks completion but also in the form of moving images recording (video) of the students when they did the math task completion activities. To complete the observed data, the researcher conducted semi-structured interviews with a purpose to deepen the process of students' thinking outside the box.

At this phase of data analysis, the researcher conducted a series of activities including: (1) transcribing verbal data namely data obtained from think alouds and semi-structured interviews; (2) studying all data both verbal data and field notes; (3) reducing the data to create abstractions; (4) arranging and coding the based on the stages or phases that have been designed, namely the exploration, idea generated and justification; (5) drawing conclusions about the process of students' thinking outside the box in solving a math assignment using the exploration stage, idea generated, and justification.

IV. FINDINGS AND DISCUSSION

The research subject was asked to work on the instrument using the think alouds. The Subject wrote down the steps of completion while speaking, told everything he was thinking dealing with the completion steps that he wrote. The subject was very cooperative, and he had no difficulty in communicating with the researcher to communicate the results of the work. The subject was very confident, as seen from the loud noise sounded when he did think alouds. The subject provided two completion ways. In exploration phase (exploration), the subject understood the problem by formulating the information on the task (what is known?) and the objective which would be reached (what was asked?), and the subject read the questions aloud:

Here known Iswanto only needs 5 tin cans to make another fully filled. All empty cans are removed. It means the five cans are used to fill $\frac{1}{5}$ part of the other cans. Here Iswanto needs 5 cans to fill all the remaining cans. Then the $\frac{1}{5}$ is the part that is not filled yet.

Based on the result of transcript, the problem situation on the mathematical task is understood by the subject that the content of tin cans was completely used to fill $\frac{3}{5}$ part of the other cans. The subject also underlined the sentence that he considered important (sentences that provided information) as Fig. 1 below. The underline shown by the subject showed that the subjects marked the important data which were known, identified the problem and tried to interpret them.

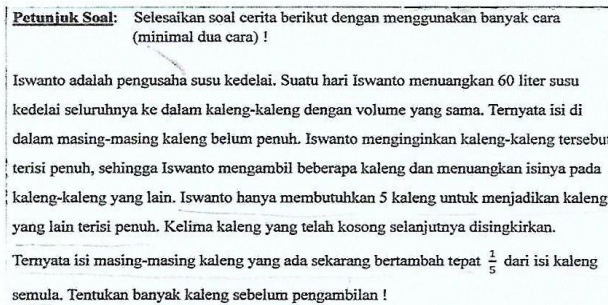
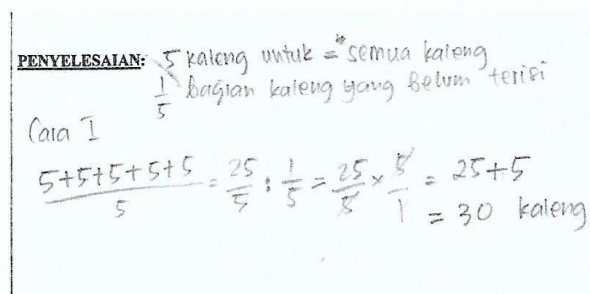


FIGURE 1. SUBJECT UNDERLINED THE SENTENCES THAT SHE CONSIDERED IMPORTANT

In Fig. 1, the Subject underlined two sentences: (1) Iswanto only needs 5 tin cans to make the other cans fully filled; and (2) the contents of each tin now exactly added $\frac{1}{5}$ more than before. However, the subject did not underline the objective (what is asked?). Subject interpreted the problem by considering $\frac{1}{5}$ part of each other cans was not filled yet, as written by the subject in Fig. 2 below. In Fig. 2, the subject wrote down the results of the interpretation in two sentences: (1) 5 cans for all cans; and (2) $\frac{1}{5}$ part of cans were not filled. The results of this interpretation were the description of a problem situation by Subject and designing a plan of the problem solution.



At the phase of forming ideas (ideas generated), the subject attempted to pursue the problem and found the core of the problem. The core of the problem in the question was that soy milk in the five tin cans was

poured in the other cans exactly $\frac{1}{5}$ each. To write the steps of the solution, subject recalled about how to convert integers into fractions and the concept of operations on fractions. Further subject implemented the completion strategy (a strategy to determine the appropriate notation) as shown in Fig. 2 While recalling the concept of fractions, Subject wrote 5 in the form of a fraction $\frac{5+5+5+5+5}{5} = \frac{25}{5}$. This was done with the intention to make it easier to perform operations on the division of fractions (equated denominator 5). The next process was dividing $\frac{25}{5}$ by $\frac{1}{5}$ (Subject explained the reason, "because five tin cans are used for $\frac{1}{5}$ of the other tin cans, then it is divided by $\frac{1}{5}$ "), $\frac{5+5+5+5+5}{5} = \frac{25}{5} : \frac{1}{5} = \frac{25}{5} \times \frac{5}{1} = 25 + 5 = 30$. Subject did not understand yet the concept of equation as $\frac{5+5+5+5+5}{5} = \frac{25}{5} : \frac{1}{5}$ (though $\frac{5+5+5+5+5}{5} \neq \frac{25}{5} : \frac{1}{5}$) and $\frac{25}{5} \times \frac{5}{1} = 25 + 5$ (though $\frac{25}{5} \times \frac{5}{1} \neq 25 + 5$). Subject focused more on the final result. Subject looked again the goals to be achieved by saying, "it means the answer is 25, and it is added with the number of cans required. This is because the question is about the number of cans before being taken. It means $25 + 5 = 30$ cans". Thus the final result obtained by the subject was 30.

At justification phase, Subject prepared the second to solve problems in a math task. Subject attempted to use an algebraic method that had been gained in the previous class, but the subject was less able to distinguish the term algebra and variable. Subject applied the strategy using appropriate notation to formulate a mathematical model as shown in Fig. 3 below.

Cara 2 = Aljabar

$$x - 5 = \frac{25}{5} : \frac{1}{5}$$

$$x - 5 = \frac{25}{5} \times \frac{5}{1}$$

$$x - 5 = 25$$

$$x = 25 + 5$$

$$x = \underline{30}$$

Jadi jumlah kaleng sebelum pengambilan = 30 buah

FIGURE 3. THE SECOND WAY OF THE RESEARCH SUBJECT IN SOLVING PROBLEMS ON A MATH ASSIGNMENT

In Fig. 3, Subject implemented the strategy using appropriate notation. Subject let many tin cans before taking x , continued by saying, "because we want to find the number of cans after the decision, then $x - 5$." Subject wrote " $x - 5 = \frac{25}{5} : \frac{1}{5}$ ", subject was able to use the division operation on fractions by first making 5 as fraction $\frac{25}{5}$ and dividing by fraction $\frac{1}{5}$. Subject made simplified operation of division into multiplication operation on the left side by writing " $x - 5 = \frac{25}{5} \times \frac{5}{1}$ ". The research subject was also able to perform multiplication operations on fraction. In this case subject did *kanselasi* numerator and denominator by the same number that was 5. Then Subject multiplied the numerator and the numerator, and multiplied the denominator and the denominator. Subjects looked doubtful when he wanted to continue the next step. Subject hesitate the completion step that he had written. It meant that the subject was reviewing the step of math task completion, and he finally made a decision by writing, " $x - 5 = 25$ ". In the next step, Subject summed both sides with the same number (summing up both sides with 5) so that the final result was 30. The subjects made the assertion by making a conclusion "so the number of cans before taking was 30 pieces". For the second completion, the subjects wrote down each step correctly.

Further subject rechecked the correctness of the answers he got as in Fig. 4 below.

Pembuktian =

$$60 : 30 = 2$$

5

$$5 \times 2 = 10$$

2 x 1 2 (1 dari 10) ↑

Subjects checked the correctness of the answers by linking 30 cans with 60 liters of soy milk. Subjects wrote "60 : 30 = 2". It meant that 60 liters of soy milk was distributed entirely into 30 cans. Each tin was filled with 2 liters of soy milk. $\frac{1}{5}$ of the can (2 liters) was $\frac{2}{5}$ liter. Subject wrote " $\frac{2 \times 1}{5} = \frac{2}{5}$ ($\frac{1}{5}$ of the can)". After calculating the overall volume of soy milk $\frac{2}{5}$ liter in 25 cans ($\frac{2}{5} \times 25 = 10$ liters) that contained as much as the volume of the soybean milk in cans ($5 \times 2 = 10$), the subject concluded that the answer 30 cans was true.

V. CONCLUSION

Reference [10] states that there are three things related to the knowledge of mathematics, namely mathematical operation, mathematical concept and mathematical idea. The mathematical operation is the process of managing and manipulating mathematical information in meaningful ways that support and build on the ideas and concepts of mathematics. Mathematical concept is theoretical, systemic, and generative while the idea of mathematics was derived from one or more of conceptual understanding, the establishment of relation between the conceptual understanding and the formation of new ideas or applications. Students who are able to think *outside the box* are the students who are able to perform mathematical operation correctly to obtain different completion ideas, and different ideas generated use the size of the students themselves. In this research, the research subject used logical reasoning to get a precise mathematical task completion.

Referring to the results of the study, the following is the Description Table of thinking outside the box of students in solving a math assignment using the exploration, ideas generated, and justification.

TABEL 1. THE DESCRIPTION THINKING OUTSIDE OF THE BOX

Exploration phase	<ul style="list-style-type: none"> • Understand the problem statement by formulating information on mathematical tasks and the objectives to be achieved. • Subjects made markers on the problem statement "(1) Iswanto only needs 5 tin cans to make other cans fully filled; (2) The five empty cans were removed; (3) In fact, the content of each tin at present added exactly $\frac{1}{5}$ from the volume of the can before." • Subjects interpreted the problem statement marked by making a description of the problem situation by writing "5 cans for = all the cans" and "$\frac{1}{5}$ part of can is unfilled".
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