# Invited Lecture

# Freudenthal Ideas Continues in Indonesia: From ICMI 1994 to ICME-14 in Shanghai

Zulkardi Zulkardi[1]

**ABSTRACT** This paper shares several realistic mathematics education (RME) projects designed and implemented at the Department of Mathematics Education, Universitas Sriwijaya, Indonesia. These projects are developed using the design research method. They are based on the foundational work of Freudenthal and his successors. The development of the PMRI approach (the Indonesian version of RME) started at an ICMI Regional Conference in Shanghai in 1994, where Robert Sembiring met Jan de Lange. We will also briefly reflect on how RME was adapted in Indonesia, inspiring research and development in mathematics education. The focus of this paper will be on (1) designing a learning environment within the PMRI approach to support students' learning mathematics literacy; (2) designing an international journal on mathematics education; (3) creating PISA-like tasks on mathematics using the Indonesian context; and (4) our way of surviving the current COVID-19 context. I will discuss these issues and illustrates their examples from PMRI practices.

*Keywords*: Design research; PISA-like; PMRI; COVID-19 context.

## 1. Introduction

### *1.1. From ICMI 1994 to ICME 2021*

Indonesia started reforming mathematics education by adapting RME in 1994. As the head of the reform team, Robert Sembiring, an Indonesian mathematician, saw Jan de Lange give a speech about RME as the plenary speaker at the International Commission of Mathematics Instruction (ICMI) conference in Shanghai. As one of the successors of Freudenthal, Jan agreed to introduce RME in Indonesia. At that time, like many countries, Indonesia changed its teaching and learning approach from Modern Mathematics influenced by New Math. Finally, Jan visited Indonesia twice, in 1998 and 2000.

The scenario continued in 1998 when six lecturers, including myself, were selected to go to the Netherland to learn RME at both University of Twente and Freudenthal Institute for Mathematics and Science Education Utrecht University. We know what, why, and how RME as an instructional theory, design research method, and curriculum

[1] Department of Mathematics Education, Faculty of Teacher Training and Education, Universitas Sriwijaya, Palembang, South-Sumatera, 30139, Indonesia. E-mail: zulkardi@unsri.ac.id

development. The Ph.D. program spans four years, and we conduct research in schools in Indonesia. After graduating in 2002, we returned to Indonesia and joined a team that started the project called PMRI.

In 2000, Jan de Lange gave the keynote presentation at the Institute Teknologi Bandung as a keynote at the Tenth National Conference on Mathematics. He presented the audience with two essential new topics: RME and Programme for International Student Assessment (PISA). In 2000, the first PISA was administered. As the PISA Expert Group on Mathematics leader, he stated that PISA and RME have a solid mathematical connection (Zulkardi, 2020a).

### *1.2. Freudenthal and Jan de lange ideas*

Three well-known ideas of Freudenthal were described in this paper that are RME, developmental research, and the journal Educational Studies in Mathematics. Moreover, the idea of a PISA-like task was inspired by Jan de Lange, the successor of Freudenthal. As the head team of PISA Mathematics and Ph.D. promotor, Jan guided that PISA study needs many suitable tasks at all difficulty levels.

The primary purpose of this paper is to report on several projects relating to PMRI at the department doctoral study program in mathematics education at Universitas Sriwijaya in Palembang, Indonesia. Freudenthal inspired three ideas in this paper described here are (1) use of design research approach in order to produce learning environments and RME learning materials on various mathematical contents using relevant Indonesian and global contexts; (2) creating PISA-like tasks on mathematics using Indonesian contexts and COVID-19 context; and (3) developing an academic journal to publish results of research primarily related PMRI to all over the world.

## 2. PMRI Continues

### *2.1. PMRI and design research continues in Indonesia*

PMRI approach and Design Research method continue in Indonesia. At Universitas Sriwijaya, PMRI is taught in all levels of mathematics education study programs, namely undergraduate and postgraduate (master and doctoral) programs. In these courses, pre-service teachers collaborate with teachers at PMRI partner schools to design teaching materials that can be used in classroom learning.

After the IMPoME end in 2015, research on PMRI in Universitas Sriwijaya continues in the magister and Ph.D. programs. The thesis uses design research as a research methodology. Up to now, seven dissertations have been published in the International journal. The following is the summary of the Ph.D. theses which used PMRI and design research as an umbrella for research projects.

*1) Task design on modelling in senior high school mathematics* (Riyanto et al., 2019)

This research produced valid and practical high school mathematics modeling tasks, a lesson plan, and a student worksheet. The products also have potentially effective. According to the findings of this study, students were highly passionate about

studying mathematics using mathematical modeling, and students could create mathematical models using their strategies. Students can use the modeling process, which increases their mathematics literacy.

2) *Developing mathematics worksheet using futsal context* (Effendi et al., 2019)

This study supports one of the government's School Literacy Movement efforts to improve students' literacy skills. This study generates reading texts in the context of futsal that will be presented in student activities and have potential effects on mathematics learning. Learning that begins with the activity of reading texts linked to the mathematical subject increases students' interest in learning and improves their literacy skills because the given context is attractive to them, and learning becomes more diversified.

3) *Developing PMRI learning environment through lesson study for pre-service primary school teachers* (Fauziah et al., 2020)

This study's development process resulted in a learning environment based on a Campus-School model (CS). The learning environment consisted of the first and second training on campus and implementation in the school. PMRI and lesson study materials were used in training and two PMRI learning simulations via lesson study, discussion, and development of learning tools, peer teaching, application of learning to lesson study model schools, final discussions, and tests. The PMRI learning environment is a valid, practical criterion and enhances the pedagogical abilities of pre-service primary school teachers.

4) *Learning integers with RME approach based on Islamic values* (Muslimin et al., 2020)

The integer learning trajectory based on Islamic values proved helpful in helping students comprehend numbers. The established learning pathways include four phases: beginning with a presentation of the context-based on Islamic principles, Iqra (literacy) to grasp the situation, resolving the context individually and in groups to construct an informal model to formal, and communicating with the presentation. Furthermore, the learning trajectory of integers with the context of the starting point based on Islamic values sharpens students' reasoning power and forms good character.

5) *On creativity through mathematization in solving non-routine problems* (Arifin et al., 2021)

This study aimed to analyze and compare students' fluency, flexibility, and originality in solving non-routine tasks in the Palembang context. The data analysis revealed that the answers supplied by the high-ability students were unique and tended to employ formal mathematics in the form of formulae, symbols, and operations. Meanwhile, moderate-ability students preferred to begin solving issues by simplifying them and then visualizing them. This study found that low-ability students had difficulty grasping the questions and made several errors in completing them.

6) *Designing geometrical learning activities for supporting students' higher order thinking skills* (Meryansumayeka et al., 2022)

The study aimed to develop a cuboid volume learning trajectory in ICT-assisted learning to improve students' higher-order thinking skills. The cuboid volume learning trajectory includes activities about the relationship between visible and invisible parts for determining the cuboid volume, the relationship between the cuboid's sides, making cuboids with a specific volume size and determining the size of the cuboid's sides, and activities to solve related problems with the cuboid volume. The ICT media employed in this study are critical in enhancing students' higher-order thinking skills.

7) *Curious mind uses mini games for early childhood in early mathematics learning* (Rahayu et al., 2022)

This study explicitly discusses how the PMRI mathematics introduction learning track uses mini-games to support children's curiosity. This study uses a Realistic Mathematics Approach at the food learning process stage called "pempek" as a starting point in introducing basic mathematics learning materials. The goal is to design learning activities and observe children's curiosity. This research resulted in a learning trajectory for introducing length and volume measurements using mini-games. The learning trajectory for submitting length measurements and volume measurements can help early childhood learn the introduction of measures and activities and games designed to support children's curiosity about introducing mathematics to measurement materials.

### *2.2. The first international journal on mathematics education in Indonesia*

Inspired by Freudenthal's idea of the importance of academic journals in publishing research results, we started an international journal in mathematics education called JME (Journal on Mathematics Education) in 2010. This idea is easily supported by the Indonesian Mathematical Society (IndoMS), not because I am the vice president of IndoMS, but because there is no international journal in mathematics education (Zulkardi, 2019). JME was launched on July 31, 2010, at the beginning of the Fifteenth National Conference on Mathematics (KNM15) at the University of Manado, North Sulawesi. JME is dedicated to publishing research articles on mathematics education by school mathematics teachers, teacher educators, and university students.

A number of authors contribute and publish their articles in JME. They are Yee, L. P. (2010) and Kaur, B. (2014) from Singapore, K. Stacey (2011) and T. Lowrie (2018) from Australia, K. Gravemeijer (2011), Galen and Eerde (2013) from the Netherlands, C. Kaune, and E. Nowinska (2013) from Germany, and F. L. Lin (2014) from Taiwan. They were a part of the beginning of this journal pioneered. Interestingly, up to Volume 7, published in January 2016, 47 (58 percent) of the 81 published articles concerned RME or PMRI. JME might alternatively be referred to as "JRME" (Journal on Realistic Mathematics Education). Furthermore, the growth in RME papers indicates the continuity of RME research in Indonesia. The journal is also indexed in

DOAJ, ERIC Database, Google Scholar, and Scopus. All articles are freely available at http://ejournal.unsri.ac.id/index.php/jme.

### *2.3. Designing PISA-like tasks on mathematics using Indonesian context*

COVID-19 has implications for crises and disruptions in education, including significant changes in mathematics education (Bakker et al., 2021). This change in teaching and learning includes alignment with learning objectives, teaching approaches, teaching materials (activities and assessments), and an emphasis on the achievement of student competencies (Gravemeijer et al., 2017; Chan et al., 2021). In Indonesia, the Minister of Education and Culture has taken a bold step by launching the "Free Learning Program." One of them is replacing the National Examination with a Minimum Competency Assessment (MCA) which focuses on numeracy and literacy (MoEC, 2019); (MoEC, 2020a). MCA questions refer to international level assessments such as PISA (MoEC, 2020a; 2020b).

Based on the low PISA results of Indonesian students, there is an urgent need to provide problems that fit the PISA criteria by adjusting the situation for Indonesian students (Zulkardi and Kohar, 2018). The COVID-19 Pandemic is an ongoing widespread issue affecting all sectors of global life and students' academic activities (Bakker and Wagner, 2020). Every day, this situation is emphasized and reported in various media to remind and increase awareness of the essentials of health procedures (Nusantara et al., 2021). The COVID-19 situation, officially verified cases, death counts, and transmission categorization are published daily in the form of a map, epidemic curve, and table, allowing readers to think mathematically about the most recent numbers and trends at the global, national, and regional levels. As a result, this unfortunate circumstance might be exploited to teach mathematics.

Research on PISA items is still being developed, with the Bangka (Dasaprawira et al., 2019) and Asian Games as contexts (Putri and Zulkardi, 2020). However, no study has used COVID-19 to create a PISA-like task on mathematics (PISAComat). Fig. 1 (in the next page) depicts the PISACOmat shown below.

PISAComat was created by modifying the original PISA items and changing the context from "Climbing Mount Fuji" to "Daily Data on COVID-19 in Indonesia". Based on PISA content, "Quantity" is associated with 2013 curriculum topics, such as arithmetic operations and rounding decimal numbers. Furthermore, the cognitive level of thinking in PISAComat is at level 3, which is reasoning.

PISAComat (as shown in Fig. 1) design process continued with task experiment and followed a formative evaluation (Zulkardi, 2002; Bakker, 2018). The following is a sample of PISAComat student responses.

Fig. 2(a) and Fig. 2(b) show the solutions given by students to answer PISAComat. S(he) understands that 106 people have died from COVID-19 in one day. Furthermore, S(he) calculates using the concept of a division of numbers, namely 106 divided by 24 (the number of hours in a day), to get the result of 4.4 people. S(he) then rounds the decimal number to integer (4). In contrast to student 2a, student 2b does not understand

**DAILY COVID-19 DATA IN INDONESIA**

**Given the information in the following picture.**


**Source:** https://covid19.go.id/

COVID-19 Response Acceleration Task Force showed the following picture and said:

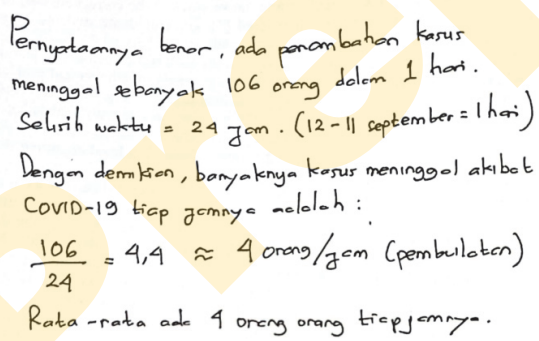
*"On September 11, 2020, an average of four people died every hour in Indonesia due to COVID-19"*

**Question**

Do you agree with the statement? Give an explanation to support your answer.

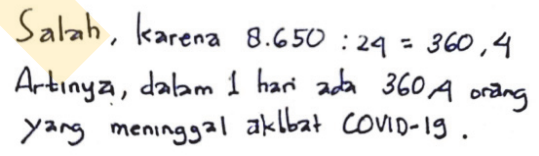
Fig. 1. PISAComat on quantity content

the symbol's meaning for adding pictures. S(he) counts the total number of deaths (8,650) and divides it by 24 (the number of hours in a day) so that it gets 360,4. Furthermore, s(he) cannot round decimal numbers and only interpret cases in the form of decimal numbers.




(a)

The statement is true; there are additional death cases of as many as 106 people in 1 day. Time difference = 24 hours (12−11 September = 1 day)
Thus, the number of deaths due to COVID-19 every hour is:
106/24 = 4.4 ≈ 4 people/hour (rounded up)
On average, there are four people (who die) every hour




(b)

It's a wrong statement because 8,650:24 = 360.4
This means, in 1 day, there are 360.4 people who died from COVID-19

Fig. 2. Students' solutions on PISAComat

### *2.4. Ways of surviving the current COVID-19 context*

*Uncertainty and COVID-19 data as starting point in learning mathematics*

Various COVID data and uncertain situations are spread across various media. COVID data in the form of infographics is very interesting to teach students to interpret mathematically. This uncertain situation needs to be taught by students to invite students' awareness to survive and coexist with COVID-19. Various mathematical contexts are related to COVID-19, including COVID-19 Data and Making Hand Sanitizer (Zulkardi et al., 2020b), Physical Distancing in Public Place (Nusantara et al., 2020a), COVID-19 Data Interpretation on TV (Nusantara et al., 2020b) Large Scale Social Restriction and Panic Buying Context (Nusantara et al., 2021a), COVID-19 Transmission Map (Nusantara et al., 2021b).

*Opportunity to learn new knowledge as props in learning mathematics*

The effects of COVID-19 provide an opportunity to learn new knowledge. Various situations demand interesting adjustments for students to learn mathematics. Before the COVID-19 Pandemic, teachers taught measurements using teaching props such as thermometers, rulers, and scales. However, during the COVID-19 Pandemic, teachers can teach measurements using a pulse oximeter and heat thermometer gun, CT-value of PCR test, etc.

*The Art of mathematics in the form of posters*

For three years in a row, the Doctoral Program in Mathematics Education has celebrated Pi Day (March 14) in conjunction with its anniversary celebration. The International Mathematical Union started this activity by conducting a Poster Challenge in 2021. Students from the Sriwijaya University mathematics education study program participated in the poster challenge. Zulkardi and Meryansumayeka mentored three teams who placed in the top 90 posters out of over 2,100 competitors. All poster items may be seen at https://www.idm314.org/2021-poster-challenge-gallery.html#.

Fig. 3 depicts three selected posters from Indonesia still on exhibit on the International Day of Mathematics (IDM) website. The three posters introduce elements of mathematics and COVID-19 in the same concept. Students may use this poster to learn mathematics and, at the same time, make sense of COVID-19 data.

## 3. Conclusion

Three great ideas from Freudenthal (RME, Design Research, and ESM) and Jan de Lange (PISA study) are continually adapted and implemented by Zulkardi as the head of the PMRI team at Universitas Sriwijaya, Indonesia. RME and design research have been settled in the courses and research at the master and doctoral programs in Universitas Sriwijaya. Also, the new study, PISA-like tasks designed on mathematics,


Fig. 3. Winning Posters at IDM 2020 designed by Student teachers Mathematics department Universitas Sriwijaya

which is used the global context, COVID-19. Finally, the development of an International Journal on Mathematics Education (JME) has reached the top journal in Asia or the top ten globally, ranked by Scimago journal.

## Acknowledgments

This article is supported by the research project PNBP Universitas Sriwijaya 2020-2021. Thanks to Ratu Ilma and Duano Nusantara for helping and reading this paper.

## References


S. Arifin, Zulkardi, R. I. I. Putri, and Y. Hartono (2021). On creativity through mathematization in solving non-routine problems. *Journal on Mathematics Education*, 12(2), 313–330. http://doi.org/10.22342/jme.12.2.13885.313-330

A. Bakker (2018). *Design Research in Education: A Practical Guide for Early Career Researchers*. London: Routledge.

A. Bakker and D. Wagner (2020). Pandemic: lessons for today and tomorrow? *Educational Studies in Mathematics*, 104(1), 1–4. https://doi.org/10.1007/s10649-020-09946-3.

M. N. Dasaprawira, Zulkardi, and E. Susanti (2019). Developing mathematics questions of PISA type using Bangka context. *Journal on Mathematics Education*, 10(2): 303–314. https://doi.org/10.22342/jme.10.2.5366.303-314.

K. N. S. Effendi, Zulkardi, R. I. I. Putri, and P. Yaniawati (2019). Developing mathematics worksheet using futsal context for school literacy movement. *Journal on Mathematics Education*, 10(2), 203–214

R. Ekawati and F. L. Lin (2014). Designing teacher professional development for mathematics teaching with variation theory. *Journal on Mathematics Education*, 5(2), 127–137. https://doi.org/10.22342/jme.5.2.1497.127-137

A. Fauziah, R. I. I. Putri, Zulkardi, and Somakim (2020). Developing PMRI learning environment through lesson study for pre-service primary school teacher. *Journal on Mathematics Education*, 11(2), 193–208. http://doi.org/ 10.22342/ jme.11.2. 10914. 193-208.

K. Gravemeijer (2011). How Concrete Is Concrete? *Journal on Mathematics Education*, 2 (1), 1–14. http://dx.doi.org/10.22342/jme.2.1.780.1-14

K. Gravemeijer, M. Stephan, C. Julie, F. Lin, and M. Ohtani (2017). What mathematics education may prepare students for the society of the future? *International Journal of Science and Mathematics Education*, 15(1), 105–123. https://doi.org/10.1007/s10763-017-9814-6

C. Kaune, E. Cohors-Fresenborg, and E. Nowinska (2011). Development of metacognitive and discursive activities in Indonesian maths teaching: a theory-based design and test of a learning environment. *Journal on Mathematics Education*, 2(1), 15–40. https://doi.org/10.22342/jme.2.1.777.15-40

B. Kaur (2014). Mathematics education in Singapore — An insider's perspective. *Journal on Mathematics Education*, 5(1), 1–16. https://doi.org/10.22342/jme.5.1.1444.1-16

Meryansumayeka, Zulkardi, R. I. I. Putri, and C. Hiltrimartin (2022). Designing geometrical learning activities assisted with ICT media for supporting students' higher-order thinking skills. *Journal on Mathematics Education*, 13(1), 135–148. https://doi.org/10.22342/jme.v13i1.pp135-148

MoEC (2020a). *Development of Minimum Competency Assessment Question* [in Bahasa]. Jakarta: Pusmenjar Kemdikbud.

MoEC (2020b). *MCA and Its Implications for Learning* [in Bahasa]. Jakarta: Pusmenjar Kemdikbud.

Muslimin, R. I. I. Putri, Zulkardi, and N. Aisyah (2020). Learning integers with realistic mathematics Education approach based on Islamic values. *Journal on Mathematics Education*, 11(3), 363–384. http://doi.org/10.22342/jme.11.3.11721.

T. C. Mutohir, T. Lowrie, and S. M. Patahuddin (2018). The development of a student survey on attitudes towards mathematics teaching-learning processes. *Journal on Mathematics Education*, 9(1), 1–14. https://doi.org/10.22342/jme.9.1.4193.1-14

D. S. Nusantara, Zulkardi, and R. I. I. Putri (2020a). Designing PISA-like mathematics problem relating change and relationship using physical distancing context. *Journal of*

*Physics Conference Series*, 1663(1), 012004. https://doi.org/10.1088/1742-6596/1663/1/012004

D. S. Nusantara, Zulkardi, and R. I. I. Putri (2020b). Designing PISA-like mathematics problem in COVID-19 Pandemic (PISAComat). *Journal of Physics Conference Series*, 1657(1), 012057. https://doi.org/10.1088/1742-6596/1657/1/012057.

D. S. Nusantara, Zulkardi, and R. I. I. Putri, R (2021a). Designing PISA-like mathematics task using a COVID-19 context (PISAComat). *Journal on Mathematics Education*, 12(2), 349–364. http://doi.org/10.22342/jme.12.2.13181.349-364.

D. S. Nusantara, Zulkardi, and R. I. I. Putri (2021b). Designing Pisa-like mathematics problem using a COVID-19 transmission map context. *AIP Conference Proceedings*, 2438(1), 020005. https://doi.org/10.1063/5.0071596.

R. I. I. Putri and Zulkardi. (2020). Designing PISA-like mathematics task using Asian Games context. *Journal on Mathematics Education*, 11(1). 135–144. https://doi.org/10.22342/jme.11.1.9786.135-144.

B. Riyanto, Zulkardi, R. I. I. Putri, and Darmawijoyo. (2019). Senior High School Mathematics Learning through Mathematics Modeling Approach. J*ournal on Mathematics Education*, 10(3), 425–444. https://doi.org/10.22342/jme.10.3.8746.

R. K. Sembiring, S. Hadi, and M. Dolk (2008). Reforming mathematics learning in Indonesian classrooms through RME. *ZDM — Mathematics Education*, 40, 927–939. https://doi.org/10.1007/s11858-008-0125-9

F. van Galen and D. van Eerde (2013). Solving Problems with the Percentage Bar. *Journal on Mathematics Education*, 4(1), 1–8. https://doi.org/10.22342/jme.4.1.558.1-8

L. P. Yee (2010). Designing a Mathematics Curriculum. *Journal on Mathematics Education*, 1(1), 1–10. http://dx.doi.org/10.22342/jme.1.1.789.1-10

Zulkardi (2002). *Developing a Learning Environment on Realistic Mathematics Education for Indonesian Student Teachers*. Disertasi, University of Twente, Enschede.

Zulkardi and A. W. Kohar (2018). Designing PISA-like mathematics tasks in Indonesia: Experiences and challenges. *Journal of Physics Conference Series*, 947(1), 012015. https://doi.org/10.1088/1742-6596/947/1/012015.

Zulkardi (2019). Celebration of A Decade of JME. *Journal on Mathematics Education*, 10(1), v–vi. https://doi.org/10.22342/jme.10.1.6916.v-vi

Zulkardi, R. I. I. Putri, and A. Wijaya (2020a). Two Decades of Realistic Mathematics in Indonesia. In van den Heuval-Panhuizen, M. (Eds.) *International Reflections on the Netherlands' Didactics of Mathematics*. Cham, Switzerland: Springer. https://doi.org/10.1007/978-3-030-20223-1_18

Zulkardi, Meryansumayeka, R. I. I. Putri, Z. Alwi, D. S. Nusantara, S. M. Ambarita, Y. Maharani, and L. Puspitasari (2020b). How do students work with PISA-like mathematical tasks using the COVID-19 context? *Journal on Mathematics Education*, 11(3), 405–416. https://doi.org/10.22342/jme.11.3.12915.405-416.

Zulkardi and R. C. I. Prahmana (2021). The journey of journal on mathematics education: From local to global. *Journal on Mathematics Education,* 12(3), 389–410. http://doi.org/10.22342/jme.12.3.15001.389-410