Designing PISA-Like Mathematics Tasks In Indonesia: Experiences and Challenges

By Zulkardi Zulkardi

WORD COUNT 4063
TIME SUBMITTED 11-MAY-2023 09:05PM
PAPER ID 99593685

Journal of Physics: Conference Series

Designing PISA-Like Mathematics Tasks In Indonesia: Experiences and Challenges

Designing PISA-Like Mathematics Tasks In Indonesia: Experiences and Challenges

Z Zulkardi[1,3], A W Kohar[2]

[1]Department of Mathematics Education, Universitas Sriwijaya, Kampus FKIP Unsri Bukit Besar Jl. Srijayanegara Palembang, Indonesia, 30136
[2]Department of Mathematics and Natural Science, Universitas Negeri Surabaya, Kampus UNESA Ketintang, Surabaya, Indonesia, 60231

[3]Corresponding author: zulkardi@gmail.com

Abstract. The insignificant improvement of Indonesian students in PISA mathematics survey triggered researchers in Indonesia to develop PISA-like mathematics tasks. Some development studies have been conducted to produce valid and practical PISA-like problems that potentially effect on improving students' mathematical literacy. This article describes the experiences of Indonesian task designers in developing PISA-like mathematics tasks as well as the potential future studies regarding to mathematical literacy as challenges for policy makers, researchers, and practitioners to improve students' mathematical literacy in Indonesia. The results of this research indicate the task designers to consider domains of PISA like: context, mathematical content, and process as the first profiles of their missions. Our analysis shows that the designers mostly experienced difficulties regarding to the authenticity of context use and language structure. Interestingly, many of them used a variety of local wisdom in Indonesia as contexts for designing PISA-like tasks. In addition, the products developed were reported to be potentially effects on students' interest and elicit students' mathematical competencies as mentioned in PISA framework. Finally, this paper discusses future studies such as issues in bringing PISA task into an instructional practice.

1. Introduction

The issue of using real-world context in mathematics education in recent decades has gained much attention from scholars and practitioners. The attention is aimed, particularly, at developing students' ability to formulate, employ, and interpret mathematics in a variety of contexts, in which PISA (Programme International for Student Assessment) call such ability as mathematical literacy [1]. However, many evidences indicate that students around the world find difficulties when dealing with context-based problems like what is found in PISA tasks [1]. In particular, Indonesian student achievement in PISA survey shows an insignificant improvement during the period of 2000-2015 [2]. Some evidence were also reported to explain the factors influencing such insignificant achievements, such as opportunity to learn regarding to non-supportive teaching practice on the context-based problem [3], teachers' insufficient knowledge on designing context-based problem, and inadequacy of learning resources supporting the use of context-based mathematical problems provided by Indonesian typical mathematics textbook [5].

To minimize the latter two factors, some effort have been carried out by researchers and practitioners in Indonesia, one of which is by providing learning resources such as developing mathematics problem like in PISA with a variety of purposes. Some concerned on designing problems used in a set of learning sequence through a design research study [6], while the other concern on

designing problems which can be used for assessment through a developmental research [7,8].This effort is in line with the inclusion of mathematical literacy in Indonesian school mathematics curriculum which follows the movement of *PMRI* (Indonesian version of realistic mathematics education) as a part of reformation of current curriculum in Indonesia. The movement indicated, for examples, by the suggestion of improving the instructional quality using PISA problems and introducing PISA problems within workshop for students and teacher [9]. Designing problems like in PISA (or PISA-like tasks) is also recognized as one of the main contents in the curriculum of mathematics education in Indonesian teacher education. For example, Stacey et al. [9] reported that numerous studies on developing PISA-like problem had been conducted by teachers at Sriwijaya University as their final research projects.

However, designing context-based mathematics problem like in PISA seems to be challenging for the beginners like students' teachers. It is not only about making problem which is plausible to solve but also making problem authentically in which the real-world included and modeled mathematically like the framework of PISA in term of mathematic concern. Some studies reported several obstacles regarding to create problems like in PISA. Paolucci and Wessels [10], for example, reported that while the item developers in their study were relatively successful with creating appropriate and motivating contexts, they were far less proficient with turning these contexts into an appropriate problem. Siswono et al [4] also reported that most of the teacher participants in their study put difficulties on finding real world context as the main obstacle when designing problem-solving tasks. Thus, it needs to be clarified whether these kinds of obstacles are experienced by task designers in Indonesia. In addition it needs to be confirmed how they deal with the PISA framework on developing PISA-like tasks. Accordingly, other task designers can learn from them for future attempts regarding task design on mathematical literacy.

To answer the above challenge, this paper presents the experiences and challenges of mathematics tasks designers in Indonesia to develop PISA-like tasks. The designers concerned the scholars or the students who took mathematical literacy as the main topic for their research projects either in undergraduate programs or graduate programs. The experiences tell how the designers apply their frameworks to develop PISA-like tasks, how they employ certain techniques to design PISA-like tasks, how they deal with PISA framework on designing PISA-like tasks, how they utilize contexts for their tasks, and what potential effects of PISA-like tasks they develop on students' mathematical literacy. Meanwhile, the challenges include the difficulties experienced by the designers when developing PISA-like tasks, namely creating more authentic, more accessible regarding to the use of language structure, and more cognitively-demanding tasks. It is expected that the discussion of this paper would be useful for those who are interested in further study particularly in designing PISA-like mathematics tasks and how to translate the tasks into instructional practices.

2. PISA-like tasks designers' experiences

We organize the discussion about PISA-like task designers' experiences into five sections as follows:

2.1. Applying formative evaluation as the framework for developing PISA-like tasks

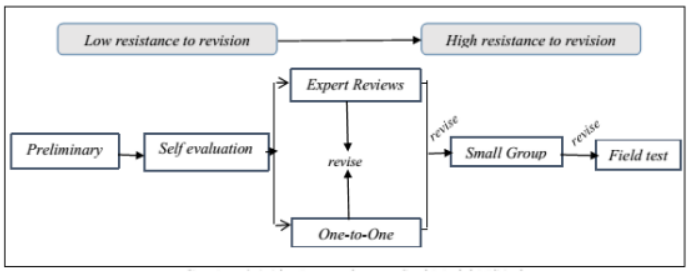


Figure 1. Formative evaluation [11]

Many of the task designers in Indonesia applied formative evaluation as the main framework for developing PISA-like tasks. Tessmer [11] defined the formative evaluation as a judgment of the strengths and weaknesses of the instruction in its development stages, for the purposes of revising the

instruction to improve its effectiveness. Thus, the emphasis of this type of research design is on the development of repetitive cycles [11]. The stages of the framework are preliminary stage and prototyping stage which include self-evaluation, expert reviews and one-to-one, small group, and field test [11]. The components were involved in this evaluation are designers, experts, and learners (in this case the student).

At the preliminary stage, the task designers took several activities: studying pieces of literature (development research on PISA-like tasks, the framework of mathematical literacy, current curriculum related with PISA results, and how to design PISA-like tasks), finding experts and learners, and developing procedures for conducting research in schools with partner teachers. Kohar et al. [7], at this stage, for instance, studied some literature and found the research focus of the study which not only describes the process and the development of the tasks, but also examines the students' mathematical literacy performanced by zooming in the three processes: formulate, employ, and interpret the students experience during solving the tasks. *At the self-evaluation stage*, the task designers evaluated and examined the initial prototype, i.e. a set of PISA-like tasks equipped with item profiles, alternatives answer, and scoring rubrics. Furthermore, they also designed several instruments such as interview guidelines to find out the students' mathematical literacy performance or other expected objectives suitable with their research focus, and a set of questionnaires to see the potential effect of the tasks.

At expert reviews, the task designers gave the prototype to several experts, typically in three ways:face-to-face review, panel review, and mails review. Face-to-face reviews are performed by giving the prototype in order to confirm the experts' reviews directly. Panel review was organized by discussing the prototype with several experts at once that save time compared to interviewing the experts separately [11]. Meanwhile, mails review was carried out by sending the prototype to the experts via email and then obtaining constructive suggestions from them. The experts were selected by the task designers were typically from mathematics expert group of PISA in Australia [7,12,13], PMRI experts [7,8,12,13,], experienced PISA-like task designers [7,13], and experienced teachers [7,12,13]. *At one-to-one*, the prototype was examined to some students [4-6 students] particularly to evaluate the clarity of tasks regarding to language and figural display and study the emergence of alternative problem solutions. The results from both experts' review and one-to-one were then simultaneously used to revise the prototype. The revised prototype was then evaluated in a*small group* consisting of 9-15 students [7,8,12,13]. At this stage, the task designers firstly obtain the students' performances in detail so that it can be considered as an overview to explore the potential effect of the prototype on students' mathematical literacy at *field test*.

2.2. Adopting PISA framework as the main basis of profiling PISA-like tasks

PISA-like task designers in Indonesia mainly consider the framework of mathematics PISA, either released in 2003 or 2012 [1]. The framework, which briefly defines mathematical literacy as an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts, contains a model to guide them characterizing the PISA-like tasks they designed. The model depicts that mathematical literacy starts from real-world problems, which are categorized into the category of contexts (personal, occupational, societal, and scientific) and contents (change and relationship, space and shape, quantity, and uncertainty and data) (see [1]). Those two categories are then completed with one additional category or domain in PISA 2012, namely process (formulate, employ, and interpret), showing the most dominant process need to be performed when solving the real-world problems. While PISA 2003 only used paper-based assessment of mathematics (PBAM), while PISA 2012 used both PBAT and computer-based assessment mathematics (CBAM) for its item profiles.

We found a variety of PISA-like tasks developed by Indonesian task designers with various focus of domains. Table 1 summarizes several examples reported in some of national and international journals.

Table 1. Profile of PISA-like tasks in Indonesia: Some examples

Authors	Domain concern			Level	Mathematical competencies	PBAM	CBAM
	context	content	process				
Ahyan et al. [8]				√		√	
Anisah et al. [15]		√			√	√	

Charmila et al. [14]	√					√	
Kamaliyah et al. [16]					√	√	
Kohar et al. [7]	√	√	√			√	
Kertayasa et al. [13]							√
Lesmana et al. [17]					√		√
Oktiningrum & Hartono [12]	√					√	

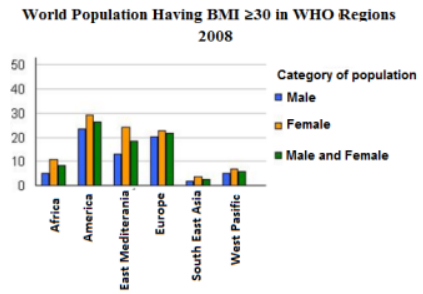
Table 1 explains that while some concerned on only one domain or one mathematical competency, as exemplified by Charmila et al. [14], which focus on a local context of a province, others concerned on more than one domain. Anisah et al. [15], for example, consider the content: quantity and the mathematical competency: reasoning and argumentation for their items. Interestingly, there were also task designers concerning on the level of PISA task for their items, such as Kamaliyah et al. [16] who developed the sixth level of PISA-like tasks. In recent years, some task designers developed their tasks using computer-based technology. For instances, Kertayasa et al. [13] created an online version of their tasks which easily accessed by many people, as well as Lesmana et al. [17].

2.3. Using problem posing as the method of designing PISA-like tasks

With regards to the method in which the task designers were inspired to design PISA-like task, some of them primarily applied problem posing forms: problem generation and problem reformulation [18], each of which respectively refers to the process of posing a problem based on a set of given information, and the process of posing a problem related to a problem that is or was the focus of problem-solving. In addition, Bairac's [19] methods of composing mathematics problem (paraphrasing, analogizing, changing the data in the statement, generalizing, and combining), and Grundmeier's [20] problem reformulation methods (switching, changing the context, changing the given, changing the wanted, extension, adding information, and rewording) were also used as methods of designing PISA-like tasks. Kohar at al [7], for example, combined such three methods when designing their PISA-like tasks. Figure 2 below shows an example of how they used such techniques.

Body Mass Index [7]

The following chart shows comparison of world population over 20-year-old with Body Mass Index, *BMI≥30*



Circle "Yes" or "No" for each of the following options.

Statement	Is this correct?
Less than 5% of South Asian people are obese	Yes/No
The number of Americans with a minimum BMI of 30 is greater than that of European with a minimum BMI of 30	s/No
In all WHO regions, there are more obese women than obese men	Yes/No
In Africa, Eastern Mediterranean, and Southeast Asia, almost every man with BMI ≥ 30, there are two women with BMI ≥ 30	Yes/No

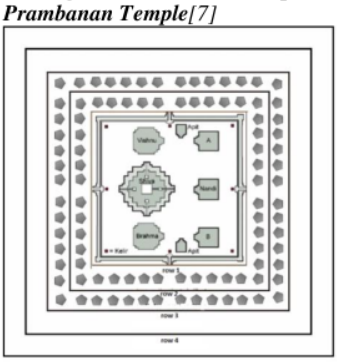
Figure 2. A task designed by using problem generation and paraphrasing particular information

2.4. Employing local wisdom as contexts to design PISA-like tasks

Developing mathematics problem using local wisdom has been obtaining a growing attention for PISA-like tasks designers in Indonesia in recent years. Not only because the awareness of the benefit of using local wisdom as contexts to encourage students' mathematical thinking process [14], but also the ease of accessing local context which is very diverse found by the task designers in Indonesia. Moreover, it is indicated that when working on mathematical literacy problem, students don't need to apply mathematical knowledge and rules to a new situation in a simple matter. Rather, it involves engagement with attaining the various attributes of the context of the problem in the task. Thus, developing PISA-like task which facilitates students' familiar situation like found in local wisdom becomes significant.

The local wisdom found in the PISA-like tasks include cultural heritages such as traditional craft and houses [14,16], traditional games[6], temples [7], and natural heritages such as local tourism objects [12]. Figure 3 shows an example of a PISA-like task which used *Prambanan* temple as cultural heritage.

Prambanan Temple*[7]*



The picture below shows the arrangement of some *Perwara* temples (indicated by " ⬟ ") when already restored on row 1 and 2 at *Prambanan* temple. The arrangement of the remaining temples which will be restored on the 3rd row and the 4th row follows the pattern of previous arrangements. What is the total number of temples that still need to be restored? Please explain your answer.

Figure 3. A task designed by harnessing cultural heritage as a local wisdom

2.5. Exploring potential effect of PISA-like task on students' interest and mathematical literacy performances

To examine the quality of PISA-like tasks, the task designers explored to what extent the PISA-like tasks they developed can promote students' mathematical literacy, elicit students' mathematical competencies, and generate students' interest and seriousness in solving the tasks. The PISA-like tasks were reported to elicit students' reasoning, communication, problem-solving strategies, representation, and mathematising [7], and creativity [21]. Additionally, they were also able to motivate students to work on the context-based problems [7,12].

3. PISA-like tasks designers' challenges

3.1. Designing more authentic PISA-like tasks

Designing PISA-like tasks is more than designing plausible problem of sufficient information. Rather, it is the effort that needs to look for and translate authentic context for tasks to be designed. Authentic contexts are known as a unique feature of PISA task which makes it different from other types of problem-solving tasks [1]. Thus, it becomes a challenge for PISA-like task designers. We found that many reports reveal their difficulties on designing PISA-like tasks in the beginning stages of formative evaluation. The comments related to camouflage context of the tasks, the context which seems to have been rather artificially derived in order to provide an opportunity to practice some particular mathematical skill, rather than being a genuine problem that someone really wants or need to solve, became mostly found from experts review. Figure 4 shows an example of how the 'camouflage context' appears on the tasks before revision and how the situation has been improved by the task designer to improve the task authenticity.

Food Boxes*[7]*

Before revision:
Some food boxes are placed on the table as shown below. Count the total number of the food boxes!
After revision:
A committee of a seminar event forgot to count the total amount of the food boxes ordered when she put it on the table. However, she can still calculate the total amount of boxes by observing the pattern of rice boxes arrangement that he arranged on the table as shown in the figure above. Help the committee to count the number of boxes. Explain your strategy!?

Figure 4. The transformation from camouflage context to a more authentic context.

3.2. Designing PISA-like task with accessible language for students

We found that it is not easy for the beginners to arrange pieces of information in a task which is clearly understood by students. The problems experienced by the task designers include mostly about having too much information provided in the tasks, using unfamiliar terms, unspecific unit of contexts, and unacceptable use of mathematical symbols. Regarding the first problems, experts suggest to task designers to avoid some repetition of ideas or sentences, avoid introducing the problems of the task with context stories that are too general, and if it possible, convert sentences that are too long in the form of tables or figures [7].

3.3. Designing higher order thinking skill (HOTS) PISA-like task

HOTS task is known as tasks which promote higher order thinking skills (HOTS) and a concept of education reformed based on learning taxonomies (such as Bloom's taxonomy). The idea is that some types of learning require more cognitive processing than others, but also have more generalized benefits. Regarding PISA task, HOTS task is the PISA task which is considered at the level of 4,5, or 6 out of six levels of PISA-task. The challenge is that task designers are encouraged to design PISA-like task which meets the requirement of HOTS and also contains authentic context.

4. Implications and Conclusion

Regarding to the authenticity of PISA-like tasks, our analysis suggests that PISA-like task designers should aware of posing tasks of camouflage context. Thus, they need to consider levels of studying of context usage for mathematics problems. A theoretical framework was developed by Salgado [22] to help a task designer in designing context-based problem by considering the level of context usage of a problem which is being posed and analyzed and how the context is used to formulate a problem in mathematical terms and to interpret the answer about the context of the given problem. It is expected that the task designers that can pose tasks having at least level 1 or 2, instead of 0. Once PISA-like tasks are designed and evaluated, the further challenge is to bring those tasks into teaching practice. In connecting to that problem, Wijaya et al [3] suggested using consultative teaching for teaching practice regarding context-based task like PISA task from comprehension stage, transformation stage, mathematical processing stage and encoding stage. Alternatively, since the framework of PISA mathematical literacy is heavily influenced by the realistic mathematics education (RME) movement, which stresses the importance of solving mathematical problems in real-world setting, we argue that this learning approach can be employed and maintained as a promising basic theory to develop mathematical literacy-based teaching program.

To conclude, we would highlight that PISA-like task designers in Indonesia have contributed to provide PISA-like tasks as potential learning resources for improving students' mathematical literacy. However, they found some challenges mainly regarding to profiling tasks and designing tasks which have a genuine or authentic task. By accustoming to design this type of tasks, the task designers participate a mathematical literacy environment which is helpful for not only improving students' performance in PISA survey but also prepare students to solve more complex problems in current situation.

References

[1] OECD2013 PISA 2012 *Assessment and analytical framework: mathematics, reading, science, problem solving and financial literacy*(Paris: OECD Publishing)
[2] OECD2016PISA 2015*Results in focus* (Paris: OECD Publishing)
[3] WijayaA, van den Heuvel-PanhuizenM, and DoormanM2015*Math Educ Res J***27**637-662
[4] Siswono T Y E Kohar A W Kurniasari I and Astuti Y P *2016 Journal of Physics: Conference Series***693** 12015-12033
[5] Wijaya A, van den Heuvel-Panhuizen M, Doorman M *2015 Educ Studies in Math***89** 41–65
[6] Jaelani A Putri R I& Hartono Y 2014 *Journal on Math Educ***4** 29-40
[7] Kohar A W, Zulkardi, Darmawijoyo 2014 Developing PISA-Like Mathematics Tasks To Promote Students' Mathematical Literacy In: Ratu Ilma (Eds) *The Second South East Asia Design/*

Development Research (SEA-DR) International Conference April 26-272014 Unsri Palembang April 26th-27th2014 Palembang
[8] Ahyan S 2014*Journal on Math Educ***5** 47-56
[9] Stacey K, Almuna F, Caraballo RM,Chesne J,Garfunkerl S, Gooya Z,...Zulkardi Z2015 PISA's influence on thought and action in mathematics education, In K Stacey & R Turner (Eds) *Assessing mathematical literacy: The PISA experience* (pp 275-306) (Dordrecht: Springer International Publishing)
[10] Paolucci C and Wessels H 2017*Journal of Teacher Educ***68** 330-344
[11] Tessmer M 1993 *Planning and conducting formative evaluations: Improving the quality of education and training*(London: Kogan Page)
[12] Oktiningrum W & Hartono Y 2016 Developing PISA-" Like" Mathematics Task with Indonesia Natural and Cultural Heritage as Context to Assess Students Mathematical Literacy *Journal on Mathematics Education***7** 1-10
[13] Kertayasa I K & Zulkardi Z (2014) Achievement Of Indonesian Student In Assessment By Using Online Mathematical ProblemsIn: Ratu Ilma (Eds) *Proceeding of The Second South East Asia Design/ Development Research (SEA-DR) International Conference April 26-272014* (Palembang: Universitas Sriwijaya)
[14] Charmila N Zulkardi Z & Darmawijoyo D Pengembangan Soal Matematika Model PISA Menggunakan Konteks Jambi *Jurnal Penelitian dan Evaluasi Pendidikan***20** 198-207
[15] Anisah A Zulkardi Z & Darmawijoyo D 2013 Pengembangan Soal Matematika Model PISA pada Konten Quantity Untuk Mengukur Kemampuan Penalaran Matematis Siswa Sekolah Menengah Pertama *Jurnal Pendidikan Matematika***5**
[16] Kamaliyah K Zulkardi Z & Darmawijoyo D 2014 Developing the sixth level of PISA-like mathematics problems for secondary school students *Journal on Math Educaton***4**9-28
[17] Lesmana H &Ilma R I 2013 Pengembangan Soal Non Rutin Berbasis Komputer Untuk Melatih Penggunaan Kemampuan Matematika Siswa *Ekuivalen-Pendidikan Matematika***4**
[18] Silver E A 1994 On mathematical problem posing*For the learning of mathematics***14**19-28.
[19] Bairac R 2005 Some methods for composing mathematical problems International *Journal for Mathematics Teaching and Learning* Available from http://wwwcimtplymouthacuk/journal/bairacpdf
[20] Grundmeier T A 2015 Developing the problem-posing abilities of prospective elementary and middle school teachers In FMSinger & NF Ellerton (Eds*) Mathematical problem posing: From research to effective practic*e (pp 411-432) (New York NY: Springer)
[21] Novita R & Putra M 2016 Using task like PISA's problem to support student's creativity in mathematics *Journal on Math Educ***7** 31-42
[22] Salgado F A 2016 Developing a Theoretical Framework for Classifying Levels of Context Use for Mathematical Problems In White, B, Chinnappan, M & Trenholm, S (Eds) *Opening up mathematics education research (Proceedings of the 39th annual conference of the Mathematics Education Research Group of Australasia)*, pp 110–117 (Adelaide: MERGA)

Designing PISA-Like Mathematics Tasks In Indonesia: Experiences and Challenges

ORIGINALITY REPORT

11%
SIMILARITY INDEX

PRIMARY SOURCES

1	miseic.conference.unesa.ac.id Internet	169 words — 5%
2	mafiadoc.com Internet	110 words — 3%
3	D S Nusantara, Zulkardi, R I I Putri. "Designing PISA-like mathematics problem in covid-19 pandemic (PISAComat)", Journal of Physics: Conference Series, 2020 Crossref	67 words — 2%
4	B Murtiyasa, S Rejeki, R Setyaningsih, A Merdekawati. "Students' Thinking in Solving Geometric Problems Based on PISA Levels", Journal of Physics: Conference Series, 2019 Crossref	56 words — 2%

EXCLUDE QUOTES	ON	EXCLUDE SOURCES	< 2%
EXCLUDE BIBLIOGRAPHY	ON	EXCLUDE MATCHES	OFF