Searching for Authentic Context in Designing PISA-like Mathematics Problem: From Indoor to Outdoor Field Experience

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Abstract. Designing problem like in PISA is known as a challenging activity for teachers particularly as the use of authentic context within that type of problem. This paper aims to describe the experiences of secondary mathematics teachers in designing PISA-like problems within an innovative training program focusing on building teachers’ understanding on the concept of mathematical literacy. The teachers were engaged in a set of problem-solving and problem-posing activities using PISA-based problem within indoor and outdoor field experiences. Within indoor field experience, the teachers worked collaboratively in groups on designing PISA-like problems with a given context through problem generation and reformulation techniques. Within outdoor field experience, they worked on designing PISA-like problems with self-chosen context from the place where the outdoor field experience took place. Our analysis indicates that there were improvements on the PISA-like problems designed by teachers based on its level use of context from indoor to outdoor experience. Also, the teachers were relatively successful with creating appropriate and motivating contexts by harnessing a variety of context consisting of personal, occupational, societal, and scientific contexts. However, they still experienced difficulties in turning these contexts into an appropriate problem satisfying PISA framework such as regarding authenticity of context use, language structure, and PISA task profile.

1. Introduction
The inclusion of context in mathematical problems has been highly recommended by current reform mathematics teacher education, mainly as the results of PISA (programme for International Student Assessment) survey which emphasizes the importance of mathematical literacy as the ability that students around the world should possess [1]. The recommendation, for instances, suggests to explore teachers’ beliefs and knowledge about context-based problem [2-3], teachers’ use of context-based problem into teaching practices [3], and efforts of improving teachers’ ability in selecting and designing context-based problem for classroom activities purposes [4]. In particular, research in relation to the latter recommendation has become one of the priorities that researchers and practitioners should further pay attention. This is due to the claim that the quality of teaching depends on how teachers select problems and how these problems unfold in the classroom in ways that allow the students to learn through those problems [5]. Moreover, it also because of the urgency on supporting teachers to create problems which connect with the interests and experiences of students, address important mathematics, engage students, and help them to see mathematics as making sense of the world [6].
One of the important features that PISA problem has is the concern about incorporating context in the problem. The problem context, which is defined as the information that is contained and mathematical, that is, the content of a mathematical problem that needs to be mathematised [7], should be selected so that it qualifies as a non-camouflage context. In other words, PISA problems do not examine students how well they indicate only their mathematical skills. Instead, PISA problems examine how well they use their mathematics knowledge to solve real world problem should be solved [6]. In addition to the authenticity of PISA problem, PISA has used almost no zero-order context items [7], i.e. the items whose context is a mere camouflage, generally involves just mathematical terms, shapes, data and the translation of textually packaged mathematical problems. Rather, PISA used first order and second order use of context, each of whose context is respectively relevant and is needed for solving the problem and the knowledge of context is needed to “mathematise” the problem in order to solve it [8].

However, teachers meet challenges when designing context-based mathematics problems as found in PISA problem. Paolucci and Wessels [4] reported that despite the preservice teachers in their study were relatively successful created worthy and motivating contexts, they were far less proficient with turning these contexts into an appropriate problem. The study of Wijaya et al [3] also asserts their teacher participants tended to perceive context-based tasks as merely plain word problems which provide only the information needed to find the solution and should explicitly provide the required mathematical procedures. Siswono et al [2] further 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. The causes of such obstacles, they admitted, covers their infrequent learning on how to design problem-solving task, like in PISA and their habits which are too often taking problems provided in their teaching book [2]. These all findings seemed to support a notion of Singer and Voica arguing that many teachers are not active problem posers, nor do they have the required skills to pose appropriate problems [9]. Thus, the need for teachers to have knowledge about designing problems like in PISA should be considered as an important part of their development of professional knowledge in teaching.

For the case of Indonesian teacher, several types of teacher development programs have been developed to promote Indonesian teacher regarding the use of context within mathematics education, such as PMRI (Pendidikan Matematika Realistik Indonesia or Indonesian version of realistic mathematics education) teacher training [10-11], mathematical modelling-based training [12], and workshop on PISA-like problem [13]. While those kinds of pieces of training were reported as valuable tools to build teachers’ awareness of such issue, the authors, however, have not found a more specific professional training which concerns on developing teachers’ capacity on designing problem like in PISA (later we call it as PISA-like problems). Hence, this present study aims to provide a professional training, called Mathematical Literacy Training for PISA-like task (MLTP), which facilitates secondary teachers to design and develop PISA-like problems by engaging them in a set of learning activities through problem solving and problem posing in indoor [classroom] and outdoor [outside the classroom] experiences. Why problem-solving and problem posing? What experiences did the teachers has during the training? To what extent the PISA-like problems designed by the teachers meet the requirement of PISA problems, particularly in relation to authenticity and variety of context? These questions become our particular concern in this article.

2. Authentic PISA-like mathematics problem

Authenticity is one characteristic of mathematics tasks that can influence how students use contexts in problem-solving [14]. Authenticity is also conceived as a measure of how realistic a problem situation is [15]. In the matter of PISA problem, Stacey and Turner [6] emphasized that mathematical problems will be more authentic to the sorts of encounters with mathematics that students might expect in the real world if the value in assessing students’ capacity to solve mathematical problems is by using problems with second-order use of context. In this study, we concerned on examining teachers’ designed PISA-like problem using this type of category. To understand the difference between zero, first, and second order of context, please see the examples provided by Salgado [7].
As a guideline to examine teachers’ profile of PISA-like tasks, we were guided by PISA framework 2012 [1] which classifies PISA task into three domain categories: by the nature of the situation (the context category: personal, occupational, scientific, and societal), the major domain of mathematics involved (the content category: quantity, change and relationship, space and shape, and uncertainty and data), and the major mathematical literacy process (the process category: formulate, employ, interpret). More elaborated characteristics of those categories have been explained by OECD [1].

3. The MLTP: Design and principles
The MLTP presented in this study is a part of our bigger project regarding professional training which concerns on developing teachers' understanding of mathematical literacy content knowledge for teaching (MLCKT) (not presented here). The first principle is that the design of MLTP builds from modified Steinbring’s model of teaching and learning mathematics [16] arguing that teacher learning is highly influenced by tasks in which teachers engage. The model shows that reflection is seen as central to teachers’ construction of knowledge. Figure 1 illustrates the reflection is carried out during a cyclic process from the process of working on the task offered by the facilitator to the process of generalizing solutions of the tasks in order to achieve the expected knowledge.

![Figure 1. Modification of Steinbring’s Model of Teaching and Learning Mathematics][16]

The model shows two loops of learning, one showing the learning by reflection of the teachers and a second showing the learning of the facilitator by reflection and observation of the process done by the teachers. Within our design, as the teachers engaging the tasks and constructing knowledge about PISA-like problem design, the facilitator will reflect on the learning offers by conjecturing the teachers’ responses toward the knowledge of PISA-like problem being learned and then guide them to the further expected knowledge. For instance, when enhancing teachers’ understanding on knowledge of PISA-like problem in an activity, we conjecture as many as possibilities of the variety of PISA-based task posed by the teachers regarding PISA’s task profile, i.e. type of context, content, and process, so that we can identify what we should guide teachers’ reflection of this knowledge through a productive discussion within further activities.

The second principle is that our professional learning course was developed around views of problem solving and problem posing activities as potential approaches to learn PISA-like problem design. Such views were based on several points. For example, it is quite well noted that there is a strong link between problem-solving performance and problem posing performance [17]. Also, the quality of the problems individuals posed, as Kilpatrick [18] maintained, might serve as an index of how well they can solve a problem and the abler they posed problems that were more complex than those posed by less able individuals. Thus, we provide problem-solving activities using PISA-based problem to increase the teachers’ problem posing ability on designing PISA-like problem. Within our design, we encouraged
teachers to use problem two problem posing techniques: problem generation (designing new problems) and problem reformulation (reformulating existing problems) [19]. By providing activities that are situated in real-life contexts, Osana & Pelczer [20] argued that a variety of different types of mathematical explorations can emerge on the problem being posed, such as assessing different solutions according to a variety of criteria and considering situations from different perspectives.

The third principle, teachers were encouraged to create a PISA-based task in an outdoor field experience based on context situation they found. Such experience, as Moss [21] suggested can not only help teachers to explore and understand the world around them but also help them feel more connected to their natural world. We involved 40 teachers (18 male and 22 female) from 20 schools in rural and urban areas at Mojokerto city, Indonesia, to join the training as long as eight days (7 hours per day). Table 1 shows the topics of the course learned by the teachers during the training.

Table 1 Learning offers of the MLTP course

| Learning Course                                      | Course Topics                                                                 |
|------------------------------------------------------|-------------------------------------------------------------------------------|
| Mathematical literacy                                | 1. the issue on mathematical literacy in teaching and learning                |
|                                                      | 2. the concept of mathematical literacy: PISA 2012 framework                 |
|                                                      | 3. PISA-based task: nature and profile                                       |
| Problem-solving and posing in mathematical literacy  | 1. problem posing techniques: problem generation, problem reformulation      |
|                                                      | 2. posing mathematical task in practice                                      |
|                                                      | 3. posing PISA-based task                                                    |
| Problem Reformulation (PISA-based task with a given problem) | posing PISA-based task related based on a given PISA problem (group)       |
| Problem Generation 1 (PISA-based task with a given context) | posing PISA-based task from a set of given information of context situation (group) |
| Problem Generation 2 (PISA-based task with self-chosen context) | posing PISA-based task from context situation created/chosen by teachers (group) |
| Problem Generation 3 (PISA-based task with self-chosen context) | posing PISA-based task from context situation created/chosen by teachers (individual) |
| Problem Generation 4 (task with context from outdoor-field activities) | posing PISA-based task from context situation created by teachers within outdoor-field activities (individual) |
| Reflection                                            | discussing MLCKT based on problem solving-posing experiences as well as further recommendation related to teachers’ response of the course |

In this paper, we reported teachers' experiences when carrying out activities from the learning course ‘mathematical literacy' to ‘reflection' in both indoor and outdoor field experiences.

To describe the teachers’ experiences, we employed some problem solving and problem posing tasks that were selected or designed primarily to explore teachers’ understanding on PISA problem. Such activities were categorized into five types as shown in table 4: problem reformulation, problem generation 1, problem generation 2, problem generation 3, problem generation 4. The following are the tasks for those types of problem posing activities. Both tasks in figure 2a, 2b, and 2c were used in group work activities, while task in figure 2d and 2e were used in individual work. Meanwhile, to gather the most probable refined knowledge of ML-based task, we analyzed the quality of teachers' posed PISA-based tasks on the task in figure 2e by categorizing them based on their profile features: content, context, process, and level use of context categories. Table 3 describes such features adopted from PISA framework (see more detail description in [1] and [8]).
(a) Task for problem generation 1
Create two problems satisfying features of PISA-based task based on the context situation given by the figure above in group. Give profile of your problems containing categories of context, content, and process. Complete your problem with some alternative answers.

(b) Task for problem reformulation
FERRIS WHEEL
A giant Ferris wheel is on the bank of a river. See the picture and diagram below.

The Ferris wheel has an external diameter of 140 metres and its highest point is 150 metres above the bed of the river. It rotates in the direction shown by the arrows.

The Ferris wheel rotates at a constant speed. The wheel makes one full rotation in exactly 40 minutes.

John starts his ride on the Ferris wheel at the boarding point, P.

Where will John be after half an hour?
A. At R
B. Between R and S
C. At S
D. Between S and P

Task 1: Solve the problem in the group.
Task 2: Create two new problems satisfying features of PISA-based tasks inspired by your work on the problem or the context situation of the problem. Give profile of your problems containing categories of context, content, and process. Complete your problem with some alternative answers.

(c) Task for problem generation 2
Create two problems with different mathematics content in the same context satisfying features of the PISA-based task in the group. You are free to choose context situation based on your interest. Give profile of each of your problems containing PISA categories of context, content, and process. Complete your problem with some alternative answers.

(d) Task for problem generation 3
Create two problems with different mathematics content in the same context satisfying features of PISA-based task individually. You are free to choose a context situation based on your interest. Give profile of each of your problems containing PISA categories of context, content, and process.

(e) Task for problem generation 4
You will join outdoor field activities at the end of this course. Find out a context situation you think is rich to design PISA-based task, then create minimum two problems in the same context you have chosen individually. Complete your problem with some alternative answers.

Figure 2. Problem posing tasks used in the MLTP

4. Mathematical Literacy Course
When identifying teachers’ initial understanding of PISA problem, we encouraged teachers to discuss the concept of mathematical literacy by discussing how the term is differentiated to other related terms, how the term can be explained by PISA problems by identifying their characteristics from PISA released item 2006 such as ‘Rock Concert’ and ‘Speed of Racing Car’ [21], and how the term can be indicated from examples of students’ solution methods of those two problems. Our findings suggested that although none of them did know about the term of ‘mathematical literacy’ yet, they had likely sufficient
understanding on the characteristics of context-based problem which corresponds to the concept of mathematical literacy.

Rock Concert Problem. For a rock concert, a rectangular field of size 100 m by 50 m was reserved for the audience. The concert was completely sold out and the field was full with all the fans standing. Which one of the following is likely to be the best estimate of the total number of people attending the concert?

A) 2 000  B) 5 000  C) 20 000  D) 50 000  E) 100 000

Some of the responses regarding such characteristics revealed by the teachers were ‘the task is found in real life’, ‘the task requires one to have a quite level of reasoning’, and ‘the task demands more than one branch of mathematics’. To illustrate the latter respond, for example, some teachers suggested one to apply knowledge of geometrical shapes as well as the procedure of standard calculation on ‘Rock concert’ problem. Additionally, one also needs to estimate area occupied by a fan and then making the relevant quantitative comparisons needed. Thus, our discussion arrived at an understanding stated by Stacey and Turner [6] revealing that for those who think that mathematics is very limited on things abstract and theoretical, mathematical literacy is interpreted broader than mathematics since the problem in mathematical literacy involves an ability to link the world of formal abstract with real-world phenomena in which in deciding solutions, one needs to consider both. For those who think the opposite, i.e. mathematical literacy is part of mathematics, the purpose of the activity of mathematics is functional meaning that there is an activity of mathematics whose purpose is to explore and understand the structures and patterns which are abstract for their own interests.

5. Indoor Experiences through problem-solving and problem posing activities

5.1. Problem-solving activities using PISA-based problems

In this activity, we, as facilitators, gave a set of PISA problems and asked the teachers to try solving the problems using their own methods. The set consists of problems with the different level of difficulty and various categories regarding content, context, and process. Once they finished, we started guiding discussion about solution methods which might emerge from the teachers' work. Next, we discussed some reflections from their experiences on the PISA problems. Our analysis indicates that they feel challenged to solve the problems although some of them experienced difficulties. The discussion shows that they often deal with word problem like found in PISA, but these kinds of problems, they admitted, are different with other types of word problems. The differences, for example, regards to the need of looking some extra information which is not directly stated in the problem which leads to use reasoning rather than applying particular mathematics formula. When asked about the level of authenticity, they agreed that PISA problems are authentic, which means the ‘the story' of the problem can be really found in real world setting.

5.2. Problem Reformulation

The teachers firstly tried designed PISA-like problems in this activity. They worked in groups comprising 4-5 teachers. First, they solved the problem in problem reformulation (Figure 2b) and then continued with designing as many as problems that might be posed by reformulating the existing problem. We expected them to design PISA-like tasks which satisfy the characteristics of PISA problem based on their experiences when following mathematical literacy course and problem-solving activities. Once they finished, we encouraged them to present their work in class discussion. The following is the mathematics problem designed and discussed during the class discussion.
A group of teachers presenting PISA-like problem

1. If Ani is sitting in room 1, while Budi in room 5, what is the smallest angle between Ani’s room and Budi’s room?

2. A Ferris wheel has 12 rooms, each of which can contain maximum 2 persons. Given that the ticket price for 10 minutes is IDR 5,000.
   a. Determine the circumstance of the Ferris wheel
   b. Determine the smallest angle that can be formed between two of the Ferris wheel rooms
   c. What is the owner’s income (in IDR) of the Ferris wheel if it operates full hours as long as three days?

Figure 3. Problem designed by teachers in problem reformulation

From the presentation session, our analysis shows that teachers at this stage had likely problems regarding insufficient information and authenticity. The insufficient information is shown at item no 1 which does not clearly state which angle that is asked to find. The phrase ‘angle between Ani’s room and Budi’s room does not make mathematical sense. Regarding authenticity, both the items (no 1 and 2) seemed to have zero-order use of context which is unacceptable for PISA-like problem. Also, despite item, no 2c is mathematically plausible, it does not make sense that a Ferris wheel can operate as long as three days without taking some rest. Thus, it needs adding some assumptions to make it realistically solvable. This experience was then emphasized as a reflection for the teacher in the next problem posing activities.

5.3. Problem Generation 1

This was the second opportunity for the teachers to design another PISA-like problem. Again, they worked in groups with same members. The teachers designed problems using task on figure 2a. The following is the problems that were presented by another group during a class discussion. Meanwhile, other teachers commented on the problems.

A Ferris wheel has 20 rooms as shown in the picture. Given that the ticket is IDR 5,000 per person. The cost of making the Ferris wheel is IDR 175 million. If the Ferris wheel is operated daily 4 hours for 6 days a week and each full spin takes 10 minutes, how many years will the owner’s income from the ticket selling cover the cost of making the Ferris wheel?

Figure 4. Problem designed in problem generation 1

During the class discussion, most of teachers who expressed opinion agreed that the teachers of the presenting group seemed to consider the previous experience in problem reformulation activity, which means they no longer used questions like the measure of angle (which is considered to have camouflage context) or open a variety of assumptions which might not be restricted. The changes were indicated by the information which confined ‘four hours per day operation’, instead of ‘a whole day operation’ for a Ferris wheel. Our analysis also shows that this problem can be categorized in the ‘first order use of context’ problem since the context of Ferris wheel construction, ticket, the cost of making Ferris wheel are needed to find out the number of years needed for the owner to cover the construction cost. However, in other presenting groups, we also still found PISA-like problems which did not yet
meet authenticity and plausibility criteria. Moreover, other difficulties experienced by the teachers are about profiling their designed problems regarding PISA item profile: content, context, and process.

5.4. Problem Generation 2

In this session, the teachers were asked to write PISA-like problems in a group on a Plano paper. All the plane papers from all groups were put on the wall around the classroom. The idea of this activity is that they visited all the papers and took some notes related to the strength and weaknesses of the PISA-like problems designed by other teachers particularly regarding authenticity, language use, and PISA item profile. Once they finished, we held a class discussion by offering the teachers to their observation results.

![Figure 5. Problem designed in problem generation 2](image)

Mother wants to cook meatball with two variants: original and premium. Here are the ingredients

| Ingredients  | original | premium |
|-------------|----------|---------|
| beef        | 1,000 grams | 2,000 grams |
| starch      | 500 grams   | 500 grams   |
| Number of meatballs | 150 items | 250 items |

1. If a mother wants to cook 100 original meatballs and 50 premium meatballs for a family event, how many beefs she should need? (in grams)
2. Mother also has 5 kilos of beefs and 2 kilos of starch. The maximum number of meatballs that she can cook is...
   a. 250 original and 400 premium
   b. 400 original and 250 premium
   c. 450 original and 250 premium
   d. 250 original and 450 premium

Figure 5 shows one of the papers studied in the class discussion. First, we encouraged the teachers to present their findings while other teachers responded. In the case of problems in figure 5, the teachers who had those papers admitted that they were inspired by the model of one of released PISA problems they ever solved in the previous problem-solving activities. The way they did is by changing the context from ‘Sauce’ to ‘Meat ball”, while the cognitive demand of the problem, which is examining proportional reasoning, is relatively same. The category of content, context, and process, they said, respectively are quantity, personal, and employ. Most of the teachers agreed that this problem can be considered as PISA-like problems. In our analysis, this problem is categorized in the first-order use of context. Thus, the teachers got a new insight into designing PISA-like problem by observing a nice example from their colleagues.

5.5. Problem Generation 3

After the teachers reflected on their own designed problems based on experiences in problem generation 2, this was their individual time to create PISA-like problems. To that, we asked the teachers to freely select context situation which might become their interest when designing PISA-like task. However, we expected that each teacher created at least four problems with the different category of contexts. Once each teacher finished writing their items, in the following day, we held a peer discussion, which is the discussion between two participants by swapping their PISA-like problems in a peer. We provided a set of checklist which each of teachers should consider as a guideline to give their evaluation of their peer’s PISA-like problems. The checklist encompasses whether the problems meet the requirement of PISA
item profile, meet the authenticity and plausibility, accommodate sufficient information, have clear figures and tables, and have easy language structure.

![Figure 6. Teachers working in a peer](image)

To clarify the difficulties around discussion among the peers, we visited each of peers to help them improve the quality of their PISA-like problems. Our experiences suggest that the teachers at this stage still experienced in turning a context situation they choose into an authentic problem, which means we did not find any PISA-like problems which meet the requirement of a problem with the second-order use of context. In addition to the organization of information within the problems they posed, we found that the context situation was written too general, which means a lot of information which does not directly relevant to the problem was included in the body on the problem. Moreover, we found some teachers tried to imitate the pattern of PISA problem which typically started from the name of context unit, a brief information, and followed by several items of problems which connect to such brief information. However, we found many of them still were not aware that it is unacceptable for PISA problems which the solution method of an item depends on the solution method of another item in a context unit. Thus, the reflections were taken primarily regarding, still, the authenticity of the context use, and the independence of solution methods across the problems.

6. Outdoor experiences through problem posing activities

In the outdoor activities, the teachers visited a theme park to find good contexts in writing PISA-like problem. The theme park provides a number of units where someone can learn about eco-green waste resources, plants, animals, or musical instruments. It was expected that the teachers could be inspired by the activities provided in the theme park. For example, when the teachers observed a demonstration of making briquettes, they were encouraged to design PISA-like problem related to briquettes, or when the teachers observed the crowd of the visitors of the theme park, they could be inspired to design PISA-like problem related to the statistics. In the theme park, the teachers were asked to design PISA-like problem individually. However, they can share ideas when finding authentic context as well as turning those into a set of PISA-like problems. Thus, instead of observing individual competence of teachers in designing PISA-like problems, we analyzed the quality of PISA-like problems resulted from this activity. Within this activity, we obtained as many as 54 items of PISA-like problems. We then coded each of items into the domain categories of content, context, process, and the level of context use. Table 2 shows the categories.

| Table 2. Profile of PISA-like problems designed by teachers in outdoor field experiences |
|------------------------------------------|--------|--------|----------|--------|------------------|--------|
| Content               | %      | Context | %      | Process | %      | Level use of context | %      |
| Quantity              | 44.4%  | Personal| 33.3%  | Formulate| 9.3%  | Zero-order use of context | 27.8%  |
| Space and shape       | 37.0%  | Occupational| 9.3% | Employ  | 85.2% | First-order use of context | 68.5%  |
Overall, we found improvements of the PISA-like problems produced by the teachers. Regarding the level of context use, we found most of the PISA-like problems were in the category of first-order use of context, although only 3.7% or 2 out of 54 items which have second-order of context use. In relation to the context category, all the contexts categories were found in the PISA-like problems. Nevertheless, only a small number of items were in the category of uncertainty and data problem. Below are examples of the problems resulted from the teacher participants.

(a) Zero-order use of context
Translation:
Mr. Parwadi has a square garden of apples, while Mrs. Parsilah has a rectangular garden of watermelon. The length of the Mrs. Parsilah's garden is 20 meters longer than the length of the side of Mr. Parwadi's garden, while the width is 3 meters longer than the length of the side of Mr. Parwadi's garden. If the area of Mrs. Parsilah's garden is 2150 m², then determine the area of Mr. Parwadi's apple garden.

(b) First-order use of context
Translation:
A briquette (or briquet) is a compressed block of coal dust or other combustible biomass material such as charcoal, sawdust, cow dung, or wood chips to start a fire.
Mr. Ali has four cows. Every day, every of his cow produces can produce 1 kilos of dung. 1 kilos of dung can produce four rectangular blocks measuring (11x8x7) cm. He wants to sell some briquettes from his cows. How much would he get if he sells a briquette of IDR 100,000 per block in ten days? Explain.

(c) Second-order use of context
Translation:
The vehicles found in the parking area of Eco Green Theme Park today consisted of 30 big buses, 10 small buses, 25 private cars, and 25
motorcycles. Estimate the number of visitors at that time.

**Figure 7. Problems produced by teachers in outdoor experiences**

Figure 7(a) shows that some teachers still designed problems with camouflage context. The context of the garden is not needed to solve the problem, which is finding the area of Mr. Parwadi's garden. The item only involves the translation of textually packaged mathematical problem. Figure 7(b) indicates an example of teachers' PISA-like task with first order use of context. The contexts of how a briquette is produced and the measure of rectangular briquettes are needed to find the income would be obtained for a certain period of time. Lastly, figure 7(c) shows an example of PISA-like problem with second order use of context. To solve this problem, one needs to involve some extra information, particularly, his/her knowledge or experiences about the number of seats for typical big bus and small bus in Indonesia. Although there will be likely a variety of assumptions need to be clarified, the information is drawn from the knowledge of context, not just the problem statement or mathematical facts, required to solve the problem. Unfortunately, we only found 2 out of 54 items showing this level of context use.

7. Discussion and Conclusion

In the end of the training, the teachers were asked to reflect on the activities during the training. To confirm their experiences, we asked them wrote their difficulties in designing PISA-like problem in an open questionnaire. The results revealed that they had difficulties in determining authentic contexts which are suitable for a particular mathematics topic, organizing information precisely, determining the profile of PISA-like tasks regarding content, context, and process, designing uncertainty and data problem, designing problem whose solution method does not depend on the other problems in the same unit of context.

Our findings point out that the teachers learned how to compose PISA-like problems gradually from indoor activities (problem-solving and problem posing) to outdoor activities. They showed their performances by reflecting on every activity they carried out. As evidence, we found only a few number of problems which had zero order of context use in outdoor activities, which was less than those in indoor activities, particularly in the beginning of training. Similar to the finding of Paloucci et al [4], we also found that the contexts provided in the outdoor activities had influenced teachers’ decision when selecting motivating and interesting context.

These all findings become reflections for the training program as well. Thus, in further study, we encourage professional developers to consider designing a set of learning activities which explicitly support teachers' development of understanding authentic context as well as the item profile using PISA mathematics framework. Our conjectures regarding teacher difficulties in profiling their items are the unique characteristics of PISA item profile itself. For example, why did teachers find difficult to determine which content should be fit with the problem they designed? It is probable because PISA problem accommodates more than one topics in mathematics [1]. Sometimes, a problem has an equal demand of involving topic in algebra and geometry which likely makes teachers confused in determining which content should be. Regarding authenticity, we suggest to not only support teachers’ understanding on the level use of context, which is crucial for PISA-like problem but also support on other aspects of the authenticity of mathematics problem as stated by Palm [22]. His aspects accommodate aspects of the event, question, information/data, presentation, solution strategies, solution requirements, circumstances, and purpose.

In sum, the professional training we designed in this study had provided teachers' experiences to design PISA-like mathematics task through problem-solving and problem posing activities, which was able to increase teachers' understanding on the concept of mathematical literacy, mainly on the PISA task design.
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