Javanese calendar as context to learn number pattern and least common multiple

Zulkardi¹ and M B T Setiawan²

¹Lecturer at Magister Program on Mathematics Education Sriwijaya University, Indonesia
²Magister Program on Mathematics Education Sriwijaya University, Indonesia

Email: zulkardi@gmail.com

Abstract. This research is about to investigate how Javanese calendar and primbon could be used as context to learn number pattern, least common multiple and modular arithmetic for high school students. This article is the first step for the research, as this research only just reach preliminary stage at this point, which consist of validation on worksheet, one to one and small group to gain data about students’ understandings regarding connection between contexts as student perception with mathematics learning which they had learned. This research using Realistic Mathematics Education (PMRI) approach. The problems which given in this research was based PISA framework. The methodology of this research is using Design Research. This research produce valid and practical problem, worksheet for learning material and support students to understand more about number pattern and least common multiple as basis to learn modular arithmetic even as the learning material itself only just enrichment in national curriculum.

Keywords: Modular Arithmetic, Design Research, Javanese Calendar, Primbon, PMRI.

1. Introduction

The use of real-world situations or context in learning mathematics made abstract mathematical concept become easy to understand by students, thus makes mathematical lessons meaningful [1] not necessarily always using real and concrete materials, context could be also use situation, phenomenon, and students perception or knowledge [2], thus mathematics should closely related to daily life. Human activity in daily life cannot be separated from the concepts utilization and application that exist in mathematics [3]. The cases which related to the daily life of students could be a starting point to learn mathematics in school [4].

Mathematics learning theory that is suitable to be used in teaching mathematics related to the context or situation in Indonesia is Realistic Mathematics Education (PMRI). Learning with PMRI starts from a context to intrigue the informal reasoning from the students, and then with set of statements used to build relationships between informal, pre-formal, and formal mathematical representations [5]. According to these principles, mathematics learning should give students the opportunity to understand the process and find ways to rediscovery of mathematics itself [6]. In this case, the used context should be meaningful and real in the form of representation that is easy to understand from students’ perspective [7-10]. Javanese calendar is well-known culture for Javanese people and also for most of Indonesian people, how local culture could provide context in mathematics learning is very interesting to be discussed and highlighted in this modern era. This perception, wisdom and knowledge has gradually fading especially from students themselves whom prefer global
culture more than their culture and local identities, thus make this context become more important to re-introduce students about their culture and also support them to learn about Number Pattern as precondition to learn about Modular Arithmetic.

Javanese calendar is numeric date system that found by Sultan Agung Mataram on 1633, he tried to uphold Islamic Religion and its cultures in Java, this calendar was combining two different numeric date which are Saka numeric system (Hindu) based on sun revolution and Hijriah numeric system (Islam) based on moon rotation [11]. Not only changed the system, Sultan Agung Mataram also changed it months’ and days’ name from Sansekerta into more or less like Arabic. This was the proof about Islamic strong influence in Java at that time [12].

This Javanese calendar has different system than any other calendar system, it has two cyclical systems: weekly cycle consist of seven days just like Gregorian calendar and five days cycle which is called *Pasaran*.

| Table 1. Gregorian and Pasaran Days in Javanese Calendar |
|-------------------|-------------------|
| **Gregorian Days** | **Pasaran**       |
| Sunday             | Legi              |
| Monday             | Pahing            |
| Tuesday            | Pon               |
| Wednesday          | Wage              |
| Thursday           | Kliwon            |
| Friday             |                   |
| Saturday           |                   |

This research was focused on using the calendar as the context to solve mathematical problem on number pattern scope with a little glimpse about primbon (Javanese traditional prophecy which system based on Modular Arithmetic). This research objective is to produce Learning Trajectory and support students’ understanding about pattern number as a precondition for the next step of the research as this research was only preliminary research from main research about Modular Arithmetic.

2. Method
This research was conducted on tenth-grade students of senior high school in Palembang, even the context is Javanese calendar, the students from Palembang are already aware about the context because they had the calendar at their home, by using design research method with development studies type through two phases: preliminary and formative evaluation [4]. Preliminary phase that includes in this research are preparation and design, the researchers reviewed some of the literature related to this research, then designed instruments such as worksheet, learning media and rubric assessment.

The next phase is a formative evaluation that includes of self-evaluation, expert reviews, one-to-one reviews, small group, and field test. But in this research, the researchers only discussed until small group. In self-evaluation, the researchers have analyzed the designed problems by ourselves and then produce prototype. After that, the prototype used in the expert reviews phase to be validated by experts, in this phase the researchers using panel review with lecturers of mathematics education in Sriwijaya University and some of the peers that had experience in developing learning material design; face-to-face with mathematics teacher. After validations with experts, a one-to-one phase was performed. This phase involving three students of senior high school with various abilities (high,
middle, low). The validation result was produced second prototype and used in the next phase. Later on, small group phase was conducted to find out the practicality of the problems developed by involving eight students with high-ability, middle-ability, and low-ability. The results of this phase produce valid and practical third prototype. Data collection techniques used was the walkthrough, document, observation, and an interview. Then the data were analyzed by the qualitative descriptive method to describe the result of each step of development.

3. Results
This research produced problems that guiding students to understand about basic of modular arithmetic, however, in this paper, researchers only covered one problem that intertwined number pattern, least common multiple and context in Javanese calendar which was valid and practical.

3.1. Preliminary
Researchers and teachers analyzed students’ ability and predicted strategies that students used for solving mathematical problem which researchers had prepared. The results of this phase were designed worksheet, which consist of mathematics problems to building up student’s comprehension about modular arithmetic using Javanese calendar and primbon as context, rubric assessment, and media. After that, the researchers got three tenth-grade students (low, moderate, and high-ability) for one-to-one review phase and eight tenth-grade students with the different ability for the small group phase.

3.2. Expert reviews and one-to-one
Expert reviews and one-to-one phase were conducted in parallel way to see the validity of problems. The first prototype was validated by experts based on existing criteria both regarding content, construct, and language. While the process of one-to-one involved three tenth-grade students of the senior high school, the initials N (high-ability), RA (moderate-ability), and ASS (low-ability). The students are asked to read and examine the problems so that the researchers could find out the responses, expressions, and understanding students ability in solving the problem. The responses and obstacles that observed focus on legibility and clarity of problems. Table 2 here shows the validation result from expert reviews and one-to-one reviews phases.

Table 2. Comments from expert and students

| Validation          | Comment/Response                      | Revise               |
|---------------------|---------------------------------------|----------------------|
| Expert reviews      | • Change the term of “Jumping Task” simply to number of the problem  
                    | • Put the information table directly after the corresponding task  
                    | • Change the term  
                    | • Reposition table of information  |
| Students            | • Can I just simply count the day manually?  
                    | • I don’t understand the meaning of this?  
                    | • Make the language simpler  |

Furthermore, the researchers revises the problem based on the results of expert validation and one-to-one. It can be concluded that the problems have designed are categorized as valid problems. It’s reflected in the comment provided by expert, then responses, expression, and student’s understanding when solving the problem [4]. The validity of the problems in terms of content (according to the domain of mathematics literacy in National Curriculum, also according to probability learning in ninth to tenth-grade); in terms of construct, the problems have been in accord with the characteristics of Realistic Mathematics Education, PISA problems level and abilities of the tenth-grade students; and
regarding the language, the problems use of enhanced spelling, understandable, and didn’t have biases comprehension [13] then the second prototype used for the next phase

Jumping Task

Problem 6

Problem translation: Uncle Karwo will go to Yogyakarta three months and twelve days from today, if today is Wednesday wage, in what Pasaran day that Uncle will go?

3.3. Small group

Small group phase was conducted to see the practicality of problems for students in the implementation. This phase involved eight tenth-grade students of the senior high school, their initials were MDK and MA (high-ability), MR, AZ, MS and MRT (moderate-ability), AF and MAR (low-ability). The students were first asked to solve the problem individually. For problem 6, students asked to discuss in their group. Almost all of the student were able to understand and solve the problem well in the learning process, except for problem 6 where the students had to actively discussing to solve the problem. From the analysis result, the students use different strategies to solve the problem.

Figure 3. MDK’s answer
In figure 3, student shows that the problem was related to least common multiple of 7 and 5 as representation of 7 days in Gregorian calendar and 5 days in Pasaran, furthermore the day will repeat after 35th days, he also make assumption that one month equal thirty days. After that, he simply count 3 days backward from 105th day as Uncle Karwo travel 102 days later and then found the answer using the Javanese calendar table.

Figure 4 shows how student have multiple ways to solve the problem, he count it manually using multiple of 7 and 5 and then found 35, 70 and 105 as the number pattern for the same day, after that he count it 3 days backward and using the same Javanese calendar table he found the answer.

Further analysis on students’ worksheet shows that most students can solve the problem pretty well with different methods. While doing the problem in group, the students shows participation, communication, argument, discussion and reasoning to solve the problem. Students with good reasoning ability can understand, formulate and solve problem correctly and adequately [14].

Based on all the research phases from expert validation, one to one review and small group, it could be concluded that the problem using Javanese calendar as context that has designed is categorized valid and practical. It’s reflected from results and comments from expert review, students’ understanding about solving the problem which had given [15-17], most of the students solve the problem and involved themselves on discussion, arguments and communicate their opinion about the solution [13, 18, 19]

Another addition, the student felt happy about the context which had given, it is interesting because they never thought that Javanese calendar which familiar to them in daily basis had mathematics literacy and intertwined with lessons they had learned. This context help them found meaningful lesson about mathematics in appreciation of the Indonesian culture [6, 20-22].

4. Conclusion
This research produce valid and practical problems using Javanese calendar as context to learn number pattern and least common multiple as the precondition and basis to learn modular arithmetic. We can conclude the validity from all expert validator state that the problem well designed from content, construct and language point of view. Practicality of the problem could be seen from the results of the small group where the students can comprehend the problem well. Learning trajectory which conclude is shown by figure below
Acknowledgments
This research is a part of Hibah Kompetitif Unsri chaired by Zulkardi. Thanks to Unsri for this and to students who was subject of this research.

References
[1] Webb D C, et al 2011 Design research in the Netherlands: Introducing logarithms using Realistic Mathematics Education Journal of Mathematics Education at Teachers College 2 47
[2] Zulkardi 2002 Developing a learning environment on realistic mathematics education for Indonesian student teachers Ph.D Thesis University of Twente (Enschede, the Netherlands)
[3] Revina S and Leung F K S 2018 Educational borrowing and mathematics curriculum: Realistic Mathematics Education in the Dutch and Indonesian primary curriculum International Journal on Emerging Mathematics Education 2 1
[4] Zulkardi and Putri R I I 2006 Mendesain Sendiri Soal Kontekstual Matematika Prosiding Konferensi Nasional Matematika ke 13 (Semarang: Universitas Negeri Semarang)
[5] Webb D C, et al 2011 Design research in the Netherlands: Introducing logarithms using Realistic Mathematics Education Journal of Mathematics Education at Teachers College 2 47
[6] Fauziah A, Putri R I I , Zulkardi and Somakim 2017 Primary school student teachers’ perception to Pendidikan Matematika Realistik Indonesia (PMRI) instruction J. Phys.: Conf. Ser. 943 012044
[7] Arifin S, Zulkardi, Putri R I I, Hartono Y and Susanti E 2017 Developing Ill-defined problem solving for the context of “South Sumatera” J. Phys.: Conf. Ser. 943 012038
[8] Haris D and Putri R I I 2011 The role of context in third grader’s learning of area measurement IndoMS J. Mathematic Education 2 55
[9] Putri R I I and Zulkardi 2017 Fraction in shot-put: a learning trajectory AIP Conference Proceedings 1868 050005
[10] Rejeki S and Putri R I I 2018 Models to support students’ understanding of measuring area of circles J. Phys.: Conf. Ser. 948 012058
[11] Musonnif A 2016 Politik Hukum dalam Perumusan Kalender Islam Ahkam 4 1 (Tulungagung: IAIN)
[12] Setyanto H 2002 Kalender Jawa, (Online) available from https://www.babadbali.com/pewarigaan/kalender-jawa.htm (accessed 25th November 2018)
[13] Zulkardi 2006 Formative Evaluation : What, Why, When, and How Available from http://www.oocities.org/zulkardi/books.html (Accessed 19th June 2019)
[14] Ahyan S, Zulkardi and Darmawijoyo 2014 Developing mathematics problems based on PISA
level Journal on Mathematics Education (IndoMS-JME) 5 47

[15] Marwan, Ikhsan M and Marwan 2016 Meningkatkan kemampuan berpikir kritis matematis siswa SMK melalui model pembelajaran berbasis masalah Jurnal Didaktik Matematika 3 9

[16] S Arifin et al 2017 J. Phys.: Conf. Ser. 943 012038

[17] Riyanto B, Zulkardi and Putri R I I 2017 Mathematical modeling in realistic mathematics education J. Phys.: Conf. Ser. 943 012049

[18] Hendroanto A, et al 2018 Photography activities for developing students’ spatial orientation and spatial visualization J. Phys.: Conf. Ser. 943 012029

[19] S Setyawan F, et al 2018 Visualizer’s representation in functions J. Phys.: Conf. Ser. 943 012004

[20] Rahayu C, Putri R I I and Zulkardi 2017 Multiplication of fraction with natural number by using hurdles Proc. Int. Conf. on 5th South East Asia Development Research (SEA-DR) 100 43

[21] Roni A, Zulkardi and Putri R I I 2017 Sprint Context of Asian Games in the Division of Fractions Proc. Int. Conf. on 5th South East Asia Development Research (SEA-DR) 100 22

[22] R I I Putri et al 2017 J. Phys.: Conf. Ser. 943 012035