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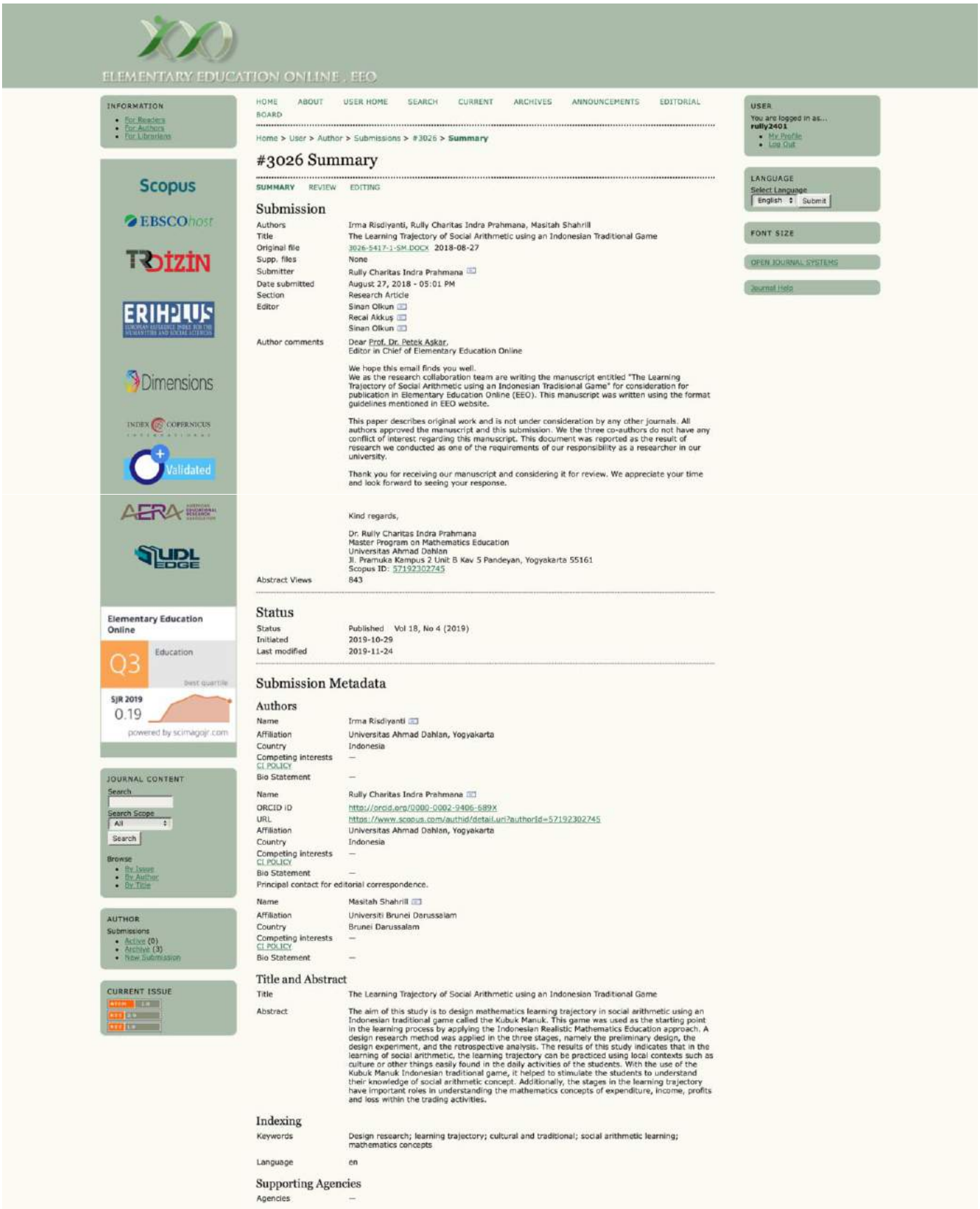

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#3026 Summary

SUMMARY REVIEW EDITING

Submission

Authors	Irma Risdiyanti, Rully Charitas Indra Prahmana, Masitah Shahrill
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Author comments	Dear Prof. Dr. Petek Aşkar, Editor in Chief of Elementary Education Online We hope this email finds you well. We as the research collaboration team are writing the manuscript entitled "The Learning Trajectory of Social Arithmetic using an Indonesian Tradisional Game" for consideration for publication in Elementary Education Online (EEO). This manuscript was written using the format guidelines mentioned in EEO website. This paper describes original work and is not under consideration by any other journals. All authors approved the manuscript and this submission. We the three co-authors do not have any conflict of interest regarding this manuscript. This document was reported as the result of research we conducted as one of the requirements of our responsibility as a researcher in our university. Thank you for receiving our manuscript and considering it for review. We appreciate your time and look forward to seeing your response. Kind regards, Dr. Rully Charitas Indra Prahmana Master Program on Mathematics Education Universitas Ahmad Dahlan Jl. Pramuka Kampus 2 Unit B Kav 5 Pandeyan, Yogyakarta 55161 Scopus ID: 57192302745
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Title and Abstract

Title	The Learning Trajectory of Social Arithmetic using an Indonesian Traditional Game
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Indexing

Keywords	Design research; learning trajectory; cultural and traditional; social arithmetic learning; mathematics concepts
Language	en

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The Learning Trajectory of Social Arithmetic using an Indonesian Tradisional Game

Endonezya Dili Tradisional Oyununu Kullanan Sosyal Aritmetik Öğrenmenin Öğrenme Yolu

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Abstract: The aim of this study is to design mathematics learning trajectory in social arithmetic using an Indonesian traditional game called the Kubuk Manuk. This game was used as the starting point in the learning process by applying the Indonesian Realistic Mathematics Education approach. A design research method was applied in the three stages, namely the preliminary design, the design experiment, and the retrospective analysis. The results of this study indicates that in the learning of social arithmetic, the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. With the use of the Kubuk Manuk Indonesian traditional game, it helped to stimulate the students to understand their knowledge of social arithmetic concept. Additionally, the stages in the learning trajectory have important roles in understanding the mathematics concepts of expenditure, income, profits and loss within the trading activities.
Keywords: Design research, learning trajectory, cultural and traditional, social arithmetic learning, mathematics concepts

Öz: Bu çalışmanın amacı, Kübük Manuk denen Endonezya geleneksel oyununu kullanarak matematik öğrenme yörüngesini sosyal aritmetik olarak tasarlamaktır. Bu oyun, Endonezya Gerçekçi Matematik Eğitimi yaklaşımını uygulayarak öğrenme sürecinde başlangıç noktası olarak kullanılmıştır. Ön tasarım, tasarım deneyi ve retrospektif analiz olmak üzere üç aşamada bir tasarım araştırması yöntemi uygulanmıştır. Bu çalışmanın sonuçları, sosyal aritmetik öğrenmede, öğrenim yörüngesinin, öğrencilerin günlük etkinliklerinde kolayca bulunabilecek kültür veya diğer şeyler gibi yerel bağlamları kullanarak uygulanabileceğini göstermektedir. Kubuk Manuk Endonezya geleneksel oyun kullanımı ile, öğrencilerin sosyal aritmetik kavram bilgilerini anlamalarını teşvik etmek için yardımcı oldu. Ek olarak, öğrenme yörüngesindeki aşamalar, matematik faaliyetlerini, harcama, gelir, kar ve ticaret faaliyetlerindeki zararı anlamada önemli rollere sahiptir.
Anahtar Sözcükler: Tasarım araştırması, öğrenme yörüngesi, kültürel ve geleneksel, sosyal aritmetik öğrenme, matematik kavramları

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INTRODUCTION

The development and application of the mathematics concept daily problems is part of a student's learning process (Tanujaya et al., 2017). Freudenthal (1991) explained that mathematics is a human activity and must be related to daily life. However, in reality, the mathematics in schools tend to be taught using practical formulas and most often, not seamlessly related with daily life and culture, as should be experienced by the students (Stacey, 2011; Arisetyawan et al., 2014; Nurhasanah et al., 2017). The society, including the teachers, generally does not regard mathematics to be related with culture, and the learning of mathematics in the classroom can also be regarded with almost having no relation to culture. In fact, culture is part of a student's life that may guide the way a student learn and regard mathematics (Revina, 2017; Revina & Leung, 2018a, 2018b). This may greatly influence the student's ability to solve mathematics projects that relates to daily life. The results of the Programme for International Student Assessment (PISA) for Indonesia showed that the students' abilities to solve and interpret problems in various situations are still considered at a level, which is low (Stacey, 2011). Subsequently, Irawan and Kencanawaty (2017) and Sembiring et al. (2010) suggested that appropriate strategies and learning methods are needed to develop students' thinking ability that orientate towards technical skills and the reformation of mathematics education based on problem-solving in the daily life. The learning method suggested is the Pendidikan Matematika Realistik Indonesia (PMRI), which is an adaptation of the Realistic Mathematics Education (RME). According to Soedjadi (2007), the PMRI is aligned with the Indonesian culture, geography and the ability of Indonesian society in general.

Wahyudi, Zulkardi and Darmawijoyo (2016) and Subijato (2015) explained that one of the contexts that can be used in PMRI is a culture that is applied into realistic mathematics learning and modified according to the local context where the school is located. Consequently, it may result in an interesting contextual learning if it is to be taught in schools as it may increase the students' ability to solve a problem that has a relation to their daily life. In addition, the cultural context can also be a solution to the lost cultural value and character of a student due to the influence of modernization (Astri et al., 2013).

As an innovation of mathematics learning that orientates to the reformation of mathematics education, presented in this study is a creation of a social arithmetic learning design using the starting point or context of the Kubuk Manuk, which is a traditional game in Indonesia. This context was chosen mainly because of its familiarity to the participants from the perspectives of culture as well as their daily life. According to Risdiyanti and Prahmana (2018), traditional games are fun as it contained concepts of mathematics for learning purposes and aspects of cultural values. The design of the Kubuk Manuk game is expected to be innovative in terms of learning mathematics so that the concept will be easy for students to understand thus enabling them to solve any daily-related problems. Furthermore, this design is expected to cultivate and develop the cultural values that may influence a student's character.

METHOD

This study utilized design research as the research method. This research design aims to improve the quality of classroom learning practice through an interactive analysis of the hypothesis condition that will include student thinking that occurs in their learning with what actually happens in the classroom (Gravemeijer, 1994; Gravemeijer & Cobb, 2006). Simonson (2006) defined design research as a systematic and flexible method that aims to improve the quality of education through repeated analysis to design or improve design and collaboration between the researcher and the teacher to develop the quality of design learning. Design research is also defined as a method that aims to develop or validate a theory about the learning process that aims in cultivating the Local Instruction Theory (LIT). Accordingly, there are three phases of design research, which are preliminary design, design experiment and analysis retrospective (Bakker, 2004; Gravameijer & Cobb, 2006; Prahmana, 2017).

Preliminary Design

Gravemeijer and Cobb (2006) explained that the preliminary design phase aims to formulate the LIT that is elaborated and refined in the experimental design phase. The activities in this phase are choosing a model teacher to conduct a literature review of the social arithmetic concepts and the PMRI, to analyze the concepts of social arithmetic in the curriculum of Indonesian mathematics education, designing learning trajectory and developing conjecture to be a Hypothetical Learning Trajectory (HLT). In this case, the conjecture functions as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the experimental design phase

Design Experiment

In this design experiment phase, the learning trajectory that has been designed in the preliminary design phase is then implemented in the learning process. The purpose of this implementation is to explore and observe the students' strategies and thinking. There are two cycles in this phase. The first cycle is a pilot experiment that aims to evaluate and improve the learning trajectory that has been designed. The second cycle is the experiment teaching that aims to implement the evaluated and revised learning trajectory in the pilot cycle of the experiment stage.

Analysis Retrospective

In this phase, all the data collected in experiment design will be analyzed by comparing the conjecture in HLT with the results of implementing the learning trajectory that has been done in the experiment design phase. Therefore, the description of learning trajectory using Kubuk Manuk Indonesian traditional game will subsequently be obtained.

RESULTS and DISCUSSION

The results of this study showed the implementation of the design learning trajectory of social arithmetic using the Kubuk Manuk traditional game as the starting point or the context of learning. The learning trajectory consists of three activities, namely the activities of playing the Kubuk Manuk games at levels 1, 2 and 3. The differences between the three activities are the number of seeds and the rules used in the game, and these are elaborated as follows.

Activity 1: Playing the Kubuk Manuk Game Level 1

This activity begins by grouping the students into groups consisting of three to four students. The teacher then introduced the Kubuk Manuk traditional game and the rules used in the game. The start of this game is an important part of introducing the learning context to make it easier for the next activity. It also embeds the social values that can develop students' ability to interact effectively with their social environment and improve the students' sportsmanship when doing an activity that is competitive in accordance with the standard competencies in Indonesian education.

To introduce this game the teacher starts by explaining that the Kubuk Manuk game originates from Java and explains the rules of the game that each member of the group must collect benguk seeds as the capital of the game, and the number of seeds must be the same. The students will grasp all the seeds in the left hand and shaken above the right hand. Then, a few seeds are thrown into the right-hand grip and the other players in the group have to make a guess. If none any students are able to guess it, the students must spread the seeds and count using both fingers. The introduction of the game is accompanied with a simulation done by the teacher in front of the class with a few students, as shown in Figure 1, while in Figure 2 the students practice by playing the Kubuk Manuk game.

Figure 1: Simulation of the *Kubuk Manuk* game

Figure 2: Student playing the *Kubuk Manuk* game

Next, the students began playing the Kubuk Manuk game with their respective group, and the students discuss and solve the problems contained in the worksheets that have been given (Figure 3). The problem in the worksheet (Figure 4) requires the students to determine the scores obtained by each student in the group and decide who is the winner and who lose the game. The students are required to present the results in front of the class (Figure 5), followed by class discussions with the teacher in order to get the same students' perceptions about the solutions of the problems in the worksheet and about the mathematical concepts that can be learned from this game (refer to Figure 6).

From the class discussions, similar perceptions were achieved among the students in which the seed capital used in the game is 'expenditure' and the seeds obtained in the game are 'income'. Hence, from this activity, the students learnt about the mathematics concepts of expenditure and income.

Figure 3: Student discuss the problem in the worksheet

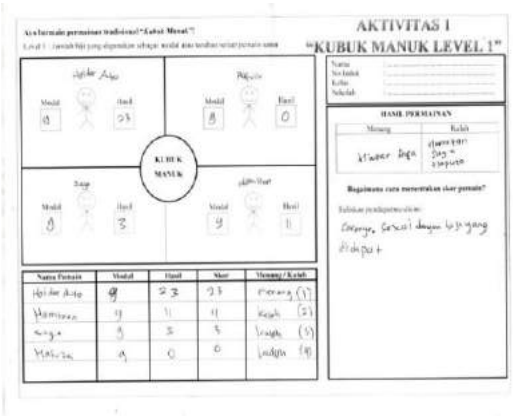


Figure 4: The results of the students wroksheet from the first activity

Figure 5: Students presenting the results

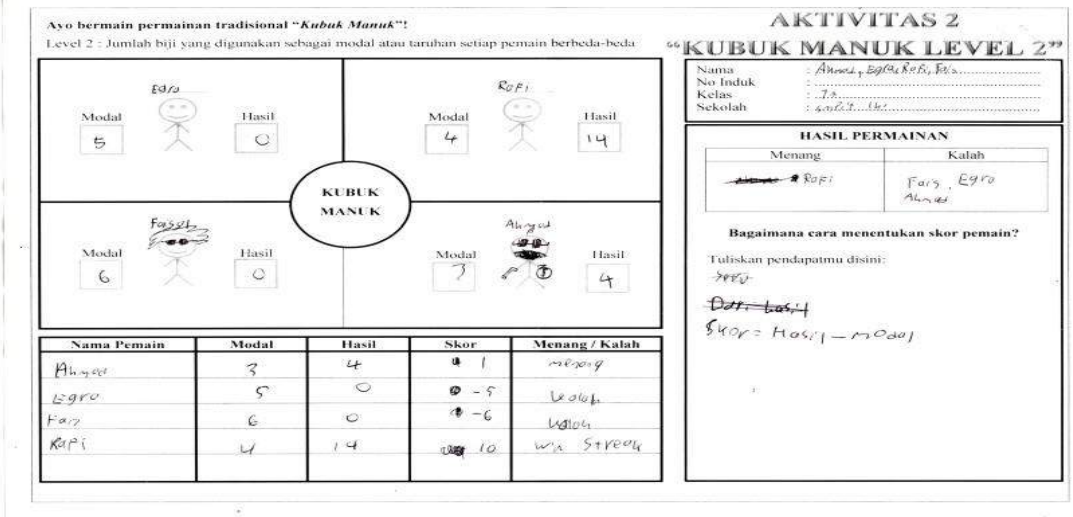
Figure 6: Class Discussion

Activity 1: Playing the Kubuk Manuk Game Level 1

The second activity is the same as the first activity, but the number of seeds used as the capital of the game is different for each player. The game begins with a simulation by the teacher, and the students continue to practice the game in their group (refer to Figure 7). Then the students discuss and solve the problem in the worksheets. The problem in the second activity worksheet is no different from the problems in the first activity worksheet that is determining the scores obtained by each player and determining the winning and losing players in the game if the seed capital used is different for each player.

Figure 7: Playing the Kubuk Manuk Game Level 2

Furthermore, in the class discussions, similar perceptions were obtained as in the first activity. However, the students must find another way to find the value of the game capital. They will need to find the value of profit or loss by subtracting the number of seeds obtained in the game by the number of seeds used as game capital. The resulting subtraction is considered as a score. The students who get the results of the subtraction will obtain a positive value, and the number of seeds obtained greater than the number of seeds used as game capital or income is greater than the expenditure, hence the students will obtain the profits. Otherwise, the students who achieved a negative result from the subtraction will indicate that the number of seeds obtained is less than the number of seeds used as capital or income is less than the expenditure, this will mean that the students get a loss. If a student who gets a zero as a result of the subtraction or the number of seeds obtained is equal to the number of seeds used as game capital, or the income is equal to the expenditure, that means the students have obtained return capital. From this second activity, the students learnt about the mathematics concept of profits, loss and the relationship between them, as indicated in Figure 8.


Ayo bermain permainan tradisional "*Kubuk Manuk*"!
Level 2 : Jumlah biji yang digunakan sebagai modal atau taruhan setiap pemain berbeda-beda

Egro — Modal 5 — Hasil 0
Rafi — Modal 4 — Hasil 14
KUBUK MANUK
Modal 6 — Hasil 0
Modal 7 — Hasil 4

Nama Pemain	Modal	Hasil	Skor	Menang / Kalah
Ahyad	3	4	1	menang
Egro	5	0	-5	kalah
Fais	6	0	-6	kalah
Rafi	4	14	10	Menang

AKTIVITAS 2
"KUBUK MANUK LEVEL 2"
Nama : Ahmad, Egro, Rafi, Fais
No Induk :
Kelas : 7.5
Sekolah :

HASIL PERMAINAN

Menang	Kalah
Rafi	Fais, Egro, Ahmad

Bagaimana cara menentukan skor pemain?
Tuliskan pendapatmu disini:
Hasil
Dari hasil
Skor = Hasil − modal

Figure 8: The Results of the Students' Worksheet in the Second Activity

Activity 3: Playing the *Kubuk Manuk* Game Level 3

The third level of the Kubuk Manuk game is the modified version of the original Kubuk Manuk game. In this level, the seeds are used in the game, and the capital must be purchased first and there are two types of groups, which are the seller group and the player group. The seller group has a role to sell the seeds that will be used in the game and also buy the seeds that has been obtained by a player in the game. Similar to the previous activity, this third activity begins with a simulation. Then, before the students play the Kubuk Manuk game, the teacher will give play or toy money to each member of the player group to buy the seeds that will be used as game capital. After that, students play the game with their groups.

Once the game is completed, each player then sells the seeds that have been obtained in the game to the seller groups. The students discuss and solve the problems in the worksheet and present the results in front of the class. The problem in the worksheet of this third activity is to determine the player's score in the game and also to determine the winning and losing players in the game. In the class discussion, the same perception was obtained in which the money used to buy the seeds that is referred to as the game capital is called cost and the money obtained from selling the seeds is called purchase. Furthermore, to determine the player's score is by subtracting the purchase with the cost and the winning player is the player who obtains the most profit. This is shown in Figure 9. The evaluation process of the students' learning that has been conducted was to find out the students' understanding of the concept of social arithmetic and the implementation to solve the problem in daily life. Consequently, from this activity, the students learn about the mathematics concepts of cost, purchase, profit, and loss in trading activity.

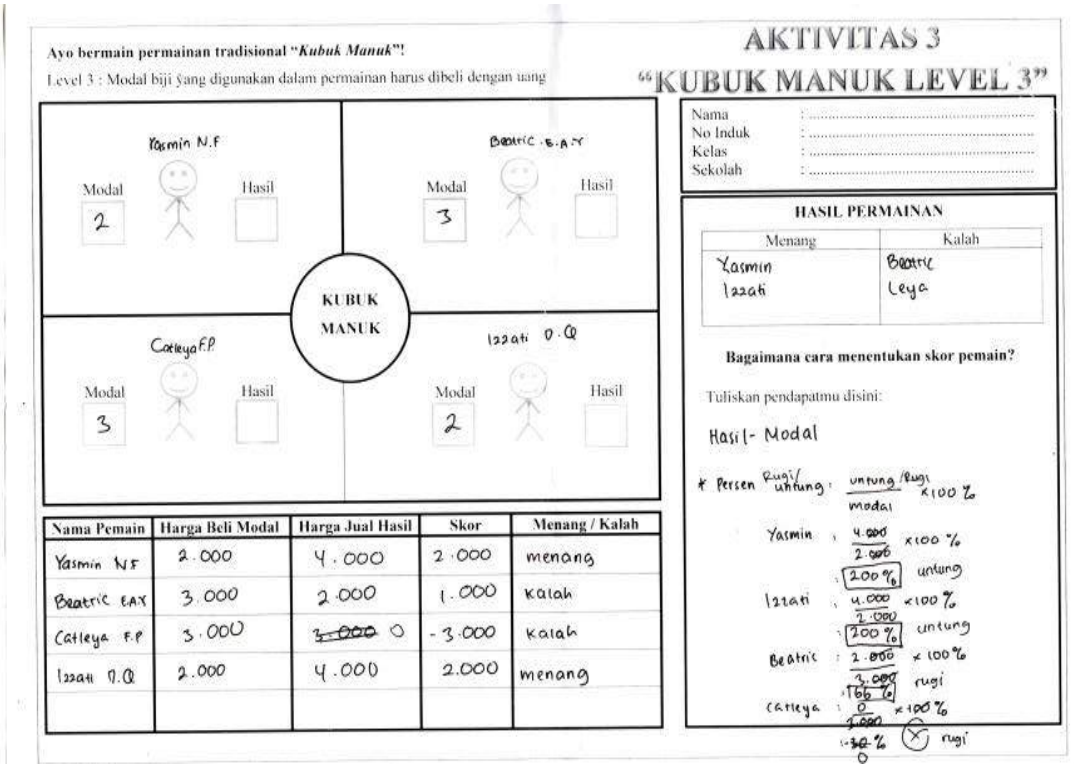


Figure 9: The Results of Students' Worksheet in the Third Activity

CONCLUSION

The results of this study indicates that in the learning of social arithmetic, the learning trajectory can be practiced using local contexts such as culture or other things easily found in the

daily activities of the students. The students were able to understand the concept of mathematics easily since it is fun for them and importantly, the game is relatable to activities in their daily life. This study was able to take on the role in developing the learning trajectory of social arithmetic learning using the Kubuk Manuk Indonesian traditional game as the local context of learning.

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Keputusan diterima setelah melewati 3 round proses review dengan total 4 orang reviewer pada tanggal 3 Agustus 2019 (round 1), 20 September 2019 (round 2), dan 9 Oktober 2019 (round 3).

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#3026 Review

SUMMARY REVIEW EDITING

Submission

Authors	Irma Risdiyanti, Rully Charitas Indra Prahmana, Masitah Shahrill
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Peer Review

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The Learning Trajectory of Social Arithmetic Using an Indonesian Traditional Game

Endonezya Geleneksel Oyununu Kullanarak Sosyal Aritmetik Öğrenmenin Öğrenme Yolu

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Abstract: The aim of this study is to design mathematics learning trajectory in social arithmetic using an Indonesian traditional game called the Kubuk Manuk. This game was used as the starting point in the learning process by applying the Indonesian Realistic Mathematics Education approach. A research method design was applied in the three stages, namely the preliminary design, the design experiment, and the retrospective analysis. The results of this study indicates that in the learning of social arithmetic, the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. With the use of the Kubuk Manuk Indonesian traditional game, the students are stimulated to understand their knowledge of social arithmetic concept. Additionally, the stages in the learning trajectory have important roles in understanding the mathematics concepts of expenditure, income, profits and loss within the trading activities.
Keywords: Design research, learning trajectory, cultural and traditional, social arithmetic learning, mathematics concepts

Öz: Bu çalışmanın amacı, Kübük Manuk denen Endonezya geleneksel oyununu kullanarak matematik öğrenme yörüngesini sosyal aritmetik olarak tasarlamaktır. Bu oyun, Endonezya Gerçekçi Matematik Eğitimi yaklaşımını uygulayarak öğrenme sürecinde başlangıç noktası olarak kullanılmıştır. Ön tasarım, tasarım deneyi ve retrospektif analiz olmak üzere üç aşamada bir tasarım araştırması yöntemi uygulanmıştır. Bu çalışmanın sonuçları, sosyal aritmetik öğrenmede, öğrenim yörüngesinin, öğrencilerin günlük etkinliklerinde kolayca bulunabilecek kültür veya diğer şeyler gibi yerel bağlamları kullanarak uygulanabileceğini göstermektedir. Kubuk Manuk Endonezya geleneksel oyun kullanımı ile, öğrencilerin sosyal aritmetik kavram bilgilerini anlamalarını teşvik etmek için yardımcı oldu. Ek olarak, öğrenme yörüngesindeki aşamalar, matematik faaliyetlerini, harcama, gelir, kar ve ticaret faaliyetlerindeki zararı anlamada önemli rollere sahiptir.
Anahtar Sözcükler: Tasarım araştırması, öğrenme yörüngesi, kültürel ve geleneksel, sosyal aritmetik öğrenme, matematik kavramları

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INTRODUCTION

The development and application of the mathematics concept daily problems is part of a student's learning process (Tanujaya et al., 2017). Freudenthal (1991) explained that mathematics is a human activity and must be related to daily life. However, in reality, the mathematics in schools tend to be taught using practical formulas and most often, not seamlessly related with daily life and culture, as should be experienced by the students (Stacey, 2011; Arisetyawan et al., 2014; Nurhasanah et al., 2017). The society, including the teachers, generally does not regard mathematics to be related with culture, and the learning of mathematics in the classroom can also be regarded with almost having no relation to culture. In fact, culture is part of a student's life that may guide the way a student learn and regard mathematics (Revina, 2017; Revina & Leung, 2018a, 2018b). This may greatly influence the student's ability to solve mathematics projects that relates to daily life. The results of the Programme for International Student Assessment (PISA) for Indonesia showed that the students' abilities to solve and interpret problems in various situations are still considered at a level, which is low (Stacey, 2011). Subsequently, Irawan and Kencanawaty (2017) and Sembiring et al. (2010) suggested that appropriate strategies and learning methods are needed to develop students' thinking ability that orientate towards technical skills and the reformation of mathematics education based on problem-solving in the daily life. The learning method suggested is the Pendidikan Matematika Realistik Indonesia (PMRI), which is an adaptation of the Realistic Mathematics Education (RME). According to Soedjadi (2007), the PMRI is aligned with the Indonesian culture, geography and the ability of Indonesian society in general.

Wahyudi, Zulkardi and Darmawijoyo (2016) and Subijato (2015) explained that one of the contexts that can be used in PMRI is a culture that is applied into realistic mathematics learning and modified according to the local context where the school is located. Consequently, it may result in an interesting contextual learning if it is to be taught in schools as it may increase the students' ability to solve a problem that has a relation to their daily life. In addition, the cultural context can also be a solution to the lost cultural values and character of a student due to the influence of modernization (Astri et al., 2013).

As an innovation of mathematics learning that orientates to the reformation of mathematics education, presented in this study, is a creation of a social arithmetic learning design using the starting point or context of the Kubuk Manuk, which is a traditional game in Indonesia. This context was chosen mainly because of its familiarity to the participants from the perspectives of culture as well as their daily life. According to Risdiyanti and Prahmana (2018), traditional games are fun as they contained concepts of mathematics for learning purposes and aspects of cultural values. The design of the Kubuk Manuk game is expected to be innovative in terms of learning mathematics so that the concept will be easy for students to understand, thus enabling them to solve any daily-related problems. Furthermore, this design is expected to cultivate and develop the cultural values that may influence a student's character.

METHOD

This study utilized design research as the research method. This research design aims to improve the quality of classroom learning practice through an interactive analysis of the hypothesis condition that will include student thinking that occurs in their learning with what actually happens in the classroom (Gravemeijer, 1994; Gravemeijer & Cobb, 2006). Simonson (2006) defined design research as a systematic and flexible method that aims to improve the quality of education through repeated analysis to design or improve design and collaboration between the researcher and the teacher to develop the quality of design learning. Design research is also defined as a method that aims to develop or validate a theory about the learning process that aims in cultivating the Local Instruction Theory (LIT). Accordingly, there are three phases of design research, which are preliminary design, design experiment and analysis retrospective (Bakker, 2004; Gravemeijer & Cobb, 2006; Prahmana, 2017).

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Preliminary Design

Gravemeijer and Cobb (2006) explained that the preliminary design phase aims to formulate the LIT that is elaborated and refined in the experimental design phase. The activities in this phase are choosing a model teacher to conduct a literature review of the social arithmetic concepts and the PMRI, to analyze the concepts of social arithmetic in the curriculum of Indonesian mathematics education, designing learning trajectory and developing conjecture to be a Hypothetical Learning Trajectory (HLT). In this case, the conjecture functions as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the experimental design phase.

Design Experiment

In this design experiment phase, the learning trajectory that has been designed in the preliminary design phase is then implemented in the learning process. The purpose of this implementation is to explore and observe the students' strategies and thinking. There are two cycles in this phase. The first cycle is a pilot experiment that aims to evaluate and improve the learning trajectory that has been designed. The second cycle is the experiment teaching that aims to implement the evaluated and revised learning trajectory in the pilot cycle of the experiment stage.

Analysis Retrospective

In this phase, all the data collected in experimental design will be analyzed by comparing the conjecture in HLT with the results of implementing the learning trajectory that has been done in the experimental design phase. Therefore, the description of learning trajectory using Kubuk Manuk Indonesian traditional game will subsequently be obtained.

RESULTS and DISCUSSION

The results of this study showed the implementation of the learning trajectory design of social arithmetic using the Kubuk Manuk traditional game as the starting point or the context of learning. The learning trajectory consists of three activities, namely the activities of playing the Kubuk Manuk games at levels 1, 2 and 3. The differences between the three activities are the number of seeds and the rules used in the game, and these are elaborated as follows.

Activity 1: Playing the Kubuk Manuk Game Level 1

This activity begins by grouping the students into groups consisting of three to four students. The teacher then introduced the Kubuk Manuk traditional game and the rules used in the game. The start of this game is an important part of introducing the learning context to make it easier for the next activity. It also embeds the social values that can develop students' ability to interact effectively with their social environment and improve the students' sportsmanship when doing an activity that is competitive in accordance with the standard competencies in Indonesian education.

To introduce this game the teacher starts by explaining that the Kubuk Manuk game originates from Java and explains the rules of the game that each member of the group must collect benguk seeds as the capital of the game, and the number of seeds must be the same. The students will grasp all the seeds in the left hand and shaken above the right hand. Then, a few seeds are thrown into the right-hand grip and the other players in the group have to make a guess. If none of the students are able to guess it, the students must spread the seeds and count using both fingers. The introduction of the game is accompanied with a simulation done by the teacher in front of the class with a few students, as shown in Figure 1, while in Figure 2 the students practice by playing the Kubuk Manuk game.

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Figure 1: Simulation of the *Kubuk Manuk* game

Figure 2: Student playing the *Kubuk Manuk* game

Next, the students began playing the Kubuk Manuk game with their respective group, and the students discuss and solve the problems contained in the worksheets that have been given (Figure 3). The problem in the worksheet (Figure 4) requires the students to determine the scores obtained by each student in the group and decide who is the winner and who lose the game. The students are required to present the results in front of the class (Figure 5), followed by the class discussions with the teacher in order to get the same students' perceptions about the solutions of the problems in the worksheet and about the mathematical concepts that can be learned from this game (refer to Figure 6).

From the class discussions, similar perceptions were achieved among the students in which the seed capital used in the game is 'expenditure' and the seeds obtained in the game are 'income'. Hence, from this activity, the students learnt about the mathematics concepts of expenditure and income.

Figure 3: Student discuss the problem in the worksheet

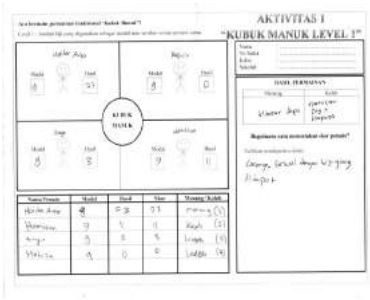

Figure 4: The results of the students wroksheet from the first activity

Figure 5: Students presenting the results

Figure 6: Class Discussion

Activity 1: Playing the Kubuk Manuk Game Level 1

The second activity is the same as the first activity, but the number of seeds used as the capital of the game is different for each player. The game begins with a simulation by the teacher, and the students continue to practice the game in their group (refer to Figure 7). Then the students discuss and solve the problem in the worksheets. The problem in the second activity worksheet is no different from the problems in the first activity worksheet that is determining the scores obtained by each player and determining the winning and losing players in the game if the seed capital used is different for each player.

Figure 7: Playing the Kubuk Manuk Game Level 2

Furthermore, in the class discussions, similar perceptions were obtained as in the first activity. However, the students must find another way to find the value of the game capital. They will need to find the value of profit or loss by subtracting the number of seeds obtained in the game by the number of seeds used as game capital. The resulting subtraction is considered as a score. The students who get the results of the subtraction will obtain a positive value, and the number of seeds obtained greater than the number of seeds used as game capital or income is greater than the expenditure, hence the students will obtain the profits. Otherwise, the students who achieved a negative result from the subtraction will indicate that the number of seeds obtained is less than the number of seeds used as capital or income is less than the expenditure, this will mean that the students get a loss. If a student gets a zero as a result of the subtraction or if the number of seeds obtained is equal to the number of seeds used as game capital, or if the income is equal to the expenditure, that means the students have obtained capital return. From this second activity, the students learnt about the mathematics concept of profits, loss and the relationship between them, as indicated in Figure 8.

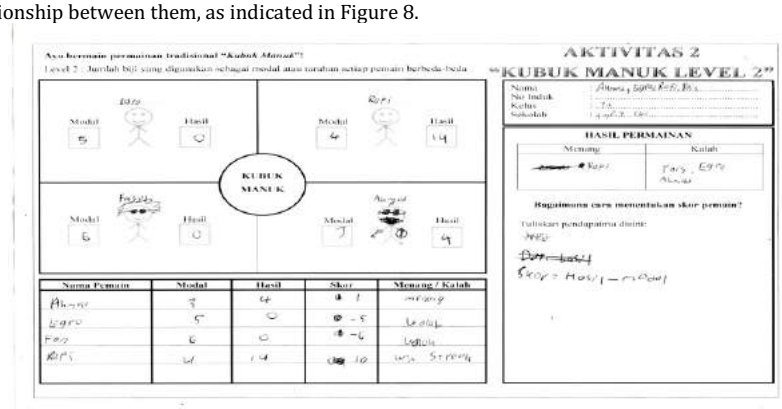

Figure 8: The Results of the Students' Worksheet in the Second Activity

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Activity 3: Playing the *Kubuk Manuk* Game Level 3

The third level of the Kubuk Manuk game is the modified version of the original Kubuk Manuk game. In this level, the seeds are used in the game, and the capital must be purchased first and there are two types of groups, which are the seller group and the player group. The seller group has a role to sell the seeds that will be used in the game and also buy the seeds that has been obtained by a player in the game. Similar to the previous activity, this third activity begins with a simulation. Then, before the students play the Kubuk Manuk game, the teacher will give play or toy money to each member of the player group to buy the seeds that will be used as game capital. After that, students play the game with their groups.

Once the game is completed, each player then sells the seeds that have been obtained in the game to the seller groups. The students discuss and solve the problems in the worksheet and present the results in front of the class. The problem in the worksheet of this third activity is to determine the player's score in the game and also to determine the winning and losing players in the game. In the class discussion, the same perception was obtained in which the money used to buy the seeds that is referred to as the game capital is called cost and the money obtained from selling the seeds is called purchase. Furthermore, to determine the player's score is by subtracting the purchase with the cost and the winning player is the player who obtains the most profit. This is shown in Figure 9. The evaluation process of the students' learning that has been conducted was to find out the students' understanding of the concept of social arithmetic and the implementation to solve the problem in daily life. Consequently, from this activity, the students learn about the mathematics concepts of cost, purchase, profit, and loss in trading activity.

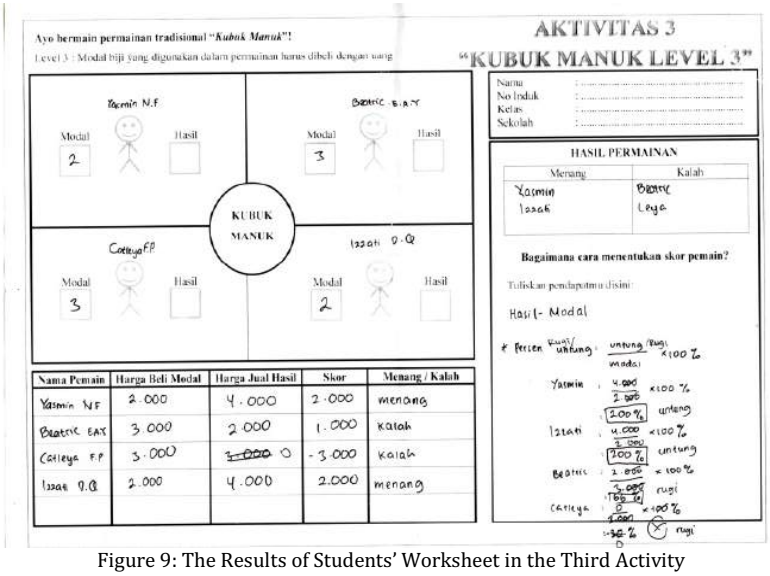

Figure 9: The Results of Students' Worksheet in the Third Activity

CONCLUSION

The results of this study indicates that in the learning of social arithmetic, the learning trajectory can be practiced using local contexts such as culture or other things easily found in the

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daily activities of the students. The students were able to understand the concept of mathematics easily since it is fun for them and importantly, the game is relatable to activities in their daily life. This study was able to take on the role in developing the learning trajectory of social arithmetic learning by using the Kubuk Manuk Indonesian traditional game as the local context of learning.

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The game introduced students the concepts such as profit, cost, puchase and so on. However, the study does not provide any evidence if the students gained understanding of these concepts, because there are not a pre and a post test. There are worksheets used by the students that could be considered as a post test. However, as I understood from the manuscript, these worksheets were not used by the authors to evaluate students' understanding of these concepts after implemantation of the game.

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The Learning Trajectory of Social Arithmetic Using an Indonesian Traditional Game

Endonezya Geleneksel Oyununu Kullanarak Sosyal Aritmetik Öğrenmenin Öğrenme Yolu

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Abstract: Indonesia has many traditional games that can be used as a starting point in learning mathematics, i.e., social arithmetic. However, the teacher always used a conventional method such as direct teaching in teaching mathematics. Several researchers said that this method made mathematics learning boring. Therefore, this study aims to design a mathematics learning trajectory in social arithmetic using a traditional Indonesian game called the *Kubuk Manuk*. This game was used as the starting point in the learning process by applying the Indonesian Realistic Mathematics Education approach. The research method used is design research consisted of three stages, namely preliminary design, teaching experiment, and retrospective analysis. The results of this study indicate that the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. With the use of the *Kubuk Manuk* Indonesian traditional game, the students are stimulated to understand their knowledge of the social arithmetic concept. Additionally, the stages in the learning trajectory have essential roles in understanding the mathematics concepts of expenditure, income, profits, and loss within the trading activities.
Keywords: Design research, learning trajectory, Indonesian traditional games, social arithmetic learning, mathematics concepts

Öz: Endonezya'da matematik öğrenmede, yani sosyal aritmetikte bir başlangıç noktası olarak kullanılabilecek birçok geleneksel oyun vardır. Ancak, öğretmen her zaman matematik öğretiminde doğrudan öğretim gibi geleneksel bir yöntem kullanmıştır. Birkaç araştırmacı, bu yöntemin matematik öğrenmeyi sıkıcı hale getirdiğini söyledi. Bu nedenle bu çalışma, *Kubuk Manuk* adlı geleneksel bir Endonezya oyununu kullanarak sosyal aritmetikte matematik öğrenme yörüngesini tasarlamayı amaçlamaktadır. Bu oyun Endonezya Gerçekçi Matematik Eğitimi yaklaşımı uygulanarak öğrenme sürecinde başlangıç noktası olarak kullanılmıştır. Kullanılan araştırma yöntemi, tasarım araştırması, ön tasarım, öğretim deneyi ve geriye dönük analiz olmak üzere üç aşamadan oluşmaktadır. Bu çalışmanın sonuçları, öğrenme yörüngesinin, kültür veya öğrencilerin günlük aktivitelerinde kolayca bulunan diğer şeyler gibi yerel bağlamlar kullanılarak uygulanabileceğini göstermektedir. *Kubuk Manuk* Endonezya geleneksel oyununun kullanılmasıyla, öğrenciler sosyal aritmetik kavramı hakkındaki bilgilerini anlamaları için teşvik edilir. Ek olarak, öğrenme yörüngesindeki aşamalar, işlemlerin matematiksel harcama, gelir, kar ve zarar kavramlarını anlamada önemli rollere sahiptir.
Anahtar Sözcükler: Tasarım araştırması, yörüngeyi öğrenme, Endonezya geleneksel oyunları, sosyal aritmetik öğrenme, matematik kavramları

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INTRODUCTION

The development and application of the mathematics concept daily problems is part of a student's learning process (Prahmana et al., 2012; Tanujaya et al., 2017; Madani et al., 2018). Freudenthal (1991) explained that mathematics is a human activity and must be related to daily life. However, mathematics in schools tend to be taught using practical formulas in reality (Arisetyawan et al., 2014). Most often, not seamlessly associated with everyday life and culture, as should be experienced by the students (Stacey, 2011; Nurhasanah et al., 2017). The society, including the teachers, generally does not regard mathematics to be related to culture, and the learning of mathematics in the classroom can also be regarded with almost having no relation to culture. Culture is part of a student's life that may guide the way a student learns and regard mathematics (Revina, 2017; Revina & Leung, 2019). Its may significantly influence the student's ability to solve mathematics projects that relate to daily life.

The results of the Programme for International Student Assessment (PISA) for Indonesia showed that the students' abilities to solve and interpret problems are still considered at a low level (Stacey, 2011). Subsequently, Abrantes (2001) and Sembiring et al. (2010) suggested the appropriate strategies and learning methods. There are needed to develop students' thinking ability that orientate towards technical skills and the reformation of mathematics education based on problem-solving in daily life (Sembiring et al. 2010). The learning method suggested to solve these problems is the Pendidikan Matematika Realistik Indonesia (PMRI), which is an adaptation of the Realistic Mathematics Education (RME) (Prahmana et al., 2012; Tanujaya et al., 2017; Ginting et al., 2018). PMRI is a movement to reform mathematics education in Indonesia (Sembiring et al., 2008). It does not just implement a new way of teaching and learning mathematics, but also is associated with a drive to achieve social transformation within Indonesia (Sembiring et al., 2010). Therefore, this research used PMRI as a learning approach to solve this problem.

The one of the contexts that can be used in PMRI is a culture that is applied into realistic mathematics learning and modified according to the local context where the school is located (Gravemeijer & Doorman, 1999; Van Den Heuvel-Panhuizan, 2005; Haris & Putri, 2011; Oktiningrum et al., 2016; Jannah & Prahmana, 2019). Consequently, it may result in exciting contextual learning if it is to be taught in schools. It may increase the students' ability to solve a problem that has a relation to their daily life. Also, the cultural context can also be a solution to the lost cultural values and character of a student due to the influence of modernization (Muhtadi et al., 2017; Risdiyanti & Prahmana, 2018; Maryati & Prahmana, 2019).

The *Kubuk Manuk* is one of the traditional Indonesian games as a cultural context. This games could be the context as an innovation of mathematics learning that orientates to the reformation of learning mathematics. This context was chosen mainly because of its familiarity with the participants. It is from the perspectives of culture as well as their daily life. Prahmana et al. (2012) stated that traditional games are fun as they contained concepts of mathematics for learning purposes and aspects of cultural values. Therefore, this research design a social arithmetic learning using the context of the *Kubuk Manuk* as the starting point and also one of the traditional games in Indonesia.

The design of the *Kubuk Manuk* game is expected to be innovative in terms of learning mathematics. Furthermore, the concept will be easy for students to understand, thus enabling them to solve any daily-related problems. Therefore, this design is expected to cultivate and develop the cultural values that may influence a student's character.

METHOD

This study utilized design research as the research method. The research aims to improve the quality of classroom learning practice. It is through an interactive analysis of the hypothesis condition that will include student thinking that occurs in their learning with what happens in

the classroom (Gravemeijer, 1994; Gravemeijer & Cobb, 2006). Simonson (2006) defined design research as a systematic and flexible method that aims to improve the quality of education. Design research is also defined as a method that seeks to develop or validate a theory about the learning process that aims in cultivating the Local Instruction Theory (LIT). LIT is a theory about the process by which students learn a mathematical topic and conjecture about the media or devices used in helping the learning process of the issue (Gravemeijer & van Eerde, 2009). There are three phases of design research namely preliminary design, teaching experiment and retrospective analysis (Bakker, 2004; Gravameijer & Cobb, 2006). For more detail, this paper presented in the next part.

Preliminary Design

Gravemeijer and Cobb (2006) explained that the preliminary design phase aims to formulate the LIT that is elaborated and refined in the experimental design phase. The activities in this phase are choosing a teacher model to teach in the learning process. Next, the literature review of the social arithmetic concepts and PMRI discusses to design the learning process. Lastly, the researcher intends the learning trajectory and developing conjecture to be a Hypothetical Learning Trajectory (HLT) through the curriculum of Indonesian mathematics education. Hypothetical learning trajectory is a theoretical model for the design of mathematics instruction consisting of three components, a learning goal, a set of learning tasks, and a hypothesized learning process (Van den Akker et al., 2006). In this case, the conjecture functions as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the experimental design phase.

After conducting a literature study, the researcher made observations at the Lukman Al Hakim Integrated Islamic Middle School, Yogyakarta to see the students' initial abilities, culture and experiences, the curriculum used at school, the learning models that have been used by teachers and to observe the potential for implementing early ideas of researchers about the design of learning social arithmetic using the traditional game *Kubuk Manuk* at the school.

The results of observations made by the researcher are then discussed together with the teacher. This was done to see the potential implementation of social arithmetic learning designs using the traditional *Kubuk Manuk* game at Lukman Hakim Middle School by adjusting the curriculum used by the school and the students' circumstances. The results of the discussion are then used as a basis in making a prototype Hypothetical Learning Trajectory (HLT) presented in Table 1.

Table 1. Learning Trajectory, Student Activities, and the Social Arithmetic Concept

Students' Learning Trajectory	Learning Activities	The Social Arithmetic Concept
İnformal Activities	Level One of the *Kubuk Manuk* Game (The seeds used by each player are the same)	Capital (Expenditures) and Results (Revenue)
Connecting Activities	Level Two of the *Kubuk Manuk* Game (The seeds used by each player are different)	Profit and loss
Formal Activities	Level Three of the *Kubuk Manuk* Game (The seeds used by each player are different and must be bought with money)	Selling price, purchase price and the percentage of profit and loss

HLT is then developed in every learning activity. The development is based on the material hypothesized learning trajectory and the concept maps that students must go through during the learning process. This development resulted in a hypothetical of student learning activities that would be completed within three meeting.

Teaching Experiment

In this teaching experiment phase, the learning trajectory that has been designed in the preliminary design phase is then implemented in the learning process. The purpose of this implementation is to explore and observe the students' strategies and thinking. There are two cycles in this phase. The first cycle is a pilot experiment that aims to evaluate and improve the learning trajectory that has been designed. The second cycle is the teaching experiment that aims to implement the evaluated and revised learning trajectory in the pilot experiment.

Analysis Retrospective

In this phase, all the data collected in experimental design will be analyzed by comparing the conjecture in HLT with the results of implementing the learning trajectory that has been done in the experimental design phase. Data analysis was carried out by researchers and worked together with her supervisor to improve the validity of this study. Therefore, the description of learning trajectory using *Kubuk Manuk* Indonesian traditional game will subsequently be obtained. The result of a design research is not design that works but the underlying principles explaining how and why this design works (Wijaya, 2008). In retrospective analysis the role of HLT has been designed compared to the learning process carried out by students so that an investigation can be carried out and explained how students obtain the concepts of social arithmetic concept generated from the *Kubuk Manuk* game.

RESULTS and DISCUSSION

The results of this study showed the implementation of the learning trajectory design of social arithmetic using the *Kubuk Manuk* traditional game as the starting point in the learning process. The learning trajectory consists of three activities, namely the activities of playing the *Kubuk Manuk* games at levels 1, 2 and 3. The differences between the three activities are the number of seeds and the rules used in the game, and these are elaborated. The summary of all learning activities can be seen in Table 2.

Table 2. The Activities in Learning Social Arithmetic using *Kubuk Manuk* game

The Learning Social Arithmetic	The Learning Phases	The Learning Description
Learning about the concepts of income (revenue) and outcome (capital)	Students play *Kubuk Manuk* game level 1	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 1 f. Students work on student worksheet 1 g. Students and teachers discuss the results of the

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		game, the results of student worksheet 1 work and social arithmetic concepts learned in the game
Learning about the concept of profit and loss	Students play *Kubuk Manuk* game level 2	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 2 f. Students work on student worksheet 2 g. Students and teachers discuss the results of the game, the results of student worksheet 2 work and social arithmetic concepts learned in the game
Learning about selling price, purchase price and the percentage of profit and loss	Students play *Kubuk Manuk* game level 3	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 3 f. Students work on student worksheet 3 g. Students and teachers discuss the results of the game, the results of student worksheet 3 work and social arithmetic concepts learned in the game

Activity 1: Level One of the Kubuk Manuk Game

This activity begins by grouping the students into groups consisting of three to four students. The teacher then introduced the *Kubuk Manuk* traditional game and the rules used in the game. The beginning of this game is an important part of introducing the learning context to make it easier for the next activity. It also embeds the social values that can develop students' ability to interact effectively with their social environment and improve the students' sportsmanship when doing an activity that is competitive in accordance with the standard competencies in Indonesian education.

To introduce this game the teacher starts by explaining that the *Kubuk Manuk* game originates from Java and explains the rules of the game that each member of the group must collect a kind of beans namely *benguk* seeds as the capital of the game, and the number of seeds must be the same. The students will grasp all the seeds in the left hand and shaken above the right hand. Then, a few seeds are thrown into the right-hand grip and the other players in the group have to make a guess. If none of the students are able to guess it, the students must spread the seeds and count using both fingers. The introduction of the game is accompanied with a simulation done by the teacher in front of the class with a few students, as shown in Figure 1.

Figure 1. Simulation of the *Kubuk Manuk* game

After the simulation finished, the students play *Kubuk Manuk* level 1 together with their respective groups, as shown in Figure 2. Students already understand how to play *Kubuk Manuk* level 1.

Figure 2. Student playing the *Kubuk Manuk* game

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It is to make a compilation to determine the leading players and opposing players, then collect the same amount of capital each player. Furthermore, the main player sings the level 1 *Kubuk Manuk* song while moving the seeds from the right-hand grip to the leading player's left hand. If not guessed then the player spreads the seeds and picks them using the index finger. Also, students help each other in playing the game even though they compete with each other to win. Seen from the attitude of student A that helps student B to grab the seeds used for the game so as not to be scattered. Its is following the purpose of choosing an ethnomathematics-based context in this learning design that is to develop student character based on values that can be drawn from the game.

Next, the students began playing the *Kubuk Manuk* game with their respective group, and the students discuss and solve the problems contained in the worksheets that have been given as can be seen in Figure 3. The capital data and results are written in the table provided in the student worksheet.

Figure 3. Student discuss the problem in the worksheet

The problem in the worksheet requires the students to determine the scores obtained by each student in the group and decide who win and who lose the game. Figure 4 shows that students have been able to identify capital (income) and results (outcome). Students can also determine the score of each player and can determine the player who wins and lose from the number of seeds obtained. Students then conduct a group discussion to solve the problems that exist in student worksheet which is about how to determine the player's score and determine the players who win and lose.

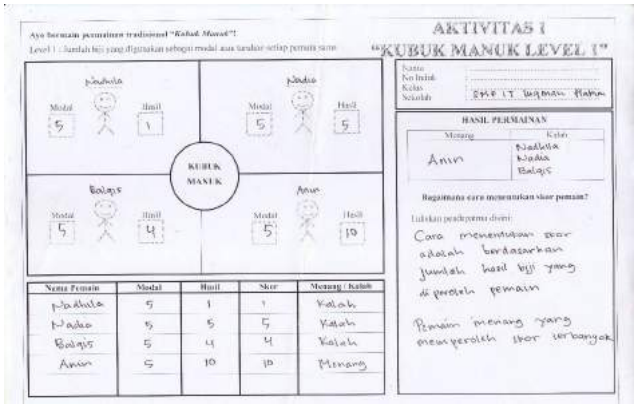

Figure 4. The results of the students' worksheet from the first activity

Furthermore, students are required to present the results in front of the class. The teacher chooses one of the groups to present their work in front of the class as shown in Figure 5.

Figure 5. Students presenting the results

The following is an excerpt from the dialogue of one group when presenting the results of their presentation in front of the class.

Student : *"Jadi kita akan mempresentasikan tentang hasil permainan kita hari ini, jadi kelompok kita ngelakuin dua kali permainan, hasil yang pertama pemenangnya adalah Salima"*
[We will present about the results of our game today, so our group has done two games, the winner of the first result is Salima"]

Teacher : *"Modalnya dulu, modalnya"*
[First capital, their capital]

Student : *"Salima, modal sepuluh dan hasil dua puluh satu, berarti untungnya sebelas. Terus ronde kedua modalnya lima belas yang menang salima lagi, dia dapat dua puluh satu. Dan yang ketiga dengan modal dua puluh pemenangnya adalah alin dengan hasil empat puluh enam. Jadi cara menentukan skor itu dilihat dari hasil mainnya. Kalau dia kalah maka dia dapat skor nol, kalau dia menang maka ia dapat skor satu"*
[Salima, the capital is ten and the income is twenty-one, means the income is eleven. Then in the second round of capital is fifteen and the winner is Salima again, he got twenty-one. And the third one with the capital is twenty and the winners is Alin with the income is forty-six. So the way to determine the score is seen from the results of the game. If she loses, her score is zero; If she wins, her score is one]

Based on the dialogue, it can be seen that through a process of playing *Kubuk Manuk* level 1 students have been able to understand the definition of capital and income. Students revealed that "*the capital is ten and the income is twenty-one*"; it can be seen that students have understood that 10 seeds collected or issued by players to play the *Kubuk Manuk* game are capital and 21 seeds obtained from a playing process the *Kubuk Manuk* game are income.

Students have also been able to predict how to determine player scores based on their thinking and understanding of the concepts of capital and income. It can be seen from the students' answers, "*So the way to determine the score is seen from the results of the game*". The ability of students to predict the player's score, shows that an indicator of students' mathematical understanding has been reached (Wijaya, 2008; Prahmana & Suwasti, 2014;

Ginting et al., 2018). Furthermore, the students also revealed "*the income is eleven*"; it means that the development of students' understanding in the group had reached the relationship of capital and income. The answer "*eleven*" is obtained by students by subtracting the outcome with capital. Students have also been able to define that "*eleven*" is the benefit of Salima.

Students have been able to see the relationship between capital, outcome, and income, because before learning activities take place students have followed the school program that is market day. In the program, students are given capital to carry out a particular business and the teacher is also accustomed to introducing terms such as capital gains and profits to students in implementing the program (Madani et al., 2018).

In the dialogue the students revealed "*If she loses, her score is zero; If she wins, her score is one* "; the answer of this student is beyond the predictions of the researcher. In HLT, researchers only predict students will answer the score with 'results' or with 'results reduced by capital' (Gravemeijer & Cobb, 2006; Gravemeijer & van Eerde, 2009; Prahmana et al., 2012). The students' answers are influenced by the experience of students outside of learning when playing games on mobile phones or when looking at a match that is when winning it will get a score of one and lose the score zero. Students perceive that the rules for determining the score used in this game are the same as those used in a game or match.

The class discussions with the teacher in order to get the same students' perceptions about the solutions of the problems in the worksheet and about the mathematical concepts that can be learned from this game (refer to Figure 6). From the class discussions, similar perceptions were achieved among the students in which the seed capital used in the game is 'outcome' and the seeds obtained in the game are 'income'. Hence, from this activity, the students learnt about the mathematics concepts of outcome and income.

Figure 6. Class Discussion

Activity 2: Level Two of the Kubuk Manuk Game

The second activity is the same as the first activity, but the number of seeds used as the capital of the game is different for each player. The game begins with a simulation by the teacher, and the students continue to practice the game in their group (refer to Figure 7). Then the students discuss and solve the problem in the worksheets. The problem in the second activity worksheet is no different from the problems in the first activity worksheet that is determining the scores obtained by each player and determining the winning and losing players in the game if the seed capital used is different for each player.

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Figure 7. Playing the *Kubuk Manuk* Game Level 2

Furthermore, in the class discussions, similar perceptions were obtained as in the first activity. However, the students must find another way to find the value of the game capital. They will need to find the value of profit or loss by subtracting the number of seeds obtained in the game by the number of seeds used as game capital. The resulting subtraction is considered as a score. The students who get the results of the subtraction will obtain a positive value. The number of seeds received more significant than the number of seeds used as game capital. On the other hands, the income is higher than the expenditure. Hence the students will receive the profits. Otherwise, the students who achieved a negative result from the subtraction will indicate that the number of seeds collected is less than the number of seeds used as capital. On the other hands, the income is less than the expenditure, and this will mean that the students get a loss. If a student gets a zero as a result of the subtraction or if the number of seeds obtained is equal to the number of seeds used as game capital, or if the income is equal to the expenditure, that means the students have obtained capital return. From this second activity, the students learnt about the mathematics concept of profits, loss and the relationship between them, as indicated in Figure 8.

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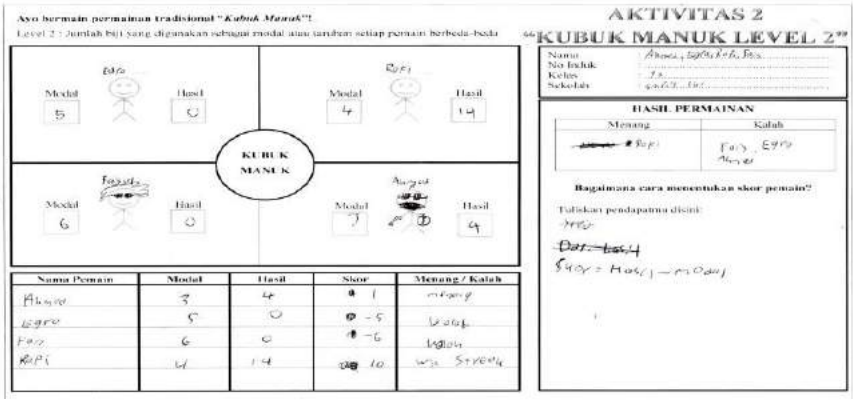

Figure 8. The Results of the Students' Worksheet in the Second Activity

Activity 3: Level Three of the Kubuk Manuk Game

The third level of the *Kubuk Manuk* game is the modified version of the original *Kubuk Manuk* game. In this level, the seeds are used in the game, and the capital must be purchased first. There are two types of groups, which are the seller group and the player group. The seller group has a role in selling the seeds that will be used in the game. They also buy the seeds that have been obtained by a player in the game. Similar to the previous activity, this third activity begins with a simulation. Then, the teacher will give the toy's money to each member of the player group to buy the seeds that will be used as game capital. After that, students play the game with their groups.

Once the game is completed, each player sells the seeds that have been obtained in the game to the seller groups. The students discuss and solve the problems in the worksheet and present the results in front of the class. The problem in the worksheet of the third activity is to determine the player's score in the game and also to determine the winning and losing players in the game. In the class discussion, the same perception was obtained in which the money used to buy the seeds that are referred to as the game capital is called cost and the money collected from selling the seeds is called purchase. Furthermore, the subtracting of the purchase with the cost is to determine the player's score. The winning player is the player who obtains the most profit shown in Figure 9. The evaluation process of the students' learning that has been conducted was to find out the students' understanding of the concept of social arithmetic and the implementation to solve the problem in daily life. Consequently, from this activity, the students learn about the mathematics concepts of cost, purchase, profit, and loss in trading activity.

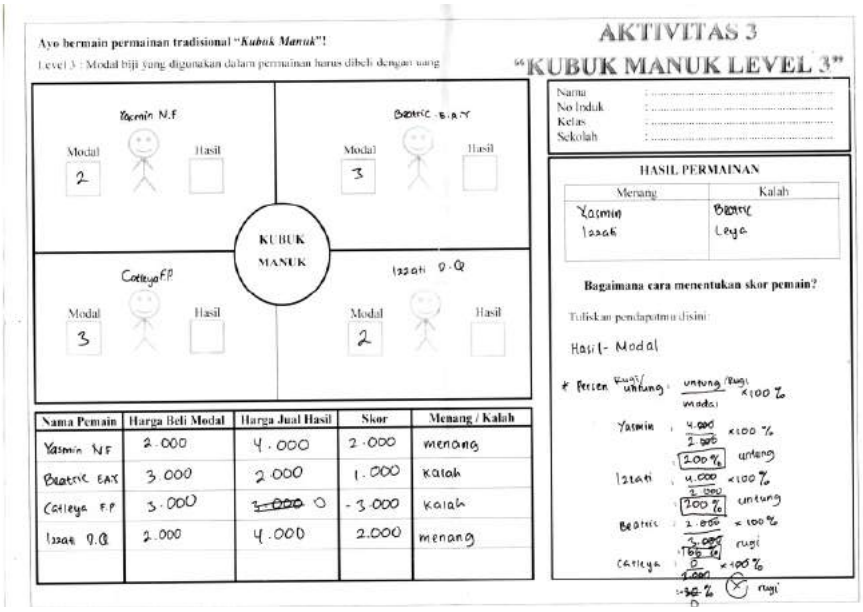

Figure 9. The Results of Students' Worksheet in the Third Activity

After the social arithmetic learning activities using the traditional *Kubuk Manuk* game were completed, the researcher gave a final evaluation question to all students. It is to find out their understanding in understanding the concept of social arithmetic (Madani et al., 2018; Van

Den Heuvel-Panhuizen, 2005). Final evaluation questions are made based on three student understanding indicators. Firstly, students can understand the concepts of income (results) and outcome (capital). Students can understand the idea of profit and loss. Lastly, students can understand the idea of the selling price, purchase price, and the percentage of profit and loss.

The results of the evaluation questions given to students can be seen that, overall, the average score of students in good categories. It means that students understand the concept of social arithmetic, namely income, outcome, profit, loss, selling price, purchase price, and the percentage of profit and loss. Therefore, the *Kubuk Manuk* game has a useful context as a context used to create ethnomathematics-based learning designs to students' understanding of the concept of social arithmetic.

CONCLUSION

The results of this study indicates that in the learning of social arithmetic, the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. The students were able to understand the concept of mathematics easily since it is fun for them and importantly, the game is relatable to activities in their daily life. This study was able to take on the role in developing the learning trajectory of social arithmetic learning by using the *Kubuk Manuk* Indonesian traditional game as the local context of learning.

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The game introduced students the concepts such as profit, cost, puchase and so on. However, the study does not provide any evidence if the students gained understanding of these concepts, because there are not a pre and a post test. There are worksheets used by the students that could be considered as a post test. However, as I understood from the manuscript, these worksheets were not used by the authors to evaluate students' understanding of these concepts after implemantation of the game.

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The Learning Trajectory of Social Arithmetic using an Indonesian Tradisional Game

Endonezya Dili Tradisional Oyununu Kullanan Sosyal Aritmetik Öğrenmenin Öğrenme Yolu

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Abstract: The aim of this study is to design mathematics learning trajectory in social arithmetic using an Indonesian traditional game called the Kubuk Manuk. This game was used as the starting point in the learning process by applying the Indonesian Realistic Mathematics Education approach. A design research method was applied in the three stages, namely the preliminary design, the design experiment, and the retrospective analysis. The results of this study indicates that in the learning of social arithmetic, the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. With the use of the Kubuk Manuk Indonesian traditional game, it helped to stimulate the students to understand their knowledge of social arithmetic concept. Additionally, the stages in the learning trajectory have important roles in understanding the mathematics concepts of expenditure, income, profits and loss within the trading activities.
Keywords: Design research, learning trajectory, cultural and traditional, social arithmetic learning, mathematics concepts

Öz: Bu çalışmanın amacı, Kübük Manuk denen Endonezya geleneksel oyununu kullanarak matematik öğrenme yörüngesini sosyal aritmetik olarak tasarlamaktır. Bu oyun, Endonezya Gerçekçi Matematik Eğitimi yaklaşımını uygulayarak öğrenme sürecinde başlangıç noktası olarak kullanılmıştır. Ön tasarım, tasarım deneyi ve retrospektif analiz olmak üzere üç aşamada bir tasarım araştırması yöntemi uygulanmıştır. Bu çalışmanın sonuçları, sosyal aritmetik öğrenmede, öğrenim yörüngesinin, öğrencilerin günlük etkinliklerinde kolayca bulunabilecek kültür veya diğer şeyler gibi yerel bağlamları kullanarak uygulanabileceğini göstermektedir. Kubuk Manuk Endonezya geleneksel oyun kullanımı ile, öğrencilerin sosyal aritmetik kavram bilgilerini anlamalarını teşvik etmek için yardımcı oldu. Ek olarak, öğrenme yörüngesindeki aşamalar, matematik faaliyetlerini, harcama, gelir, kar ve ticaret faaliyetlerindeki zararı anlamada önemli rollere sahiptir.
Anahtar Sözcükler: Tasarım araştırması, öğrenme yörüngesi, kültürel ve geleneksel, sosyal aritmetik öğrenme, matematik kavramları

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INTRODUCTION

The development and application of the mathematics concept daily problems is part of a student's learning process (Tanujaya et al., 2017). Freudenthal (1991) explained that mathematics is a human activity and must be related to daily life. However, in reality, the mathematics in schools tend to be taught using practical formulas and most often, not seamlessly related with daily life and culture, as should be experienced by the students (Stacey, 2011; Arisetyawan et al., 2014; Nurhasanah et al., 2017). The society, including the teachers, generally does not regard mathematics to be related with culture, and the learning of mathematics in the classroom can also be regarded with almost having no relation to culture. In fact, culture is part of a student's life that may guide the way a student learn and regard mathematics (Revina, 2017; Revina & Leung, 2018a, 2018b). This may greatly influence the student's ability to solve mathematics projects that relates to daily life. The results of the Programme for International Student Assessment (PISA) for Indonesia showed that the students' abilities to solve and interpret problems in various situations are still considered at a level, which is low (Stacey, 2011). Subsequently, Irawan and Kencanawaty (2017) and Sembiring et al. (2010) suggested that appropriate strategies and learning methods are needed to develop students' thinking ability that orientate towards technical skills and the reformation of mathematics education based on problem-solving in the daily life. The learning method suggested is the Pendidikan Matematika Realistik Indonesia (PMRI), which is an adaptation of the Realistic Mathematics Education (RME). According to Soedjadi (2007), the PMRI is aligned with the Indonesian culture, geography and the ability of Indonesian society in general.

Wahyudi, Zulkardi and Darmawijoyo (2016) and Subijato (2015) explained that one of the contexts that can be used in PMRI is a culture that is applied into realistic mathematics learning and modified according to the local context where the school is located. Consequently, it may result in an interesting contextual learning if it is to be taught in schools as it may increase the students' ability to solve a problem that has a relation to their daily life. In addition, the cultural context can also be a solution to the lost cultural value and character of a student due to the influence of modernization (Astri et al., 2013).

As an innovation of mathematics learning that orientates to the reformation of mathematics education, presented in this study is a creation of a social arithmetic learning design using the starting point or context of the Kubuk Manuk, which is a traditional game in Indonesia. This context was chosen mainly because of its familiarity to the participants from the perspectives of culture as well as their daily life. According to Risdiyanti and Prahmana (2018), traditional games are fun as it contained concepts of mathematics for learning purposes and aspects of cultural values. The design of the Kubuk Manuk game is expected to be innovative in terms of learning mathematics so that the concept will be easy for students to understand thus enabling them to solve any daily-related problems. Furthermore, this design is expected to cultivate and develop the cultural values that may influence a student's character.

METHOD

This study utilized design research as the research method. This research design aims to improve the quality of classroom learning practice through an interactive analysis of the hypothesis condition that will include student thinking that occurs in their learning with what actually happens in the classroom (Gravemeijer, 1994; Gravemeijer & Cobb, 2006). Simonson (2006) defined design research as a systematic and flexible method that aims to improve the quality of education through repeated analysis to design or improve design and collaboration between the researcher and the teacher to develop the quality of design learning. Design research is also defined as a method that aims to develop or validate a theory about the learning process that aims in cultivating the Local Instruction Theory (LIT). Accordingly, there are three phases of design research, which are preliminary design, design experiment and analysis retrospective (Bakker, 2004; Gravameijer & Cobb, 2006; Prahmana, 2017).

Preliminary Design

Gravemeijer and Cobb (2006) explained that the preliminary design phase aims to formulate the LIT that is elaborated and refined in the experimental design phase. The activities in this phase are choosing a model teacher to conduct a literature review of the social arithmetic concepts and the PMRI, to analyze the concepts of social arithmetic in the curriculum of Indonesian mathematics education, designing learning trajectory and developing conjecture to be a Hypothetical Learning Trajectory (HLT). In this case, the conjecture functions as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the experimental design phase

Design Experiment

In this design experiment phase, the learning trajectory that has been designed in the preliminary design phase is then implemented in the learning process. The purpose of this implementation is to explore and observe the students' strategies and thinking. There are two cycles in this phase. The first cycle is a pilot experiment that aims to evaluate and improve the learning trajectory that has been designed. The second cycle is the experiment teaching that aims to implement the evaluated and revised learning trajectory in the pilot cycle of the experiment stage.

Analysis Retrospective

In this phase, all the data collected in experiment design will be analyzed by comparing the conjecture in HLT with the results of implementing the learning trajectory that has been done in the experiment design phase. Therefore, the description of learning trajectory using Kubuk Manuk Indonesian traditional game will subsequently be obtained.

RESULTS and DISCUSSION

The results of this study showed the implementation of the design learning trajectory of social arithmetic using the Kubuk Manuk traditional game as the starting point or the context of learning. The learning trajectory consists of three activities, namely the activities of playing the Kubuk Manuk games at levels 1, 2 and 3. The differences between the three activities are the number of seeds and the rules used in the game, and these are elaborated as follows.

Activity 1: Playing the Kubuk Manuk Game Level 1

This activity begins by grouping the students into groups consisting of three to four students. The teacher then introduced the Kubuk Manuk traditional game and the rules used in the game. The start of this game is an important part of introducing the learning context to make it easier for the next activity. It also embeds the social values that can develop students' ability to interact effectively with their social environment and improve the students' sportsmanship when doing an activity that is competitive in accordance with the standard competencies in Indonesian education.

To introduce this game the teacher starts by explaining that the Kubuk Manuk game originates from Java and explains the rules of the game that each member of the group must collect benguk seeds as the capital of the game, and the number of seeds must be the same. The students will grasp all the seeds in the left hand and shaken above the right hand. Then, a few seeds are thrown into the right-hand grip and the other players in the group have to make a guess. If none any students are able to guess it, the students must spread the seeds and count using both fingers. The introduction of the game is accompanied with a simulation done by the teacher in front of the class with a few students, as shown in Figure 1, while in Figure 2 the students practice by playing the Kubuk Manuk game.

Figure 1: Simulation of the *Kubuk Manuk* game

Figure 2: Student playing the *Kubuk Manuk* game

Next, the students began playing the Kubuk Manuk game with their respective group, and the students discuss and solve the problems contained in the worksheets that have been given (Figure 3). The problem in the worksheet (Figure 4) requires the students to determine the scores obtained by each student in the group and decide who is the winner and who lose the game. The students are required to present the results in front of the class (Figure 5), followed by class discussions with the teacher in order to get the same students' perceptions about the solutions of the problems in the worksheet and about the mathematical concepts that can be learned from this game (refer to Figure 6).

From the class discussions, similar perceptions were achieved among the students in which the seed capital used in the game is 'expenditure' and the seeds obtained in the game are 'income'. Hence, from this activity, the students learnt about the mathematics concepts of expenditure and income.

Figure 3: Student discuss the problem in the worksheet

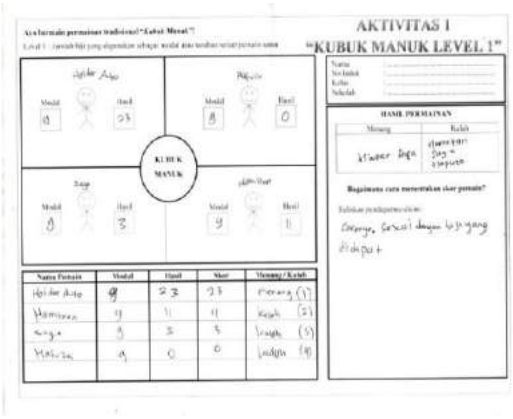

Figure 4: The results of the students wroksheet from the first activity

Figure 5: Students presenting the results

Figure 6: Class Discussion

Activity 1: Playing the Kubuk Manuk Game Level 1

The second activity is the same as the first activity, but the number of seeds used as the capital of the game is different for each player. The game begins with a simulation by the teacher, and the students continue to practice the game in their group (refer to Figure 7). Then the students discuss and solve the problem in the worksheets. The problem in the second activity worksheet is no different from the problems in the first activity worksheet that is determining the scores obtained by each player and determining the winning and losing players in the game if the seed capital used is different for each player.

Figure 7: Playing the Kubuk Manuk Game Level 2

Furthermore, in the class discussions, similar perceptions were obtained as in the first activity. However, the students must find another way to find the value of the game capital. They will need to find the value of profit or loss by subtracting the number of seeds obtained in the game by the number of seeds used as game capital. The resulting subtraction is considered as a score. The students who get the results of the subtraction will obtain a positive value, and the number of seeds obtained greater than the number of seeds used as game capital or income is greater than the expenditure, hence the students will obtain the profits. Otherwise, the students who achieved a negative result from the subtraction will indicate that the number of seeds obtained is less than the number of seeds used as capital or income is less than the expenditure, this will mean that the students get a loss. If a student who gets a zero as a result of the subtraction or the number of seeds obtained is equal to the number of seeds used as game capital, or the income is equal to the expenditure, that means the students have obtained return capital. From this second activity, the students learnt about the mathematics concept of profits, loss and the relationship between them, as indicated in Figure 8.

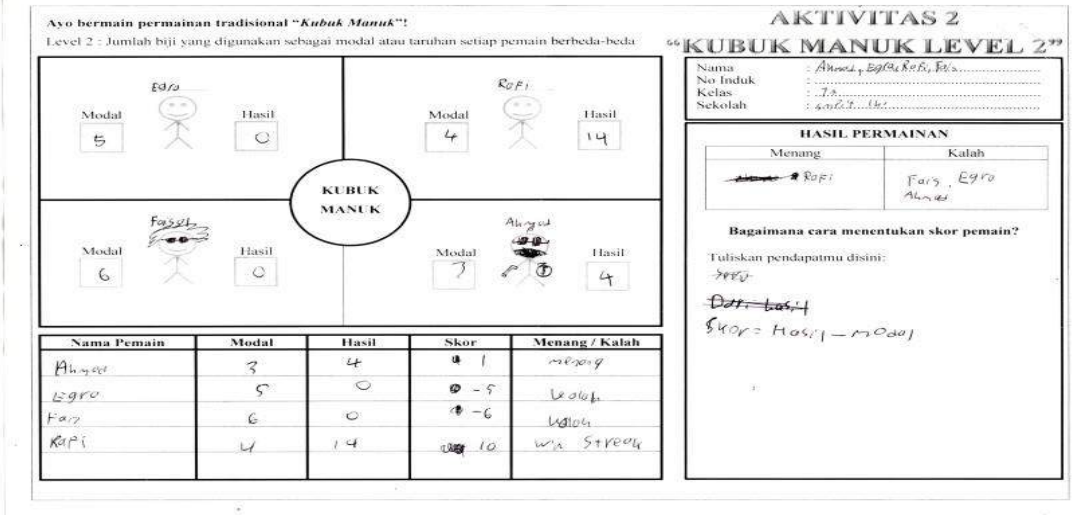

Figure 8: The Results of the Students' Worksheet in the Second Activity

Activity 3: Playing the *Kubuk Manuk* Game Level 3

The third level of the Kubuk Manuk game is the modified version of the original Kubuk Manuk game. In this level, the seeds are used in the game, and the capital must be purchased first and there are two types of groups, which are the seller group and the player group. The seller group has a role to sell the seeds that will be used in the game and also buy the seeds that has been obtained by a player in the game. Similar to the previous activity, this third activity begins with a simulation. Then, before the students play the Kubuk Manuk game, the teacher will give play or toy money to each member of the player group to buy the seeds that will be used as game capital. After that, students play the game with their groups.

Once the game is completed, each player then sells the seeds that have been obtained in the game to the seller groups. The students discuss and solve the problems in the worksheet and present the results in front of the class. The problem in the worksheet of this third activity is to determine the player's score in the game and also to determine the winning and losing players in the game. In the class discussion, the same perception was obtained in which the money used to buy the seeds that is referred to as the game capital is called cost and the money obtained from selling the seeds is called purchase. Furthermore, to determine the player's score is by subtracting the purchase with the cost and the winning player is the player who obtains the most profit. This is shown in Figure 9. The evaluation process of the students' learning that has been conducted was to find out the students' understanding of the concept of social arithmetic and the implementation to solve the problem in daily life. Consequently, from this activity, the students learn about the mathematics concepts of cost, purchase, profit, and loss in trading activity.

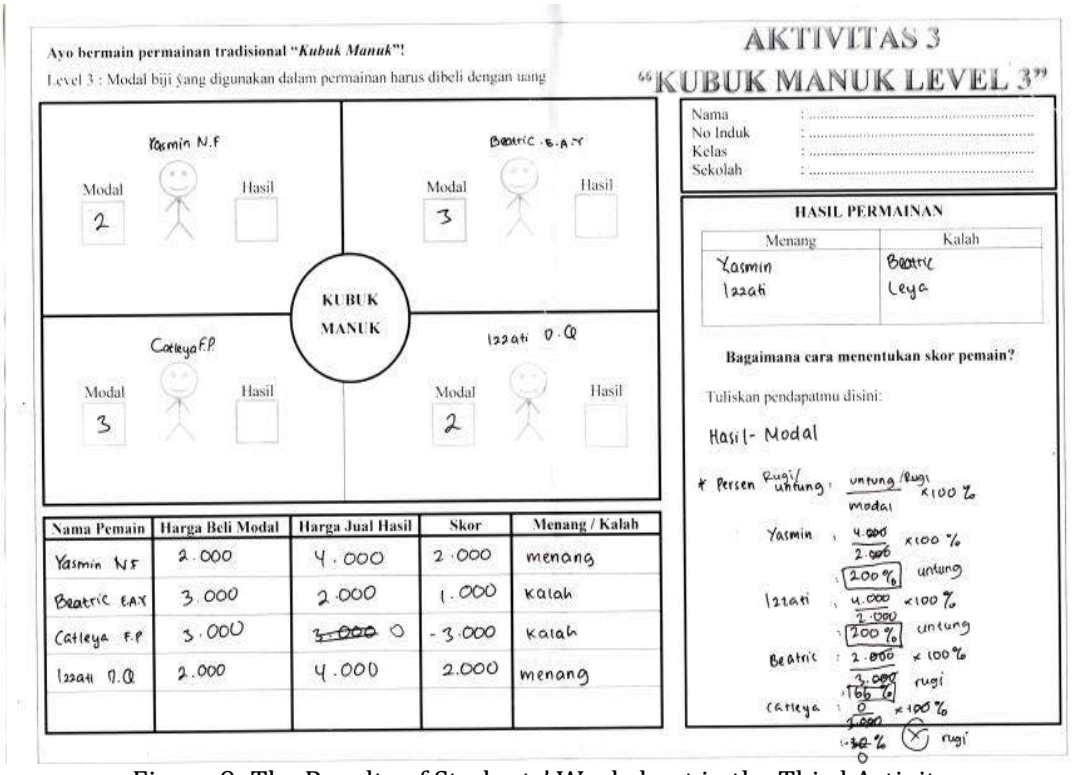

Figure 9: The Results of Students' Worksheet in the Third Activity

CONCLUSION

The results of this study indicates that in the learning of social arithmetic, the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. The students were able to understand the concept of mathematics

easily since it is fun for them and importantly, the game is relatable to activities in their daily life. This study was able to take on the role in developing the learning trajectory of social arithmetic learning using the Kubuk Manuk Indonesian traditional game as the local context of learning.

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The Learning Trajectory of Social Arithmetic Using an Indonesian Traditional Game

Endonezya Geleneksel Oyununu Kullanarak Sosyal Aritmetik Öğrenmenin Öğrenme Yolu

Abstract: Indonesia has many traditional games that can be used as a starting point in learning mathematics, i.e., social arithmetic. However, the teacher always used a conventional method such as direct teaching in teaching mathematics. Several researchers said that this method made mathematics learning boring. Therefore, this study aims to design a mathematics learning trajectory in social arithmetic using a traditional Indonesian game called the *Kubuk Manuk*. This game was used as the starting point in the learning process by applying the Indonesian Realistic Mathematics Education approach. The research method used is design research consisted of three stages, namely preliminary design, teaching experiment, and retrospective analysis. The results of this study indicate that the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. With the use of the *Kubuk Manuk* Indonesian traditional game, the students are stimulated to understand their knowledge of the social arithmetic concept. Additionally, the stages in the learning trajectory have essential roles in understanding the mathematics concepts of expenditure, income, profits, and loss within the trading activities.
Keywords: Design research, learning trajectory, Indonesian traditional games, social arithmetic learning, mathematics concepts

Öz: Endonezya'da matematik öğrenmede, yani sosyal aritmetikte bir başlangıç noktası olarak kullanılabilecek birçok geleneksel oyun vardır. Ancak, öğretmen her zaman matematik öğretiminde doğrudan öğretim gibi geleneksel bir yöntem kullanmıştır. Birkaç araştırmacı, bu yöntemin matematik öğrenmeyi sıkıcı hale getirdiğini söyledi. Bu nedenle bu çalışma, *Kubuk Manuk* adlı geleneksel bir Endonezya oyununu kullanarak sosyal aritmetikte matematik öğrenme yörüngesini tasarlamayı amaçlamaktadır. Bu oyun Endonezya Gerçekçi Matematik Eğitimi yaklaşımı uygulanarak öğrenme sürecinde başlangıç noktası olarak kullanılmıştır. Kullanılan araştırma yöntemi, tasarım araştırması, ön tasarım, öğretim deneyi ve geriye dönük analiz olmak üzere üç aşamadan oluşmaktadır. Bu çalışmanın sonuçları, öğrenme yörüngesinin, kültür veya öğrencilerin günlük aktivitelerinde kolayca bulunan diğer şeyler gibi yerel bağlamlar kullanılarak uygulanabileceğini göstermektedir. *Kubuk Manuk* Endonezya geleneksel oyununun kullanılmasıyla, öğrenciler sosyal aritmetik kavramı hakkındaki bilgilerini anlamaları için teşvik edilir. Ek olarak, öğrenme yörüngesindeki aşamalar, işlemlerin matematiksel harcama, gelir, kar ve zarar kavramlarını anlamada önemli rollere sahiptir.
Anahtar Sözcükler: Tasarım araştırması, yörüngeyi öğrenme, Endonezya geleneksel oyunları, sosyal aritmetik öğrenme, matematik kavramları

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INTRODUCTION

The development and application of the mathematics concept daily problems is part of a student's learning process (Prahmana et al., 2012; Tanujaya et al., 2017; Madani et al., 2018). Freudenthal (1991) explained that mathematics is a human activity and must be related to daily life. However, mathematics in schools tend to be taught using practical formulas in reality (Arisetyawan et al., 2014). Most often, not seamlessly associated with everyday life and culture, as should be experienced by the students (Stacey, 2011; Nurhasanah et al., 2017). The society, including the teachers, generally does not regard mathematics to be related to culture, and the learning of mathematics in the classroom can also be regarded with almost having no relation to culture. Culture is part of a student's life that may guide the way a student learns and regard mathematics (Revina, 2017; Revina & Leung, 2019). Its may significantly influence the student's ability to solve mathematics projects that relate to daily life.

The results of the Programme for International Student Assessment (PISA) for Indonesia showed that the students' abilities to solve and interpret problems are still considered at a low level (Stacey, 2011). Subsequently, Abrantes (2001) and Sembiring et al. (2010) suggested the appropriate strategies and learning methods. There are needed to develop students' thinking ability that orientate towards technical skills and the reformation of mathematics education based on problem-solving in daily life (Sembiring et al. 2010). The learning method suggested to solve these problems is the Pendidikan Matematika Realistik Indonesia (PMRI), which is an adaptation of the Realistic Mathematics Education (RME) (Prahmana et al., 2012; Tanujaya et al., 2017; Ginting et al., 2018). PMRI is a movement to reform mathematics education in Indonesia (Sembiring et al., 2008). It does not just implement a new way of teaching and learning mathematics, but also is associated with a drive to achieve social transformation within Indonesia (Sembiring et al., 2010). Therefore, this research used PMRI as a learning approach to solve this problem.

The one of the contexts that can be used in PMRI is a culture that is applied into realistic mathematics learning and modified according to the local context where the school is located (Gravemeijer & Doorman, 1999; Van Den Heuvel-Panhuizan, 2005; Haris & Putri, 2011; Oktiningrum et al., 2016; Jannah & Prahmana, 2019). Consequently, it may result in exciting contextual learning if it is to be taught in schools. It may increase the students' ability to solve a problem that has a relation to their daily life. Also, the cultural context can also be a solution to the lost cultural values and character of a student due to the influence of modernization (Muhtadi et al., 2017; Risdiyanti & Prahmana, 2018; Maryati & Prahmana, 2019).

The *Kubuk Manuk* is one of the traditional Indonesian games as a cultural context. This games could be the context as an innovation of mathematics learning that orientates to the reformation of learning mathematics. This context was chosen mainly because of its familiarity with the participants. It is from the perspectives of culture as well as their daily life. Prahmana et al. (2012) stated that traditional games are fun as they contained concepts of mathematics for learning purposes and aspects of cultural values. Therefore, this research design a social arithmetic learning using the context of the *Kubuk Manuk* as the starting point and also one of the traditional games in Indonesia.

The design of the *Kubuk Manuk* game is expected to be innovative in terms of learning mathematics. Furthermore, the concept will be easy for students to understand, thus enabling them to solve any daily-related problems. Therefore, this design is expected to cultivate and develop the cultural values that may influence a student's character.

METHOD

This study utilized design research as the research method. The research aims to improve the quality of classroom learning practice. It is through an interactive analysis of the hypothesis condition that will include student thinking that occurs in their learning with what happens in

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the classroom (Gravemeijer, 1994; Gravemeijer & Cobb, 2006). Simonson (2006) defined design research as a systematic and flexible method that aims to improve the quality of education. Design research is also defined as a method that seeks to develop or validate a theory about the learning process that aims in cultivating the Local Instruction Theory (LIT). LIT is a theory about the process by which students learn a mathematical topic and conjecture about the media or devices used in helping the learning process of the issue (Gravemeijer & van Eerde, 2009). There are three phases of design research namely preliminary design, teaching experiment and retrospective analysis (Bakker, 2004; Gravameijer & Cobb, 2006). For more detail, this paper presented in the next part.

Preliminary Design

Gravemeijer and Cobb (2006) explained that the preliminary design phase aims to formulate the LIT that is elaborated and refined in the experimental design phase. The activities in this phase are choosing a teacher model to teach in the learning process. Next, the literature review of the social arithmetic concepts and PMRI discusses to design the learning process. Lastly, the researcher intends the learning trajectory and developing conjecture to be a Hypothetical Learning Trajectory (HLT) through the curriculum of Indonesian mathematics education. Hypothetical learning trajectory is a theoretical model for the design of mathematics instruction consisting of three components, a learning goal, a set of learning tasks, and a hypothesized learning process (Van den Akker et al., 2006). In this case, the conjecture functions as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the experimental design phase.

After conducting a literature study, the researcher made observations at the Lukman Al Hakim Integrated Islamic Middle School, Yogyakarta to see the students' initial abilities, culture and experiences, the curriculum used at school, the learning models that have been used by teachers and to observe the potential for implementing early ideas of researchers about the design of learning social arithmetic using the traditional game *Kubuk Manuk* at the school.

The results of observations made by the researcher are then discussed together with the teacher. This was done to see the potential implementation of social arithmetic learning designs using the traditional *Kubuk Manuk* game at Lukman Hakim Middle School by adjusting the curriculum used by the school and the students' circumstances. The results of the discussion are then used as a basis in making a prototype Hypothetical Learning Trajectory (HLT) presented in Table 1.

Table 1. Learning Trajectory, Student Activities, and the Social Arithmetic Concept

Students' Learning Trajectory	Learning Activities	The Social Arithmetic Concept
Informal Activities	Level One of the *Kubuk Manuk* Game (The seeds used by each player are the same)	Capital (Expenditures) and Results (Revenue)
Connecting Activities	Level Two of the *Kubuk Manuk* Game (The seeds used by each player are different)	Profit and loss
Formal Activities	Level Three of the *Kubuk Manuk* Game (The seeds used by each player are different and must be bought with money)	Selling price, purchase price and the percentage of profit and loss

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HLT is then developed in every learning activity. The development is based on the material hypothesized learning trajectory and the concept maps that students must go through during the learning process. This development resulted in a hypothetical of student learning activities that would be completed within three meeting.

Teaching Experiment

In this teaching experiment phase, the learning trajectory that has been designed in the preliminary design phase is then implemented in the learning process. The purpose of this implementation is to explore and observe the students' strategies and thinking. There are two cycles in this phase. The first cycle is a pilot experiment that aims to evaluate and improve the learning trajectory that has been designed. The second cycle is the teaching experiment that aims to implement the evaluated and revised learning trajectory in the pilot experiment.

Analysis Retrospective

In this phase, all the data collected in experimental design will be analyzed by comparing the conjecture in HLT with the results of implementing the learning trajectory that has been done in the experimental design phase. Data analysis was carried out by researchers and worked together with her supervisor to improve the validity of this study. Therefore, the description of learning trajectory using *Kubuk Manuk* Indonesian traditional game will subsequently be obtained. The result of a design research is not design that works but the underlying principles explaining how and why this design works (Wijaya, 2008). In retrospective analysis the role of HLT has been designed compared to the learning process carried out by students so that an investigation can be carried out and explained how students obtain the concepts of social arithmetic concept generated from the *Kubuk Manuk* game.

RESULTS and DISCUSSION

The results of this study showed the implementation of the learning trajectory design of social arithmetic using the *Kubuk Manuk* traditional game as the starting point in the learning process. The learning trajectory consists of three activities, namely the activities of playing the *Kubuk Manuk* games at levels 1, 2 and 3. The differences between the three activities are the number of seeds and the rules used in the game, and these are elaborated. The summary of all learning activities can be seen in Table 2.

Table 2. The Activities in Learning Social Arithmetic using *Kubuk Manuk* game

The Learning Social Arithmetic	The Learning Phases	The Learning Description
Learning about the concepts of income (revenue) and outcome (capital)	Students play *Kubuk Manuk* game level 1	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 1 f. Students work on student worksheet 1 g. Students and teachers discuss the results of the

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		game, the results of student worksheet 1 work and social arithmetic concepts learned in the game
Learning about the concept of profit and loss	Students play *Kubuk Manuk* game level 2	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 2 f. Students work on student worksheet 2 g. Students and teachers discuss the results of the game, the results of student worksheet 2 work and social arithmetic concepts learned in the game
Learning about selling price, purchase price and the percentage of profit and loss	Students play *Kubuk Manuk* game level 3	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 3 f. Students work on student worksheet 3 g. Students and teachers discuss the results of the game, the results of student worksheet 3 work and social arithmetic concepts learned in the game

Activity 1: Level One of the Kubuk Manuk Game

This activity begins by grouping the students into groups consisting of three to four students. The teacher then introduced the *Kubuk Manuk* traditional game and the rules used in the game. The beginning of this game is an important part of introducing the learning context to make it easier for the next activity. It also embeds the social values that can develop students' ability to interact effectively with their social environment and improve the students' sportsmanship when doing an activity that is competitive in accordance with the standard competencies in Indonesian education.

To introduce this game the teacher starts by explaining that the *Kubuk Manuk* game originates from Java and explains the rules of the game that each member of the group must collect a kind of beans namely *benguk* seeds as the capital of the game, and the number of seeds must be the same. The students will grasp all the seeds in the left hand and shaken above the right hand. Then, a few seeds are thrown into the right-hand grip and the other players in the group have to make a guess. If none of the students are able to guess it, the students must spread the seeds and count using both fingers. The introduction of the game is accompanied with a simulation done by the teacher in front of the class with a few students, as shown in Figure 1.

Figure 1. Simulation of the *Kubuk Manuk* game

After the simulation finished, the students play *Kubuk Manuk* level 1 together with their respective groups, as shown in Figure 2. Students already understand how to play *Kubuk Manuk* level 1.

Figure 2. Student playing the *Kubuk Manuk* game

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It is to make a compilation to determine the leading players and opposing players, then collect the same amount of capital each player. Furthermore, the main player sings the level 1 *Kubuk Manuk* song while moving the seeds from the right-hand grip to the leading player's left hand. If not guessed then the player spreads the seeds and picks them using the index finger. Also, students help each other in playing the game even though they compete with each other to win. Seen from the attitude of student A that helps student B to grab the seeds used for the game so as not to be scattered. Its is following the purpose of choosing an ethnomathematics-based context in this learning design that is to develop student character based on values that can be drawn from the game.

Next, the students began playing the *Kubuk Manuk* game with their respective group, and the students discuss and solve the problems contained in the worksheets that have been given as can be seen in Figure 3. The capital data and results are written in the table provided in the student worksheet.

Figure 3. Student discuss the problem in the worksheet

The problem in the worksheet requires the students to determine the scores obtained by each student in the group and decide who win and who lose the game. Figure 4 shows that students have been able to identify capital (income) and results (outcome). Students can also determine the score of each player and can determine the player who wins and lose from the number of seeds obtained. Students then conduct a group discussion to solve the problems that exist in student worksheet which is about how to determine the player's score and determine the players who win and lose.

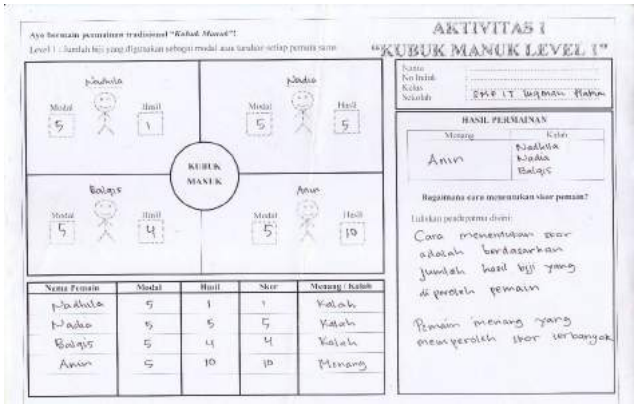

Figure 4. The results of the students' worksheet from the first activity

Furthermore, students are required to present the results in front of the class. The teacher chooses one of the groups to present their work in front of the class as shown in Figure 5.

Figure 5. Students presenting the results

The following is an excerpt from the dialogue of one group when presenting the results of their presentation in front of the class.

Student : *"Jadi kita akan mempresentasikan tentang hasil permainan kita hari ini, jadi kelompok kita ngelakuin dua kali permainan, hasil yang pertama pemenangnya adalah Salima"*
[We will present about the results of our game today, so our group has done two games, the winner of the first result is Salima"]

Teacher : *"Modalnya dulu, modalnya"*
[First capital, their capital]

Student : *"Salima, modal sepuluh dan hasil dua puluh satu, berarti untungnya sebelas. Terus ronde kedua modalnya lima belas yang menang salima lagi, dia dapat dua puluh satu. Dan yang ketiga dengan modal dua puluh pemenangnya adalah alin dengan hasil empat puluh enam. Jadi cara menentukan skor itu dilihat dari hasil mainnya. Kalau dia kalah maka dia dapat skor nol, kalau dia menang maka ia dapat skor satu"*
[Salima, the capital is ten and the income is twenty-one, means the income is eleven. Then in the second round of capital is fifteen and the winner is Salima again, he got twenty-one. And the third one with the capital is twenty and the winners is Alin with the income is forty-six. So, the way to determine the score is seen from the results of the game. If she loses, her score is zero; If she wins, her score is one].

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Based on the dialogue, it can be seen that through a process of playing *Kubuk Manuk* level 1 students have been able to understand the definition of capital and income. Students revealed that "*the capital is ten and the income is twenty-one*"; it can be seen that students have understood that 10 seeds collected or issued by players to play the *Kubuk Manuk* game are capital and 21 seeds obtained from a playing process the *Kubuk Manuk* game are income.

Students have also been able to predict how to determine player scores based on their thinking and understanding of the concepts of capital and income. It can be seen from the students' answers, "*So the way to determine the score is seen from the results of the game*". The ability of students to predict the player's score, shows that an indicator of students' mathematical understanding has been reached (Wijaya, 2008; Prahmana & Suwasti, 2014;

Ginting et al., 2018). Furthermore, the students also revealed "*the income is eleven*"; it means that the development of students' understanding in the group had reached the relationship of capital and income. The answer "*eleven*" is obtained by students by subtracting the outcome with capital. Students have also been able to define that "*eleven*" is the benefit of Salima.

Students have been able to see the relationship between capital, outcome, and income, because before learning activities take place students have followed the school program that is market day. In the program, students are given capital to carry out a particular business and the teacher is also accustomed to introducing terms such as capital gains and profits to students in implementing the program (Madani et al., 2018).

In the dialogue the students revealed "*If she loses, her score is zero; If she wins, her score is one* "; the answer of this student is beyond the predictions of the researcher. In HLT, researchers only predict students will answer the score with 'results' or with 'results reduced by capital' (Gravemeijer & Cobb, 2006; Gravemeijer & van Eerde, 2009; Prahmana et al., 2012). The students' answers are influenced by the experience of students outside of learning when playing games on mobile phones or when looking at a match that is when winning it will get a score of one and lose the score zero. Students perceive that the rules for determining the score used in this game are the same as those used in a game or match.

The class discussions with the teacher in order to get the same students' perceptions about the solutions of the problems in the worksheet and about the mathematical concepts that can be learned from this game (refer to Figure 6). From the class discussions, similar perceptions were achieved among the students in which the seed capital used in the game is 'outcome' and the seeds obtained in the game are 'income'. Hence, from this activity, the students learnt about the mathematics concepts of outcome and income.

Figure 6. Class Discussion

Activity 2: Level Two of the Kubuk Manuk Game

The second activity is the same as the first activity, but the number of seeds used as the capital of the game is different for each player. The game begins with a simulation by the teacher, and the students continue to practice the game in their group (refer to Figure 7). Then the students discuss and solve the problem in the worksheets. The problem in the second activity worksheet is no different from the problems in the first activity worksheet that is determining the scores obtained by each player and determining the winning and losing players in the game if the seed capital used is different for each player.

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Figure 7. Playing the *Kubuk Manuk* Game Level 2

Furthermore, in the class discussions, similar perceptions were obtained as in the first activity. However, the students must find another way to find the value of the game capital. They will need to find the value of profit or loss by subtracting the number of seeds obtained in the game by the number of seeds used as game capital. The resulting subtraction is considered as a score. The students who get the results of the subtraction will obtain a positive value. The number of seeds received more significant than the number of seeds used as game capital. On the other hands, the income is higher than the expenditure. Hence the students will receive the profits. Otherwise, the students who achieved a negative result from the subtraction will indicate that the number of seeds collected is less than the number of seeds used as capital. On the other hands, the income is less than the expenditure, and this will mean that the students get a loss. If a student gets a zero as a result of the subtraction or if the number of seeds obtained is equal to the number of seeds used as game capital, or if the income is equal to the expenditure, that means the students have obtained capital return. From this second activity, the students learnt about the mathematics concept of profits, loss and the relationship between them, as indicated in Figure 8.

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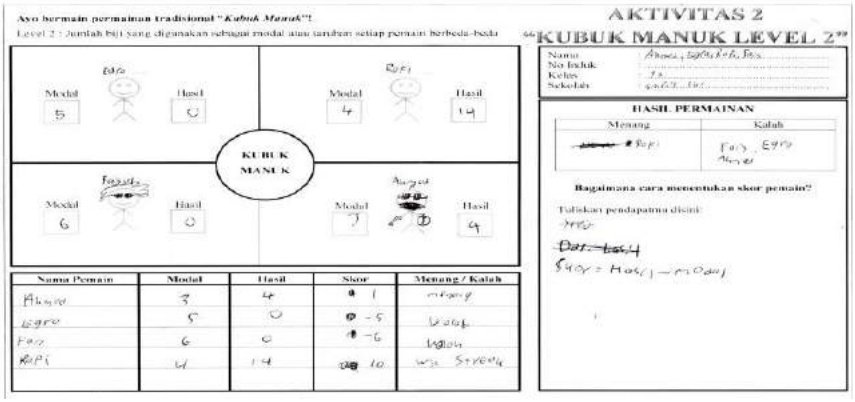

Figure 8. The Results of the Students' Worksheet in the Second Activity

Activity 3: Level Three of the Kubuk Manuk Game

The third level of the *Kubuk Manuk* game is the modified version of the original *Kubuk Manuk* game. In this level, the seeds are used in the game, and the capital must be purchased first. There are two types of groups, which are the seller group and the player group. The seller group has a role in selling the seeds that will be used in the game. They also buy the seeds that have been obtained by a player in the game. Similar to the previous activity, this third activity begins with a simulation. Then, the teacher will give the toy's money to each member of the player group to buy the seeds that will be used as game capital. After that, students play the game with their groups.

Once the game is completed, each player sells the seeds that have been obtained in the game to the seller groups. The students discuss and solve the problems in the worksheet and present the results in front of the class. The problem in the worksheet of the third activity is to determine the player's score in the game and also to determine the winning and losing players in the game. In the class discussion, the same perception was obtained in which the money used to buy the seeds that are referred to as the game capital is called cost and the money collected from selling the seeds is called purchase. Furthermore, the subtracting of the purchase with the cost is to determine the player's score. The winning player is the player who obtains the most profit shown in Figure 9. The evaluation process of the students' learning that has been conducted was to find out the students' understanding of the concept of social arithmetic and the implementation to solve the problem in daily life. Consequently, from this activity, the students learn about the mathematics concepts of cost, purchase, profit, and loss in trading activity.

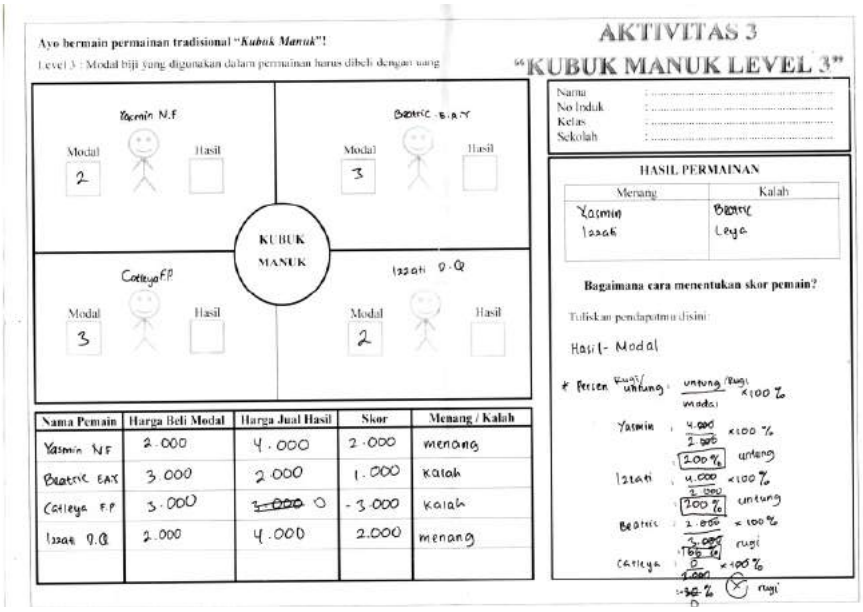

Figure 9. The Results of Students' Worksheet in the Third Activity

After the social arithmetic learning activities using the traditional *Kubuk Manuk* game were completed, the researcher gave a final evaluation question to all students. It is to find out their understanding in understanding the concept of social arithmetic (Madani et al., 2018; Van

Den Heuvel-Panhuizen, 2005). Final evaluation questions are made based on three student understanding indicators. Firstly, students can understand the concepts of income (results) and outcome (capital). Students can understand the idea of profit and loss. Lastly, students can understand the idea of the selling price, purchase price, and the percentage of profit and loss.

The results of the evaluation questions given to students can be seen that, overall, the average score of students in good categories. It means that students understand the concept of social arithmetic, namely income, outcome, profit, loss, selling price, purchase price, and the percentage of profit and loss. Therefore, the *Kubuk Manuk* game has a useful context as a context used to create ethnomathematics-based learning designs to students' understanding of the concept of social arithmetic.

CONCLUSION

The results of this study indicates that in the learning of social arithmetic, the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. The students were able to understand the concept of mathematics easily since it is fun for them and importantly, the game is relatable to activities in their daily life. This study was able to take on the role in developing the learning trajectory of social arithmetic learning by using the *Kubuk Manuk* Indonesian traditional game as the local context of learning.

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The game introduced students the concepts such as profit, cost, puchase and so on. However, the study does not provide any evidence if the students gained understanding of these concepts, because there are not a pre and a post test. There are worksheets used by the students that could be considered as a post test. However, as I understood from the manuscript, these worksees were not used by the authors to evaluate students' understanding of these concepts after implemantation of the game.

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The Learning Trajectory of Social Arithmetic Using an Indonesian Traditional Game

Endonezya Geleneksel Oyununu Kullanarak Sosyal Aritmetik Öğrenmenin Öğrenme Yolu

Abstract: Indonesia has many traditional games that can be used as a starting point in learning mathematics, i.e., social arithmetic. However, the teacher always used a conventional method such as direct teaching in teaching mathematics. Several researchers said that this method made mathematics learning boring. Therefore, this study aims to design a mathematics learning trajectory in social arithmetic using a traditional Indonesian game called the *Kubuk Manuk*. This game was used as the starting point in the learning process by applying the Indonesian Realistic Mathematics Education approach. The research method used is design research consisted of three stages, namely preliminary design, teaching experiment, and retrospective analysis. The results of this study indicate that the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. With the use of the *Kubuk Manuk* Indonesian traditional game, the students are stimulated to understand their knowledge of the social arithmetic concept. Additionally, the stages in the learning trajectory have essential roles in understanding the mathematics concepts of expenditure, income, profits, and loss within the trading activities.
Keywords: Design research, learning trajectory, Indonesian traditional games, social arithmetic learning, mathematics concepts

Öz: Endonezya'da matematik öğrenmede, yani sosyal aritmetikte bir başlangıç noktası olarak kullanılabilecek birçok geleneksel oyun vardır. Ancak, öğretmen her zaman matematik öğretiminde doğrudan öğretim gibi geleneksel bir yöntem kullanmıştır. Birkaç araştırmacı, bu yöntemin matematik öğrenmeyi sıkıcı hale getirdiğini söyledi. Bu nedenle bu çalışma, *Kubuk Manuk* adlı geleneksel bir Endonezya oyununu kullanarak sosyal aritmetikte matematik öğrenme yörüngesini tasarlamayı amaçlamaktadır. Bu oyun Endonezya Gerçekçi Matematik Eğitimi yaklaşımı uygulanarak öğrenme sürecinde başlangıç noktası olarak kullanılmıştır. Kullanılan araştırma yöntemi, tasarım araştırması, ön tasarım, öğretim deneyi ve geriye dönük analiz olmak üzere üç aşamadan oluşmaktadır. Bu çalışmanın sonuçları, öğrenme yörüngesinin, kültür veya öğrencilerin günlük aktivitelerinde kolayca bulunan diğer şeyler gibi yerel bağlamlar kullanılarak uygulanabileceğini göstermektedir. *Kubuk Manuk* Endonezya geleneksel oyununun kullanılmasıyla, öğrenciler sosyal aritmetik kavramı hakkındaki bilgilerini anlamaları için teşvik edilir. Ek olarak, öğrenme yörüngesindeki aşamalar, işlemlerin matematiksel harcama, gelir, kar ve zarar kavramlarını anlamada önemli rollere sahiptir.
Anahtar Sözcükler: Tasarım araştırması, yörüngeyi öğrenme, Endonezya geleneksel oyunları, sosyal aritmetik öğrenme, matematik kavramları

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INTRODUCTION

The development and application of the mathematics concept daily problems is part of a student's learning process (Prahmana et al., 2012; Tanujaya et al., 2017; Madani et al., 2018). Freudenthal (1991) explained that mathematics is a human activity and must be related to daily life. However, mathematics in schools tend to be taught using practical formulas in reality (Arisetyawan et al., 2014). Most often, not seamlessly associated with everyday life and culture, as should be experienced by the students (Stacey, 2011; Nurhasanah et al., 2017). The society, including the teachers, generally does not regard mathematics to be related to culture, and the learning of mathematics in the classroom can also be regarded with almost having no relation to culture. Culture is part of a student's life that may guide the way a student learns and regard mathematics (Revina, 2017; Revina & Leung, 2019). Its may significantly influence the student's ability to solve mathematics projects that relate to daily life.

The results of the Programme for International Student Assessment (PISA) for Indonesia showed that the students' abilities to solve and interpret problems are still considered at a low level (Stacey, 2011). Subsequently, Abrantes (2001) and Sembiring et al. (2010) suggested the appropriate strategies and learning methods. There are needed to develop students' thinking ability that orientate towards technical skills and the reformation of mathematics education based on problem-solving in daily life (Sembiring et al. 2010). The learning method suggested to solve these problems is the Pendidikan Matematika Realistik Indonesia (PMRI), which is an adaptation of the Realistic Mathematics Education (RME) (Prahmana et al., 2012; Tanujaya et al., 2017; Ginting et al., 2018). PMRI is a movement to reform mathematics education in Indonesia (Sembiring et al., 2008). It does not just implement a new way of teaching and learning mathematics, but also is associated with a drive to achieve social transformation within Indonesia (Sembiring et al., 2010). Therefore, this research used PMRI as a learning approach to solve this problem.

The one of the contexts that can be used in PMRI is a culture that is applied into realistic mathematics learning and modified according to the local context where the school is located (Gravemeijer & Doorman, 1999; Van Den Heuvel-Panhuizan, 2005; Haris & Putri, 2011; Oktiningrum et al., 2016; Jannah & Prahmana, 2019). Consequently, it may result in exciting contextual learning if it is to be taught in schools. It may increase the students' ability to solve a problem that has a relation to their daily life. Also, the cultural context can also be a solution to the lost cultural values and character of a student due to the influence of modernization (Muhtadi et al., 2017; Risdiyanti & Prahmana, 2018; Maryati & Prahmana, 2019).

The *Kubuk Manuk* is one of the traditional Indonesian games as a cultural context. This games could be the context as an innovation of mathematics learning that orientates to the reformation of learning mathematics. This context was chosen mainly because of its familiarity with the participants. It is from the perspectives of culture as well as their daily life. Prahmana et al. (2012) stated that traditional games are fun as they contained concepts of mathematics for learning purposes and aspects of cultural values. Therefore, this research design a social arithmetic learning using the context of the *Kubuk Manuk* as the starting point and also one of the traditional games in Indonesia.

The design of the *Kubuk Manuk* game is expected to be innovative in terms of learning mathematics. Furthermore, the concept will be easy for students to understand, thus enabling them to solve any daily-related problems. Therefore, this design is expected to cultivate and develop the cultural values that may influence a student's character.

METHOD

This study utilized design research as the research method. The research aims to improve the quality of classroom learning practice. It is through an interactive analysis of the hypothesis condition that will include student thinking that occurs in their learning with what happens in

the classroom (Gravemeijer, 1994; Gravemeijer & Cobb, 2006). Simonson (2006) defined design research as a systematic and flexible method that aims to improve the quality of education. Design research is also defined as a method that seeks to develop or validate a theory about the learning process that aims in cultivating the Local Instruction Theory (LIT). LIT is a theory about the process by which students learn a mathematical topic and conjecture about the media or devices used in helping the learning process of the issue (Gravemeijer & van Eerde, 2009). There are three phases of design research namely preliminary design, teaching experiment and retrospective analysis (Bakker, 2004; Gravameijer & Cobb, 2006). For more detail, this paper presented in the next part.

Preliminary Design

Gravemeijer and Cobb (2006) explained that the preliminary design phase aims to formulate the LIT that is elaborated and refined in the experimental design phase. The activities in this phase are choosing a teacher model to teach in the learning process. Next, the literature review of the social arithmetic concepts and PMRI discusses to design the learning process. Lastly, the researcher intends the learning trajectory and developing conjecture to be a Hypothetical Learning Trajectory (HLT) through the curriculum of Indonesian mathematics education. Hypothetical learning trajectory is a theoretical model for the design of mathematics instruction consisting of three components, a learning goal, a set of learning tasks, and a hypothesized learning process (Van den Akker et al., 2006). In this case, the conjecture functions as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the experimental design phase.

After conducting a literature study, the researcher made observations at the Lukman Al Hakim Integrated Islamic Middle School, Yogyakarta to see the students' initial abilities, culture and experiences, the curriculum used at school, the learning models that have been used by teachers and to observe the potential for implementing early ideas of researchers about the design of learning social arithmetic using the traditional game *Kubuk Manuk* at the school.

The results of observations made by the researcher are then discussed together with the teacher. This was done to see the potential implementation of social arithmetic learning designs using the traditional *Kubuk Manuk* game at Lukman Hakim Middle School by adjusting the curriculum used by the school and the students' circumstances. The results of the discussion are then used as a basis in making a prototype Hypothetical Learning Trajectory (HLT) presented in Table 1.

Table 1. Learning Trajectory, Student Activities, and the Social Arithmetic Concept

Students' Learning Trajectory	Learning Activities	The Social Arithmetic Concept
Informal Activities	Level One of the *Kubuk Manuk* Game (The seeds used by each player are the same)	Capital (Expenditures) and Results (Revenue)
Connecting Activities	Level Two of the *Kubuk Manuk* Game (The seeds used by each player are different)	Profit and loss
Formal Activities	Level Three of the *Kubuk Manuk* Game (The seeds used by each player are different and must be bought with money)	Selling price, purchase price and the percentage of profit and loss

HLT is then developed in every learning activity. The development is based on the material hypothesized learning trajectory and the concept maps that students must go through during the learning process. This development resulted in a hypothetical of student learning activities that would be completed within three meeting.

Teaching Experiment

In this teaching experiment phase, the learning trajectory that has been designed in the preliminary design phase is then implemented in the learning process. The purpose of this implementation is to explore and observe the students' strategies and thinking. There are two cycles in this phase. The first cycle is a pilot experiment that aims to evaluate and improve the learning trajectory that has been designed. The second cycle is a teaching experiment that aims to implement the evaluated and revised learning trajectory in the pilot experiment.

Analysis Retrospective

In this phase, all the data collected in experimental design will be analyzed by comparing the conjecture in HLT with the results of implementing the learning trajectory that has been done in the experimental design phase. Data analysis was carried out by researchers and worked together with her supervisor to improve the validity of this study. Therefore, the description of learning trajectory using *Kubuk Manuk* Indonesian traditional game will subsequently be obtained. The result of a design research is not design that works but the underlying principles explaining how and why this design works (Wijaya, 2008). In retrospective analysis the role of HLT has been designed compared to the learning process carried out by students so that an investigation can be carried out and explained how students obtain the concepts of social arithmetic concept generated from the *Kubuk Manuk* game.

RESULTS and DISCUSSION

The results of this study showed the implementation of the learning trajectory design of social arithmetic using the *Kubuk Manuk* traditional game as the starting point in the learning process. The learning trajectory consists of three activities, namely the activities of playing the *Kubuk Manuk* games at levels 1, 2 and 3. The differences between the three activities are the number of seeds and the rules used in the game, and these are elaborated. The summary of all learning activities can be seen in Table 2.

Table 2. The Activities in Learning Social Arithmetic using *Kubuk Manuk* game

The Learning Social Arithmetic	The Learning Phases	The Learning Description
Learning about the concepts of income (revenue) and outcome (capital)	Students play *Kubuk Manuk* game level 1	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 1 f. Students work on student worksheet 1 g. Students and teachers discuss the results of the

		game, the results of student worksheet 1 work and social arithmetic concepts learned in the game
Learning about the concept of profit and loss	Students play *Kubuk Manuk* game level 2	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 2 f. Students work on student worksheet 2 g. Students and teachers discuss the results of the game, the results of student worksheet 2 work and social arithmetic concepts learned in the game
Learning about selling price, purchase price and the percentage of profit and loss	Students play *Kubuk Manuk* game level 3	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 3 f. Students work on student worksheet 3 g. Students and teachers discuss the results of the game, the results of student worksheet 3 work and social arithmetic concepts learned in the game

Activity 1: Level One of the Kubuk Manuk Game

This activity begins by grouping the students into groups consisting of three to four students. The teacher then introduced the *Kubuk Manuk* traditional game and the rules used in the game. The first game is an important part of introducing the learning context to make it easier for the next activity. It also embeds the social values that can develop students' ability to interact effectively with their social environment and improve the students' sportsmanship when doing an activity that is competitive in accordance with the standard competencies in Indonesian education.

To introduce this game the teacher starts by explaining that the *Kubuk Manuk* game originates from Java and explains the rules of the game that each member of the group must collect a kind of beans namely *benguk* seeds as the capital of the game, and the number of seeds must be the same. The students will grasp all the seeds in the left hand and shaken above the right hand. Then, a few seeds are thrown into the right-hand grip and the other players in the group have to make a guess. If none of the students are able to guess it, the students must spread the seeds and count using both fingers. The introduction of the game is accompanied with a simulation done by the teacher in front of the class with a few students, as shown in Figure 1.

Figure 1. Simulation of the *Kubuk Manuk* game

After the simulation finished, the students play *Kubuk Manuk* level 1 together with their respective groups, as shown in Figure 2. Students already understand how to play *Kubuk Manuk* level 1.

Figure 2. Student playing the *Kubuk Manuk* game

It is to make a compilation to determine the leading players and opposing players, then collect the same amount of capital each player. Furthermore, the main player sings the level 1 *Kubuk Manuk* song while moving the seeds from the right-hand grip to the leading player's left hand. If not guessed then the player spreads the seeds and picks them using the index finger. Also, students help each other in playing the game even though they compete with each other to win. Seen from the attitude of student A that helps student B to grab the seeds used for the game so as not to be scattered. Its is following the purpose of choosing an ethnomathematics-based context in this learning design that is to develop student character based on values that can be drawn from the game.

Next, the students began playing the *Kubuk Manuk* game with their respective group, and the students discuss and solve the problems contained in the worksheets that have been given as can be seen in Figure 3. The capital data and results are written in the table provided in the student worksheet.

Figure 3. Student discuss the problem in the worksheet

The problem in the worksheet requires the students to determine the scores obtained by each student in the group and decide who win and who lose the game. Figure 4 shows that students have been able to identify capital (income) and results (outcome). Students can also determine the score of each player and can determine the player who wins and lose from the number of seeds obtained. Students then conduct a group discussion to solve the problems that exist in student worksheet which is about how to determine the player's score and determine the players who win and lose.

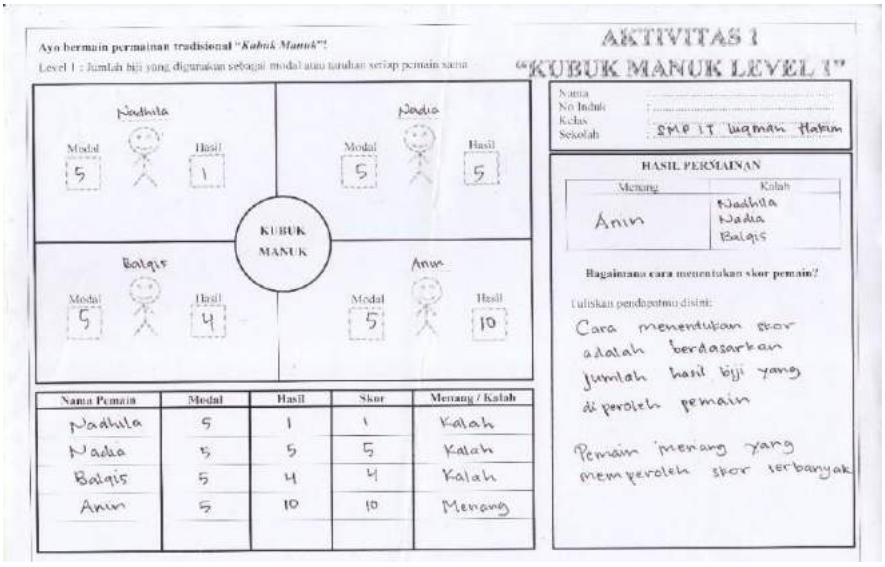

Figure 4. The results of the students' worksheet from the first activity

Furthermore, students are required to present the results in front of the class. The teacher chooses one of the groups to present their work in front of the class as shown in Figure 5.

Figure 5. Students presenting the results

The following is an excerpt from the dialogue of one group when presenting the results of their presentation in front of the class.

Student : *"Jadi kita akan mempresentasikan tentang hasil permainan kita hari ini, jadi kelompok kita ngelakuin dua kali permainan, hasil yang pertama pemenangnya adalah Salima"*
[We will present about the results of our game today, so our group has done two games, the winner of the first result is Salima"]

Teacher : *"Modalnya dulu, modalnya"*
[First capital, their capital]

Student : *"Salima, modal sepuluh dan hasil dua puluh satu, berarti untungnya sebelas. Terus ronde kedua modalnya lima belas yang menang salima lagi, dia dapat dua puluh satu. Dan yang ketiga dengan modal dua puluh pemenangnya adalah alin dengan hasil empat puluh enam. Jadi cara menentukan skor itu dilihat dari hasil mainnya. Kalau dia kalah maka dia dapat skor nol, kalau dia menang maka ia dapat skor satu"*
[Salima, the capital is ten and the income is twenty-one, means the income is eleven. Then in the second round of capital is fifteen and the winner is Salima again, he got twenty-one. And the third one with the capital is twenty and the winners is Alin with the income is forty-six. So, the way to determine the score is seen from the results of the game. If she loses, her score is zero; If she wins, her score is one].

Based on the dialogue, it can be seen that through a process of playing *Kubuk Manuk* level 1 students have been able to understand the definition of capital and income. Students revealed that "*the capital is ten and the income is twenty-one*"; it can be seen that students have understood that 10 seeds collected or issued by players to play the *Kubuk Manuk* game are capital and 21 seeds obtained from a playing process the *Kubuk Manuk* game are income.

Students have also been able to predict how to determine player scores based on their thinking and understanding of the concepts of capital and income. It can be seen from the students' answers, "*So the way to determine the score is seen from the results of the game*". The ability of students to predict the player's score, shows that an indicator of students' mathematical understanding has been reached (Wijaya, 2008; Prahmana & Suwasti, 2014;

Ginting et al., 2018). Furthermore, the students also revealed "*the income is eleven*"; it means that the development of students' understanding in the group had reached the relationship of capital and income. The answer "*eleven*" is obtained by students by subtracting the outcome with capital. Students have also been able to define that "*eleven*" is the benefit of Salima.

Students have been able to see the relationship between capital, outcome, and income, because before learning activities take place students have followed the school program that is market day. In the program, students are given capital to carry out a particular business and the teacher is also accustomed to introducing terms such as capital gains and profits to students in implementing the program (Madani et al., 2018).

In the dialogue the students revealed "*If she loses, her score is zero; If she wins, her score is one* "; the answer of this student is beyond the predictions of the researcher. In HLT, researchers only predict students will answer the score with 'results' or with 'results reduced by capital' (Gravemeijer & Cobb, 2006; Gravemeijer & van Eerde, 2009; Prahmana et al., 2012). The students' answers are influenced by the experience of students outside of learning when playing games on mobile phones or when looking at a match that is when winning it will get a score of one and lose the score zero. Students perceive that the rules for determining the score used in this game are the same as those used in a game or match.

The class discussions with the teacher in order to get the same students' perceptions about the solutions of the problems in the worksheet and about the mathematical concepts that can be learned from this game (refer to Figure 6). From the class discussions, similar perceptions were achieved among the students in which the seed capital used in the game is 'outcome' and the seeds obtained in the game are 'income'. Hence, from this activity, the students learnt about the mathematics concepts of outcome and income.

Figure 6. Class Discussion

Activity 2: Level Two of the Kubuk Manuk Game

The second activity is the same as the first activity, but the number of seeds used as the capital of the game is different for each player. The game begins with a simulation by the teacher, and the students continue to practice the game in their group (refer to Figure 7). Then the students discuss and solve the problem in the worksheets. The problem in the second activity worksheet is no different from the problems in the first activity worksheet that is determining the scores obtained by each player and determining the winning and losing players in the game if the seed capital used is different for each player.

Figure 7. Playing the *Kubuk Manuk* Game Level 2

Furthermore, in the class discussions, similar perceptions were obtained as in the first activity. However, the students must find another way to find the value of the game capital. They will need to find the value of profit or loss by subtracting the number of seeds obtained in the game by the number of seeds used as game capital. The resulting subtraction is considered as a score. The students who get the results of the subtraction will obtain a positive value. The number of seeds received more significant than the number of seeds used as game capital. On the other hands, the income is higher than the expenditure. Hence the students will receive the profits. Otherwise, the students who achieved a negative result from the subtraction will indicate that the number of seeds collected is less than the number of seeds used as capital. On the other hands, the income is less than the expenditure, and this will mean that the students get a loss. If a student gets a zero as a result of the subtraction or if the number of seeds obtained is equal to the number of seeds used as game capital, or if the income is equal to the expenditure, that means the students have obtained capital return. From this second activity, the students learnt about the mathematics concept of profits, loss and the relationship between them, as indicated in Figure 8.

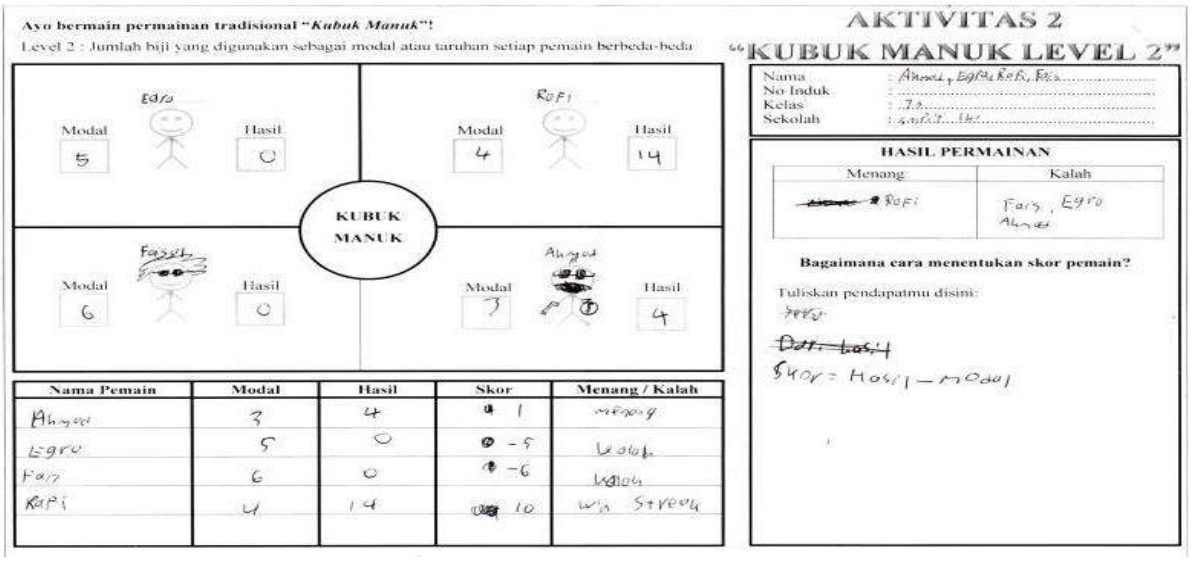

Figure 8. The Results of the Students' Worksheet in the Second Activity

Activity 3: Level Three of the Kubuk Manuk Game

The third level of the *Kubuk Manuk* game is the modified version of the original *Kubuk Manuk* game. In this level, the seeds are used in the game, and the capital must be purchased first. There are two types of groups, which are the seller group and the player group. The seller group has a role in selling the seeds that will be used in the game. They also buy the seeds that have been obtained by a player in the game. Similar to the previous activity, this third activity begins with a simulation. Then, the teacher will give the toy's money to each member of the player group to buy the seeds that will be used as game capital. After that, students play the game with their groups.

Once the game is completed, each player sells the seeds that have been obtained in the game to the seller groups. The students discuss and solve the problems in the worksheet and present the results in front of the class. The problem in the worksheet of the third activity is to determine the player's score in the game and also to determine the winning and losing players in the game. In the class discussion, the same perception was obtained in which the money used to buy the seeds that are referred to as the game capital is called cost and the money collected from selling the seeds is called purchase. Furthermore, the subtracting of the purchase with the cost is to determine the player's score. The winning player is the player who obtains the most profit shown in Figure 9. The evaluation process of the students' learning that has been conducted was to find out the students' understanding of the concept of social arithmetic and the implementation to solve the problem in daily life. Consequently, from this activity, the students learn about the mathematics concepts of cost, purchase, profit, and loss in trading activity.

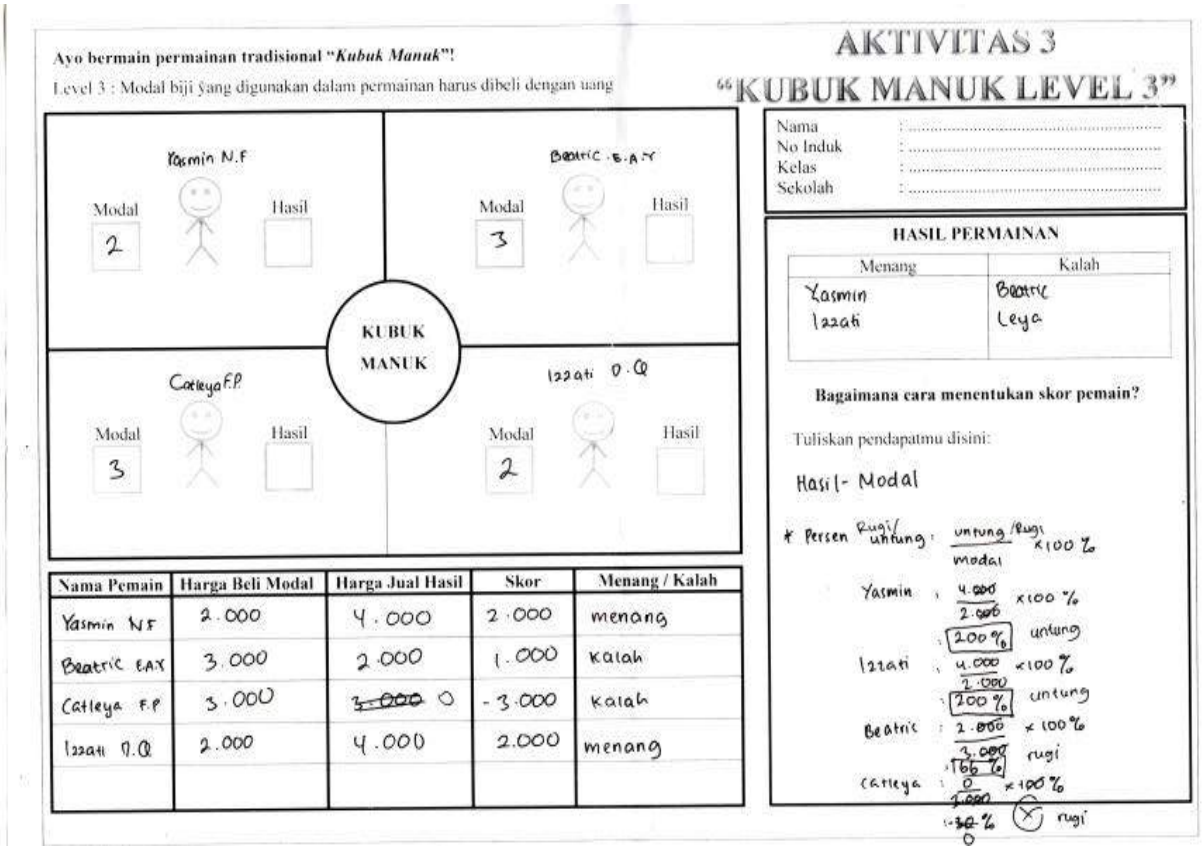

Figure 9. The Results of Students' Worksheet in the Third Activity

After the social arithmetic learning activities using the traditional *Kubuk Manuk* game were completed, the researcher gave a final evaluation question to all students. It is to find out their understanding in understanding the concept of social arithmetic (Madani et al., 2018; Van

Den Heuvel-Panhuizen, 2005). Final evaluation questions are made based on three student understanding indicators. Firstly, students can understand the concepts of income (results) and outcome (capital). Students can understand the idea of profit and loss. Lastly, students can understand the idea of the selling price, purchase price, and the percentage of profit and loss.

After the social arithmetic learning activities using the traditional *Kubuk Manuk* game were completed, the researcher gave a final evaluation question to all students to find out their understanding of the social arithmetic concept. The evaluation question is based on student understanding indicators that have been formulated in the mathematics textbook for Junior High School from the Indonesian Education Ministry. The explanation for each indicator of student understanding is as follows:

a. Students can understand the concepts of income (results) and outcome (capital)

All students are given evaluation questions that are done independently or not in groups. In the evaluation question one of them is about the concept of income and outcome. It is given to find out students' understanding of the concept. Questions in the evaluation questions regarding the concept of income and outcome along with examples of student answers are as follows:

Question 1:
Mr. Subur is a chicken porridge seller in the Jakarta area. As usual, every morning Mr. Subur goes to the market, shopping for staples to make chicken porridge. To buy these staples, Mr. Subur spent IDR 1,000,000. Then the staple is processed into chicken porridge, which is sold at IDR 10,000. On that day, Mr. Subur was able to sell 110 servings of chicken porridge. How much income did Mr. Subur get on that day?

Figure 10 shows that when presented a problem with social arithmetic, students have been able to identify outcome and income correctly. Almost all students answered correctly to the first question in the evaluation problem as in the example problem and the answer that shown in Figure 8.

Figure 10. The students answer for the first problem

Overall, the average student score for this question is 1.85 with an Ideal Maximum Score of 2. The assessment category is divided into 3 parts, namely first, 0 <= value <1 is included in the poor category; second, 1 <= value <2 is included in good category; and third, value = 2 is included in the excellent category. Therefore, the student's average score for this question falls into good category. So, it can be concluded that after students do social arithmetic learning using the *Kubuk Manuk* game, students can get good understanding in the concepts of income (capital) and outcome (results).

b. Students can understand the concept of profit and loss

In the evaluation questions also given questions to measure students' understanding of the second indicator that students are able to understand the concept of profit and loss. The question is as follows:
Question 2:
A businessman spends IDR 1,000,000 to run the business. In January, he bears a loss of IDR 250,000. So, how much income obtained in January?

Question 3:
An egg bean seller issued a capital of IDR 2,000,000 to run the business. Then, he sells his egg beans for IDR 2,000 per pack. If he targets to get a profit of IDR 200,000 from the business. So, what is the minimum package that must be sold by the seller?

Figure 11 explains that when presented a problem about social arithmetic, students have been able to correctly identify profit and loss as a result of income and outcome differences.

Almost all students answered correctly to the second and third question in the evaluation problem as in the example problem and the answer that shown in Figure 9.

Figure 11. Student answer for question 2 (left) and question 3 (right)

Overall, the average value of students for question 2 is 1.75 and the average value of students for question 3 is 1.70 with an Ideal Maximum Score of 2. So, it can be concluded that after students do social arithmetic learning using the *Kubuk Manuk* game students can finally understand the concept of profit and loss.

c. Students can understand the concept of selling price, buying price, and profit and loss percentages.

The students' understanding of third indicator that students are able to understand the concept of profit and loss measure in the last evaluation questions. The question is as follows:

Question 4:
Mr. Widodo buys a motorcycle at a price of IDR 4,000,000. Because of one day his son was sick and he needed money to pay for his son's treatment at the hospital. Then, He sold the motorbike at a price of IDR 4,200,000. Mr. Widodo experienced loss or gain? What is the percentage?

Question 5:
Mr. Anton bought the house at a price of IDR 50,000,000. Because of family problems, Mr. Anton was forced to sell the house at a loss of 5%. Determine the selling price of Mr. Anton's land?

Figure 12 describes the student answer presented a solution about social arithmetic problem namely percentages of loss and profit. Students have been able to correctly identify the selling price and purchase price and are able to calculate the percentage of profits and losses.

Figure 12. Student answer for question 4 (left) and question 5 (right)

Overall, the average score of students for question 4 is 1.6 and the average value of students for question 5 is 1.6 with an Ideal Maximum Score of 2. Therefore, it can be concluded that after students do social arithmetic learning using the *Kubuk Manuk* game. Students can understand the selling price, the purchase price, and the profit and loss percentage.

Finally, the results of the evaluation questions given to students can be seen that, overall, the average score of students in good categories. It means that students understand the concept of social arithmetic, namely income, outcome, profit, loss, selling price, purchase price, and the percentage of profit and loss. Therefore, the *Kubuk Manuk* game has a useful context as a tool used to create Ethnomathematics-based learning designs to students' understanding of the concept of social arithmetic.

CONCLUSION

The results of this study indicates that in the learning of social arithmetic, the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. The students were able to understand the concept of mathematics easily since it is fun for them and importantly, the game is relatable to activities in

their daily life. This study was able to take on the role in developing the learning trajectory of social arithmetic learning by using the *Kubuk Manuk* Indonesian traditional game as the local context of learning.

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The Learning Trajectory of Social Arithmetic Using an Indonesian Traditional Game

Endonezya Geleneksel Oyununu Kullanarak Sosyal Aritmetik Öğrenmenin Öğrenme Yolu

Abstract: Indonesia has many traditional games that can be used as a starting point in learning mathematics, i.e., social arithmetic. However, the teacher always used a conventional method such as direct teaching in teaching mathematics. Several researchers said that this method made mathematics learning boring. Therefore, this study aims to design a mathematics learning trajectory in social arithmetic using a traditional Indonesian game called the *Kubuk Manuk*. This game was used as the starting point in the learning process by applying the Indonesian Realistic Mathematics Education approach. The research method used is design research consisted of three stages, namely preliminary design, teaching experiment, and retrospective analysis. The results of this study indicate that the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. With the use of the *Kubuk Manuk* Indonesian traditional game, the students are stimulated to understand their knowledge of the social arithmetic concept. Additionally, the stages in the learning trajectory have essential roles in understanding the mathematics concepts of expenditure, income, profits, and loss within the trading activities.
Keywords: Design research, learning trajectory, Indonesian traditional games, social arithmetic learning, mathematics concepts

Öz: Endonezya'da matematik öğrenmede, yani sosyal aritmetikte bir başlangıç noktası olarak kullanılabilecek birçok geleneksel oyun vardır. Ancak, öğretmen her zaman matematik öğretiminde doğrudan öğretim gibi geleneksel bir yöntem kullanmıştır. Birkaç araştırmacı, bu yöntemin matematik öğrenmeyi sıkıcı hale getirdiğini söyledi. Bu nedenle bu çalışma, *Kubuk Manuk* adlı geleneksel bir Endonezya oyununu kullanarak sosyal aritmetikte matematik öğrenme yörüngesini tasarlamayı amaçlamaktadır. Bu oyun Endonezya Gerçekçi Matematik Eğitimi yaklaşımı uygulanarak öğrenme sürecinde başlangıç noktası olarak kullanılmıştır. Kullanılan araştırma yöntemi, tasarım araştırması, ön tasarım, öğretim deneyi ve geriye dönük analiz olmak üzere üç aşamadan oluşmaktadır. Bu çalışmanın sonuçları, öğrenme yörüngesinin, kültür veya öğrencilerin günlük aktivitelerinde kolayca bulunan diğer şeyler gibi yerel bağlamlar kullanılarak uygulanabileceğini göstermektedir. *Kubuk Manuk* Endonezya geleneksel oyununun kullanılmasıyla, öğrenciler sosyal aritmetik kavramı hakkındaki bilgilerini anlamaları için teşvik edilir. Ek olarak, öğrenme yörüngesindeki aşamalar, işlemlerin matematiksel harcama, gelir, kar ve zarar kavramlarını anlamada önemli rollere sahiptir.
Anahtar Sözcükler: Tasarım araştırması, yörüngeyi öğrenme, Endonezya geleneksel oyunları, sosyal aritmetik öğrenme, matematik kavramları

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INTRODUCTION

The development and application of the mathematics concept daily problems is part of a student's learning process (Prahmana et al., 2012; Tanujaya et al., 2017; Madani et al., 2018). Freudenthal (1991) explained that mathematics is a human activity and must be related to daily life. However, mathematics in schools tend to be taught using practical formulas in reality (Arisetyawan et al., 2014). Most often, not seamlessly associated with everyday life and culture, as should be experienced by the students (Stacey, 2011; Nurhasanah et al., 2017). The society, including the teachers, generally does not regard mathematics to be related to culture, and the learning of mathematics in the classroom can also be regarded with almost having no relation to culture. Culture is part of a student's life that may guide the way a student learns and regard mathematics (Revina, 2017; Revina & Leung, 2019). Its may significantly influence the student's ability to solve mathematics projects that relate to daily life.

The results of the Programme for International Student Assessment (PISA) for Indonesia showed that the students' abilities to solve and interpret problems are still considered at a low level (Stacey, 2011). Subsequently, Abrantes (2001) and Sembiring et al. (2010) suggested the appropriate strategies and learning methods. There are needed to develop students' thinking ability that orientate towards technical skills and the reformation of mathematics education based on problem-solving in daily life (Sembiring et al. 2010). The learning method suggested to solve these problems is the Pendidikan Matematika Realistik Indonesia (PMRI), which is an adaptation of the Realistic Mathematics Education (RME) (Prahmana et al., 2012; Tanujaya et al., 2017; Ginting et al., 2018). PMRI is a movement to reform mathematics education in Indonesia (Sembiring et al., 2008). It does not just implement a new way of teaching and learning mathematics, but also is associated with a drive to achieve social transformation within Indonesia (Sembiring et al., 2010). Therefore, this research used PMRI as a learning approach to solve this problem.

The one of the contexts that can be used in PMRI is a culture that is applied into realistic mathematics learning and modified according to the local context where the school is located (Gravemeijer & Doorman, 1999; Van Den Heuvel-Panhuizan, 2005; Haris & Putri, 2011; Oktiningrum et al., 2016; Jannah & Prahmana, 2019). Consequently, it may result in exciting contextual learning if it is to be taught in schools. It may increase the students' ability to solve a problem that has a relation to their daily life. Also, the cultural context can also be a solution to the lost cultural values and character of a student due to the influence of modernization (Muhtadi et al., 2017; Risdiyanti & Prahmana, 2018; Maryati & Prahmana, 2019).

The *Kubuk Manuk* is one of the traditional Indonesian games as a cultural context. This games could be the context as an innovation of mathematics learning that orientates to the reformation of learning mathematics. This context was chosen mainly because of its familiarity with the participants. It is from the perspectives of culture as well as their daily life. Prahmana et al. (2012) stated that traditional games are fun as they contained concepts of mathematics for learning purposes and aspects of cultural values. Therefore, this research design a social arithmetic learning using the context of the *Kubuk Manuk* as the starting point and also one of the traditional games in Indonesia.

The design of the *Kubuk Manuk* game is expected to be innovative in terms of learning mathematics. Furthermore, the concept will be easy for students to understand, thus enabling them to solve any daily-related problems. Therefore, this design is expected to cultivate and develop the cultural values that may influence a student's character.

METHOD

This study utilized design research as the research method. The research aims to improve the quality of classroom learning practice. It is through an interactive analysis of the hypothesis condition that will include student thinking that occurs in their learning with what happens in

the classroom (Gravemeijer, 1994; Gravemeijer & Cobb, 2006). Simonson (2006) defined design research as a systematic and flexible method that aims to improve the quality of education. Design research is also defined as a method that seeks to develop or validate a theory about the learning process that aims in cultivating the Local Instruction Theory (LIT). LIT is a theory about the process by which students learn a mathematical topic and conjecture about the media or devices used in helping the learning process of the issue (Gravemeijer & van Eerde, 2009). There are three phases of design research namely preliminary design, teaching experiment and retrospective analysis (Bakker, 2004; Gravameijer & Cobb, 2006). For more detail, this paper presented in the next part.

Preliminary Design

Gravemeijer and Cobb (2006) explained that the preliminary design phase aims to formulate the LIT that is elaborated and refined in the experimental design phase. The activities in this phase are choosing a teacher model to teach in the learning process. Next, the literature review of the social arithmetic concepts and PMRI discusses to design the learning process. Lastly, the researcher intends the learning trajectory and developing conjecture to be a Hypothetical Learning Trajectory (HLT) through the curriculum of Indonesian mathematics education. Hypothetical learning trajectory is a theoretical model for the design of mathematics instruction consisting of three components, a learning goal, a set of learning tasks, and a hypothesized learning process (Van den Akker et al., 2006). In this case, the conjecture functions as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the experimental design phase.

After conducting a literature study, the researcher made observations at the Lukman Al Hakim Integrated Islamic Middle School, Yogyakarta to see the students' initial abilities, culture and experiences, the curriculum used at school, the learning models that have been used by teachers and to observe the potential for implementing early ideas of researchers about the design of learning social arithmetic using the traditional game *Kubuk Manuk* at the school.

The results of observations made by the researcher are then discussed together with the teacher. This was done to see the potential implementation of social arithmetic learning designs using the traditional *Kubuk Manuk* game at Lukman Hakim Middle School by adjusting the curriculum used by the school and the students' circumstances. The results of the discussion are then used as a basis in making a prototype Hypothetical Learning Trajectory (HLT) presented in Table 1.

Table 1. Learning Trajectory, Student Activities, and the Social Arithmetic Concept

Students' Learning Trajectory	Learning Activities	The Social Arithmetic Concept
Informal Activities	Level One of the *Kubuk Manuk* Game (The seeds used by each player are the same)	Capital (Expenditures) and Results (Revenue)
Connecting Activities	Level Two of the *Kubuk Manuk* Game (The seeds used by each player are different)	Profit and loss
Formal Activities	Level Three of the *Kubuk Manuk* Game (The seeds used by each player are different and must be bought with money)	Selling price, purchase price and the percentage of profit and loss

HLT is then developed in every learning activity. The development is based on the material hypothesized learning trajectory and the concept maps that students must go through during the learning process. This development resulted in a hypothetical of student learning activities that would be completed within three meeting.

Teaching Experiment

In this teaching experiment phase, the learning trajectory that has been designed in the preliminary design phase is then implemented in the learning process. The purpose of this implementation is to explore and observe the students' strategies and thinking. There are two cycles in this phase. The first cycle is a pilot experiment that aims to evaluate and improve the learning trajectory that has been designed. The second cycle is a teaching experiment that aims to implement the evaluated and revised learning trajectory in the pilot experiment.

Analysis Retrospective

In this phase, all the data collected in experimental design will be analyzed by comparing the conjecture in HLT with the results of implementing the learning trajectory that has been done in the experimental design phase. Data analysis was carried out by researchers and worked together with her supervisor to improve the validity of this study. Therefore, the description of learning trajectory using *Kubuk Manuk* Indonesian traditional game will subsequently be obtained. The result of a design research is not design that works but the underlying principles explaining how and why this design works (Wijaya, 2008). In retrospective analysis the role of HLT has been designed compared to the learning process carried out by students so that an investigation can be carried out and explained how students obtain the concepts of social arithmetic concept generated from the *Kubuk Manuk* game.

RESULTS and DISCUSSION

The results of this study showed the implementation of the learning trajectory design of social arithmetic using the *Kubuk Manuk* traditional game as the starting point in the learning process. The learning trajectory consists of three activities, namely the activities of playing the *Kubuk Manuk* games at levels 1, 2 and 3. The differences between the three activities are the number of seeds and the rules used in the game, and these are elaborated. The summary of all learning activities can be seen in Table 2.

Table 2. The Activities in Learning Social Arithmetic using *Kubuk Manuk* game

The Learning Social Arithmetic	The Learning Phases	The Learning Description
Learning about the concepts of income (revenue) and outcome (capital)	Students play *Kubuk Manuk* game level 1	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 1 f. Students work on student worksheet 1 g. Students and teachers discuss the results of the

		game, the results of student worksheet 1 work and social arithmetic concepts learned in the game
Learning about the concept of profit and loss	Students play *Kubuk Manuk* game level 2	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 2 f. Students work on student worksheet 2 g. Students and teachers discuss the results of the game, the results of student worksheet 2 work and social arithmetic concepts learned in the game
Learning about selling price, purchase price and the percentage of profit and loss	Students play *Kubuk Manuk* game level 3	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 3 f. Students work on student worksheet 3 g. Students and teachers discuss the results of the game, the results of student worksheet 3 work and social arithmetic concepts learned in the game

Activity 1: Level One of the Kubuk Manuk Game

This activity begins by grouping the students into groups consisting of three to four students. The teacher then introduced the *Kubuk Manuk* traditional game and the rules used in the game. The first game is an important part of introducing the learning context to make it easier for the next activity. It also embeds the social values that can develop students' ability to interact effectively with their social environment and improve the students' sportsmanship when doing an activity that is competitive in accordance with the standard competencies in Indonesian education.

To introduce this game the teacher starts by explaining that the *Kubuk Manuk* game originates from Java and explains the rules of the game that each member of the group must collect a kind of beans namely *benguk* seeds as the capital of the game, and the number of seeds must be the same. The students will grasp all the seeds in the left hand and shaken above the right hand. Then, a few seeds are thrown into the right-hand grip and the other players in the group have to make a guess. If none of the students are able to guess it, the students must spread the seeds and count using both fingers. The introduction of the game is accompanied with a simulation done by the teacher in front of the class with a few students, as shown in Figure 1.

Figure 1. Simulation of the *Kubuk Manuk* game

After the simulation finished, the students play *Kubuk Manuk* level 1 together with their respective groups, as shown in Figure 2. Students already understand how to play *Kubuk Manuk* level 1.

Figure 2. Student playing the *Kubuk Manuk* game

It is to make a compilation to determine the leading players and opposing players, then collect the same amount of capital each player. Furthermore, the main player sings the level 1 *Kubuk Manuk* song while moving the seeds from the right-hand grip to the leading player's left hand. If not guessed then the player spreads the seeds and picks them using the index finger. Also, students help each other in playing the game even though they compete with each other to win. Seen from the attitude of student A that helps student B to grab the seeds used for the game so as not to be scattered. Its is following the purpose of choosing an ethnomathematics-based context in this learning design that is to develop student character based on values that can be drawn from the game.

Next, the students began playing the *Kubuk Manuk* game with their respective group, and the students discuss and solve the problems contained in the worksheets that have been given as can be seen in Figure 3. The capital data and results are written in the table provided in the student worksheet.

Figure 3. Student discuss the problem in the worksheet

The problem in the worksheet requires the students to determine the scores obtained by each student in the group and decide who win and who lose the game. Figure 4 shows that students have been able to identify capital (income) and results (outcome). Students can also determine the score of each player and can determine the player who wins and lose from the number of seeds obtained. Students then conduct a group discussion to solve the problems that exist in student worksheet which is about how to determine the player's score and determine the players who win and lose.

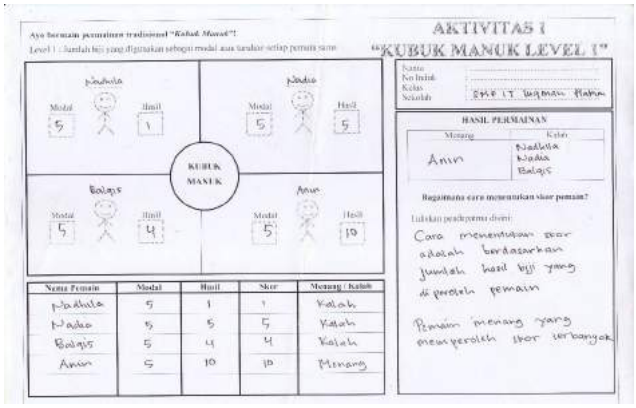


Figure 4. The results of the students' worksheet from the first activity

Furthermore, students are required to present the results in front of the class. The teacher chooses one of the groups to present their work in front of the class as shown in Figure 5.

Figure 5. Students presenting the results

The following is an excerpt from the dialogue of one group when presenting the results of their presentation in front of the class.

Student : *"Jadi kita akan mempresentasikan tentang hasil permainan kita hari ini, jadi kelompok kita ngelakuin dua kali permainan, hasil yang pertama pemenangnya adalah Salima"*
[We will present about the results of our game today, so our group has done two games, the winner of the first result is Salima"]

Teacher : *"Modalnya dulu, modalnya"*
[First capital, their capital]

Student : *"Salima, modal sepuluh dan hasil dua puluh satu, berarti untungnya sebelas. Terus ronde kedua modalnya lima belas yang menang salima lagi, dia dapat dua puluh satu. Dan yang ketiga dengan modal dua puluh pemenangnya adalah alin dengan hasil empat puluh enam. Jadi cara menentukan skor itu dilihat dari hasil mainnya. Kalau dia kalah maka dia dapat skor nol, kalau dia menang maka ia dapat skor satu"*
[Salima, the capital is ten and the income is twenty-one, means the income is eleven. Then in the second round of capital is fifteen and the winner is Salima again, he got twenty-one. And the third one with the capital is twenty and the winners is Alin with the income is forty-six. So, the way to determine the score is seen from the results of the game. If she loses, her score is zero; If she wins, her score is one].

Based on the dialogue, it can be seen that through a process of playing *Kubuk Manuk* level 1 students have been able to understand the definition of capital and income. Students revealed that "*the capital is ten and the income is twenty-one*"; it can be seen that students have understood that 10 seeds collected or issued by players to play the *Kubuk Manuk* game are capital and 21 seeds obtained from a playing process the *Kubuk Manuk* game are income.

Students have also been able to predict how to determine player scores based on their thinking and understanding of the concepts of capital and income. It can be seen from the students' answers, "*So the way to determine the score is seen from the results of the game*". The ability of students to predict the player's score, shows that an indicator of students' mathematical understanding has been reached (Wijaya, 2008; Prahmana & Suwasti, 2014;

Ginting et al., 2018). Furthermore, the students also revealed "*the income is eleven*"; it means that the development of students' understanding in the group had reached the relationship of capital and income. The answer "*eleven*" is obtained by students by subtracting the outcome with capital. Students have also been able to define that "*eleven*" is the benefit of Salima.

Students have been able to see the relationship between capital, outcome, and income, because before learning activities take place students have followed the school program that is market day. In the program, students are given capital to carry out a particular business and the teacher is also accustomed to introducing terms such as capital gains and profits to students in implementing the program (Madani et al., 2018).

In the dialogue the students revealed "*If she loses, her score is zero; If she wins, her score is one* "; the answer of this student is beyond the predictions of the researcher. In HLT, researchers only predict students will answer the score with 'results' or with 'results reduced by capital' (Gravemeijer & Cobb, 2006; Gravemeijer & van Eerde, 2009; Prahmana et al., 2012). The students' answers are influenced by the experience of students outside of learning when playing games on mobile phones or when looking at a match that is when winning it will get a score of one and lose the score zero. Students perceive that the rules for determining the score used in this game are the same as those used in a game or match.

The class discussions with the teacher in order to get the same students' perceptions about the solutions of the problems in the worksheet and about the mathematical concepts that can be learned from this game (refer to Figure 6). From the class discussions, similar perceptions were achieved among the students in which the seed capital used in the game is 'outcome' and the seeds obtained in the game are 'income'. Hence, from this activity, the students learnt about the mathematics concepts of outcome and income.

Figure 6. Class Discussion

Activity 2: Level Two of the Kubuk Manuk Game

The second activity is the same as the first activity, but the number of seeds used as the capital of the game is different for each player. The game begins with a simulation by the teacher, and the students continue to practice the game in their group (refer to Figure 7). Then the students discuss and solve the problem in the worksheets. The problem in the second activity worksheet is no different from the problems in the first activity worksheet that is determining the scores obtained by each player and determining the winning and losing players in the game if the seed capital used is different for each player.

Figure 7. Playing the *Kubuk Manuk* Game Level 2

Furthermore, in the class discussions, similar perceptions were obtained as in the first activity. However, the students must find another way to find the value of the game capital. They will need to find the value of profit or loss by subtracting the number of seeds obtained in the game by the number of seeds used as game capital. The resulting subtraction is considered as a score. The students who get the results of the subtraction will obtain a positive value. The number of seeds received more significant than the number of seeds used as game capital. On the other hands, the income is higher than the expenditure. Hence the students will receive the profits. Otherwise, the students who achieved a negative result from the subtraction will indicate that the number of seeds collected is less than the number of seeds used as capital. On the other hands, the income is less than the expenditure, and this will mean that the students get a loss. If a student gets a zero as a result of the subtraction or if the number of seeds obtained is equal to the number of seeds used as game capital, or if the income is equal to the expenditure, that means the students have obtained capital return. From this second activity, the students learnt about the mathematics concept of profits, loss and the relationship between them, as indicated in Figure 8.

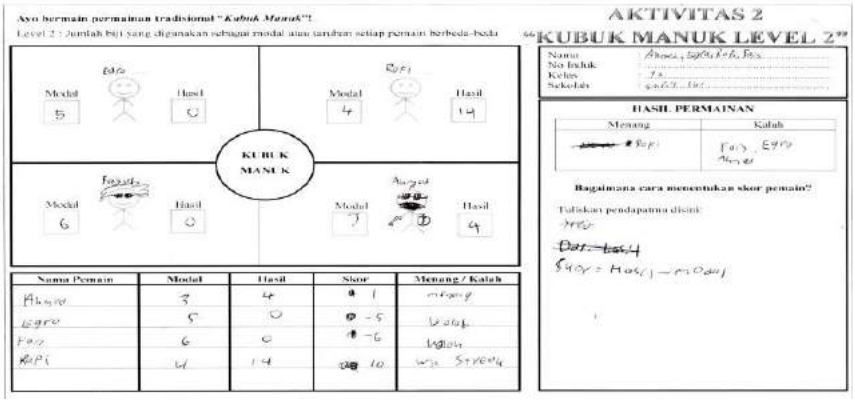


Figure 8. The Results of the Students' Worksheet in the Second Activity

Activity 3: Level Three of the Kubuk Manuk Game

The third level of the *Kubuk Manuk* game is the modified version of the original *Kubuk Manuk* game. In this level, the seeds are used in the game, and the capital must be purchased first. There are two types of groups, which are the seller group and the player group. The seller group has a role in selling the seeds that will be used in the game. They also buy the seeds that have been obtained by a player in the game. Similar to the previous activity, this third activity begins with a simulation. Then, the teacher will give the toy's money to each member of the player group to buy the seeds that will be used as game capital. After that, students play the game with their groups.

Once the game is completed, each player sells the seeds that have been obtained in the game to the seller groups. The students discuss and solve the problems in the worksheet and present the results in front of the class. The problem in the worksheet of the third activity is to determine the player's score in the game and also to determine the winning and losing players in the game. In the class discussion, the same perception was obtained in which the money used to buy the seeds that are referred to as the game capital is called cost and the money collected from selling the seeds is called purchase. Furthermore, the subtracting of the purchase with the cost is to determine the player's score. The winning player is the player who obtains the most profit shown in Figure 9. The evaluation process of the students' learning that has been conducted was to find out the students' understanding of the concept of social arithmetic and the implementation to solve the problem in daily life. Consequently, from this activity, the students learn about the mathematics concepts of cost, purchase, profit, and loss in trading activity.

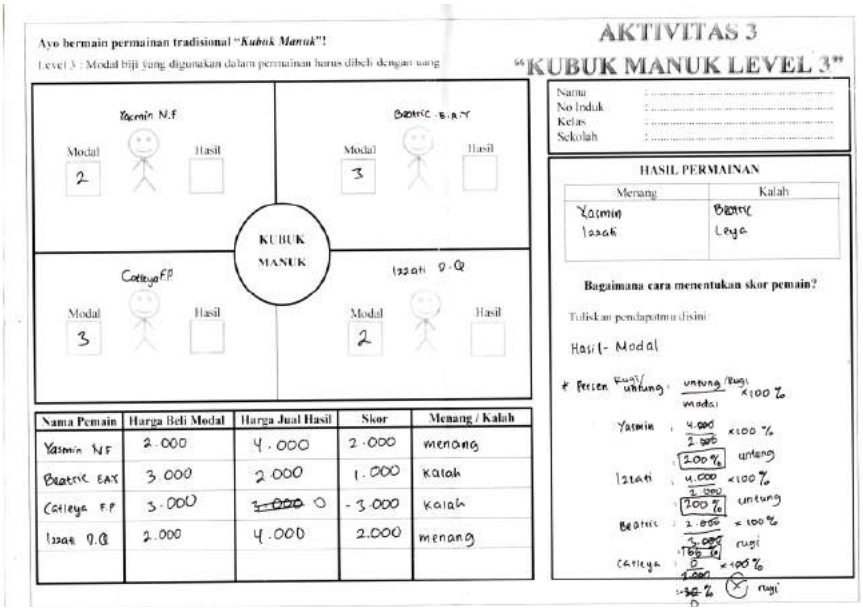


Figure 9. The Results of Students' Worksheet in the Third Activity

After the social arithmetic learning activities using the traditional *Kubuk Manuk* game were completed, the researcher gave a final evaluation question to all students. It is to find out their understanding in understanding the concept of social arithmetic (Madani et al., 2018; Van

Den Heuvel-Panhuizen, 2005). Final evaluation questions are made based on three student understanding indicators. Firstly, students can understand the concepts of income (results) and outcome (capital). Students can understand the idea of profit and loss. Lastly, students can understand the idea of the selling price, purchase price, and the percentage of profit and loss.

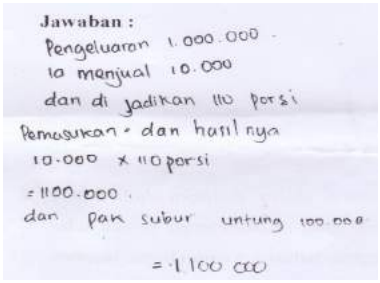
After the social arithmetic learning activities using the traditional *Kubuk Manuk* game were completed, the researcher gave a final evaluation question to all students to find out their understanding of the social arithmetic concept. The evaluation question is based on student understanding indicators that have been formulated in the mathematics textbook for Junior High School from the Indonesian Education Ministry. The explanation for each indicator of student understanding is as follows:

a. Students can understand the concepts of income (results) and outcome (capital)

All students are given evaluation questions that are done independently or not in groups. In the evaluation question one of them is about the concept of income and outcome. It is given to find out students' understanding of the concept. Questions in the evaluation questions regarding the concept of income and outcome along with examples of student answers are as follows:

Question 1:
Mr. Subur is a chicken porridge seller in the Jakarta area. As usual, every morning Mr. Subur goes to the market, shopping for staples to make chicken porridge. To buy these staples, Mr. Subur spent IDR 1,000,000. Then the staple is processed into chicken porridge, which is sold at IDR 10,000. On that day, Mr. Subur was able to sell 110 servings of chicken porridge. How much income did Mr. Subur get on that day?

Figure 10 shows that when presented a problem with social arithmetic, students have been able to identify outcome and income correctly. Almost all students answered correctly to the first question in the evaluation problem as in the example problem and the answer that shown in Figure 8.



Answer:
Output 1.000.000
He sold at 10.000
and able to sell 110 servings of chicken porridge

Income and the results
10.000 x 110 servings of chicken porridge
= 1.100.000

And Mr. Subur gets profit 100.000

Figure 10. The students answer for the first problem

Overall, the average student score for this question is 1.85 with an Ideal Maximum Score of 2. The assessment category is divided into 3 parts, namely first, 0 <= value <1 is included in the poor category; second, 1 <= value <2 is included in good category; and third, value = 2 is included in the excellent category. Therefore, the student's average score for this question falls into good category. So, it can be concluded that after students do social arithmetic learning using the *Kubuk Manuk* game, students can get good understanding in the concepts of income (capital) and outcome (results).

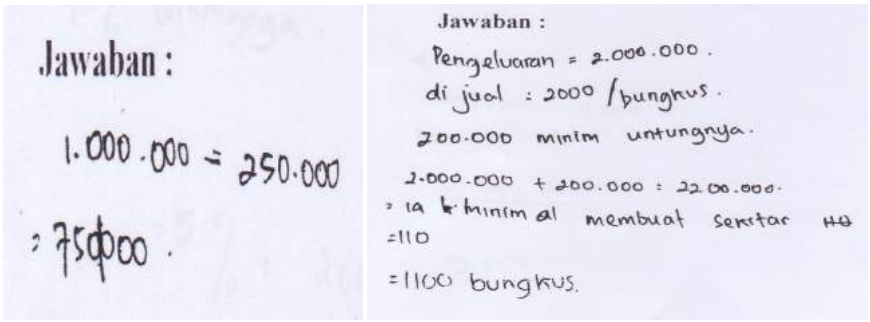
b. Students can understand the concept of profit and loss

In the evaluation questions also given questions to measure students' understanding of the second indicator that students are able to understand the concept of profit and loss. The question is as follows:
Question 2:

A businessman spends IDR 1,000,000 to run the business. In January, he bears a loss of IDR 250,000. So, how much income obtained in January?

Question 3:
An egg bean seller issued a capital of IDR 2,000,000 to run the business. Then, he sells his egg beans for IDR 2,000 per pack. If he targets to get a profit of IDR 200,000 from the business. So, what is the minimum package that must be sold by the seller?

Figure 11 explains that when presented a problem about social arithmetic, students have been able to correctly identify profit and loss as a result of income and outcome differences. Almost all students answered correctly to the second and third question in the evaluation problem as in the example problem and the answer that shown in Figure 9.



Answer: 1.000.000 – 250.000 = 750.000	Answer: Outcome = 2.000.000 He sold 2.000 per pack 200.000 should be his minimum profit 2.000.000 + 200.000 = 2.200.000 So, he should sell minimum 1.100 pack

Figure 11. Student answer for question 2 (left) and question 3 (right)

Overall, the average value of students for question 2 is 1.75 and the average value of students for question 3 is 1.70 with an Ideal Maximum Score of 2. So, it can be concluded that after students do social arithmetic learning using the *Kubuk Manuk* game students can finally understand the concept of profit and loss.

c. Students can understand the concept of selling price, buying price, and profit and loss percentages.

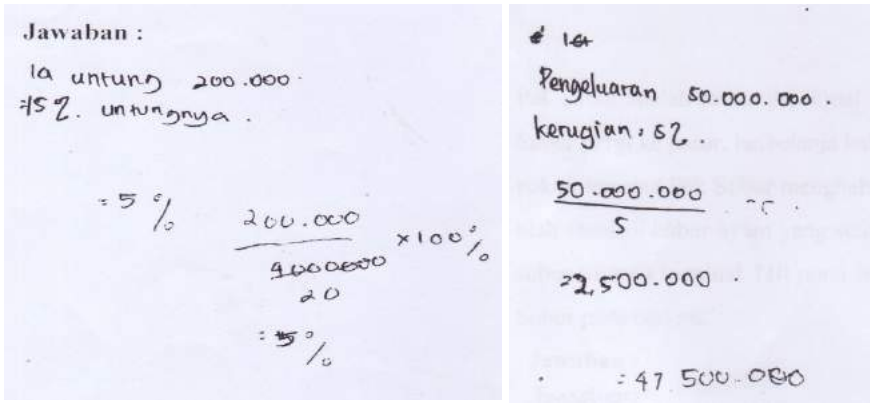
The students' understanding of third indicator that students are able to understand the concept of profit and loss measure in the last evaluation questions. The question is as follows:

Question 4:
Mr. Widodo buys a motorcycle at a price of IDR 4,000,000. Because of one day his son was sick and he needed money to pay for his son's treatment at the hospital. Then, He sold the motorbike at a price of IDR 4,200,000. Mr. Widodo experienced loss or gain? What is the percentage?

Question 5:

Mr. Anton bought the house at a price of IDR 50,000,000. Because of family problems, Mr. Anton was forced to sell the house at a loss of 5%. Determine the selling price of Mr. Anton's land?

Figure 12 describes the student answer presented a solution about social arithmetic problem namely percentages of loss and profit. Students have been able to correctly identify the selling price and purchase price and are able to calculate the percentage of profits and losses.



Answer: His profit is 200.000 = (200.000/4.000.000) x 100% = 5 %	Outcome 50.000.000 His lose is 5 % (50.000.000/5) = 2.500.000 = 47.500.000

Figure 12. Student answer for question 4 (left) and question 5 (right)

Overall, the average score of students for question 4 is 1.6 and the average value of students for question 5 is 1.6 with an Ideal Maximum Score of 2. Therefore, it can be concluded that after students do social arithmetic learning using the *Kubuk Manuk* game. Students can understand the selling price, the purchase price, and the profit and loss percentage.

Finally, the results of the evaluation questions given to students can be seen that, overall, the average score of students in good categories. It means that students understand the concept of social arithmetic, namely income, outcome, profit, loss, selling price, purchase price, and the percentage of profit and loss. Therefore, the *Kubuk Manuk* game has a useful context as a tool used to create Ethnomathematics-based learning designs to students' understanding of the concept of social arithmetic.

CONCLUSION

Commented [WK1]: It is necessary to support with literature

The results of this study indicates that in the learning of social arithmetic, the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. The students were able to understand the concept of mathematics easily since it is fun for them and importantly, the game is relatable to activities in their daily life. This study was able to take on the role in developing the learning trajectory of social arithmetic learning by using the *Kubuk Manuk* Indonesian traditional game as the local context of learning.

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The Learning Trajectory of Social Arithmetic using an Indonesian Traditional Game

Endonezya Geleneksel Oyununu Kullanarak Sosyal Aritmetik Öğrenmenin Öğrenme Yolu

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Abstract: Indonesia has many traditional games that can be used as a starting point in learning mathematics, i.e., social arithmetic. However, the teacher always used a conventional method such as direct teaching in teaching mathematics. Several researchers said that this method made mathematics learning boring. Therefore, this study aims to design a mathematics learning trajectory in social arithmetic using a traditional Indonesian game called the *Kubuk Manuk*. This game was used as the starting point in the learning process by applying the Indonesian Realistic Mathematics Education approach. The research method used is design research consisted of three stages, namely preliminary design, teaching experiment, and retrospective analysis. The results of this study indicate that the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. With the use of the *Kubuk Manuk* Indonesian traditional game, the students are stimulated to understand their knowledge of the social arithmetic concept. Additionally, the stages in the learning trajectory have essential roles in understanding the mathematics concepts of expenditure, income, profits, and loss within the trading activities.
Keywords: Design research, learning trajectory, Indonesian traditional games, social arithmetic learning, mathematics concepts

Öz: Endonezya'da matematik öğrenmede, yani sosyal aritmetikte bir başlangıç noktası olarak kullanılabilecek birçok geleneksel oyun vardır. Ancak, öğretmen her zaman matematik öğretiminde doğrudan öğretim gibi geleneksel bir yöntem kullanmıştır. Birkaç araştırmacı, bu yöntemin matematik öğrenmeyi sıkıcı hale getirdiğini söyledi. Bu nedenle bu çalışma, *Kubuk Manuk* adlı geleneksel bir Endonezya oyununu kullanarak sosyal aritmetikte matematik öğrenme yörüngesini tasarlamayı amaçlamaktadır. Bu oyun Endonezya Gerçekçi Matematik Eğitimi yaklaşımı uygulanarak öğrenme sürecinde başlangıç noktası olarak kullanılmıştır. Kullanılan araştırma yöntemi, tasarım araştırması, ön tasarım, öğretim deneyi ve geriye dönük analiz olmak üzere üç aşamadan oluşmaktadır. Bu çalışmanın sonuçları, öğrenme yörüngesinin, kültür veya öğrencilerin günlük aktivitelerinde kolayca bulunan diğer şeyler gibi yerel bağlamlar kullanılarak uygulanabileceğini göstermektedir. *Kubuk Manuk* Endonezya geleneksel oyununun kullanılmasıyla, öğrenciler sosyal aritmetik kavramı hakkındaki bilgilerini anlamaları için teşvik edilir. Ek olarak, öğrenme yörüngesindeki aşamalar, işlemlerin matematiksel harcama, gelir, kar ve zarar kavramlarını anlamada önemli rollere sahiptir.
Anahtar Sözcükler: Tasarım araştırması, yörüngeyi öğrenme, Endonezya geleneksel oyunları, sosyal aritmetik öğrenme, matematik kavramları

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INTRODUCTION

The development and application of the mathematics concept daily problems is part of a student's learning process (Prahmana et al., 2012; Tanujaya et al., 2017; Madani et al., 2018). Freudenthal (1991) explained that mathematics is a human activity and must be related to daily life. However, mathematics in schools tend to be taught using practical formulas in reality (Arisetyawan et al., 2014). Most often, not seamlessly associated with everyday life and culture, as should be experienced by the students (Stacey, 2011; Nurhasanah et al., 2017). The society, including the teachers, generally does not regard mathematics to be related to culture, and the learning of mathematics in the classroom can also be regarded with almost having no relation to culture. Culture is part of a student's life that may guide the way a student learns and regard mathematics (Revina, 2017; Revina & Leung, 2019). Its may significantly influence the student's ability to solve mathematics projects that relate to daily life.

The results of the Programme for International Student Assessment (PISA) for Indonesia showed that the students' abilities to solve and interpret problems are still considered at a low level (Stacey, 2011). Subsequently, Abrantes (2001) and Sembiring et al. (2010) suggested the appropriate strategies and learning methods. There are needed to develop students' thinking ability that orientate towards technical skills and the reformation of mathematics education based on problem-solving in daily life (Sembiring et al. 2010). The learning method suggested to solve these problems is the Pendidikan Matematika Realistik Indonesia (PMRI), which is an adaptation of the Realistic Mathematics Education (RME) (Prahmana et al., 2012; Tanujaya et al., 2017; Ginting et al., 2018). PMRI is a movement to reform mathematics education in Indonesia (Sembiring et al., 2008). It does not just implement a new way of teaching and learning mathematics, but also is associated with a drive to achieve social transformation within Indonesia (Sembiring et al., 2010). Therefore, this research used PMRI as a learning approach to solve this problem.

The one of the contexts that can be used in PMRI is a culture that is applied into realistic mathematics learning and modified according to the local context where the school is located (Gravemeijer & Doorman, 1999; Van Den Heuvel-Panhuizan, 2005; Haris & Putri, 2011; Oktiningrum et al., 2016; Jannah & Prahmana, 2019). Consequently, it may result in exciting contextual learning if it is to be taught in schools. It may increase the students' ability to solve a problem that has a relation to their daily life. Also, the cultural context can also be a solution to the lost cultural values and character of a student due to the influence of modernization (Muhtadi et al., 2017; Risdiyanti & Prahmana, 2018; Maryati & Prahmana, 2019).

The *Kubuk Manuk* is one of the traditional Indonesian games as a cultural context. This games could be the context as an innovation of mathematics learning that orientates to the reformation of learning mathematics. This context was chosen mainly because of its familiarity with the participants. It is from the perspectives of culture as well as their daily life. Prahmana et al. (2012) stated that traditional games are fun as they contained concepts of mathematics for learning purposes and aspects of cultural values. Therefore, this research design a social arithmetic learning using the context of the *Kubuk Manuk* as the starting point and also one of the traditional games in Indonesia.

The design of the *Kubuk Manuk* game is expected to be innovative in terms of learning mathematics. Furthermore, the concept will be easy for students to understand, thus enabling them to solve any daily-related problems. Therefore, this design is expected to cultivate and develop the cultural values that may influence a student's character.

METHOD

This study utilized design research as the research method. The research aims to improve the quality of classroom learning practice. It is through an interactive analysis of the hypothesis condition that will include student thinking that occurs in their learning with what happens in the classroom (Gravemeijer, 1994; Gravemeijer & Cobb, 2006). Simonson (2006) defined design research as a systematic and flexible method that aims to improve the quality of education.

Design research is also defined as a method that seeks to develop or validate a theory about the learning process that aims in cultivating the Local Instruction Theory (LIT). LIT is a theory about the process by which students learn a mathematical topic and conjecture about the media or devices used in helping the learning process of the issue (Gravemeijer & van Eerde, 2009). There are three phases of design research namely preliminary design, teaching experiment and retrospective analysis (Bakker, 2004; Gravameijer & Cobb, 2006). For more detail, this paper presented in the next part.

Preliminary Design

Gravemeijer and Cobb (2006) explained that the preliminary design phase aims to formulate the LIT that is elaborated and refined in the experimental design phase. The activities in this phase are choosing a teacher model to teach in the learning process. Next, the literature review of the social arithmetic concepts and PMRI discusses to design the learning process. Lastly, the researcher intends the learning trajectory and developing conjecture to be a Hypothetical Learning Trajectory (HLT) through the curriculum of Indonesian mathematics education. Hypothetical learning trajectory is a theoretical model for the design of mathematics instruction consisting of three components, a learning goal, a set of learning tasks, and a hypothesized learning process (Van den Akker et al., 2006). In this case, the conjecture functions as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the experimental design phase.

After conducting a literature study, the researcher made observations at the Lukman Al Hakim Integrated Islamic Middle School, Yogyakarta to see the students' initial abilities, culture and experiences, the curriculum used at school, the learning models that have been used by teachers and to observe the potential for implementing early ideas of researchers about the design of learning social arithmetic using the traditional game *Kubuk Manuk* at the school.

The results of observations made by the researcher are then discussed together with the teacher. This was done to see the potential implementation of social arithmetic learning designs using the traditional *Kubuk Manuk* game at Lukman Hakim Middle School by adjusting the curriculum used by the school and the students' circumstances. The results of the discussion are then used as a basis in making a prototype Hypothetical Learning Trajectory (HLT) presented in Table 1.

Table 1. Learning Trajectory, Student Activities, and the Social Arithmetic Concept

Students' Learning Trajectory	Learning Activities	The Social Arithmetic Concept
Informal Activities	Level One of the *Kubuk Manuk* Game (The seeds used by each player are the same)	Capital (Expenditures) and Results (Revenue)
Connecting Activities	Level Two of the *Kubuk Manuk* Game (The seeds used by each player are different)	Profit and loss
Formal Activities	Level Three of the *Kubuk Manuk* Game (The seeds used by each player are different and must be bought with money)	Selling price, purchase price and the percentage of profit and loss

HLT is then developed in every learning activity. The development is based on the material hypothesized learning trajectory and the concept maps that students must go through during

the learning process. This development resulted in a hypothetical of student learning activities that would be completed within three meeting.

Teaching Experiment

In this teaching experiment phase, the learning trajectory that has been designed in the preliminary design phase is then implemented in the learning process. The purpose of this implementation is to explore and observe the students' strategies and thinking. There are two cycles in this phase. The first cycle is a pilot experiment that aims to evaluate and improve the learning trajectory that has been designed. The second cycle is a teaching experiment that aims to implement the evaluated and revised learning trajectory in the pilot experiment.

Analysis Retrospective

In this phase, all the data collected in experimental design will be analyzed by comparing the conjecture in HLT with the results of implementing the learning trajectory that has been done in the experimental design phase. Data analysis was carried out by researchers and worked together with her supervisor to improve the validity of this study. Therefore, the description of learning trajectory using *Kubuk Manuk* Indonesian traditional game will subsequently be obtained. The result of a design research is not design that works but the underlying principles explaining how and why this design works (Wijaya, 2008). In retrospective analysis the role of HLT has been designed compared to the learning process carried out by students so that an investigation can be carried out and explained how students obtain the concepts of social arithmetic concept generated from the *Kubuk Manuk* game.

RESULTS and DISCUSSION

The results of this study showed the implementation of the learning trajectory design of social arithmetic using the *Kubuk Manuk* traditional game as the starting point in the learning process. The learning trajectory consists of three activities, namely the activities of playing the *Kubuk Manuk* games at levels 1, 2 and 3. The differences between the three activities are the number of seeds and the rules used in the game, and these are elaborated. The summary of all learning activities can be seen in Table 2.

Table 2. The Activities in Learning Social Arithmetic using *Kubuk Manuk* game

The Learning Social Arithmetic	The Learning Phases	The Learning Description
Learning about the concepts of income (revenue) and outcome (capital)	Students play *Kubuk Manuk* game level 1	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 1 f. Students work on student worksheet 1 g. Students and teachers discuss the results of the game, the results of student worksheet 1 work

		and social arithmetic concepts learned in the game
Learning about the concept of profit and loss	Students play *Kubuk Manuk* game level 2	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 2 f. Students work on student worksheet 2 g. Students and teachers discuss the results of the game, the results of student worksheet 2 work and social arithmetic concepts learned in the game
Learning about selling price, purchase price and the percentage of profit and loss	Students play *Kubuk Manuk* game level 3	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 3 f. Students work on student worksheet 3 g. Students and teachers discuss the results of the game, the results of student worksheet 3 work and social arithmetic concepts learned in the game

Activity 1: Level One of the Kubuk Manuk Game

This activity begins by grouping the students into groups consisting of three to four students. The teacher then introduced the *Kubuk Manuk* traditional game and the rules used in the game. The first game is an important part of introducing the learning context to make it easier for the next activity. It also embeds the social values that can develop students' ability to interact effectively with their social environment and improve the students' sportsmanship when doing an activity that is competitive in accordance with the standard competencies in Indonesian education.

To introduce this game the teacher starts by explaining that the *Kubuk Manuk* game originates from Java and explains the rules of the game that each member of the group must collect a kind of beans namely *benguk* seeds as the capital of the game, and the number of seeds must be the same. The students will grasp all the seeds in the left hand and shaken above the right hand. Then, a few seeds are thrown into the right-hand grip and the other players in the group have to make a guess. If none of the students are able to guess it, the students must spread the seeds and count using both fingers. The introduction of the game is accompanied with a simulation done by the teacher in front of the class with a few students, as shown in Figure 1.

Figure 1. Simulation of the *Kubuk Manuk* game

After the simulation finished, the students play *Kubuk Manuk* level 1 together with their respective groups, as shown in Figure 2. Students already understand how to play *Kubuk Manuk* level 1.

Figure 2. Student playing the *Kubuk Manuk* game

It is to make a compilation to determine the leading players and opposing players, then collect the same amount of capital each player. Furthermore, the main player sings the level 1 *Kubuk Manuk* song while moving the seeds from the right-hand grip to the leading player's left hand. If not guessed then the player spreads the seeds and picks them using the index finger. Also, students help each other in playing the game even though they compete with each other to win. Seen from the attitude of student A that helps student B to grab the seeds used for the game so as not to be scattered. Its is following the purpose of choosing an ethnomathematics-based context in this learning design that is to develop student character based on values that can be drawn from the game.

Next, the students began playing the *Kubuk Manuk* game with their respective group, and the students discuss and solve the problems contained in the worksheets that have been given as can be seen in Figure 3. The capital data and results are written in the table provided in the student worksheet.

Figure 3. Student discuss the problem in the worksheet

The problem in the worksheet requires the students to determine the scores obtained by each student in the group and decide who win and who lose the game. Figure 4 shows that students have been able to identify capital (income) and results (outcome). Students can also determine the score of each player and can determine the player who wins and lose from the number of seeds obtained. Students then conduct a group discussion to solve the problems that exist in student worksheet which is about how to determine the player's score and determine the players who win and lose.

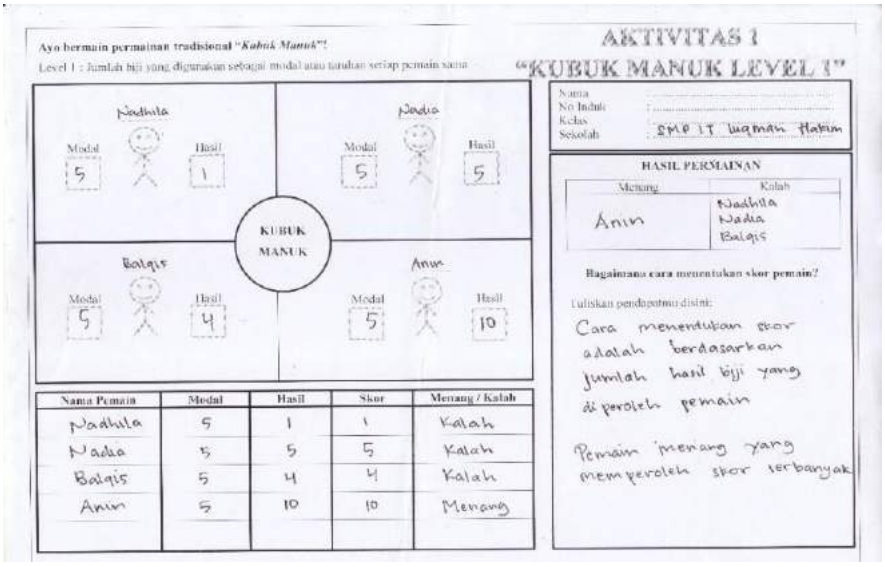


Figure 4. The results of the students' worksheet from the first activity

Furthermore, students are required to present the results in front of the class. The teacher chooses one of the groups to present their work in front of the class as shown in Figure 5.

Figure 5. Students presenting the results

The following is an excerpt from the dialogue of one group when presenting the results of their presentation in front of the class.

Student : *"Jadi kita akan mempresentasikan tentang hasil permainan kita hari ini, jadi kelompok kita ngelakuin dua kali permainan, hasil yang pertama pemenangnya adalah Salima"*
[We will present about the results of our game today, so our group has done two games, the winner of the first result is Salima"]

Teacher : *"Modalnya dulu, modalnya"*
[First capital, their capital]

Student : *"Salima, modal sepuluh dan hasil dua puluh satu, berarti untungnya sebelas. Terus ronde kedua modalnya lima belas yang menang salima lagi, dia dapat dua puluh satu. Dan yang ketiga dengan modal dua puluh pemenangnya adalah alin dengan hasil empat puluh enam. Jadi cara menentukan skor itu dilihat dari hasil mainnya. Kalau dia kalah maka dia dapat skor nol, kalau dia menang maka ia dapat skor satu"*
[Salima, the capital is ten and the income is twenty-one, means the income is eleven. Then in the second round of capital is fifteen and the winner is Salima again, he got twenty-one. And the third one with the capital is twenty and the winners is Alin with the income is forty-six. So, the way to determine the score is seen from the results of the game. If she loses, her score is zero; If she wins, her score is one].

Based on the dialogue, it can be seen that through a process of playing *Kubuk Manuk* level 1 students have been able to understand the definition of capital and income. Students revealed that "*the capital is ten and the income is twenty-one*"; it can be seen that students have understood that 10 seeds collected or issued by players to play the *Kubuk Manuk* game are capital and 21 seeds obtained from a playing process the *Kubuk Manuk* game are income.

Students have also been able to predict how to determine player scores based on their thinking and understanding of the concepts of capital and income. It can be seen from the students' answers, "*So the way to determine the score is seen from the results of the game*". The ability of students to predict the player's score, shows that an indicator of students' mathematical understanding has been reached (Wijaya, 2008; Prahmana & Suwasti, 2014;

Ginting et al., 2018). Furthermore, the students also revealed "*the income is eleven*"; it means that the development of students' understanding in the group had reached the relationship of capital and income. The answer "*eleven*" is obtained by students by subtracting the outcome with capital. Students have also been able to define that "*eleven*" is the benefit of Salima.

Students have been able to see the relationship between capital, outcome, and income, because before learning activities take place students have followed the school program that is market day. In the program, students are given capital to carry out a particular business and the teacher is also accustomed to introducing terms such as capital gains and profits to students in implementing the program (Madani et al., 2018).

In the dialogue the students revealed "*If she loses, her score is zero; If she wins, her score is one* "; the answer of this student is beyond the predictions of the researcher. In HLT, researchers only predict students will answer the score with 'results' or with 'results reduced by capital' (Gravemeijer & Cobb, 2006; Gravemeijer & van Eerde, 2009; Prahmana et al., 2012). The students' answers are influenced by the experience of students outside of learning when playing games on mobile phones or when looking at a match that is when winning it will get a score of one and lose the score zero. Students perceive that the rules for determining the score used in this game are the same as those used in a game or match.

The class discussions with the teacher in order to get the same students' perceptions about the solutions of the problems in the worksheet and about the mathematical concepts that can be learned from this game (refer to Figure 6). From the class discussions, similar perceptions were achieved among the students in which the seed capital used in the game is 'outcome' and the seeds obtained in the game are 'income'. Hence, from this activity, the students learnt about the mathematics concepts of outcome and income.

Figure 6. Class Discussion

Activity 2: Level Two of the Kubuk Manuk Game

The second activity is the same as the first activity, but the number of seeds used as the capital of the game is different for each player. The game begins with a simulation by the teacher, and the students continue to practice the game in their group (refer to Figure 7). Then the students discuss and solve the problem in the worksheets. The problem in the second activity worksheet is no different from the problems in the first activity worksheet that is determining the scores obtained by each player and determining the winning and losing players in the game if the seed capital used is different for each player.

Figure 7. Playing the *Kubuk Manuk* Game Level 2

Furthermore, in the class discussions, similar perceptions were obtained as in the first activity. However, the students must find another way to find the value of the game capital. They will need to find the value of profit or loss by subtracting the number of seeds obtained in the game by the number of seeds used as game capital. The resulting subtraction is considered as a score. The students who get the results of the subtraction will obtain a positive value. The number of seeds received more significant than the number of seeds used as game capital. On the other hands, the income is higher than the expenditure. Hence the students will receive the profits. Otherwise, the students who achieved a negative result from the subtraction will indicate that the number of seeds collected is less than the number of seeds used as capital. On the other hands, the income is less than the expenditure, and this will mean that the students get a loss. If a student gets a zero as a result of the subtraction or if the number of seeds obtained is equal to the number of seeds used as game capital, or if the income is equal to the expenditure, that means the students have obtained capital return. From this second activity, the students learnt about the mathematics concept of profits, loss and the relationship between them, as indicated in Figure 8.

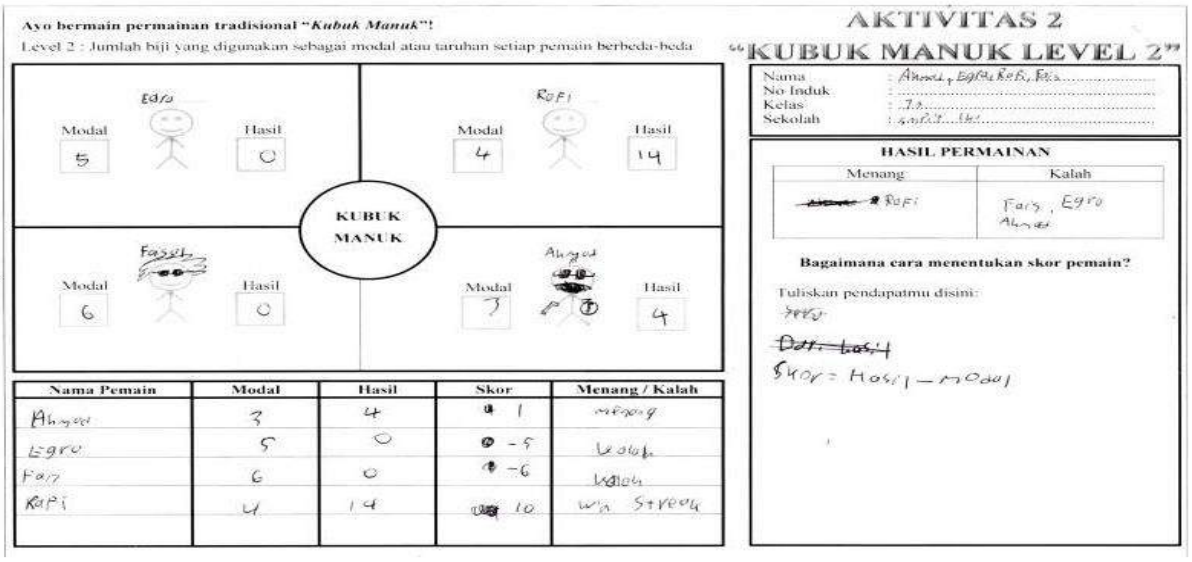


Figure 8. The Results of the Students' Worksheet in the Second Activity

Activity 3: Level Three of the Kubuk Manuk Game

The third level of the *Kubuk Manuk* game is the modified version of the original *Kubuk Manuk* game. In this level, the seeds are used in the game, and the capital must be purchased first. There are two types of groups, which are the seller group and the player group. The seller group has a role in selling the seeds that will be used in the game. They also buy the seeds that have been obtained by a player in the game. Similar to the previous activity, this third activity begins with a simulation. Then, the teacher will give the toy's money to each member of the player group to buy the seeds that will be used as game capital. After that, students play the game with their groups.

Once the game is completed, each player sells the seeds that have been obtained in the game to the seller groups. The students discuss and solve the problems in the worksheet and present the results in front of the class. The problem in the worksheet of the third activity is to determine the player's score in the game and also to determine the winning and losing players in the game. In the class discussion, the same perception was obtained in which the money used to buy the seeds that are referred to as the game capital is called cost and the money collected from selling the seeds is called purchase. Furthermore, the subtracting of the purchase with the cost is to determine the player's score. The winning player is the player who obtains the most profit shown in Figure 9. The evaluation process of the students' learning that has been conducted was to find out the students' understanding of the concept of social arithmetic and the implementation to solve the problem in daily life. Consequently, from this activity, the students learn about the mathematics concepts of cost, purchase, profit, and loss in trading activity.

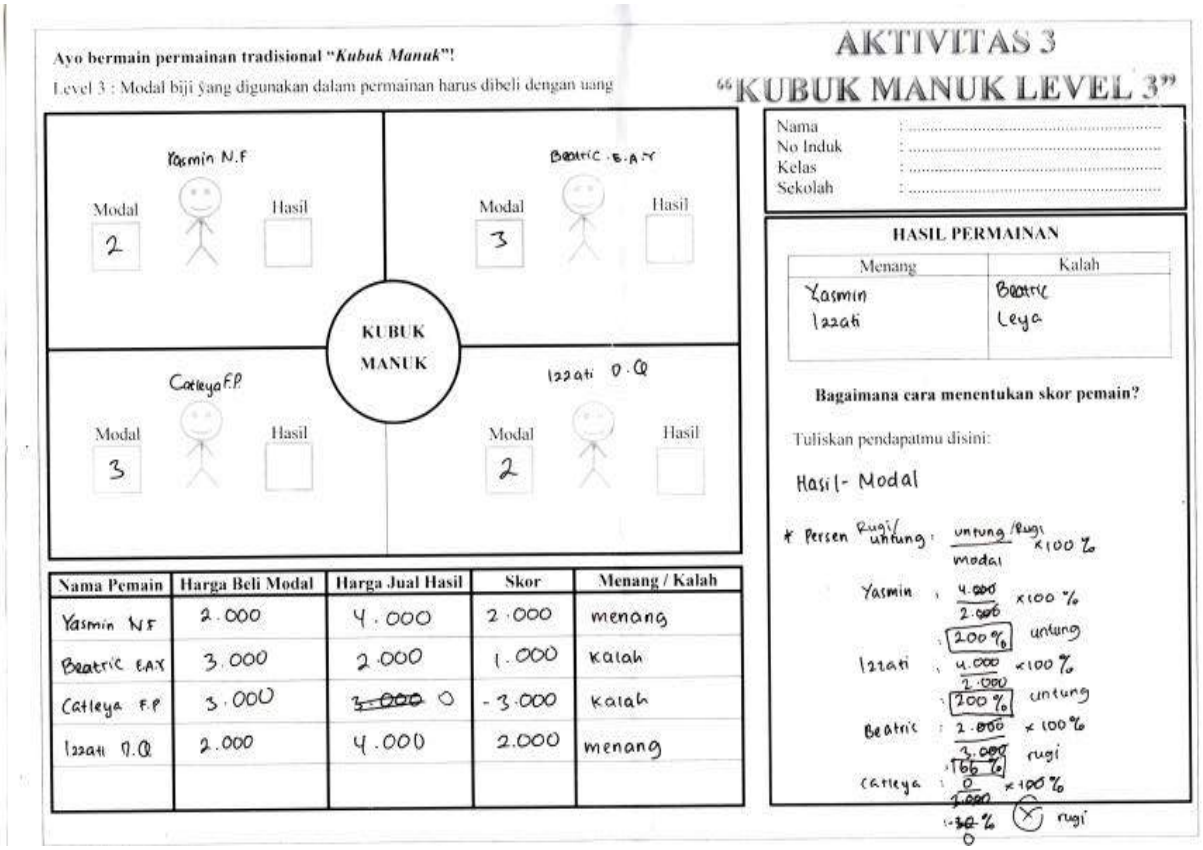


Figure 9. The Results of Students' Worksheet in the Third Activity

After the social arithmetic learning activities using the traditional *Kubuk Manuk* game were completed, the researcher gave a final evaluation question to all students. It is to find out their understanding in understanding the concept of social arithmetic (Madani et al., 2018; Van

Den Heuvel-Panhuizen, 2005). Final evaluation questions are made based on three student understanding indicators. Firstly, students can understand the concepts of income (results) and outcome (capital). Students can understand the idea of profit and loss. Lastly, students can understand the idea of the selling price, purchase price, and the percentage of profit and loss.

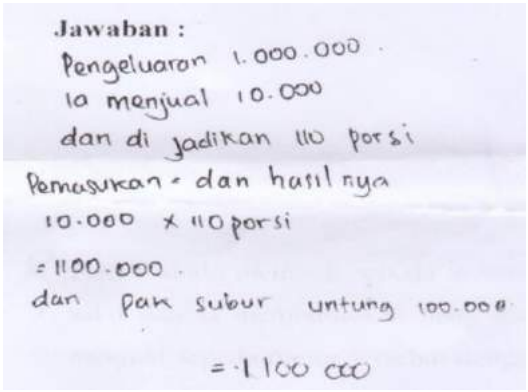
After the social arithmetic learning activities using the traditional *Kubuk Manuk* game were completed, the researcher gave a final evaluation question to all students to find out their understanding of the social arithmetic concept. The evaluation question is based on student understanding indicators that have been formulated in the mathematics textbook for Junior High School from the Indonesian Education Ministry. The explanation for each indicator of student understanding is as follows:

a. Students can understand the concepts of income (results) and outcome (capital)

All students are given evaluation questions that are done independently or not in groups. In the evaluation question one of them is about the concept of income and outcome. It is given to find out students' understanding of the concept. Questions in the evaluation questions regarding the concept of income and outcome along with examples of student answers are as follows:

Question 1:
Mr. Subur is a chicken porridge seller in the Jakarta area. As usual, every morning Mr. Subur goes to the market, shopping for staples to make chicken porridge. To buy these staples, Mr. Subur spent IDR 1,000,000. Then the staple is processed into chicken porridge, which is sold at IDR 10,000. On that day, Mr. Subur was able to sell 110 servings of chicken porridge. How much income did Mr. Subur get on that day?

Figure 10 shows that when presented a problem with social arithmetic, students have been able to identify outcome and income correctly. Almost all students answered correctly to the first question in the evaluation problem as in the example problem and the answer that shown in Figure 8.



Answer:
Output 1.000.000
He sold at 10.000
and able to sell 110 servings of chicken porridge

Income and the results
10.000 x 110 servings of chicken porridge
= 1.100.000

And Mr. Subur gets profit 100.000

Figure 10. The students answer for the first problem

Overall, the average student score for this question is 1.85 with an Ideal Maximum Score of 2. The assessment category is divided into 3 parts, namely first, 0 <= value <1 is included in the poor category; second, 1 <= value <2 is included in good category; and third, value = 2 is included in the excellent category. Therefore, the student's average score for this question falls into good category. So, it can be concluded that after students do social arithmetic learning using the *Kubuk Manuk* game, students can get good understanding in the concepts of income (capital) and outcome (results).

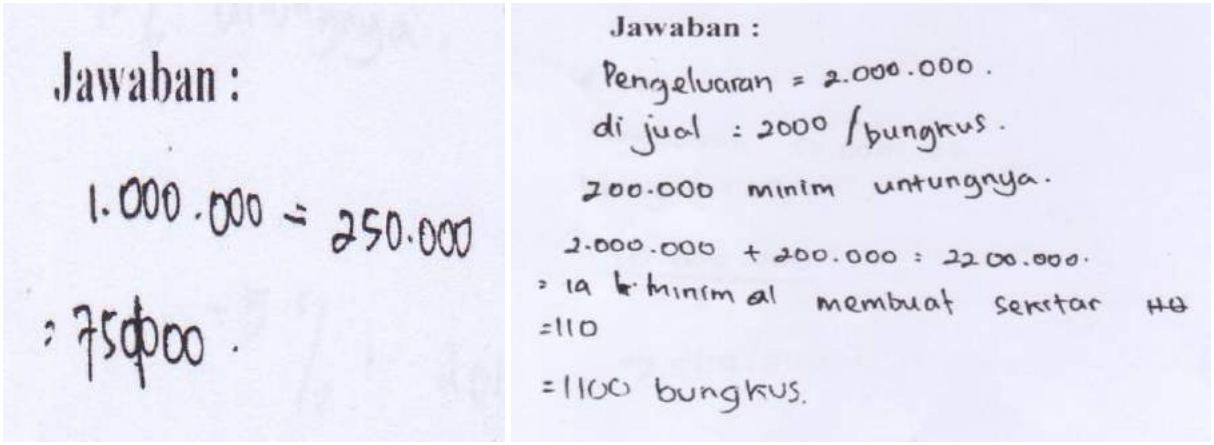
b. Students can understand the concept of profit and loss

In the evaluation questions also given questions to measure students' understanding of the second indicator that students are able to understand the concept of profit and loss. The question is as follows:

Question 2:
A businessman spends IDR 1,000,000 to run the business. In January, he bears a loss of IDR 250,000. So, how much income obtained in January?

Question 3:
An egg bean seller issued a capital of IDR 2,000,000 to run the business. Then, he sells his egg beans for IDR 2,000 per pack. If he targets to get a profit of IDR 200,000 from the business. So, what is the minimum package that must be sold by the seller?

Figure 11 explains that when presented a problem about social arithmetic, students have been able to correctly identify profit and loss as a result of income and outcome differences. Almost all students answered correctly to the second and third question in the evaluation problem as in the example problem and the answer that shown in Figure 9.



Answer:
1.000.000 – 250.000
= 750.000

Answer:
Outcome = 2.000.000
He sold 2.000 per pack
200.000 should be his minimum profit
2.000.000 + 200.000 = 2.200.000
So, he should sell minimum
1.100 pack

Figure 11. Student answer for question 2 (left) and question 3 (right)

Overall, the average value of students for question 2 is 1.75 and the average value of students for question 3 is 1.70 with an Ideal Maximum Score of 2. So, it can be concluded that after students do social arithmetic learning using the *Kubuk Manuk* game students can finally understand the concept of profit and loss. These research results add empirical evidence stated that games could help the student to understand the mathematics concept as having been done by several previous studies (Wijaya, 2008; Prahmana, et al. 2012; Byun & Joung, 2018).

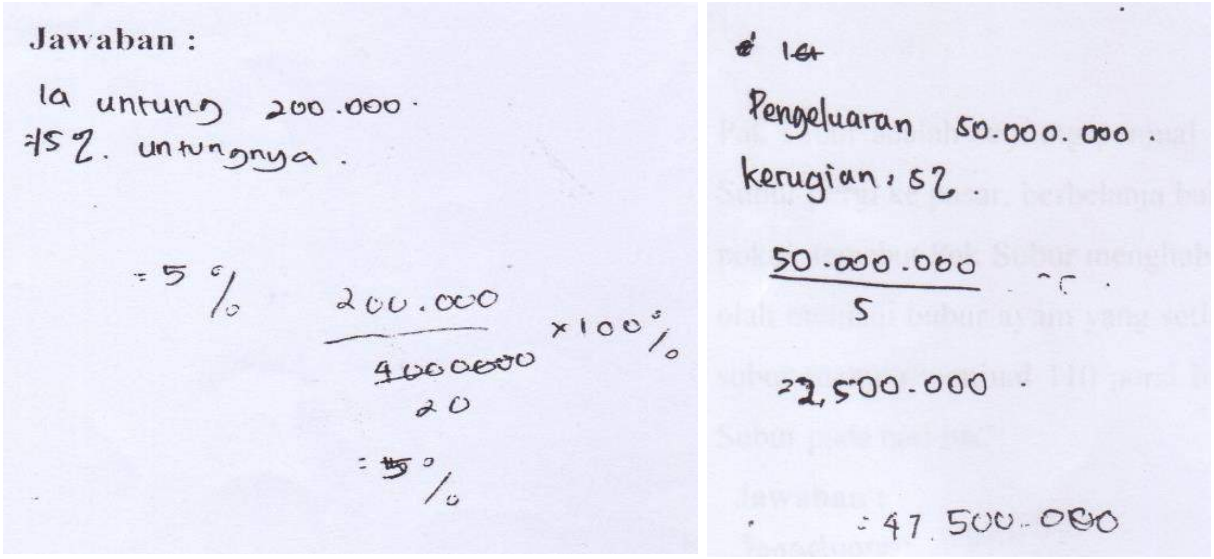
c. Students can understand the concept of selling price, buying price, and profit and loss percentages.

The students' understanding of third indicator that students are able to understand the concept of profit and loss measure in the last evaluation questions. The question is as follows:

Question 4:
Mr. Widodo buys a motorcycle at a price of IDR 4,000,000. Because of one day his son was sick and he needed money to pay for his son's treatment at the hospital. Then, He sold the motorbike at a price of IDR 4,200,000. Mr. Widodo experienced loss or gain? What is the percentage?

Question 5:
Mr. Anton bought the house at a price of IDR 50,000,000. Because of family problems, Mr. Anton was forced to sell the house at a loss of 5%. Determine the selling price of Mr. Anton's land?

Figure 12 describes the student answer presented a solution about social arithmetic problem namely percentages of loss and profit. Students have been able to correctly identify the selling price and purchase price and are able to calculate the percentage of profits and losses.



Answer: His profit is 200.000 = (200.000/4.000.000) x 100% = 5 %	Outcome 50.000.000 His lose is 5 % (50.000.000/5) = 2.500.000 = 47.500.000

Figure 12. Student answer for question 4 (left) and question 5 (right)

Overall, the average score of students for question 4 is 1.6 and the average value of students for question 5 is 1.6 with an Ideal Maximum Score of 2. Therefore, it can be concluded that after students do social arithmetic learning using the *Kubuk Manuk* game. Students can understand the selling price, the purchase price, and the profit and loss percentage.

Finally, the results of the evaluation questions given to students can be seen that, overall, the average score of students in good categories. It means that students understand the concept of social arithmetic, namely income, outcome, profit, loss, selling price, purchase price, and the percentage of profit and loss. Therefore, the *Kubuk Manuk* game has a useful context as a tool used to create Ethnomathematics-based learning designs to students' understanding of the concept of social arithmetic. These results supported several previous research results that stated the learning activity related to daily activity, such as traditional games and also culture, namely Ethnomathematics could be the starting point in learning mathematics (Wijaya, 2008; Prahmana et al., 2012; Tanujaya et al., 2017; Ginting et al., 2018; Jannah & Prahmana, 2019; Maryati & Prahmana, 2019).

CONCLUSION

In the learning of social arithmetic, the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. The

students were able to understand the concept of mathematics easily since it is fun for them and importantly, the game is relatable to activities in their daily life. This study was able to take on the role in developing the learning trajectory of social arithmetic learning by using the *Kubuk Manuk* Indonesian traditional game as the local context of learning.

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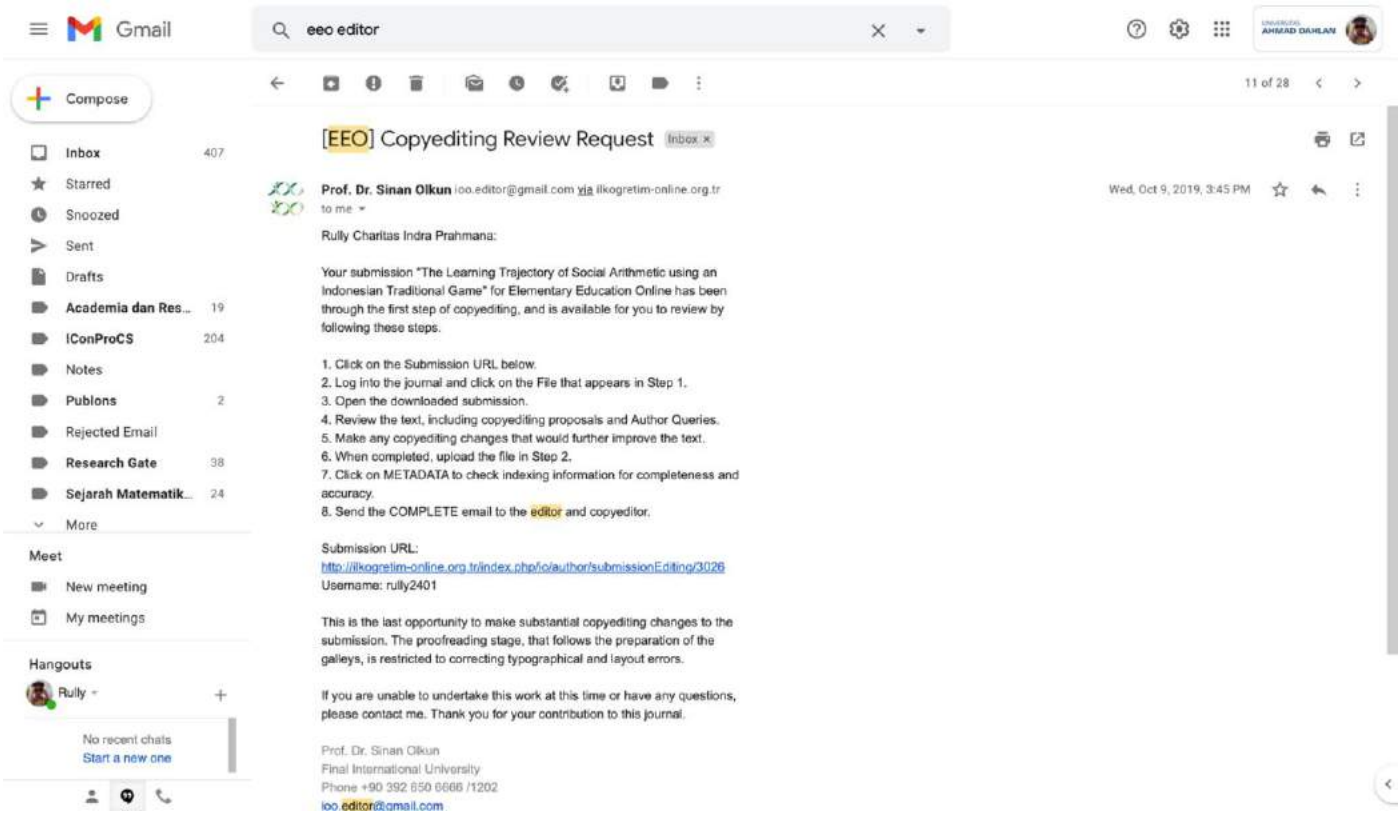

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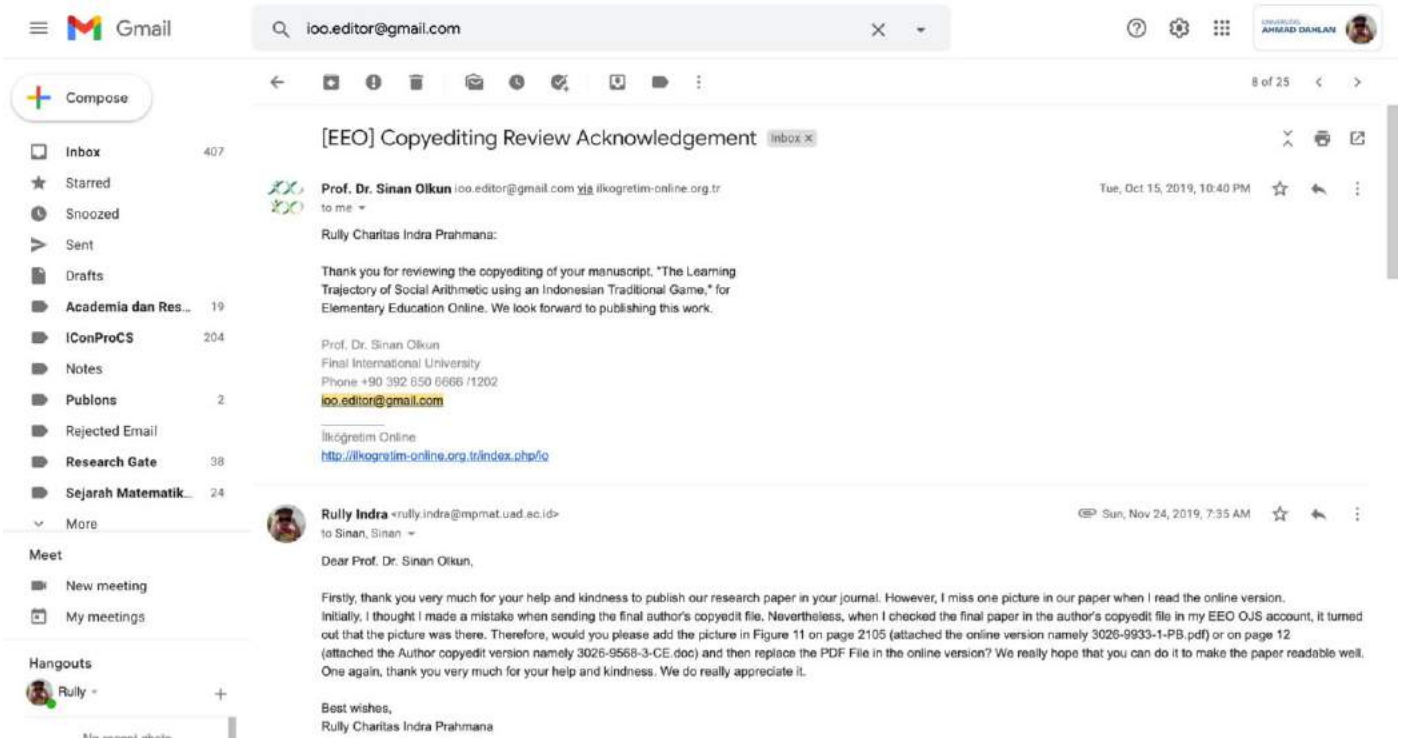

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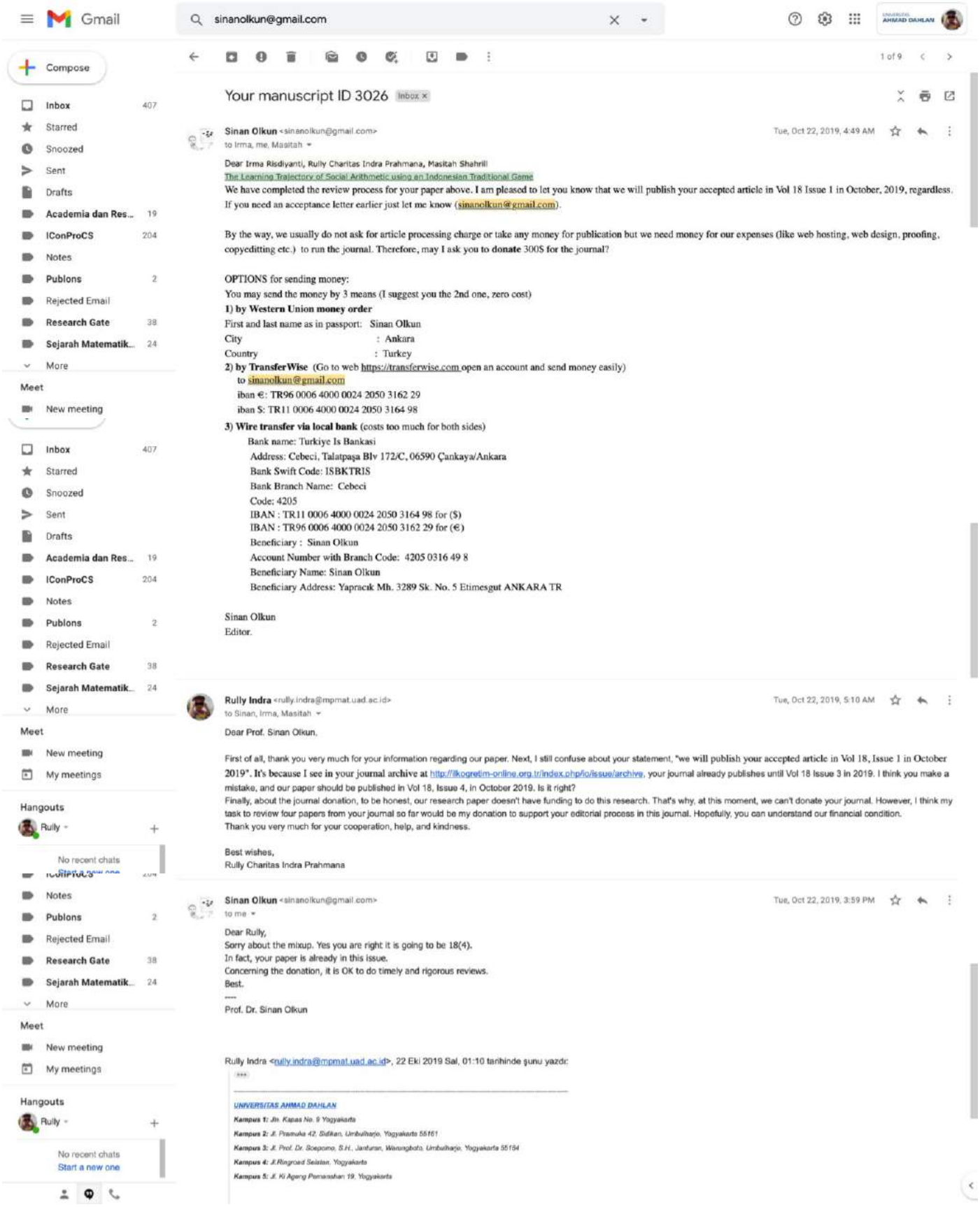

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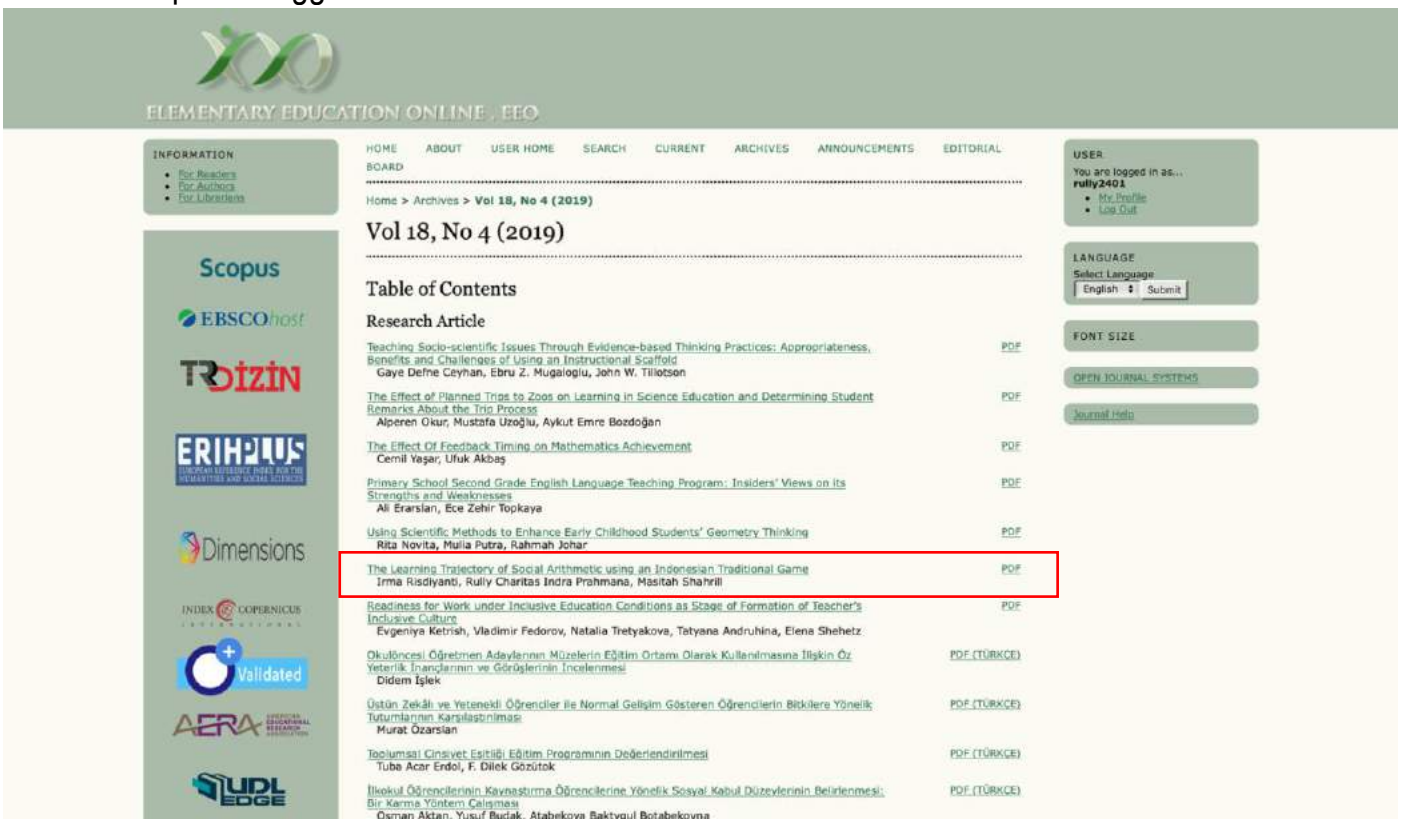

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The Learning Trajectory of Social Arithmetic using an Indonesian Traditional Game

Endonezya Geleneksel Oyununu Kullanarak Sosyal Aritmetik Öğrenmenin Öğrenme Yolu

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Abstract: Indonesia has many traditional games that can be used as a starting point in learning mathematics, i.e., social arithmetic. However, the teacher always used a conventional method such as direct teaching in teaching mathematics. Several researchers said that this method made mathematics learning boring. Therefore, this study aims to design a mathematics learning trajectory in social arithmetic using a traditional Indonesian game called the *Kubuk Manuk*. This game was used as the starting point in the learning process by applying the Indonesian Realistic Mathematics Education approach. The research method used is design research consisted of three stages, namely preliminary design, teaching experiment, and retrospective analysis. The results of this study indicate that the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. With the use of the *Kubuk Manuk* Indonesian traditional game, the students are stimulated to understand their knowledge of the social arithmetic concept. Additionally, the stages in the learning trajectory have essential roles in understanding the mathematics concepts of expenditure, income, profits, and loss within the trading activities.

Keywords: Design research, learning trajectory, Indonesian traditional games, social arithmetic learning, mathematics concepts

Öz: Endonezya'da matematik öğrenmede, yani sosyal aritmetikte bir başlangıç noktası olarak kullanılabilecek birçok geleneksel oyun vardır. Ancak, öğretmen her zaman matematik öğretiminde doğrudan öğretim gibi geleneksel bir yöntem kullanmıştır. Birkaç araştırmacı, bu yöntemin matematik öğrenmeyi sıkıcı hale getirdiğini söyledi. Bu nedenle bu çalışma, *Kubuk Manuk* adlı geleneksel bir Endonezya oyununu kullanarak sosyal aritmetikte matematik öğrenme yörüngesini tasarlamayı amaçlamaktadır. Bu oyun Endonezya Gerçekçi Matematik Eğitimi yaklaşımı uygulanarak öğrenme sürecinde başlangıç noktası olarak kullanılmıştır. Kullanılan araştırma yöntemi, tasarım araştırması, ön tasarım, öğretim deneyi ve geriye dönük analiz olmak üzere üç aşamadan oluşmaktadır. Bu çalışmanın sonuçları, öğrenme yörüngesinin, kültür veya öğrencilerin günlük aktivitelerinde kolayca bulunan diğer şeyler gibi yerel bağlamlar kullanılarak uygulanabileceğini göstermektedir. *Kubuk Manuk* Endonezya geleneksel oyununun kullanılmasıyla, öğrenciler sosyal aritmetik kavramı hakkındaki bilgilerini anlamaları için teşvik edilir. Ek olarak, öğrenme yörüngesindeki aşamalar, işlemlerin matematiksel harcama, gelir, kar ve zarar kavramlarını anlamada önemli rollere sahiptir.

Anahtar Sözcükler: Tasarım araştırması, yörüngeyi öğrenme, Endonezya geleneksel oyunları, sosyal aritmetik öğrenme, matematik kavramları

INTRODUCTION

The development and application of the mathematics concept daily problems is part of a student's learning process (Prahmana et al., 2012; Tanujaya et al., 2017; Madani et al., 2018). Freudenthal (1991) explained that mathematics is a human activity and must be related to daily life. However, mathematics in schools tend to be taught using practical formulas in reality

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(Arisetyawan et al., 2014). Most often, not seamlessly associated with everyday life and culture, as should be experienced by the students (Stacey, 2011; Nurhasanah et al., 2017). The society, including the teachers, generally does not regard mathematics to be related to culture, and the learning of mathematics in the classroom can also be regarded with almost having no relation to culture. Culture is part of a student's life that may guide the way a student learns and regard mathematics (Revina, 2017; Revina & Leung, 2019). It's may significantly influence the student's ability to solve mathematics projects that relate to daily life.

The results of the Programme for International Student Assessment (PISA) for Indonesia showed that the students' abilities to solve and interpret problems are still considered at a low level (Stacey, 2011). Subsequently, Abrantes (2001) and Sembiring et al. (2010) suggested the appropriate strategies and learning methods. There are needed to develop students' thinking ability that orientate towards technical skills and the reformation of mathematics education based on problem-solving in daily life (Sembiring et al. 2010). The learning method suggested to solve these problems is the Pendidikan Matematika Realistik Indonesia (PMRI), which is an adaptation of the Realistic Mathematics Education (RME) (Prahmana et al., 2012; Tanujaya et al., 2017; Ginting et al., 2018). PMRI is a movement to reform mathematics education in Indonesia (Sembiring et al., 2008). It does not just implement a new way of teaching and learning mathematics, but also is associated with a drive to achieve social transformation within Indonesia (Sembiring et al., 2010). Therefore, this research used PMRI as a learning approach to solve this problem.

The one of the contexts that can be used in PMRI is a culture that is applied into realistic mathematics learning and modified according to the local context where the school is located (Gravemeijer & Doorman, 1999; Van Den Heuvel-Panhuizan, 2005; Haris & Putri, 2011; Oktiningrum et al., 2016; Jannah & Prahmana, 2019). Consequently, it may result in exciting contextual learning if it is to be taught in schools. It may increase the students' ability to solve a problem that has a relation to their daily life. Also, the cultural context can also be a solution to the lost cultural values and character of a student due to the influence of modernization (Muhtadi et al., 2017; Risdiyanti & Prahmana, 2018; Maryati & Prahmana, 2019).

The *Kubuk Manuk* is one of the traditional Indonesian games as a cultural context. This games could be the context as an innovation of mathematics learning that orientates to the reformation of learning mathematics. This context was chosen mainly because of its familiarity with the participants. It is from the perspectives of culture as well as their daily life. Prahmana et al. (2012) stated that traditional games are fun as they contained concepts of mathematics for learning purposes and aspects of cultural values. Therefore, this research design a social arithmetic learning using the context of the *Kubuk Manuk* as the starting point and also one of the traditional games in Indonesia.

The design of the *Kubuk Manuk* game is expected to be innovative in terms of learning mathematics. Furthermore, the concept will be easy for students to understand, thus enabling them to solve any daily-related problems. Therefore, this design is expected to cultivate and develop the cultural values that may influence a student's character.

METHOD

This study utilized design research as the research method. The research aims to improve the quality of classroom learning practice. It is through an interactive analysis of the hypothesis condition that will include student thinking that occurs in their learning with what happens in the classroom (Gravemeijer, 1994; Gravemeijer & Cobb, 2006). Simonson (2006) defined design research as a systematic and flexible method that aims to improve the quality of education. Design research is also defined as a method that seeks to develop or validate a theory about the learning process that aims in cultivating the Local Instruction Theory (LIT). LIT is a theory about the process by which students learn a mathematical topic and conjecture about the media or devices used in helping the learning process of the issue (Gravemeijer & van Eerde, 2009). There are three phases of design research namely preliminary design, teaching experiment and

retrospective analysis (Bakker, 2004; Gravameijer & Cobb, 2006). For more detail, this paper presented in the next part.

Preliminary Design

Gravemeijer and Cobb (2006) explained that the preliminary design phase aims to formulate the LIT that is elaborated and refined in the experimental design phase. The activities in this phase are choosing a teacher model to teach in the learning process. Next, the literature review of the social arithmetic concepts and PMRI discusses to design the learning process. Lastly, the researcher intends the learning trajectory and developing conjecture to be a Hypothetical Learning Trajectory (HLT) through the curriculum of Indonesian mathematics education. Hypothetical learning trajectory is a theoretical model for the design of mathematics instruction consisting of three components, a learning goal, a set of learning tasks, and a hypothesized learning process (Van den Akker et al., 2006). In this case, the conjecture functions as a guideline that will develop in every learning activity. It also has to be flexible and able to be revised during the experimental design phase.

After conducting a literature study, the researcher made observations at the Lukman Al Hakim Integrated Islamic Middle School, Yogyakarta to see the students' initial abilities, culture and experiences, the curriculum used at school, the learning models that have been used by teachers and to observe the potential for implementing early ideas of researchers about the design of learning social arithmetic using the traditional game *Kubuk Manuk* at the school.

The results of observations made by the researcher are then discussed together with the teacher. This was done to see the potential implementation of social arithmetic learning designs using the traditional *Kubuk Manuk* game at Lukman Hakim Middle School by adjusting the curriculum used by the school and the students' circumstances. The results of the discussion are then used as a basis in making a prototype Hypothetical Learning Trajectory (HLT) presented in Table 1.

Table 1. *Learning trajectory, student activities, and the social arithmetic concept*

Students' Learning Trajectory	Learning Activities	The Social Arithmetic Concept
Informal Activities	Level One of the *Kubuk Manuk* Game (The seeds used by each player are the same)	Capital (Expenditures) and Results (Revenue)
Connecting Activities	Level Two of the *Kubuk Manuk* Game (The seeds used by each player are different)	Profit and loss
Formal Activities	Level Three of the *Kubuk Manuk* Game (The seeds used by each player are different and must be bought with money)	Selling price, purchase price and the percentage of profit and loss

HLT is then developed in every learning activity. The development is based on the material hypothesized learning trajectory and the concept maps that students must go through during the learning process. This development resulted in a hypothetical of student learning activities that would be completed within three meeting.

Teaching Experiment

In this teaching experiment phase, the learning trajectory that has been designed in the preliminary design phase is then implemented in the learning process. The purpose of this implementation is to explore and observe the students' strategies and thinking. There are two cycles in this phase. The first cycle is a pilot experiment that aims to evaluate and improve the learning trajectory that has been designed. The second cycle is a teaching experiment that aims to implement the evaluated and revised learning trajectory in the pilot experiment.

Analysis Retrospective

In this phase, all the data collected in experimental design will be analyzed by comparing the conjecture in HLT with the results of implementing the learning trajectory that has been done in the experimental design phase. Data analysis was carried out by researchers and worked together with her supervisor to improve the validity of this study. Therefore, the description of learning trajectory using *Kubuk Manuk* Indonesian traditional game will subsequently be obtained. The result of a design research is not design that works but the underlying principles explaining how and why this design works (Wijaya, 2008). In retrospective analysis the role of HLT has been designed compared to the learning process carried out by students so that an investigation can be carried out and explained how students obtain the concepts of social arithmetic concept generated from the *Kubuk Manuk* game.

RESULTS and DISCUSSION

The results of this study showed the implementation of the learning trajectory design of social arithmetic using the *Kubuk Manuk* traditional game as the starting point in the learning process. The learning trajectory consists of three activities, namely the activities of playing the *Kubuk Manuk* games at levels 1, 2 and 3. The differences between the three activities are the number of seeds and the rules used in the game, and these are elaborated. The summary of all learning activities can be seen in Table 2.

Table 2. *The activities in learning social arithmetic using kubuk manuk game*

The Learning Social Arithmetic	The Learning Phases	The Learning Description
Learning about the concepts of income (revenue) and outcome (capital)	Students play *Kubuk Manuk* game level 1	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 1 f. Students work on student worksheet 1 g. Students and teachers discuss the results of the game, the results of student worksheet 1 work and social arithmetic concepts learned in the game
Learning about the concept of profit and loss	Students play *Kubuk Manuk* game level 2	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 2 f. Students work on student worksheet 2 g. Students and teachers discuss the results of the game, the results of student worksheet 2 work and social arithmetic concepts learned in the game
Learning about selling price, purchase price and the percentage of profit and loss	Students play *Kubuk Manuk* game level 3	a. Students actively ask and answer questions from the teacher b. Students pay attention to the teacher's explanation c. Students respond to what the teacher has said d. The teacher divides students into groups of 4-5 students randomly e. Students practice *Kubuk Manuk* game level 3 f. Students work on student worksheet 3 g. Students and teachers discuss the results of the game, the results of student worksheet 3 work and social arithmetic concepts learned in the game

Activity 1: Level One of the Kubuk Manuk Game

This activity begins by grouping the students into groups consisting of three to four students. The teacher then introduced the *Kubuk Manuk* traditional game and the rules used in the game. The first game is an important part of introducing the learning context to make it easier for the next activity. It also embeds the social values that can develop students' ability to interact effectively with their social environment and improve the students' sportsmanship when doing an activity that is competitive in accordance with the standard competencies in Indonesian education.

To introduce this game the teacher starts by explaining that the *Kubuk Manuk* game originates from Java and explains the rules of the game that each member of the group must collect a kind of beans namely *benguk* seeds as the capital of the game, and the number of seeds must be the same. The students will grasp all the seeds in the left hand and shaken above the right hand. Then, a few seeds are thrown into the right-hand grip and the other players in the group have to make a guess. If none of the students are able to guess it, the students must spread the seeds and count using both fingers. The introduction of the game is accompanied with a simulation done by the teacher in front of the class with a few students, as shown in Figure 1.

FIGURE 1. Simulation of the *Kubuk Manuk* game

After the simulation finished, the students play *Kubuk Manuk* level 1 together with their respective groups, as shown in Figure 2. Students already understand how to play *Kubuk Manuk* level 1.

FIGURE 2. Student playing the *Kubuk Manuk* game

It is to make a compilation to determine the leading players and opposing players, then collect the same amount of capital each player. Furthermore, the main player sings the level 1 *Kubuk Manuk* song while moving the seeds from the right-hand grip to the leading player's left hand. If not guessed then the player spreads the seeds and picks them using the index finger. Also, students help each other in playing the game even though they compete with each other to win. Seen from the attitude of student A that helps student B to grab the seeds used for the game so as not to be scattered. Its is following the purpose of choosing an ethnomathematics-based context in this learning design that is to develop student character based on values that can be drawn from the game.

Next, the students began playing the *Kubuk Manuk* game with their respective group, and the students discuss and solve the problems contained in the worksheets that have been given as can be seen in Figure 3. The capital data and results are written in the table provided in the student worksheet.

FIGURE 3. Student discuss the problem in the worksheet

The problem in the worksheet requires the students to determine the scores obtained by each student in the group and decide who win and who lose the game. Figure 4 shows that students have been able to identify capital (income) and results (outcome). Students can also determine the score of each player and can determine the player who wins and lose from the number of seeds obtained. Students then conduct a group discussion to solve the problems that exist in student worksheet which is about how to determine the player's score and determine the players who win and lose.

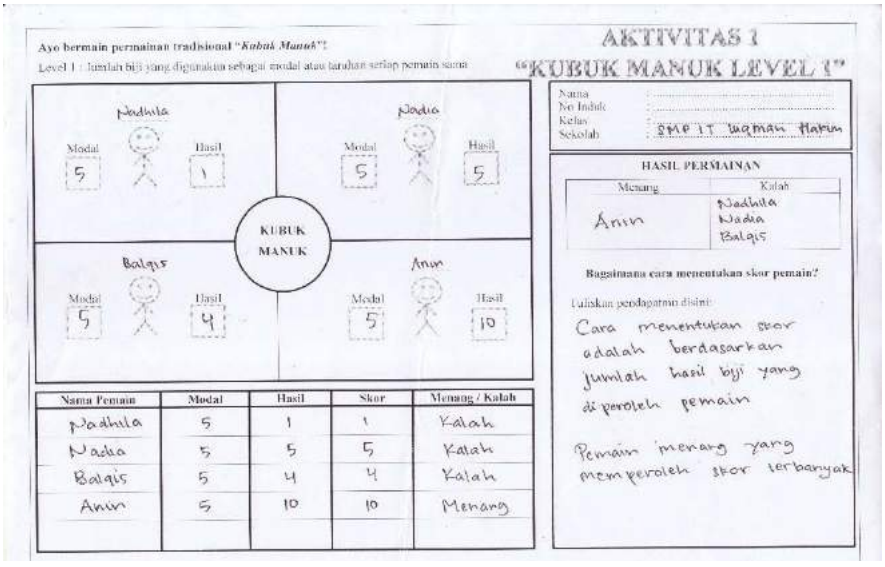


FIGURE 4. The results of the students' worksheet from the first activity

Furthermore, students are required to present the results in front of the class. The teacher chooses one of the groups to present their work in front of the class as shown in Figure 5.

FIGURE 5. Students presenting the results

The following is an excerpt from the dialogue of one group when presenting the results of their presentation in front of the class.

Student : *"Jadi kita akan mempresentasikan tentang hasil permainan kita hari ini, jadi kelompok kita ngelakuin dua kali permainan, hasil yang pertama pemenangnya adalah Salima"*
[We will present about the results of our game today, so our group has done two games, the winner of the first result is Salima"]

Teacher : *"Modalnya dulu, modalnya"*
[First capital, their capital]

Student : *"Salima, modal sepuluh dan hasil dua puluh satu, berarti untungnya sebelas. Terus ronde kedua modalnya lima belas yang menang salima lagi, dia dapat dua puluh satu. Dan yang ketiga dengan modal dua puluh pemenangnya adalah alin dengan hasil empat puluh enam. Jadi cara menentukan skor itu dilihat dari hasil mainnya. Kalau dia kalah maka dia dapat skor nol, kalau dia menang maka ia dapat skor satu"*
[Salima, the capital is ten and the income is twenty-one, means the income is eleven. Then in the second round of capital is fifteen and the winner is Salima again, he got twenty-one. And the third one with the capital is twenty and the winners is Alin with the income is forty-six. So, the way to determine the score is seen from the results of the game. If she loses, her score is zero; If she wins, her score is one].

Based on the dialogue, it can be seen that through a process of playing *Kubuk Manuk* level 1 students have been able to understand the definition of capital and income. Students revealed that "*the capital is ten and the income is twenty-one*"; it can be seen that students have understood that 10 seeds collected or issued by players to play the *Kubuk Manuk* game are capital and 21 seeds obtained from a playing process the *Kubuk Manuk* game are income.

Students have also been able to predict how to determine player scores based on their thinking and understanding of the concepts of capital and income. It can be seen from the students' answers, "*So the way to determine the score is seen from the results of the game*". The ability of students to predict the player's score, shows that an indicator of students' mathematical understanding has been reached (Wijaya, 2008; Prahmana & Suwasti, 2014;

Ginting et al., 2018). Furthermore, the students also revealed "*the income is eleven*"; it means that the development of students' understanding in the group had reached the relationship of capital and income. The answer "*eleven*" is obtained by students by subtracting the outcome with capital. Students have also been able to define that "*eleven*" is the benefit of Salima.

Students have been able to see the relationship between capital, outcome, and income, because before learning activities take place students have followed the school program that is market day. In the program, students are given capital to carry out a particular business and the teacher is also accustomed to introducing terms such as capital gains and profits to students in implementing the program (Madani et al., 2018).

In the dialogue the students revealed "*If she loses, her score is zero; If she wins, her score is one* "; the answer of this student is beyond the predictions of the researcher. In HLT, researchers only predict students will answer the score with 'results' or with 'results reduced by capital' (Gravemeijer & Cobb, 2006; Gravemeijer & van Eerde, 2009; Prahmana et al., 2012). The students' answers are influenced by the experience of students outside of learning when playing games on mobile phones or when looking at a match that is when winning it will get a score of one and lose the score zero. Students perceive that the rules for determining the score used in this game are the same as those used in a game or match.

The class discussions with the teacher in order to get the same students' perceptions about the solutions of the problems in the worksheet and about the mathematical concepts that can be learned from this game (refer to Figure 6). From the class discussions, similar perceptions were achieved among the students in which the seed capital used in the game is 'outcome' and the seeds obtained in the game are 'income'. Hence, from this activity, the students learnt about the mathematics concepts of outcome and income.

FIGURE 6. Class Discussion

Activity 2: Level Two of the Kubuk Manuk Game

The second activity is the same as the first activity, but the number of seeds used as the capital of the game is different for each player. The game begins with a simulation by the teacher, and the students continue to practice the game in their group (refer to Figure 7). Then the students discuss and solve the problem in the worksheets. The problem in the second activity worksheet is no different from the problems in the first activity worksheet that is determining the scores obtained by each player and determining the winning and losing players in the game if the seed capital used is different for each player.

FIGURE 7. Playing the *Kubuk Manuk* Game Level 2

Furthermore, in the class discussions, similar perceptions were obtained as in the first activity. However, the students must find another way to find the value of the game capital. They will need to find the value of profit or loss by subtracting the number of seeds obtained in the game by the number of seeds used as game capital. The resulting subtraction is considered as a score. The students who get the results of the subtraction will obtain a positive value. The number of seeds received more significant than the number of seeds used as game capital. On the other hands, the income is higher than the expenditure. Hence the students will receive the profits. Otherwise, the students who achieved a negative result from the subtraction will indicate that the number of seeds collected is less than the number of seeds used as capital. On the other hands, the income is less than the expenditure, and this will mean that the students get a loss. If a student gets a zero as a result of the subtraction or if the number of seeds obtained is equal to the number of seeds used as game capital, or if the income is equal to the expenditure, that means the students have obtained capital return. From this second activity, the students learnt about the mathematics concept of profits, loss and the relationship between them, as indicated in Figure 8.

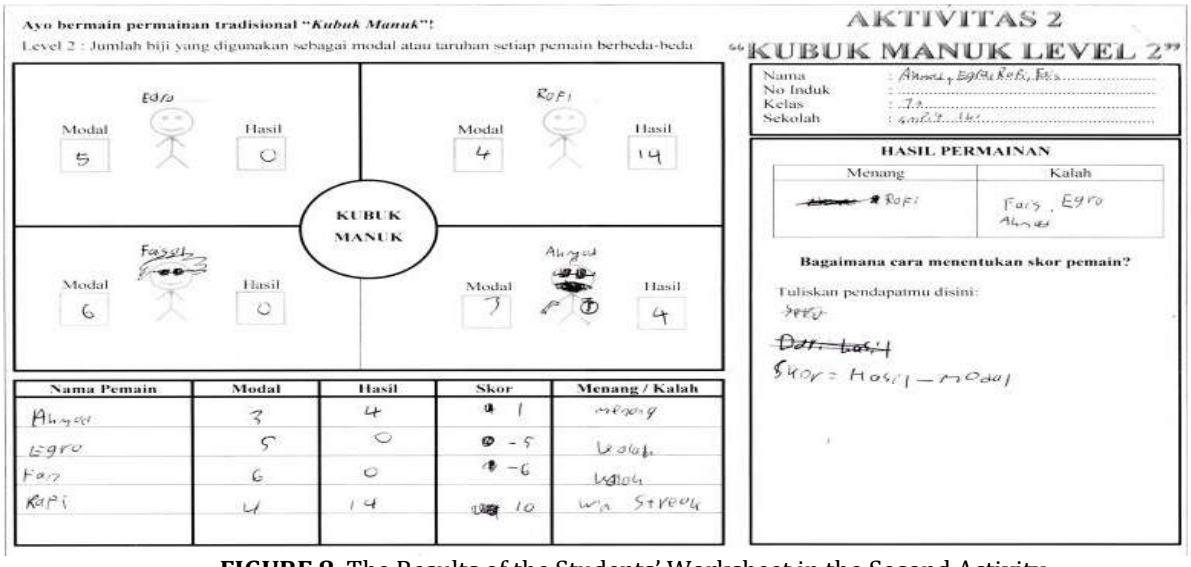


FIGURE 8. The Results of the Students' Worksheet in the Second Activity

Activity 3: Level Three of the Kubuk Manuk Game

The third level of the *Kubuk Manuk* game is the modified version of the original *Kubuk Manuk* game. In this level, the seeds are used in the game, and the capital must be purchased first. There are two types of groups, which are the seller group and the player group. The seller group has a role in selling the seeds that will be used in the game. They also buy the seeds that have been obtained by a player in the game. Similar to the previous activity, this third activity begins with a simulation. Then, the teacher will give the toy's money to each member of the player group to buy the seeds that will be used as game capital. After that, students play the game with their groups.

Once the game is completed, each player sells the seeds that have been obtained in the game to the seller groups. The students discuss and solve the problems in the worksheet and present the results in front of the class. The problem in the worksheet of the third activity is to determine the player's score in the game and also to determine the winning and losing players in the game. In the class discussion, the same perception was obtained in which the money used to buy the seeds that are referred to as the game capital is called cost and the money collected from selling the seeds is called purchase. Furthermore, the subtracting of the purchase with the cost is to determine the player's score. The winning player is the player who obtains the most profit shown in Figure 9. The evaluation process of the students' learning that has been conducted was to find out the students' understanding of the concept of social arithmetic and the implementation to solve the problem in daily life. Consequently, from this activity, the students learn about the mathematics concepts of cost, purchase, profit, and loss in trading activity.

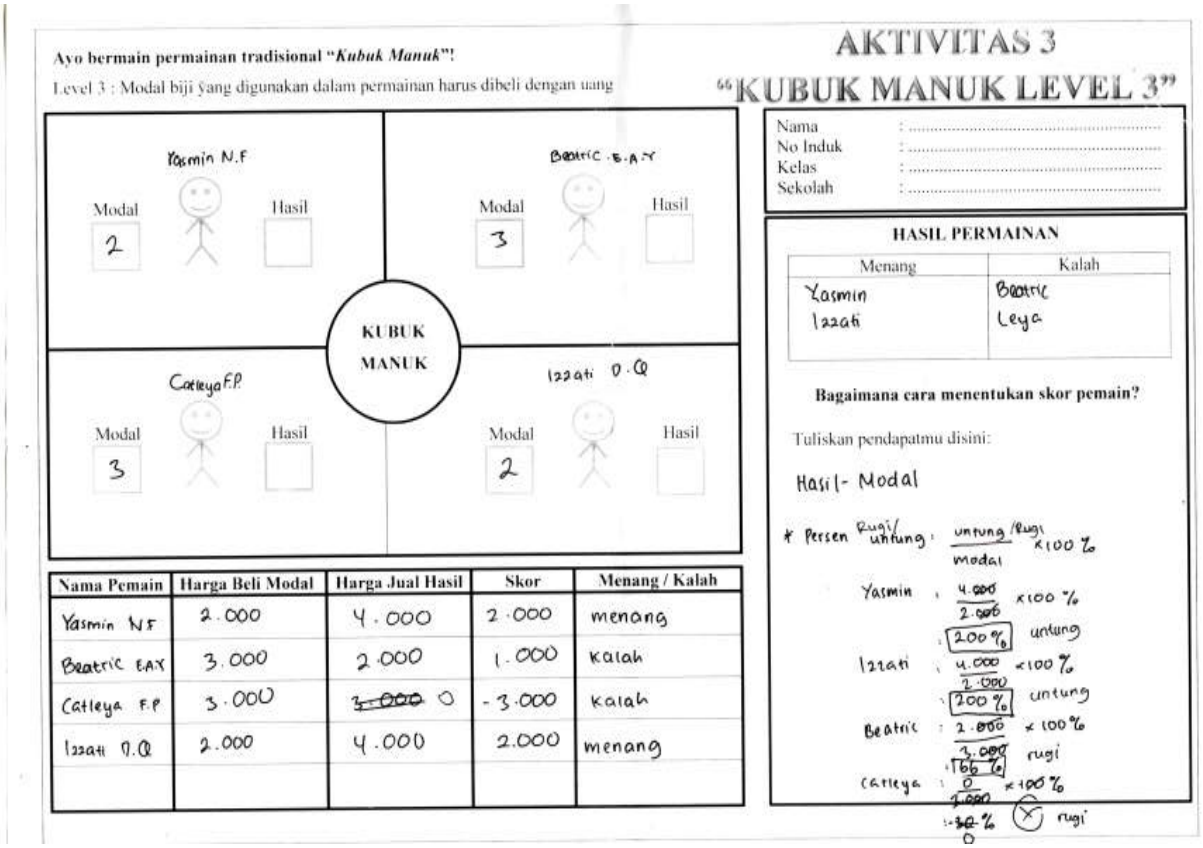


FIGURE 9. The Results of Students' Worksheet in the Third Activity

After the social arithmetic learning activities using the traditional *Kubuk Manuk* game were completed, the researcher gave a final evaluation question to all students. It is to find out their understanding in understanding the concept of social arithmetic (Madani et al., 2018; Van Den Heuvel-Panhuizen, 2005). Final evaluation questions are made based on three student

understanding indicators. Firstly, students can understand the concepts of income (results) and outcome (capital). Students can understand the idea of profit and loss. Lastly, students can understand the idea of the selling price, purchase price, and the percentage of profit and loss.

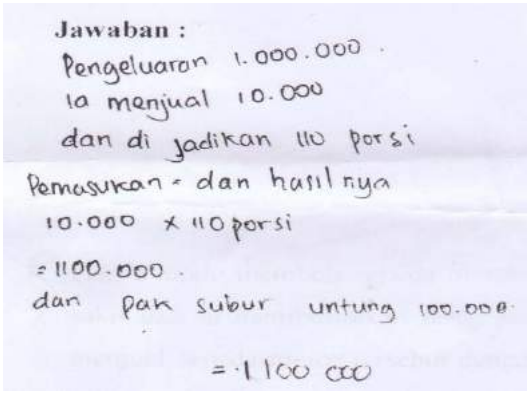
After the social arithmetic learning activities using the traditional *Kubuk Manuk* game were completed, the researcher gave a final evaluation question to all students to find out their understanding of the social arithmetic concept. The evaluation question is based on student understanding indicators that have been formulated in the mathematics textbook for Junior High School from the Indonesian Education Ministry. The explanation for each indicator of student understanding is as follows:

a. Students can understand the concepts of income (results) and outcome (capital)

All students are given evaluation questions that are done independently or not in groups. In the evaluation question one of them is about the concept of income and outcome. It is given to find out students' understanding of the concept. Questions in the evaluation questions regarding the concept of income and outcome along with examples of student answers are as follows:

Question 1:
Mr. Subur is a chicken porridge seller in the Jakarta area. As usual, every morning Mr. Subur goes to the market, shopping for staples to make chicken porridge. To buy these staples, Mr. Subur spent IDR 1,000,000. Then the staple is processed into chicken porridge, which is sold at IDR 10,000. On that day, Mr. Subur was able to sell 110 servings of chicken porridge. How much income did Mr. Subur get on that day?

Figure 10 shows that when presented a problem with social arithmetic, students have been able to identify outcome and income correctly. Almost all students answered correctly to the first question in the evaluation problem as in the example problem and the answer that shown in Figure 8.



Answer:
Output 1.000.000
He sold at 10.000
and able to sell 110 servings of chicken porridge

Income and the results
10.000 x 110 servings of chicken porridge
= 1.100.000

And Mr. Subur gets profit 100.000

FIGURE 10. The students answer for the first problem

Overall, the average student score for this question is 1.85 with an Ideal Maximum Score of 2. The assessment category is divided into 3 parts, namely first, 0 <= value <1 is included in the poor category; second, 1 <= value <2 is included in good category; and third, value = 2 is included in the excellent category. Therefore, the student's average score for this question falls into good category. So, it can be concluded that after students do social arithmetic learning using the *Kubuk Manuk* game, students can get good understanding in the concepts of income (capital) and outcome (results).

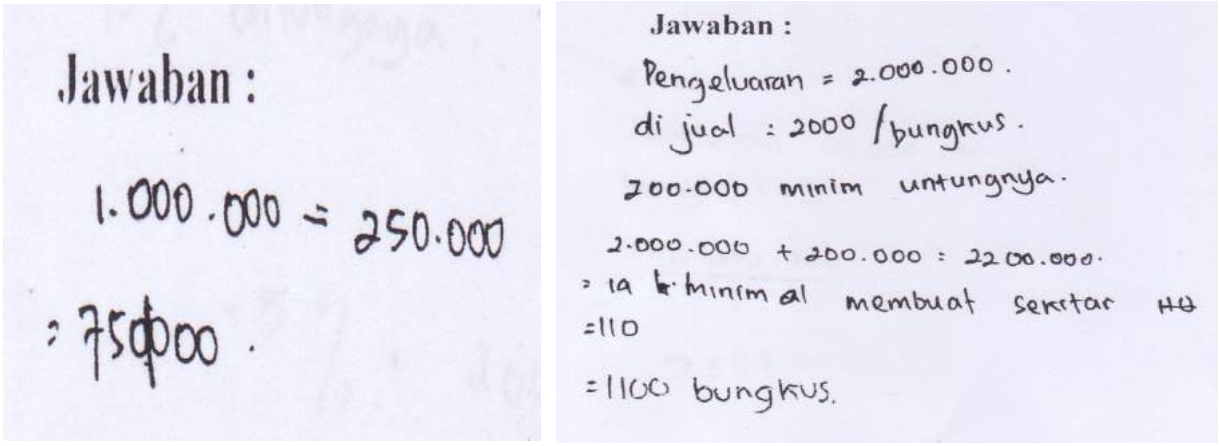
b. Students can understand the concept of profit and loss

In the evaluation questions also given questions to measure students' understanding of the second indicator that students are able to understand the concept of profit and loss. The question is as follows:
Question 2:

A businessman spends IDR 1,000,000 to run the business. In January, he bears a loss of IDR 250,000. So, how much income obtained in January?

Question 3:
An egg bean seller issued a capital of IDR 2,000,000 to run the business. Then, he sells his egg beans for IDR 2,000 per pack. If he targets to get a profit of IDR 200,000 from the business. So, what is the minimum package that must be sold by the seller?

Figure 11 explains that when presented a problem about social arithmetic, students have been able to correctly identify profit and loss as a result of income and outcome differences. Almost all students answered correctly to the second and third question in the evaluation problem as in the example problem and the answer that shown in Figure 9.



Answer: 1.000.000 – 250.000 = 750.000	Answer: Outcome = 2.000.000 He sold 2.000 per pack 200.000 should be his minimum profit 2.000.000 + 200.000 = 2.200.000 So, he should sell minimum 1.100 pack

FIGURE 11. Student answer for question 2 (left) and question 3 (right)

Overall, the average value of students for question 2 is 1.75 and the average value of students for question 3 is 1.70 with an Ideal Maximum Score of 2. So, it can be concluded that after students do social arithmetic learning using the *Kubuk Manuk* game students can finally understand the concept of profit and loss. These research results add empirical evidence stated that games could help the student to understand the mathematics concept as having been done by several previous studies (Wijaya, 2008; Prahmana et al., 2012; Byun & Joung, 2018).

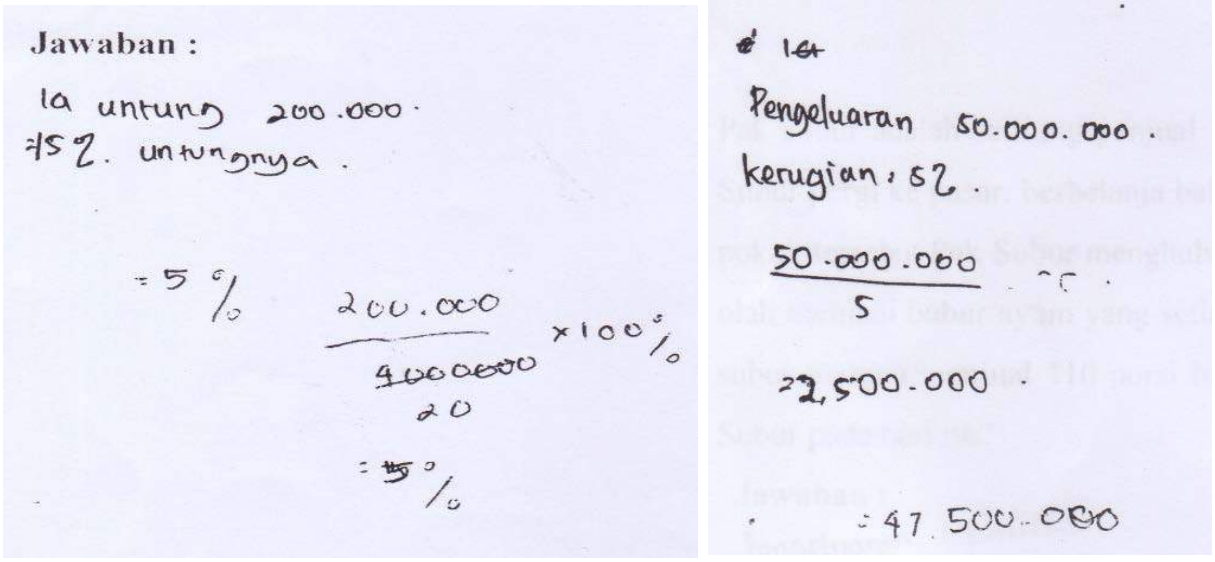
c. Students can understand the concept of selling price, buying price, and profit and loss percentages.

The students' understanding of third indicator that students are able to understand the concept of profit and loss measure in the last evaluation questions. The question is as follows:

Question 4:
Mr. Widodo buys a motorcycle at a price of IDR 4,000,000. Because of one day his son was sick and he needed money to pay for his son's treatment at the hospital. Then, He sold the motorbike at a price of IDR 4,200,000. Mr. Widodo experienced loss or gain? What is the percentage?

Question 5:
Mr. Anton bought the house at a price of IDR 50,000,000. Because of family problems, Mr. Anton was forced to sell the house at a loss of 5%. Determine the selling price of Mr. Anton's land?

Figure 12 describes the student answer presented a solution about social arithmetic problem namely percentages of loss and profit. Students have been able to correctly identify the selling price and purchase price and are able to calculate the percentage of profits and losses.



Answer: His profit is 200.000 = (200.000/4.000.000) x 100% = 5 %	Outcome 50.000.000 His lose is 5 % (50.000.000/5) = 2.500.000 = 47.500.000

FIGURE 12. Student answer for question 4 (left) and question 5 (right)

Overall, the average score of students for question 4 is 1.6 and the average value of students for question 5 is 1.6 with an Ideal Maximum Score of 2. Therefore, it can be concluded that after students do social arithmetic learning using the *Kubuk Manuk* game. Students can understand the selling price, the purchase price, and the profit and loss percentage.

Finally, the results of the evaluation questions given to students can be seen that, overall, the average score of students in good categories. It means that students understand the concept of social arithmetic, namely income, outcome, profit, loss, selling price, purchase price, and the percentage of profit and loss. Therefore, the *Kubuk Manuk* game has a useful context as a tool used to create Ethnomathematics-based learning designs to students' understanding of the concept of social arithmetic. These results supported several previous research results that stated the learning activity related to daily activity, such as traditional games and also culture, namely Ethnomathematics could be the starting point in learning mathematics (Wijaya, 2008; Prahmana et al., 2012; Tanujaya et al., 2017; Ginting et al., 2018; Jannah & Prahmana, 2019; Maryati & Prahmana, 2019).

CONCLUSION

In the learning of social arithmetic, the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. The students were able to understand the concept of mathematics easily since it is fun for them and importantly, the game is relatable to activities in their daily life. This study was able to take on

the role in developing the learning trajectory of social arithmetic learning by using the *Kubuk Manuk* Indonesian traditional game as the local context of learning.

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The learning trajectory of social arithmetic using an indonesian traditional game (Article)

[Endonezya geleneksel oyununu kullanarak sosyal aritmetik öğrenmenin öğrenme yolu]

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Abstract

Indonesia has many traditional games that can be used as a starting point in learning mathematics, i.e., social arithmetic. However, the teacher always used a conventional method such as direct teaching in teaching mathematics. Several researchers said that this method made mathematics learning boring. Therefore, this study aims to design a mathematics learning trajectory in social arithmetic using a traditional Indonesian game called the Kubuk Manuk. This game was used as the starting point in the learning process by applying the Indonesian Realistic Mathematics Education approach. The research method used is design research consisted of three stages, namely preliminary design, teaching experiment, and retrospective analysis. The results of this study indicate that the learning trajectory can be practiced using local contexts such as culture or other things easily found in the daily activities of the students. With the use of the Kubuk Manuk Indonesian traditional game, the students are stimulated to understand their knowledge of the social arithmetic concept. Additionally, the stages in the learning trajectory have essential roles in understanding the mathematics concepts of expenditure, income, profits, and loss within the trading activities.

Author keywords

Design research | Indonesian traditional games | Learning trajectory | Mathematics concepts | Social arithmetic learning

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