HONG KONG JOURNAL OF SOCIAL SCIENCES

香港社會科學學報

最新第62期 (2023年秋/冬季) Vol. 62 Autumn/Winter 2023

Open Access Article https://doi.org/10.55463/hkjss.issn.1021-3619.62.49

Elementary School Students: A Practical Situation Analysis of an Ethnomathematics Learning Mobile Application

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Received: September 17, 2023 ▪ Reviewed: October 12, 2023

▪ Accepted: November 14, 2023 ▪ Published: January 29, 2024

Abstract:
This study aimed to analyze elementary school students' didactical situation in traditional games using a mathematics learning mobile application. This study analyzed the traditional games of *endog-endogan, engklek,* and *congklak,* which originate from the Sundanese culture in West Java, Indonesia. This qualitative study used a didactic research design involving 524 students. In the learning obstacle stage, 304 students in grades 1-6 of elementary school participated. In the initial didactic stage, 152 students from grades 1-6 of elementary school were involved, while in the revised design stage, another 152 students from grades 1–6 elementary school were involved. The instruments employed in these stages were the obstacle learning test, worksheet, documentation, and observation. The study findings revealed that the subjects experienced learning obstacles in epistemology on addition, subtraction, integers, and fractions. Through the initial didactic design process and revision, a mobile ethnomathematics learning teaching material application was developed with optimal *endog-endogan* and *engklek* games, with almost all teachers' predictions being the same as elementary school students' responses. Hence, mobile applications featuring traditional games can serve as a viable alternative to facilitate the acquisition of mathematical knowledge, making the learning process more accessible and adaptable to the topics studied. This combination of mobile applications with traditional games in teaching fills the gap in the lack of potential research on ethnomathematics learning in elementary schools.

Keywords: mobile application, ethnomathematics, traditional games, elementary school students.

小學生：民族數學學習行動應用的實踐情境分析

摘要：
本研究旨在利用數學學習行動應用程式分析小學生在傳統遊戲中的教學情況。本研究分析了恩多根、恩克萊克和康克拉克等傳統遊戲，這些遊戲起源於印尼西爪哇的巽他文化。這項定性研究採用了教學研究設計，涉及524名學生。學習障礙階段，小學16年級304名學生參與。最初的教學階段有152名小學16年級的學生

參與，而在修改設計階段，又有152名小學16年級的學生參與。這些階段所使用的工具是障礙學習測驗、工作表、文件和觀察。研究結果顯示，受試者在加法、減法、整數和分數方面遇到了認識論學習障礙。透過最初的教學設計過程和修改，透過最佳的內多糖和恩格勒克遊戲開發了移動民族數學學習教材應用程序，幾乎所有教師的預測與小學生的反因此，以傳統遊戲為特色的行動應用程式可以作為促進數學知識獲取的可行替代方案，使學習過程更容易理解並更適合所研究的主題。這種行動應用程式與傳統遊戲在教學中的結合填補了小學民族數學學習潛在研究的空白。

关键词：行動應用、民族數學、傳統遊戲、小學生。

1. Introduction

In this study, students demonstrated a high level of learning in mobile and traditional offline games. Conversely, when the perceptions of the people in charge of the study were considered, they perceived that children grasped the concepts more effectively when the traditional method was used (Furió et al., 2013). Specifically, mathematics learning with mobile and traditional technologies (Sayibu et al., 2022) will be more effective if students actively elaborate on the correlation between local culture and mathematical knowledge because the concept of learning mathematics is valuable in solving everyday problems. Student engagement in mathematics is also vital to students' academic achievement and long-term participation in science, technology, engineering, and mathematics (STEM) courses and careers. An increasing body of research has established a correlation between advanced science and math student engagement and higher grades, scores on advanced standardized tests, and an increased probability of enrolling in advanced science and math courses (Lent et al., 2008). Since engagement serves as a reliable indicator of academic achievements and a soft state that can be enhanced through developments in the social and academic context, it possesses tremendous potential as a primary target for interventions (Appleton et al., 2008).

Elementary schools can combine the creativity of mathematics learning with culture-based learning. One of them is Sundanese ethnomathematics mobile application learning. Culturally enriched mathematical concepts concur that students should emulate and appreciate not only their native culture but also the customs and behaviors of other cultures. The legacy of Confucian culture in the mathematics classroom is one example of a finding that supports the correlation between culture and mathematics (Schultes & Shannon, 1997; Simamora et al., 2018; Sum & Kwon, 2020). In addition, the interrelationship between mathematics, culture, environment, and habits of action necessitates the consideration of students' cultural diversity as a means to enhance their information performance (d'Entremont, 2015).

2. Literature Review

2.1. Ethnomathematics Learning

This paper examines the relationship between mathematics and culture with traditional forms of Sundanese culture in West Java, Indonesia, arranged according to Sundanese ethnomathematics concepts. The traditional games used in the mobile application are endog-endogan, engklek, and congklak. Sundanese culture originates from the resident population of West Java, Indonesia. They are the second leading population in Indonesia, other than the Javanese in Central and Eastern Java, with an estimated 48 million individuals in 2018. Sundanese are usually Muslims and socialize easily. Based on researchers from Austronesian Southeast Asia (Bellwood, 2006; Roosita et al., 2008; Blust, 2013), Sundanese culture originated in Taiwan and reached Java between 1,500 and 1,000 BC. Within the Sundanese population, various traditional communities that belong to the Komunitas Adat exist. This non-nomadic community possesses deeply ingrained traditional customs that are more robust than those of contemporary communities. This indigenous community continues to reside in partially developed settlements dispersed throughout several regions of West Java.

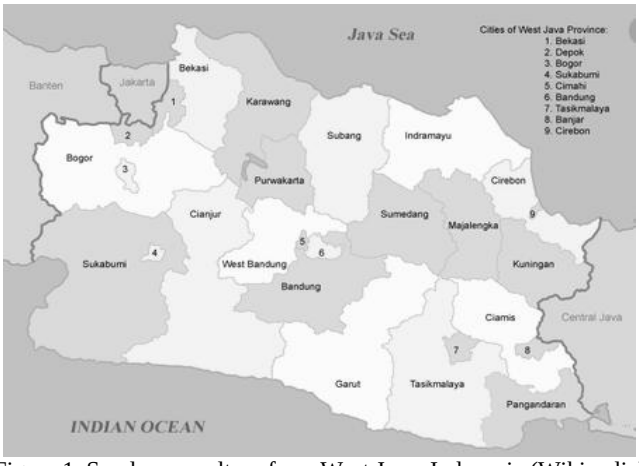


Figure 1. Sundanese culture from West Java, Indonesia (Wikipedia)

The idea of Sundanese ethnomathematics, as described by Supriadi (Supriadi, 2019a, 2019b, 2019c, 2020), refers to the manifestation of ideas rooted in Sundanese culture through the development of mathematical thinking, recognizing mathematics as a cultural product.

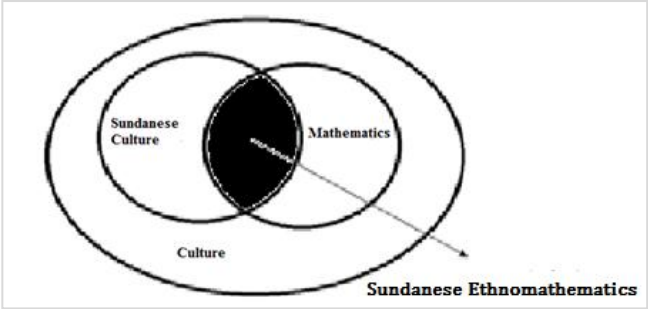


Figure 2. Sundanese culture from West Java, Indonesia (Developed by the authors)

Sundanese ethnomathematics learning can be useful in improving the mathematical thinking development of elementary school students because it prioritizes their mathematical thinking development. The mathematical thinking talent in elementary schools that will be developed through this learning is classified as innovative by deliberately using the Sundanese cultural background. The student's opinion-design thinking skill that needs to be considered is the talent for creative belief in mathematics. The dependability of ethnomathematics learning on culture, according to the results of Achor et al. (2009) and Verner et al. (2013, 2019), is that the geometry learning of students who are skilled at ethnomathematics is at an advanced level. Therefore, the purpose of this study is to optimize teaching resources according to the description of Sundanese ethnomathematics learning using *endog-endogan*, *engklek*, and *congklak* mobile application games.

3. Method

3.1. Participants

A didactic research design was employed to conduct this qualitative study with the participation of 524 students. Specifically, 304 students in grades 1-6 of elementary school participated in the learning obstacle stage. Following the acquisition of learning obstacle data, the second phase proceeded with the compilation of a student worksheet tailored to Sundanese ethnomathematics learning. This involved using *endog-endogan*, *engklek*, and *congklak* mobile application activities as part of the initial didactic design stage. During this initial didactic design stage, 152 elementary school students in grades one through 6 participated. After the initial didactic design, another 152 students in grades 1-6 of elementary school were involved in the revised didactic design stage to obtain revised learning obstacles through the reconstruction of a student worksheet and revision of the didactic design.

3.2. Learning Process

Endog-endogan, *engklek*, and *congklak* are traditional Sundanese games. This game used a mobile application as the medium.

Figure 3. Sundanese ethnomathematics mobile application (Developed by the authors)

3.3. Measurement

Table 1. Instrument of mathematics learning obstacle with students' response prediction (Developed by the authors)

Class	Learning obstacle test
1	a) Udin helped his mother to make eight cakes, but Udin only made one charred cake. Write down the number listed in the description above! *(Prediction: 8 and 1)* b) How to do this using addition or subtraction operations? (*Prediction: reduction*) c) Try to complete this box with numbers and operations! (*Prediction: 8-1=7*) d) How many cakes does Udin have now? *(Prediction: 7)*
2	a) Consider the arrangement of these numbers. Fill in the blank with a continuation! 33 36 39 42 ... (*Prediction: 45*) b) Make a number arrangement similar to that in the problem above! Make a note with the same difference (*Prediction: There are various alternative answers, for example, 45 48 51 54 57.*) c) If you have found the pattern or the difference between the numbers, what if the difference is replaced by 1 or 2? Try to make a new arrangement of numbers! (*Prediction: There are various alternative answers, for example, 33 34 35 36* 37)
3	a) How to reduce 720 to 257? Try making math sentences! (*Predictions 720 - 257 =)* b) How do you work on unit numbers, dozens, and hundreds? (*Predictions:* *720* *257 _* Determine the results of reduction! (*Predictions 463*)
4	a) Consider the sum of these fractions 2/4 and 3/4. Determine the numerator and denominator of the two fractions above, which have the same number. (*Prediction: Numerators 2 and 3. Denominators 4 and 4. The same number is the denominator of 4.)* b) Make mathematical sentences with numbers and complete them with additional operations! (*Prediction: 2/4 + ¾ =)* c)Determine the sum by completing the mathematical

	sentence (how to pronounce it)! (*Prediction: 5/4*)
5	a) Consider the sum of these fractions: …+ ….= 5/4. Determine the number of numbers and denominators!
	b) Make 4 examples of fractions. Then, fill in the numerators and denominators that have not been filled in so that the results are 5/4.
	c) Make a problem similar to the problem above if the numerator is replaced by the denominator and the denominator is replaced by the numerator.
6	Add these two numbers together: -13+ (5) = ...
	a) Write down the names of the numbers 13 and 5! (*Prediction: Negative 13 and Positive 5*)
	b) If you will add the two numbers together, how do you do it? (*Prediction: children answer correctly and how.*)
	c)Is it the same as 5-13? (*Prediction: different*)
	d) Try to make two problems that are similar to the sum of the two numbers as above, with the sum equal to 5! (*Prediction: -10 + 5 = 5, -13 + 8 = 5)*

3.4. Data Analysis

The present study employed qualitative research methods, specifically the didactical design research approach (Hudson, 2008; Artigue, 2009; Suryadi, 2010; Turk & Arslan, 2012; Martinez et al., 2013), to develop knowledge materials for ethnomathematics learning via mobile applications in the Sudanese context. Data collection techniques in this study comprised the initial learning obstacle test, the initial didactic test, revision of the didactic design, interviews, and observation. It was determined that the learning obstacle test would be used to develop a didactic design based on the collected data and analyze student responses. Before the test, the researchers made predictions of answers, which were divided into three types: those that aligned with the predictions, those that were partially consistent with the predictions, and those that were inconsistent with the predictions.

4. Results

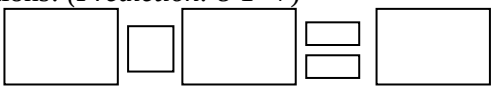
4.1. Analysis of the Learning Obstacles of Grade 1 Students

Grade 1 answered three questions as follows:

a) Udin helped his mother to make eight cakes, but Udin only made one charred cake. Write down the number listed in the description above! (*Prediction: 8 and 1*)

b) How to do this using addition or subtraction operations? (*Prediction: reduction*)

c) Try to complete this box with numbers and operations! *(Prediction: 8-1=7*)



d) How many cakes does Udin have now? (*Prediction:* 7)

Table 2. Student responses from Grade 1 (Developed by the authors)

Number	Student responses	Total
1a	8	6
	8 7	3
	8 and 1	1
	8 1	15
	1 8	1
	8 = 1	1
	1 2 3 4 5 6	1
1b	Reduction	23
	Addition	2
1c	8-1=7	30
1d	7	13

4.2. Analysis of the Learning Obstacles of Grade 2 Students

Grade 2 answered three questions as follows:

a) Consider the arrangement of these numbers! Fill in the blank with a continuation!

33 36 39 42 .... (*Prediction: 45*).

All students answered this item correctly, so it was excluded from the obstacle.

b) Make a number arrangement similar to that in the problem above! Note make with the same difference. (*Prediction: there are various alternative answers, for example, 45 48 51 54 57*)

c) If you have found the pattern or the difference between the numbers, what if the difference is replaced by 1 or 2? Try to make a new arrangement of numbers! (*Prediction: there are various alternative answers, for example, 33 34 35 36* 37

Table 3. Student responses from Grade 2 (Developed by the authors)

Number	Student responses	Total
2a	45	32
2b	10 13 16 19 22	4
	45 48 51 54	5
	33 36 39 42 45	7
	13 16 19 22 25 28 31	1
	41 44 47 30 33	1
	53 56 59 62 65	2
	39 36 33 42 45	1
	54 56 58 60 62	1
	56 60 64 68 72	1
	22+3=25	1
	39 43 46 49 53	1
	48 51 53 56 59 63	1
	22 24 29 32 34	1
	Did not answer	5
2c	39 47 43 45 47	1
	60 66 72 78 84	1
	63 66 69 72 75	2
	31 32 33 35 36	1
	53 56 59 62	1
	54 56 58 60 62	1
	20 26 32 38 44	1
	33 34 35 36 37	3
	33 35 38 41 44	2
	33 36 39 42 45	3
	1 3 5 7 9 11	1
	33 35 37 39 41	2
	10 12 14 16 18	4
	37 39 41 45 47 49 51 53	1
	40 42 44 46 48	1
	33 35 37 39 41	1
	42 46 50 54 58	2
	53 57 61 65	1

Continuation of Table 3	
41 43 45 47	1
45 48 51 54	2

4.3. Analysis of the Learning Obstacles of Grade 3 Students

Grade 3 answered three questions as follows:

a) How to reduce 720 to 257? Try making math sentences! (*Predictions 720 - 257 =)*

b) How do you work on unit numbers, dozens, and hundreds?

(*Predictions:*

720
257 _

Determine the results of reduction! (*Predictions 463*).

Table 4. Student responses from Grade 3 (Developed by the authors)

Number	Student responses	Total
3a	Students do not answer	3
	Seven hundred and twenty minus two hundred and fifty-seven	4
	720 257-	2
	Number = hundreds + tens + units 720 = 7 + 2 + 0 257 = 2 + 5 + 7	1
	720 257 = 977	1
	Number = hundreds + tens + units 720 = 7 = 2 = 0 257 = 2 = 5 = 7	1
	720 257 = 537	1
	Is added to 720 257	1
	720 257- 537	1
	Mrs. Ahmad bought a cake for Eid.	1
	Mrs. Ahmad bought 8 of the 4 items in the meal to determine whether the cake was delicious or not, so the answer was 4.	
	720 257- 463	1
	Reduce seven hundred and twenty by two hundred and fifty-seven	3
	720 257- 477	1
	720-257	1
	720 257- 463	
	720 257- 470	1
	10 + 100	1
	2 6 = 12	1
	9 + 9	1
3b	720 257- 527	1
	720 257- 537	2
	720 – 257	5
	The way is to make the math sentence and then fill it in the math sentence.	2
	units tens of hundreds 3x3 23 100 34 _ 2331	1
	10 100 = 200	1
	300 200 = 100|200 100 = 100	1
	By adding up like this 720 257- 537	1
	Students do not answer	6
	720 257- 537	2
	1. Hundreds = 100 200 2. Tens = 20, 30 3. Units = 3,2	1
	Count it	1
	112 1 hundred 1 ten 2 unit	1
	Count it	1
3c	Students do not answer	5
	537	7
	530 five hundred thirty rupiah	1
	720 257 = 977	1
	463	6
	477	1
	473	1
	20 5 = 15	2
	10 7 = 3	1
	Number = hundreds + tens + units 720 = 700 + 20 + 0 257 = 200 + 50 + 7	1

4.4. Analysis of the Learning Obstacles of Grade 4 Students

Grade 4 answered three questions as follows:

a) Consider the sum of fractions 2/4 and 3/4. Determine the numerator and denominator of the two fractions above, which have the same number (*prediction: numerators 2 and 3, denominators 4 and 4. The same number is the denominator of 4)*

b) Make mathematical sentences with numbers that are complete with additional operations! (*Prediction: 2/4 + 3/4 =)*

c) Determine the sum by completing the mathematical sentence (how to pronounce it)! (*Prediction: 5/4*).

Table 5. Students' responses from Grade 4 (Developed by the authors)

Number	Student responses	Total
4a	Numbers 2 and 3 Denominators 4 and 4	2
	4	2
	4/4	1
	The denominator	1
	Numerator (4)	1
	Numerator	2
	2/4	1
	2 and 3 4 and 4	1
	The same number as the denominator	1
	The denominator	9

	Continuation of Table 5	
	3/4 + 2/4 = 12 × 8 = 152	1
	students did not answer	3
4b	2/4 + 3/4 = 5/4	1
	Two-quarters and three-quarters	1
	Equating the denominator or finding the least common multiple of the denominator after it has been crossed or (simplifying numbers that can still be simplified summed up)	2
	The sum of the fraction half plus one-third is five-sixths.	1
	$\frac{1}{2}\frac{2}{2} = 2 + 4 = 6$	1
	$\frac{2}{4} + \frac{3}{6} = \frac{5}{10}$	2
	$\frac{2}{4} \times \frac{3}{4} = \frac{5}{4}$	1
	$\frac{2}{3}\frac{4}{6}\frac{7}{10}\frac{11}{9}\frac{3}{4}$	1
	$\frac{2}{4} + \frac{3}{4} = \frac{5}{4}$	1
	$\frac{7}{2} + \frac{5}{2}$	1
	$\frac{3}{4} \times \frac{4}{5} = 12 + 20 = 32$	1
	$\frac{2}{4} - \frac{2}{4}$	1
	Students did not answer	8
4c	$\frac{4}{5}$	3
	$\frac{2}{3} + \frac{2}{2} = \frac{4}{5}$	3
	$\frac{5}{2} + \frac{5}{4} = \frac{5}{4}$	1
	$- + - = \frac{6}{8}$	1
	$\frac{2}{2} + \frac{2}{3} = \frac{4}{5}$	2
	$\frac{5}{5}\frac{6}{5}$	2
	Students did not answer	10
5b	$\frac{3}{4}$	1
	$\frac{2}{4} + \frac{3}{4} = \frac{5}{4}$	1
	$\frac{1}{4} + \frac{4}{4} = \frac{5}{4}\frac{3}{4} + \frac{2}{4} = \frac{5}{4}$	1
	$\frac{3}{2} + \frac{2}{2} = \frac{5}{4}\frac{7}{5}\frac{8}{10}\frac{3}{2}\frac{9}{7}$	1
	$\frac{2}{8} + \frac{5}{1} = \frac{7}{9}\frac{5}{8} + \frac{1}{1} = \frac{6}{9}\frac{9}{8} + \frac{1}{1} = \frac{10}{9}\frac{7}{2} + \frac{2}{6} = \frac{9}{8}$	1
	$\frac{3}{2} + \frac{2}{2}$	1
	Students do not answer	3
	$\frac{3}{2} + \frac{5}{2} = \frac{8}{4}\frac{3}{2} + \frac{3}{3} = \frac{6}{5}\frac{4}{5} + \frac{4}{2} = \frac{8}{7}\frac{5}{2} + \frac{1}{3} = \frac{6}{5}$	1
	$\frac{3}{2} + \frac{2}{2} = \frac{5}{4}$	1
	$\frac{2}{3} + \frac{3}{4} = \frac{5}{4}$	1
	$\frac{1}{2} + \frac{2}{5} = \frac{5}{4}\frac{11}{22} + \frac{1}{5} = \frac{5}{4}$	1
	$\frac{4}{1}$	1
	$\frac{3}{2} + \frac{2}{4} = \frac{5}{6}\frac{3}{2} + \frac{2}{2} = \frac{5}{4}$	1
5c	$\frac{2}{5} + \frac{2}{4} = \frac{4}{5}$	1
	$\frac{2}{3} + \frac{2}{2} = \frac{4}{5}$	2
	Pay attention to the sum of these fractions.	1
	$\frac{5}{2} + \frac{3}{3} = \frac{8}{5}$	
	Students do not answer	3
	$\frac{2}{3} + \frac{2}{2} = \frac{4}{5}$	1
	$\frac{3}{2} + \frac{2}{2} = \frac{5}{4}$	1
	$\frac{2}{2} + \frac{2}{3} = \frac{4}{5}$	1
	$\frac{3}{2} + \frac{1}{3} = \frac{4}{5}$	1
	$\frac{2}{5} + \frac{1}{2} = \frac{4}{5}$	1
	$\frac{3}{3} + \frac{2}{3} = \frac{5}{6}$	1
	$\frac{4}{2} + \frac{4}{3} = \frac{4}{5}$	1

4.5. Analysis of the Learning Obstacles of Grade 5 Students

Grade 5 answered three questions as follows:

a) Consider the sum of these fractions: … + …. = 5/4. Determine the number of numbers and denominators!

b) Make four examples of fractions. Then, fill in the numerators and denominators that have not been filled in so that the results are 5/4.

c) Make a problem similar to the problem above if the denominator replaces the numerator and the numerator replaces the denominator!

Table 6. Student responses from Grade 5 (Developed by the authors)

Number	Student responses	Total
5a	Students do not answer	4
	3/2	1
	(3 numerators) (2 denominators)	
	Denominator 3, 2 numerators (2 and 2)	1
	5 numerators, 4 denominators	3
	2 numerators, 2 denominators	1
	5 and 4	1

4.6. Analysis of the Learning Obstacles of Grade 6 Students

Grade 6 answered four questions as follows:

Add these two numbers together: -13+ (5) = ...

a. Write down the names of the numbers 13 and 5! - 13 and 5! (*Prediction: negative 13 and positive 5*

b. If you will add the two numbers together, how do you do it? (*Prediction: children answer correctly and how.*)

c. Is it the same as 5-13? (*Prediction: different*)

d. Try to make two problems that are similar to the sum of the two numbers as above, with the sum equal to 5! (*Prediction: -10 + 5 = 5, -13 + 8 = 5)*

Table 7. Student responses from Grade 6 (Developed by the authors)

Number	Student responses	Total
6a	Negative thirteen and positive five	1
	13: negative thirteen 5: positive five	5
	134	1
	13 negative and 5 positive	1
	Negative 13 and 5	1
6b	Added and determined negative and positive	1
	Negative 13 plus 5	1
	-13 + (5) = negative -13 is made less like the method below	1

	12- 5 = 8	
	Larger numbers are added up, but the results are negative because larger numbers are negative.	1
	Negative 13 plus 5	1
	-13 5 – 8	1
	-13+(5) = 8	1
	Adit has a debt of -13, and Adit only pays the debt of 5, so he still has a debt. of -8	1
	The student did not answer	1
6c	Different	2
	Same	4
	The correct one is 13.	1
	It is the same because addiction is reduced.	1
	The student did not answer	1
6d	-5- (10) 15 – 10	1
	10 – 5= 15 – 5 =	1
	-10 + 5	1
	-10 + (5) =5	1
	-12 + (7) = 5 10 + (-3)	1
	15 + (-10) -10 - -5 = 5	1
	6 + (-1) = 5	1
	10 5 = 5 -5 + (10) = 5	1
	-10 + (15) = 5	
	The student did not answer	1

4.7. Analysis of the Initial Didactic Design of Learning with Endog-Endogan Games for Grade 1

The learning process design of the mobile application with the *endog-endogan* game can be seen in Figure 4.

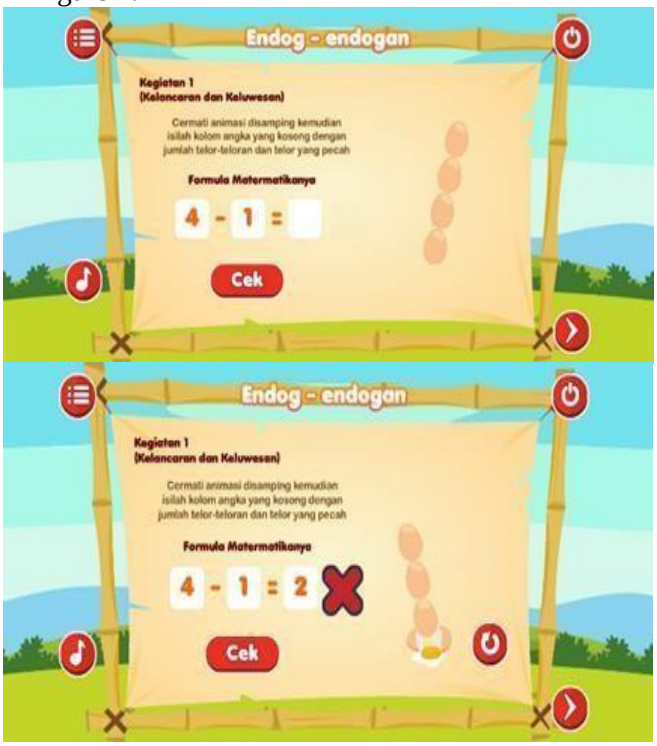
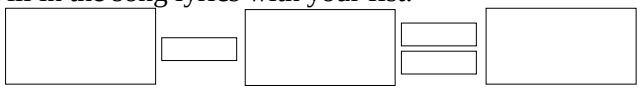


Figure 4. Sundanese ethnomathematics mobile application using the *endog-endogan* game (Developed by the authors)

For grade 1, the researchers gave the following instructions.

Come on, play *endog-endogan* games with Indonesian children. Let us gather in groups, and then put socks on your hands. Come on, make a fist in the egg, and start singing. Apply *endog-endogan* for the following reduction: Please fill in the numbers in the box according to the number of hands of your five friends. Subtract the numbers according to a friend's agreement and continue with the *endog-endogan* song. Fill in the song lyrics with your fist.



Endog-endogan endog peupeus,…. prek 2x
(....eggs crack ...., Prek (sounds))
(The students think counting the rest)
Endog-endogan nu teu peupeus aya opat
(There are .... eggs that do not crack)
Goleang-goleang, mata sapi bolotot
(Stir fry, cow eye goggles)

After learning by singing the *endog-endogan* song above, the students answered the worksheet. The results of the students' answers are listed in Table 8.

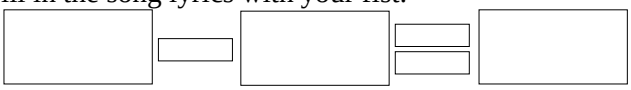
Table 8. Students' responses from Grade 1 in the initial didactic design (Developed by the authors)

Student responses	**Total**
1+3=4	23
6+4=10	5
4+6=10	4
1+9=10	4
9+1=10	5
4 + 6 (number 6 is written upside down) = 10	2
4 (number 4 is written upside down) + 6 (number 6 is written upside down) = 10	1
1 + 9 (number 9 is written upside down) = 10	1
10-3=7	5
10-6=4	3
10-4 = 6 (upside down)	1
10-6 (upside down) = 4	3
10-2=8	5
10-4=6	6

4.8. Analysis of the Initial Didactic Design of Learning with Endog-Endogan Games for Grade 2

For grade 2, the researchers gave the following instructions.

Come and play the *endog-endogan* game with children who love Indonesian games. Let us gather, and then wear socks to your hands. Come on, make an egg, and start singing *endog-endogan* for the following reduction. Please fill in the numbers in the box according to the number of hands of your five friends. Subtract the numbers according to the friend's agreement and continue with *endog-endogan* singing. Fill in the song lyrics with your fist.



Endog-endogan, endog 5

(Make five blue socks; prepare 10 brown heads)

Peupeus 12 prek 2x

(Solve ten first, then replace 1 blue sock with brown)

Endog-endogan, nu teu peupeus ...

(Fill according to the egg that is not broken)

Goleang-goleang, mata sapi bolotot

(Stir fry, cow eye goggles)

Following their comprehension of the aforementioned *endog-endogan* song, the students completed the worksheet. The responses provided by the students are detailed in Table 9.

Table 9. Students' responses from grade 2 in the initial didactic design (Developed by the authors)

Student responses	Total
10 e (number 9 is written upside down.) = 1	1
10 2 = 8	5
10 5 = 5	5
50- 12 = 38	3
10 2 = 38	1
10 9 = 1	2
10 3 = 7	1
10 7 = 3	2
10 4 = 6	5
38	4
50 12 = 38	12
Students do not answer.	6
40 210 = + 2	2
50 -	1

4.9. Analysis of the Initial Didactic Design of Learning Engklek Games for Grade 4

For grade 4, the researchers used *engklek* games containing fractional concepts. The game design is shown in Figure 5.

Figure 5. Sundanese ethnomathematics mobile application of the game (Developed by the authors)

Engklek in 1 green box, then write the pieces .... ($\frac{1}{4}$) then continue jumping on the 2 green boxes so that they have fractional values ... ($\frac{1}{4}$) added by .... ($\frac{1}{4}$)

Thus, it produces a distance of 3 greens obtained from the crank to 1 green box added to 2 green boxes, so it has a value of 3 green boxes. Compare which one is bigger .... ($\frac{1}{4}$). The activity was combined so that it becomes the sum of fractions ($\frac{1}{4} + \frac{2}{4} = \frac{3}{4}$).

The students completed the worksheet after learning the *engklek* game rule mentioned above. Table 10 lists the responses from the students.

Table 10. Students' responses from grade 4 in the initial didactic design (Developed by the authors)

Student responses	Total
$\frac{2}{4}$	19
$\frac{1}{4} < \frac{2}{4}$	1
$\frac{1}{4} + \frac{2}{4} = \frac{3}{4}$	19
$\frac{2}{4} + \frac{1}{4} = \frac{3}{4}$	5

4.10. Analysis of the Initial Didactic Design of Learning with Endog-Endogan Games for Grade 5

For grade, the researchers gave the instructions below.

Come on, play *endog-endogan*.

Make a palm, then save one egg head, and write the pieces!

Your other friend, make 4 palms, then save two egg heads, and write the fraction value!

Upon learning by singing the *endog-endogan* song mentioned earlier, the students proceed to complete the worksheet. The outcomes of the students' responses are indicated in Table 11.

Table 11. Students' responses from grade 5 in the initial didactic design (Developed by the authors)

Student responses	Total
Students do not answer	1
$\frac{1}{1}$	14

$\frac{1}{4}$	6
$\frac{2}{4}$	21

4.11. Analysis of the Initial Didactic Design of Learning with Congklak and Endog-Endogan Games for Grade 6

For class 6, the researchers used *congklak* and *endog-endogan* games, which contained the whole number concept. The game design is shown in Figure 6.

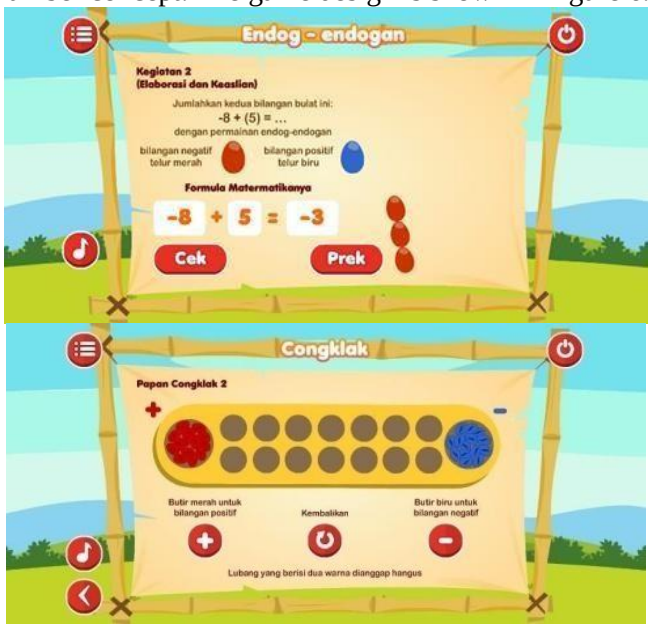


Figure 6. Sundanese ethnomathematics mobile application of *congklak* and *endog-endogan* games (Developed by the authors)

The use of *congklak* can follow the rules of the game by using the different colors of the player to indicate plus and minus. The researchers then provided instructions and asked them to answer the worksheet. Using *congklak*, the students attempted to answer the same four questions as in the previous stage.

Add these two numbers together: -13+ (5) = ...

a. Write down the names of the numbers -13 and 5!

b. If you will add the two numbers together, how do you do it?

c. Is it the same as 5-13?

d. Try to create two problems that are similar to the sum of the two numbers above, with the sum equal to 5!

Subsequently, the researchers provided explicit directives to "Make 13 red egg socks with a negative value and then 5 blue egg socks. Then, if we attach one red and one blue egghead, it is 0. Determine the remaining egg socks!"

The researchers then instructed the participants to respond by singing.

Try making another game, -12+ (5) =

Endog-endogan endog..... peupeus ....., prek 2x

(..... eggs crack ...., Prek (sounds))

(The students think counting the rest)

Endog-endogan nu teu peupeus aya .....

(There are ..... eggs that do not crack)

Goleang-goleang, mata sapi bolotot

(Stir fry, cow eye goggles)

After learning by singing the *endog-endogan* song mentioned above, the children completed the worksheet. Table 12 lists the students' responses.

Table 12. Students' responses from grade 6 in the initial didactic design (Developed by the authors)

Student responses	Total
8	3
-8	19
Negative 8	2
Negative thirteen and positive five	20
13 negative, 5 positive	3
Thirteen = negative thirteen, 5 positive five	1
By *endog-endogan* ways	18
Playing *endog-endogan*	2
Endog-endogan	4
Same - 8	11
Same	7
Yes	1
-8	3
-8 same	2
3+2 = 5, 4+1 = 5	1
-6+1 = -5, -13+8 = -5	
7+12 = 5	1
-15+20 = 5	5
-5+10 = 5	2
-7+12 = 5	
-7+12 = 5	2
-8+13 = 5	
-2+7 = 5 and -4+9 = 5	5
-6+11 = 5	1
-7+12 = 5	
8+(-3) = 5, -6+11 = 5	3
-8+13 = 5, -9+14 = 5	1
10+15 = 5	1
6+11 = 5	
10+(-5) = 5	1
15+(-10) = 5	
2+3 = 5	2
-6+11 = 5	
-9+14 = 5	1
-10+15 = 5	

All worksheets for grades 1-6 were then compiled and accessed on the student's worksheet page in the application (Figure 7).

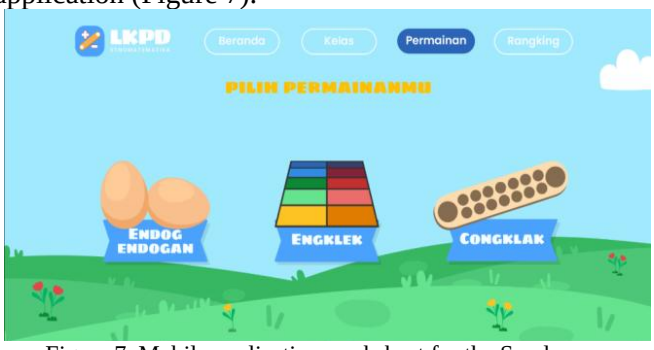


Figure 7. Mobile application worksheet for the Sundanese ethnomathematics game (Developed by the authors)

4.12. Analysis of the Revised Didactic Design with the Endog-Endogan Game in the Reduction Material for Grade 1

The researchers developed the instructions below for this stage.

Play *endog-endogan* with children to learn about Indonesian games. Let us gather in groups, and then put socks on your hands. Come on, make a fist in the egg, and start singing.

a. Play *endog-endogan* with children to learn about Indonesian games.

b. Let us gather and then wear socks on your hands.

c. Invite your friends to make eggs.

d. Then, break the eggs.

e. Fill in the following table with the number of eggs and broken ones differently.

Table 13. Question for grade 1 in the revision of didactic design (Developed by the authors)

Number of eggs	Number of broken eggs	Eggs that do not break	Mathematical sentences
4 eggs (2 of your friends)	1	3	4–1 = 3

The instruction to solve the problem used the *endog-endogan* song.

a. Choose one of the math sentences and fill in the lyrics below!

Endog-endogan endog..... peupeus ....., prek 2x

(..... eggs crack ...., Prek (sounds))

(The students think counting the rest)

Endog-endogan nu teu peupeus aya .....

(There are .... eggs that do not crack)

Goleang-goleang, mata sapi bolotot

(Spinning around, cow eyes bulging)

After learning by singing the *endog-endogan* song above, the students answered the worksheet. The results of the students' answers are presented in Table 14.

Table 14. Students' responses from grade 1 in the revision of the didactic design (Developed by the authors)

Students response				Total
Number of eggs	**Number of broken eggs**	**Eggs that do not break**	**Mathematical sentences**	
4 eggs (2 of your friends)	1	3	4–1 = 3	2
14	10	4	14-10 = 4	
14	3	11	14-3 = 11	
14	7	7	14-7 = 7	
4 eggs (2 of your friends)	1	3	4–1 = 3	5
8	3	5	8-3 = 5	
5	2	3	5-2 = 3	
4	2	2	4-2 = 2	
4 eggs (2 of your friends)	1	3	4–1 = 3	3
6	2	4	6-2 = 4	
5	1	4	5-1 = 4	
4	3	1	4-3 = 1	
4 eggs (2 of your friends)	1	3	4–1 = 3	2
6	3	3	6-3 = 3	
5	2	3	5-2 = 3	
4	2	2	4-2 = 2	
4 eggs (2 of your friends)	1	3	4–1 = 3	2
4	2	2	4-2 = 2	
6	3	3	6-3 = 3	
4 eggs (2 of your friends)	1	3	4–1 = 3	5
14	10	4	14-10 = 4	
14	3	11	14-3 = 11	
14	7	7	14-7 = 7	
4 eggs (2 of your friends)	1	3	4–1 = 3	2
6	2	4	6-2 = 4	
6	3	3	6-3 = 3	
6	4	2	6-4 = 2	
4 eggs (2 of your friends)	1	3	4–1 = 3	2
4	3	1	4-3 = 1	

4.13. Analysis of the Revised Didactic Design with the Endog-Endogan Game in Reduction Material for Grade 2

At this stage, the researchers created the following instructions.

Come to play *endog-endogan* with children to learn about Indonesian games. Let us gather in groups, and then put socks on your hands. Come on, make a fist in the egg, and start singing.

a. Pay *endog-end*ogan with children to learn about Indonesian games.

b. Let us gather and then wear socks on your hands.

c. Invite your friends to make eggs.

d. Then, break the eggs.

e. Fill in the following table with the number of eggs and broken ones differently.

Table 15. Question for grade 2 in the revision of the didactic design (Developed by the authors)

Number of eggs	Number of broken eggs	Eggs that do not break	Mathematical sentences
16 eggs (8 of your friends)	7	9	16–7=9
16	8	8	16 8 = 8
16	9	7	16–9 =7
16	10	6	16–10 = 6

The *endog-endogan* song was used as part of the problem-solving instructions.

a. Choose one of the math sentences and fill in the lyrics below!

Endog-endogan endog..... peupeus ....., prek 2x

(..... eggs crack ...., prek (sounds))

(The students think counting the rest)

Endog-endogan nu teu peupeus aya .....

(There are .... eggs that do not crack)

Goleang-goleang, mata sapi bolotot
(Spinning around, cow eyes bulging)

The students completed the worksheet after learning the *endog-endogan* song. The results of the students' answers are displayed in Table 16.

Table 16. Students' responses from grade 2 in the revision of the didactic design (Developed by the authors)

Students response				**Total**
Number of eggs	**Number of broken eggs**	**Eggs that do not break**	**Mathematical sentences**	
16 eggs (8 of your friends)	7	9	16–7 = 9	3
12	2	10	12 2 = 10	
12	4	8	12 4 = 8	
12	3	9	12 3 = 9	
16 eggs (8 of your friends)	7	9	16–7 = 9	1
6	1	5	6 1 = 5	
12	2	10	12 2 = 10	
12	4	8	12 4 = 8	
16 eggs (8 of your friends)	7	9	16–7 = 9	4
8	2	6	8 2 = 6	
8	3	5	8 3 = 5	
8	4	4	8 4 = 4	
16 eggs (8 of your friends)	7	9	16–7 = 9	5
10	4	6	10 4 = 6	
10	3	7	10 3 = 7	
10	2	8	10 2 = 8	
16 eggs (8 of your friends)	7	9	16–7 = 9	3
8	1	7	8 1 = 7	
8	2	6	8 2 = 6	
8	7	1	8 7 = 1	
16 eggs (8 of your friends)	7	9	16–7 = 9	3
6	1	5	6 1 = 5	
12	2	10	12 2 = 10	
12	4	8	12 4 = 8	
16 eggs (8 of your friends)	7	9	16–7 = 9	5
8	3	5	8 3 = 5	
5	2	3	5 2 = 3	
4	2	2	4 – 2 = 2	
16 eggs (8 of your friends)	7	9	16–7 = 9	3
6	2	4	6 2 = 4	
5	1	4	5 1 = 4	
4	3	1	4 3 = 1	
16 eggs (8 of your friends)	7	9	16–7=9	4
6	3	3	6 3 = 3	
5	2	3	5 – 2 = 3	
4	2	2	4 2 = 2	
16 eggs (8 of your friends)	7	9	16–7=9	3
4	2	2	4 3 =	
6	3	3	6 – 3 = 3	
16 eggs (8 of your friends)	7	9	16–7 = 9	7
14	10	4	14 10 = 4	
14	3	11	14 3 = 11	
16 eggs (8 of your friends)	7	9	16–7 = 9	3
4	3	1	4 3 = 1	
16 eggs (8 of your friends)	7	9	16–7=9	2
6	2	4	6 2 = 4	
6	3	3	6 – 3 = 3	
6	4	2	6 4 = 2	

4.14. Analysis of the Revised Didactic Design with the Endog-Endogan Game in Reduction Material for Grade 3

The researchers instructed the students for this stage.

Come and play *endog-endogan* with children who love Indonesian games. Please gather in groups and continue wearing socks on your hands. Let us head to drawing eggs and start drawing!

a. Come and play *endog-endogan* with children who love Indonesian games.

b. Let us gather and then wear socks on your hands.

c. Invite your friends to make eggs.

d. Then, break the eggs.

e. Fill in the following table with the number of eggs and broken ones differently.

The students completed the worksheet after learning by singing the *endog-endogan* song mentioned above. Table 17 reveals the responses from the students.

Table 17. Students' responses from grade 3 in the revision of the didactic design (Developed by the authors)

Students response				**Total**
Number of eggs	**Number of broken eggs**	**Eggs that do not break**	**Mathematical sentences**	
28 eggs	19	9	28–19 = 9	3
4	-1	3	4-1 = 3	
-8	-3	-5	8-3 = 5	
28 eggs	19	9	28–19 = 9	4
6	-2	4	6-2 = 4	
8	5	3	8-3 = 5	
28 eggs	19	9	28–19 = 9	3
12	9	3	12-9 = 3	
4	1	3	4-1 = 3	
28 eggs	19	9	28–19 = 9	3
6	1	5	6-1 = 5	
5	5	0	5-5 = 0	
28 eggs	19	9	28–19 = 9	3
6	3	3	6-1 = 3	
12	9	3	12-9 = 3	

4.15. Analysis of Revised Didactic Design with the Endog-Endogan Game in Fraction Material for Grade 4

The researchers provided instructions for this stage.

Let us play *endog-endogan* in fraction material.

Make 3 egg balls with your friend, then cover with 2 pieces of blue socks for the head and 1 red sock. Notice how many red eggs there are from the total number of eggs.

1 head of red egg (numerator) =

Number of eggs (denominator) =

Write down the pieces!

At this stage, the researcher also provided a problem to solve and gave instructions.

Invite your friend to make 3 pieces of head, then use 1 sock, and then save 2 egg heads using red socks.

2 red eggs (numerator) =

Number of eggs (denominator) =

Write down the pieces!

• Compare the two fractions; which one is bigger?

• Activities are attempted to combine them into fraction summations.

After learning by singing the *endog-endogan* game above, the students answered the worksheet. Table 18 shows the results of the students' responses.

Table 18. Students' responses from grade 4 in the revision of the didactic design (Developed by the authors)

Students response	Total
$\frac{1}{3}$	23
$\frac{2}{3}$	23
$\frac{3}{2}$	23
$\frac{1}{3}+\frac{2}{3}=\frac{3}{3}$	23

4.16. Analysis of Revised Didactic Design with the Endog-Endogan Game in Fraction Material for Class 5

For this stage, the researchers developed the following instructions.

"Let us play *endog-endogan* in broken material."

Activity 1

a. Make the shape of eggs as shown below

1 red egg (numerator) =

All number of eggs (denominator) = write down the fraction!

b. Invite your other friends to form eggs, as shown in the picture below.

1 red egg (numerator) =

All numbers of eggs (denominators) = write down the fraction!

c. Make 2 forms of eggs, as shown in sections A and B. Write down the value of the fraction.

d. We find the fraction worth that part value of 1 and 2. Try writing it!

e. Try the sum of the two fractions and predict what the sum will be.

The students completed the worksheet after learning by singing the *endog-endogan* game. The results of the students' answers are listed in Table 19.

Table 19. Students' responses from grade 5 in the revision of the didactic design (Developed by the authors)

Number	Students Response	Total
1a	$\frac{1}{3}$	18
1b	$\frac{1}{2}$	18
1c	$\frac{1}{3}=\frac{2}{6}$ $\frac{1}{2}=\frac{3}{6}$	18
1d	$\frac{1}{3}$ and $\frac{2}{6}$	7
	$\frac{1}{3}$and $\frac{2}{6}$, $\frac{1}{2}$and $\frac{3}{6}$	8
	$\frac{2}{6}$: 2 = $\frac{1}{3}$ so $\frac{2}{6}=\frac{1}{3}$	3
1e	$\frac{1}{3}+\frac{1}{2}=\frac{2}{5}$	3
	$\frac{1}{3}+\frac{1}{2}=$ $\frac{2}{6}+\frac{3}{6}=\frac{5}{6}$	14
	$\frac{1}{3}+\frac{1}{2}=\frac{5}{6}$	1

4.17. Analysis of Revised Didactic Design with the Endog-Endogan Game in Integer Material for Grade 6

The researchers developed the following instructions for this stage:

Let us play *endog-endogan*, a Sundanese children's game from West Java, Indonesia.

Add these two integers together: -13+ (5) = ... with an *endog-endogan* game.

Game Step 1:

a. Make 13 red egg sock ball heads with negative values, then 5 blue egg sock ballets with positive values. Stack your fist in the picture like a pile of eggs.

b. Then, if we attach 1 head of red and blue eggs, the two eggs break out.

c. Determine the remaining egg socks!

d. So the answer to -13+ (5) = ...

Game Step 2:

Try making an *endog-endogan* game with 13+ (-5) = …

a. Make 13 blue egg heads with positive values.

b. Then, make five red eggs with a negative value.

c. Stack your fist in the picture like a pile of eggs.

d. Remember, if a pair of 1 red and one blue egg meets, they will break.

e. Please play and determine the remaining eggs that do not break.

f. Write down the answer 13+ (-5) = ...

After learning by singing the *endog-endogan* game above, the students answered the worksheet. The responses provided by the students are detailed in Table 20.

Table 20. Students' responses from grade 5 in the revision of the didactic design (Developed by the authors)

Number	Students response	Total
Game 1	-8	11
	8 eggs	2
	-8 (eight) negative red	3
	8 negative/red	2
	8	4
	Students who do not answer	4
	-8	23
	Negative 8	3
Game 2	Positive 8	3
	8	23

5. Discussion

Didactic situations in learning mathematics (Turk & Arslan, 2012; Modestou & Gagatsis, 2013) in the examined grade levels generated some learning obstacles (LO) that hindered students' ability to think mathematically for grades 1-6 according to didactic theory and epistemological obstacles (Brousseau, 2002). The presence of these obstacles stemmed from the students' inadequate understanding of particular contexts. The analysis of obstacles to learning at each level is as follows:

Grade 1 students have not been able to distinguish between the arrangement of unit numbers, tens and hundreds, or numerical systems. The same problem has been examined by Wong and Chan (2019), who showed that grade 1 students at elementary schools experienced difficulties in the number system process. Understanding story problems with long sentences makes it difficult for students to solve mathematical problems. However, students find it easier to count questions in the form of mathematical symbols than story problems. A previous study by Phonapichat et al. (2014) reported comparable results, stating that students struggled to comprehend lengthy mathematical sentences due to decreased motivation to read.

Because they were accustomed to solving math problems using only numbers, grade 2 students continued to struggle to comprehend story problems that were modeled into mathematical models. When presented with a question in the form of a story, the students' cognitive processes were not prepared to process it. When students posed a question regarding an identical narrative, they were able to compose it. However, they encountered challenges when the discussion strayed from the example. Students were, therefore, accustomed to writing using pre-existing templates.

When compared to students who believed that greater numbers were easier to reduce with smaller numbers, grade 3 students still had trouble reducing numbers. As a result, visualization is required to help students answer these questions. Similar findings regarding students' difficulties in reduction operations have been found (Kinda, 2013; Peters, 2014).

Grade 4 students faced challenges when attempting to add fractions. They contended that the process involves adding the denominators and numerators together. The challenge that students face in comprehending fractions aligns with the conclusions of Ciosek and Samborska (2016). In addition, grade 5 students continued to struggle with comprehending fractions presented in the context of narrative problems. Misconceptions also arose among grade 4 students who had not yet grasped adding fractions. They mistakenly added the denominators to the denominators and the numerators to the numerators.

Therefore, comparing and categorizing integers remained difficult tasks for grade 6 students. The sum of natural numbers was still used in integer operations, and symbol numbers were still regarded as equivalent to minus and negative numbers. Students' challenges in comprehending integers are consistent with the results reported by Whitacre et al. (2017).

After students were given the obstacle learning test, the teacher designed teaching materials, or what is called the initial didactic design. There were six teaching materials from grades 1-6 using the traditional game with a mobile application learning approach from West Java, Indonesia, which is the *endog-endogan* game.

The initial didactic design is a set of lessons targeted at overcoming existing learning obstacles. The learning was ethnomathematics learning mobile application using *endog-endogan* games, a series of learning activities that serve as a learning path for students to achieve learning goals more meaningfully referred to as learning trajectory (Simon et al., 2018). The learning activities were *endog-endoga*n and modified to encourage students to think about mathematical concepts. Related to this, learning activities must be organized for developing thinking and learning (Clements & Sarama, 2004).

In addition, didactic design (DDA) refers to didactic situation theory (Turk & Arslan, 2012). In this study, a Sundanese ethnomathematics learning mobile application was developed to design material conditions and social contracts that frame together the expected didactic situations, especially from the student's point of view. Based on the results of the students' responses, learning obstacles for each level in grades 1-6 began to decrease. It was evident that many of the students' answers matched the teacher's predictions. In pedagogic relations, teachers distributed worksheets together, but they were less than optimal (Simon et al., 2018). Thus, teachers performed ADP (Anticipate Pedagogical Didactic) by improving or revising DDA and changing the way teaching materials were distributed in the didactic design revision (RDD) stage.

Afterward, the revision of the didactic design is a refinement or metaphysical step of the teacher so that learning is better. Differences in cultural backgrounds did not make it difficult for students to adapt to *endog-endogan* game-learning situations. Brousseau (2002) argues that the modern conception of a teacher is how

teachers can wisely trigger students' adaptation to a problem. Students have learned that they can adapt thoughtfully using prior knowledge (Radford, 2008). In this case, Sundanese ethnomathematics learning mobile application games led to student independence in understanding the concepts of addition, subtraction, integers, and fractions.

A didactical situation, also known as a didactic situation, pertains to the degree of autonomy that students possess during the learning process (Brousseau, 2002; Modestou & Gagatsis, 2013). The developed Sundanese ethnomathematics learning mobile application has been correlated with mathematical concepts; therefore, the teacher's primary responsibility is to establish a didactic situation by connecting students with the material. Furthermore, students perceived Sundanese ethnomathematics learning as more tangible, significant, and pleasurable (Mania & Alam, 2021).

From grades 1-6 elementary students, Sundanese ethnomathematics learning mobile applications with *endog-endogan* games yielded optimal responses. The responses constructed solely based on the teacher's predictions demonstrated this.

6. Conclusion

Sundanese ethnomathematics learning mobile application materials have built an independent learning environment for students in grades 1-6 in understanding addition, subtraction, fraction, and integer material. Following the didactic design research stage, the researchers uncovered some conceptual learning obstacles in the epistemological concepts of addition, subtraction, integers, and fractions. In the initial didactic design stage using the Sundanese game, the subject responded well to the instruction and showed an understanding of the concept but was still divided into several groups of responses. Then, the didactic design revision stage developed complete instruction and determined the suitability of the game and its fitness to solve the conceptual problem. All students easily adapted to the game, and no obstacles existed in their cultural backgrounds. Student responses to optimal teaching materials are consistent with all the teacher's predictions of student responses.

These findings imply that the Sundanese mobile application game successfully meets the needs of students in elementary school mathematics learning. The game developed by responsive didactic design research could be a powerful alternative for teachers. For further research, researchers with ethnomathematics interests could address the investigation into deeper implementation and development of this design and another potential traditional game. This investigation could be directed at improving another student's mathematical ability.

7. Limitations and Further Study

Limitations of this study were its reliance on a small sample size of developed games and its exclusive focus on addressing a single learning obstacle. The other Sundanese game addition will require a different design to address the various learning obstacles using an ethnomathematics approach.

Authors' Contributions

All authors contributed equally to this research. The first author, as the leader and manager, led the research into article writing. The second author was in charge of the instrument and data collection. The third was the developer of the mobile application design and instruction. The fourth author oversaw the reporting and implementation of the design among elementary school students.

Acknowledgments

The authors extend their gratitude to the Elementary School Teacher Study Program, Universitas Pendidikan Indonesia, Luhur Jaya Elementary School in Lebak Regency, Banten, where this research was conducted, and research funding from the Indonesian Ministry of Research, Technology, and Higher Education for permitting them to conduct this study.

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