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Development of Didactic Design for Learning Mathematics in Pesantren: Integration of Mathematics and Fiqh Learning

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Abstrak

Perlu dikembangkan model pembelajaran matematika di pesantren yang dikaitkan dengan permasalahan yang sesuai dengan situasi di pondok pesantren, misalnya terkait dengan fiqh. Penelitian ini menggunakan Design Didactical Research (DDR). Pengembangan desain didaktis ini dilakukan dengan menggunakan Theory of Didactical Situation (TDS). Pembelajaran matematika di pesantren dirancang sebagai berikut: pembacaan ayat suci Al-Qur'an dan Hadits terkait materi pembelajaran matematika; materi dan tujuan pembelajaran yang terkait dengan ilmu keislaman; dan memberikan gambaran tentang manfaat mempelajari materi yang akan dipelajari dalam kehidupan sehari-hari, terutama ketika nantinya menjadi kader ulama. Pengembangan desain didaktis didasarkan pada teori situasi didaktis, yaitu: Situasi Devolusi, santri diberikan tantangan untuk menyelesaikan masalah zakat dan waris; Situasi Matematis, santri yang belum mampu menyelesaikan tantangan utama dibimbing melalui soal, tabel, dan petunjuk. Demikian pula santri yang sudah memiliki tebakan pemecahan masalah terus melakukan langkah-langkah untuk menguji keabsahan asumsi tersebut dengan menjawab beberapa pertanyaan, memperhatikan tabel, dan melaksanakan instruksi; Situasi Kelembagaan, santri membuat kesimpulan dengan bimbingan guru tentang poin-poin penting.
Kata Kunci: Didactical Design Research; Pesantren; Santri; Teori Situasi Didaktis.

Abstract

It is necessary to develop a mathematics learning model in pesantren that is associated with problems that are following the situation in the Islamic boarding school, for example, related to fiqh. This study used Design Didactical Research (DDR). The development of this didactic design was carried out using the Theory of Didactical Situation (TDS). The learning mathematics in pesantren is designed as follows: reading of the holy verses of Al-Qur'an and Hadith related to mathematics learning materials; the material and learning objectives associated with Islamic knowledge; and giving an overview of the benefits of studying the material to be studied in everyday life, especially when later becoming a cadre of the ulama. Didactic design development is based on the theory of didactic situation, namely: In the case of Devolution, santri are given the challenge of solving zakat and inheritance problems; in Mathematical Situations, santri who have not been able to complete the main difficulties are guided through questions, tables, and instructions. Likewise, santri, who already has problem-solving guesses, continues to test the validity of these assumptions by answering several questions, paying attention to tables, and carrying out instructions; 3) Situation of Institutionalization, santri makes conclusions with teacher guidance about essential points.
Keywords: Didactical Design Research; Islamic Boarding School; Santri; Theory of Didactical Situation.

I. INTRODUCTION

Pondok pesantren, or Islamic boarding schools, provide education and teaching related to learning, understanding, living, and practicing Islamic teachings (Dhofier, 1982; Mastuhu, 1994; Nasir & Abdushomad, 2005). Pondok pesantren initially emphasized the education of traditional Islamic religious studies but developed into a more structured one, even studying common knowledge (science) (Syafe'i, 2017). The education curriculum in pondok pesantren consists of the pesantren and general education curricula. This public education curriculum contains at least: a) citizenship education (al-tarbiyah al-wathaniyah); b) Indonesian Language (al-lughah al-indunisiyah); c) mathematics (al-riyadhiyat); and d) natural science (al-ulum al-thabi'iyah) (PMA, 2020).

Mathematics is a common knowledge that must be given to Santri (pesantren students). Mathematics subjects must be given to students to equip them with the ability to think logically, analytically, systematically, critically, and creatively and work together. This competence is needed so that Santri can have the ability to obtain, manage, and use as much information as possible for the benefit of the prosperity of the earth (isti'mar) as a mandate given by Allah SWT. One of the competencies that are expected to be achieved through mathematics lessons at Pesantren is to master mathematical concepts, especially arithmetic and algebra concepts, in solving daily life problems and calculation problems in the situation of fiqh zakat and fiqh mawarits (Pontren, 2015)

In Islam's history, mathematics is one part of a dedication to religion. For example, Muslim scholars want to help determine the exact times for the five daily prayers, as well as the direction of the Qibla, and the determination of the precise days of the year for Eid al-Fitr, the month of Ramadan, and the season of Hajj. Mathematics is used to strengthen fiqh, such as mawarits (inheritance), washaya (will), and tijarah (commerce) fiqh. Mathematics consists of mathematics (ar riyadiyat), logic (mantiq), and ethics. Mathematics (ar riyadiyat) consists of geometry, arithmetic, astronomy, and music. Meanwhile, logic consists of syllogism and dialectics (Schwartz, 2014).

The mathematics learning model in pesantren, which the Ministry of Religion expects is to pay attention to several things so that these competencies can be achieved by santri, namely: 1) mathematics learning begins with the introduction of problems that match the situation (muqtadhal hal) of each pesantren; 2) By proposing contextual problems, santri are gradually guided to master mathematical manipulation concepts and technique (Pontren, 2015). Therefore, there needs to be a study that provides an overview of what kind of mathematics learning is suitable in pesantren.

Based on the above description, developing a mathematics learning model associated with problems following the situation in pesantren, for example, related to fiqh, is necessary. This also aligns with the recommendations from the Research and Development Agency of the Religion Ministry in 2017 regarding making distinctive mathematics learning for pesantren different from other educational units (SMA or MA) (Balitbang, 2017).

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There is no clear example, whether from the Indonesian Ministry of Religion or based on research that has been done, of what kind of mathematics learning is appropriate or suitable in pesantren. The Ministry of Religion of the Republic of Indonesia only provides recommendations for learning mathematics as expected at pesantren. Then previous studies have not provided a comprehensive example of what mathematics should be taught in pesantren and how it should be taught. This research is expected to give examples of mathematics learning that can minimize learning obstacles Santri faces and must be like the mathematics learning process (interaction of teachers, santri, and the pesantren environment).

The development of mathematics learning can be focused on developing didactic designs because didactic situations in mathematics are organized situations that cause one or more students to adjust their knowledge to mathematics as a reference (Brousseau & Warfield, 2014; Afriansyah, Permatasari, Hamdani, & Maulani, 2023). Teachers and students have different thoughts and expectations about the developing didactic situation (Suryadi, 2019; Mujib & Sulistiana, 2023). An idea about this didactic situation is the Theory of Didactical Situation (TDS) developed in France by Brousseau between 1970-1990, which has become a center for didactic mathematics studies in French-speaking countries (Polotskaia & Boublil-Ekimova, 2019; Putri & Nasution, 2023). According to TDS, in the learning process of specific mathematical knowledge, there is an interaction between three elements: students, teachers, and the milieu or environment (Miyakawa & Winsløw, 2009; Susanti, Retnawati, Arliani, & Irfan, 2023; Robiah & Nuraeni, 2023).

II. METHOD

This study used Design Didactical Research (DDR). The Indonesian version of the DDR research design developed in 2010 is based on interpretive and critical paradigms (Suryadi, 2019). This research was conducted in three stages, namely:

The first stage was carried out to find out the learning obstacles faced by Santri obtained through phenomenological studies (interpretive paradigm). The data is collected through tests, interviews, and observations at this stage. These data were analyzed to determine the learning obstacles Santri faced: ontogenic, didactic, and epistemological barriers. The results of the interpretive paradigm research are described in the form of descriptions of learning obstacles Santri experienced during mathematics lessons.

The second stage is the development of a didactic design to improve the stages of learning to minimize the obstacles faced by Santri in learning mathematics. The results of the first research stage become the basis for developing a didactic design. The research results describe learning obstacles obtained through phenomenological studies, which are then used as the basis for further research as a follow-up to produce new didactic designs (Suryadi, 2019). A new didactic method was developed to improve the sequence or stages of learning to minimize learning obstacles students face. The foundation of

this process is the philosophy of critical pedagogy (Suryadi, 2019). The didactic design is essential in informing the relationship between research and practice in the field (Artigue, Haspekian, & Corblin-Lenfant, 2014).

The third stage is implementing the didactic design developed to see its impact on Santri and mathematics learning. Furthermore, this new didactic design was implemented to see its effects on students. After the implementation, the students were given tests and interviewed to see the effectiveness of the didactic method that had been developed.

Figure 1 describes three stages carried out in the didactic design development process.

The development of this didactic design was carried out using the Theory of Didactical Situation (TDS). Each of these didactic processes is a sequence of situations, each corresponding to one of three types (Brousseau & Warfield, 2014):

The situation of Devolution is a situation in which the teacher regulates: a) Students to accept the challenge of an exciting and instructive mathematical situation for which instruction is given at the outset: conditions, rules, objectives, and above all, the criteria for success; b) Students to do so without the help of the teacher and take responsibility themselves.

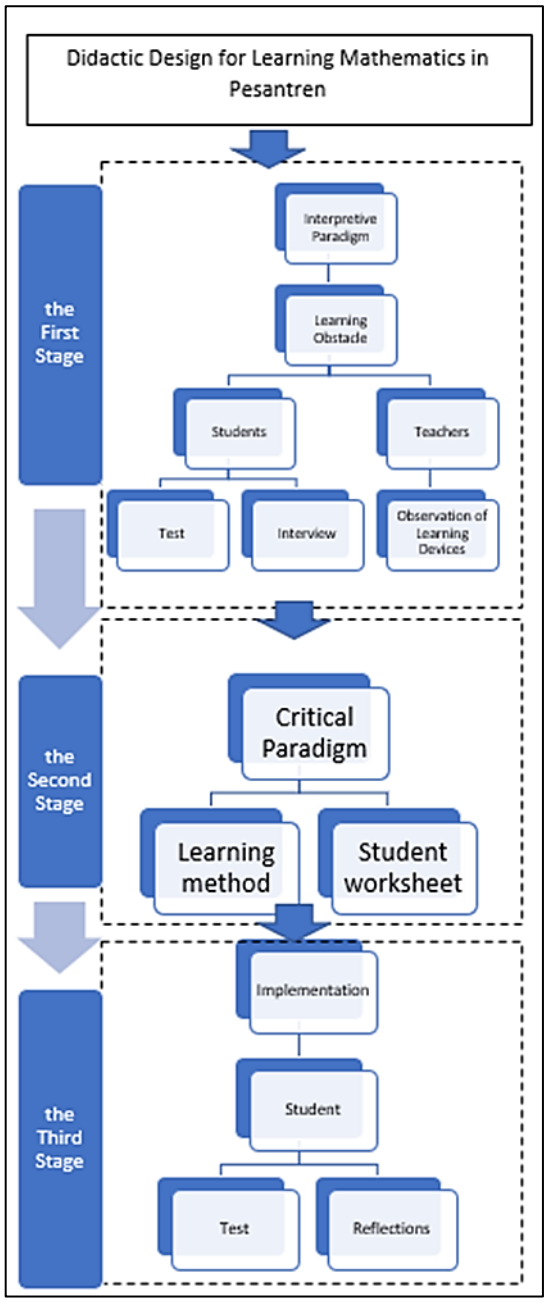

Figure 1. Stages of Didactic Design Development

Mathematical Situation, a situation that supports students in autonomous mathematical activities, individually and collectively, is a representation used by mathematicians. In this situation: a) Students are involved in generating new statements and discussing their validity; b) Students are involved in making decisions, formulating hypotheses, predicting, and assessing the consequences, trying to communicate information, producing and

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organizing models, arguments, and evidence, etc.; and c) Students evaluate and improve on their own the consequences of their choices.

The situation of Institutionalization is a situation where teachers: a) Record progress in mathematical situations from questions and answers that have been obtained or studied and from those that have emerged and place them in a curriculum perspective; b) Distinguish between the pieces of knowledge (reconnaissance) that have arisen from those that have stated false and those that are true, and between those which will serve as references; and c) Draw conclusions to organize further sequences (exercises, problems, etc.).

The result of this study is the didactic design for mathematics learning in *pesantren* based on the learning obstacles students face and the Theory of Didactical Situation (TDS).

III. RESULT AND DISCUSSION

The learning design was developed to minimize the students' learning obstacles. There are several learning obstacles experienced by students in learning mathematics at Pesantren, namely: 1) instrumental ontogenic barriers and conceptual ontogenic obstacles affect psychological ontogenic obstacles. These obstacles cause Santri's motivation and interest in learning mathematics to decrease. Student motivation and interest in learning are low (psychological ontogenic obstacles) caused by inappropriate learning design (instrumental ontogenic obstacles) and student difficulties in understanding the material in the learning process ((conceptual ontogenic obstacles); 2) didactic blocks occur because the mathematics curriculum used in the pesantren is the same as the mathematics curriculum in typical high school (SMA or Madrasah Aliyah) so that it affects mathematics learning in the classroom. Based on the results of interviews with students and teachers, students felt that the mathematics taught was not related to their lives in pesantren; and 3) epistemological obstacles occur because the learning process solely depends on high school mathematics textbooks, so the mathematical context presented is not different from familiar high school students (Ramdhani & Suryadi, 2018; Ramdhani, Suryadi, & Prabawanto, 2019a, 2019b; Ramdhani, Suryadi, & Prabawanto, 2021).

Based on the learning obstacles faced by Santri, mathematics learning was developed as follows:

Reading the holy verses of the Al-Qur'an and Hadith related to mathematics learning material is expected to increase the motivation of Santri to learn mathematics. For example: a) Reciting the holy verses of the Koran about zakat, namely Surah At-Taubah verse 103 and Al-Baqarah verse 43; and b) Reciting the holy verses of the Al-Quran about inheritance in al-Qur'an, namely Al-Baqarah verses 181-182, and Surat An-Nissa verses 7-8 and verses 11-12.

This is also done based on the research results, which state that learning mathematics by adding selected Qur'anic verses in questions can improve student learning outcomes (Saksono, 2015).

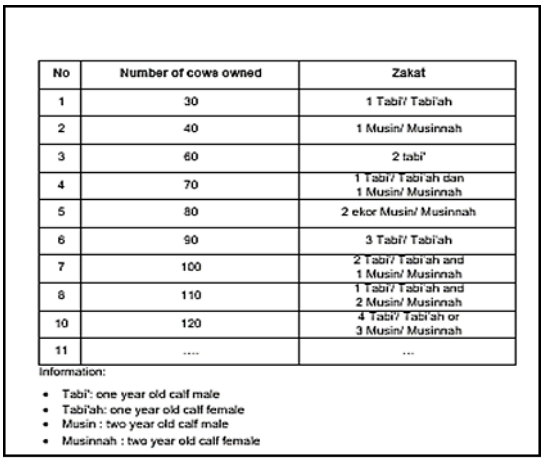
Learning objectives and materials related to Islamic knowledge are also expected to increase student motivation in learning mathematics. For example: a) Linking the material and learning objectives with zakat on livestock (cattle); b) Linking the material and learning objectives with fiqh mawarist (inheritance).

Learning mathematics adapted to the pesantren environment immersed in Islamic nuances is expected to increase students' motivation to learn mathematics (Hasanah, 2014). This is also done to avoid epistemological obstacles because, according to Carvalho et al., they are related to children's conceptions obtained from their daily lives (Carvalho, Silva, Lima, Coquet, & Clément, 2004).

In the closing of the learning activity, teachers and Santri make conclusions about essential points that appear in learning activities with the topic being studied. The didactic designs that have been developed are then validated by four experts, namely a mathematics education expert, a didactical design expert, a mathematics teacher, and a fiqh teacher.

The following is the didactical design developed based on the Theory of Didactical Situation (TDS), Integration of Mathematics Learning with Fiqh of Zakat.

The situation of Devolution: a) Santri are challenged to determine the amount of zakat on livestock (cows) that must be given based on the table presented; Santri are instructed to pay attention to the table regarding zakat on cows, then asked to fill in the dots on the table; Santri are required to explain the relationship between cows that are owned and zakat that must be spent; and Santri were instructed to make a mathematical model (formula) for n cows they owned associated with zakat that had to be finished. b) Santri was instructed to determine how many cows he owned if he had to pay zakat seven tabi 'and six musinnah and how much zakat should be paid if you have 1,220 cows, and Challenges are presented in students' worksheets.



No	Number of cows owned	Zakat
1	30	1 Tabi'/ Tabi'ah
2	40	1 Musin/ Musinnah
3	60	2 tabi'
4	70	1 Tabi'/ Tabi'ah dan 1 Musin/ Musinnah
5	80	2 ekor Musin/ Musinnah
6	90	3 Tabi'/ Tabi'ah
7	100	2 Tabi'/ Tabi'ah and 1 Musin/ Musinnah
8	110	1 Tabi'/ Tabi'ah and 2 Musin/ Musinnah
10	120	4 Tabi'/ Tabi'ah or 3 Musin/ Musinnah
11	....	...

Information:

- Tabi': one year old calf male
- Tabi'ah: one year old calf female
- Musin : two year old calf male
- Musinnah : two year old calf female

Figure 2. Zakat on Cow in Worksheet

Mathematical Situation: a) *Santri* are encouraged to find patterns or sequences based on the tables presented and discuss them with their peers. The didactic anticipation was made as follows, Santri who did not find a pattern are guided to look at several tables given. The tables are marked with the hope that the students will get easier to find the pattern (Figure 3), *Santri* who can find patterns are also guided to look at given tables to confirm their answers.

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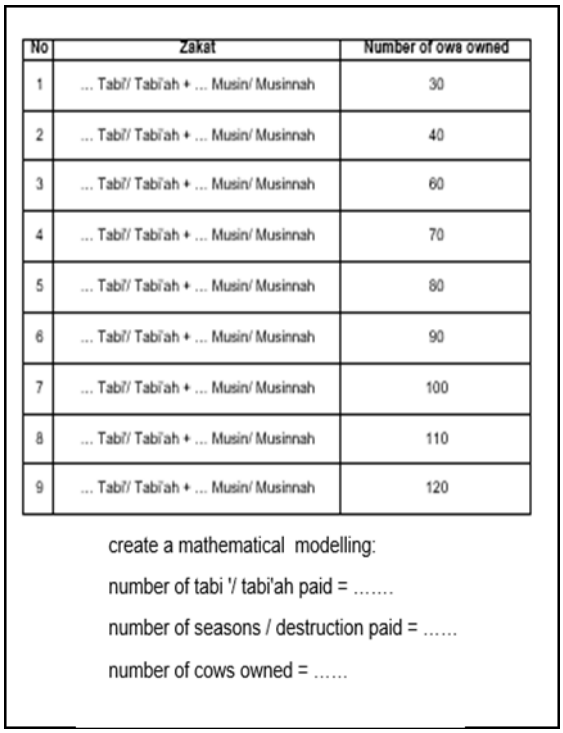
No	Number of cows owned	Zakat
1	30	1 Tabi'/ Tabi'ah
2	40	1 Musin/ Musinnah
3	60	2 tabi'
4	70	1 Tabi'/ Tabi'ah dan 1 Musin/ Musinnah
5	80	2 ekor Musin/ Musinnah
6	90	3 Tabi'/ Tabi'ah
7	100	2 Tabi'/ Tabi'ah and 1 Musin/ Musinnah
8	110	1 Tabi'/ Tabi'ah and 2 Musin/ Musinnah
10	120	4 Tabi'/ Tabi'ah or 3 Musin/ Musinnah
11	....	...

Figure 3. Help Santri to Find Patterns

b) Students were asked to make a mathematical model (formula) for *n* cows they owned associated with zakat that had to be spent. The didactic anticipation was made as follows,



No	Zakat	Number of cows owned
1	... Tabi'/ Tabi'ah + ... Musin/ Musinnah	30
2	... Tabi'/ Tabi'ah + ... Musin/ Musinnah	40
3	... Tabi'/ Tabi'ah + ... Musin/ Musinnah	60
4	... Tabi'/ Tabi'ah + ... Musin/ Musinnah	70
5	... Tabi'/ Tabi'ah + ... Musin/ Musinnah	80
6	... Tabi'/ Tabi'ah + ... Musin/ Musinnah	90
7	... Tabi'/ Tabi'ah + ... Musin/ Musinnah	100
8	... Tabi'/ Tabi'ah + ... Musin/ Musinnah	110
9	... Tabi'/ Tabi'ah + ... Musin/ Musinnah	120

create a mathematical modelling:

number of tabi '/ tabi'ah paid = ...

number of seasons / destruction paid = ...

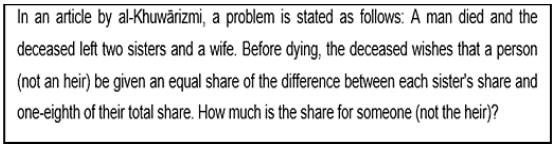
number of cows owned = ...

Figure 4. Help Santri to Find Formula

c) *Santri* was asked to determine how many cows he owned if he had to pay zakat seven *tabi'/tabi'ah* and six *musin/ musinnah* and how much zakat should be paid if you had 1,220 cows, d) *Santri* was given guidance for using mathematical models that have been found.

The situation of Institutionalization: a) The teacher provides other problems and exercises about zakat on goats (or sheep); and b) Santri makes conclusions with teacher guidance about the essential points in learning activities about the sequence, zakat on cattle, and generalization procedures.

Integration of Mathematics Learning with Fiqh of Mawarits (inheritance). The situation of Devolution: a) Santri are challenged to find someone's share based on the deceased's will; b) Challenges are given in worksheets.



In an article by al-Khuwārizmi, a problem is stated as follows: A man died and the deceased left two sisters and a wife. Before dying, the deceased wishes that a person (not an heir) be given an equal share of the difference between each sister's share and one-eighth of their total share. How much is the share for someone (not the heir)?

Figure 5. Inheritance Problem in Worksheet

Mathematical Situation: a) Santri is guided through worksheets to make mathematical modeling;

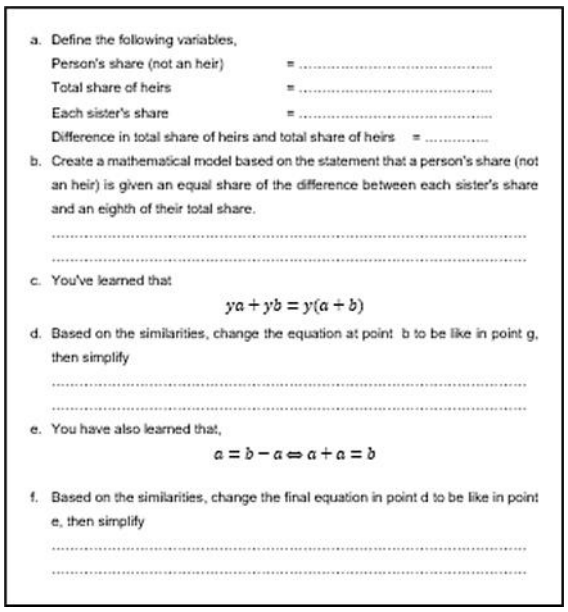

a. Define the following variables,
Person's share (not an heir) = ...
Total share of heirs = ...
Each sister's share = ...
Difference in total share of heirs and total share of heirs = ...
b. Create a mathematical model based on the statement that a person's share (not an heir) is given an equal share of the difference between each sister's share and an eighth of their total share.
.....
.....
c. You've learned that
$$ya + yb = y(a + b)$$
d. Based on the similarities, change the equation at point b to be like in point g, then simplify
.....
.....
e. You have also learned that,
$$a = b - a \Leftrightarrow a + a = b$$
f. Based on the similarities, change the final equation in point d to be like in point e, then simplify
.....
.....

Figure 6. Instruction for Creating Mathematical Models

b) Santri, who has difficulty being guided through the steps on the worksheet to create mathematical modeling;

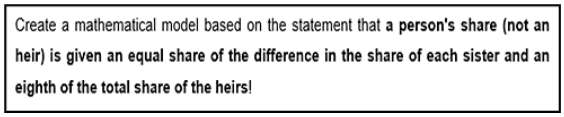

Create a mathematical model based on the statement that **a person's share (not an heir) is given an equal share of the difference in the share of each sister and an eighth of the total share of the heirs!**

Figure 7. Another guide for creating mathematical models

c) After finding the section for that person, santri is asked a few more questions.

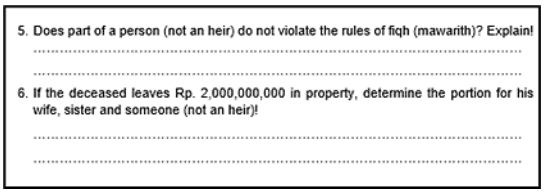

5. Does part of a person (not an heir) do not violate the rules of fiqh (mawarith)? Explain!
.....
.....
6. If the deceased leaves Rp. 2,000,000,000 in property, determine the portion for his wife, sister and someone (not an heir)!
.....
.....

Figure 8. Follow-up Questions on Worksheets

In the situation of Institutionalization, student, with teacher guidance, make conclusions about essential points that appear in learning activities about the use of algebra in the distribution of inheritance and procedures for analogous reasoning.

Based on the discussion above, there are several main findings in this research, namely: 1) to minimize ontogenic obstacles, students can recite the holy verses of the Qur'an and hadith related to the mathematics material to be taught; 2) To minimize the didactic obstacles, teachers need to choose essential mathematics materials that relate to Islamic religious knowledge or thinking skills which are necessary for *santri*; and 3) to minimize epistemological obstacles that occur because the learning process is not following the context of the *pesantren* environment is to integrate mathematics material with Islamic religious knowledge material, for example with *fiqh*.

The didactic design that was developed based on the Theory of Didactical Situation (TDS) integration mathematics learning with zakat *fiqh*, namely 1) situation of devolution, *santri* are given the challenge to determine the amount of zakat on cattle; 2) mathematical situation, *santri* are encouraged to find patterns or sequences based on the tables presented and discuss them with their friends and *santr*i was instructed to make a mathematical model (formula) for n cows; and 3) situation of institutionalization, the teacher provides other problems and exercises, and *santri* make conclusions with teacher guidance about essential points that appear in learning activities about the sequence and zakat on cattle.

These distinguish this research from other development research in mathematics learning in *pesantren* because further examination is not based on the learning obstacles faced by Santri and does not use TDS. Several previous studies have not integrated the learning of mathematics and *fiqh*, especially with *zakat* and

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inheritance. For example, 1) Yusnita (2011) developed mathematics learning in *pesantren* using the 4-D model (define, design, develop and disseminate) and learning to associate with objects in *pesantren*; 2) Kirbani (2013) developed an assessment of mathematics learning in *pesantren* based on literature study; 3) Saksono (2015); 4) Mutia (2014) the development of mathematics modules to see the validity, practicality, and effectiveness; and 5) and Hasanah (2014) suggested how to learn mathematics using an Islamic boarding school environment and Fathani (2019) provides an explanation of the importance of mathematics for students and the integration of mathematics with Islamic religious knowledge based on a literature study.

Some of the differences in this study are expected to provide another color in development research, especially the development of mathematics learning in *pesantren*. This research will also likely give an overview of what kind of mathematics learning is suitable for use in *pesantren*. Although the teaching that has been developed may not necessarily be used in every mathematics material or every *pesantren*, the study provides an overview of the importance of analyzing learning obstacles before setting.

The didactic design of learning mathematics in *pesantren* is designed as follows, 1) reading of the holy verses of Al-Qur'an and Hadith related to mathematics learning materials; 2) the material and learning objectives associated with Islamic knowledge; and 3) giving an overview of the benefits of studying the material to be studied in everyday life, especially when later becoming a cadre of the ulama.

Didactic design development is based on the theory of didactic situation, namely: 1) The situation of Devolution, *santri* are given the challenge of solving zakat and inheritance problems, and challenges are given in worksheets; 2) Mathematical Situation, *santri* who have not been able to complete the main challenges are guided through questions, tables, and instructions as part of the math process. Likewise, *santri,* who already has problem-solving guesses continue to take steps to test the validity of these assumptions by answering several questions, paying attention to tables, and carrying out instructions to evaluate their guesses and are expected to be able to carry out the correct mathematical process; 3) Situation of Institutionalization, student make conclusions with teacher guidance about essential points that appear in learning activities.

IV. CONCLUSION

The didactic design of learning mathematics in *pesantren* is designed as follows: reading of the holy verses of Al-Qur'an and Hadith related to mathematics learning materials; the material and learning objectives associated with Islamic knowledge; and giving an overview of the benefits of studying the material to be studied in everyday life, especially when later becoming a cadre of the *ulama*. Didactic design development is based on the theory of didactic situation, namely: In the case of Devolution, santri are given the challenge of solving zakat and inheritance

problems, and challenges are given in worksheets; Mathematical Situation, *santri* who have not been able to complete the main difficulties are guided through questions, tables, and instructions as part of the math process. Likewise, *santri,* who already has problem-solving guesses, continues to take steps to test the validity of these assumptions by answering several questions, paying attention to tables, and carrying out instructions to evaluate their guesses and are expected to be able to carry out the correct mathematical process; Situation of Institutionalization, student make conclusions with teacher guidance about essential points that appear in learning activities. The results of tests and interviews show that the learning obstacles faced by students in learning mathematics in *pesantren* can be minimized. *Santri* is more motivated through learning mathematics integrated with *fiqh*. *Santri* feels that mathematics is closer to their lives in *pesantren*. But in full, the results of tests and interviews after implementing the didactic design are described in another article.

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