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PERCENTAGE BAR: A MODEL FOR HELPING FIFTH GRADE STUDENTS UNDERSTAND PERCENTAGES

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Abstrak

Penelitian ini bertujuan untuk mengembangkan teori instruksional lokal untuk mendukung pengembangan pemahaman dasar siswa tentang persentase. *Design research* dipilih sebagai sarana yang tepat untuk mencapai tujuan. Penelitian ini dilakukan di Sekolah Dasar Pusri Palembang, Kelas 5 yang totalnya melibatkan 42 orang siswa dan satu guru kelas. Pendidikan Matematika Realistik Indonesia (PMRI) yang diadaptasi dari *Realistic Mathematics Education* (RME) sengaja dipilih sebagai pendekatan dalam proses belajar mengajar. Penelitian ini mengungkapkan bahwa *percentage bar* yang disajikan sebagai model dalam pembelajaran membantu siswa untuk memahami persentase. Siswa menggunakannya sebagai alat untuk penalaran dan juga sebagai alat untuk menghitung. *Bar* ini juga membantu mereka menyampaikan pemikiran mereka kepada orang lain. Bagi beberapa orang siswa, yang biasanya menggunakan cara formal untuk menyelesaikan masalah persentase, *percentage bar* menjadi cara lain untuk membuktikan solusi masalah persentase.
Kata Kunci: persen, batang persen, *design research, percentage bar,* PMRI, siswa kelas lima

Abstract

This present study is aimed to develop a local instructional theory to support students development of basic understanding of percentages. Design research was chosen as an appropriate mean to achieve the goal. The study was conducted in Pusri Primary School Palembang, Grade 5 involving 42 students in total and one classroom teacher. Pendidikan Matematika Realistik Indonesia (PMRI) which was adapted from Realistic Mathematics Education (RME) was deliberately chosen as an approach in the teaching and learning process. This study revealed that a percentage bar which is served as a model in learning helped students to understand percentages. Students used it as a tool for reasoning and also as a tool for calculating. It also helped them to represent the percents stated and to communicate their thoughts to others. For some students who usually utilized the formal way to solve percentage problems, found the bar as another way to prove the result.
Keyword: percent, percentage bar, design research, PMRI, fifth grade students.

I. INTRODUCTION

Percent is prevalent in our daily life. It is one of the most widely used mathematical concepts. By only reading the newspaper or watching television we can be reminded how abundant the use of percent is. It is present in the food we eat (e.g., 10% fat), the clothes we wear (e.g., 100% cotton), the financial transactions we carry out (e.g., 2.5% interest), the things we use (e.g., 80% graphite), the games we play (e.g., 75% hits) and the survey reports that we read (e.g., 30% of the population). Understanding percentage, in fact, cannot be separated from fractions, decimals, and proportions. Of course, one way to represents proportion is by using percentage. Galen et al. (2008) stated that the relationships between fractions, percentages, decimals, and proportions or ratios can be dealt with in a natural way if we make the context as the central feature in teaching and give students the chance to explore these contexts in many different ways. According to Reys et al. (2007), students understand percent when they can use it in many different ways.

However, some studies which were conducted in this topic revealed that incorrect usage of percent is common among students and adults. Flagrant errors abound, suggesting that often the most basic ideas are unclear. Reinup (2010) affirmed in her study that students are often puzzled which of these meanings of fractions and decimals they must use in different exercises. The study conducted by Parker and Leinhardt (1995) resulted the four reasons why percent is hard to learn. The first reason is because percent is a simple pragmatic expression of "so many of this for 100 of that" propagates many multiple and related meanings. In another words, percentages are relationships based on a one-hundred-part whole and it gives relative measure, not an absolute measure (Fosnot & Dolk, 2002). Another reason is percent has several meanings at the same time. The third reason is percentage use an extremely concise linguistic form and the last reason is that percentage have been poorly taught such that students have a limited view of the concept as meaning only part of a whole. These reasons indeed related to the teaching and learning process of percentages in the classroom.

Furthermore, Veronika et al. (2012) asserted in her study that students found difficulties to implement their learning experience to solve another percentage problem. Students could not explain the meaning of percentage which was proven from their inability to make a representation of percentage values. They tend to follow an algorithm or a procedure to solve percentage problems, yet still confused facing the unsual percentage numbers such as 13 percent, 27 percent, etc. Directly giving algorithm for students to solve problems usually do have a bad impact. Students only think how to solve problems using fixed procedures and make them far from a meaningful learning (Afriansyah, 2012). This result is not different from what Van den Heuvel-Panhuizen (1994) stated that many

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percentage problems indicate that education is primarily focused on procedures and recall instead of getting a real understanding of percentage.

There is a need from students to help in bridging their understanding in learning percentages. The students need a model to help them gaining certain insight in learning percentages. As stated by Jupri and Drijvers (2016) that formulating a mathematical model – evidence by errors in formulating equations, schemas or diagrams – is the main dificulty. Considering this fact, the teaching and learning of percentage need to focus on how a model helps students in understanding percentage.

In the present study, *Pendidikan Matematika Realistik Indonesia* (PMRI) approach which is an adaptation od Realistic Mathematics Education (RME) was implemented. The process of designing a sequence of instructional activities that starts with experience based activities in this research was inspired by five tenets for RME defined by Treffers (1987). One of them is using models and symbols for progressive mathematization. Students' informal knowledge as the result of experiences based activities needs to be developed into a formal knowledge of percentage. The instructional activities which were designed began with finding the best shape for presenting the percent.

Based on the Indonesian contexts and situations, the researcher aims at developing a local instructional theory to support students' development of basic understanding of percentage for young students age 10 or 11 in 5thgrade. In this present study, the research question is *how can a percentage bar support students' understanding in learning percentages?*

II. METHODOLOGY

A. Research Approach

To answer the research question and achieve the research goals, the research method used for this study is Design Research. There are three phases of conducting a design experiment which are preparing experiment, experimenting in the classroom, and retrospective analysis (Gravemeijer & Cobb, 2006).

1. Preparing for the experiment.

In this phase, a sequence of instructional activities containing conjectures of students' strategies and thinking is developed. The conjectured Hypothetical Learning Trajectory (HLT) is dynamic and could be adjusted to the students' actual learning during the teaching experiment.

2. Teaching experiment

The teaching experiment emphasizes that ideas and conjectures could be adjusted while interpreting students learning process. In the present study, there were two cycles of teaching experiment which were divided into six lessons. The first cycle was a pilot experiment. The goal of the pilot experiment was to adjust and to improve the initial HLT in order to get a better design for the second cycle.

3. Retrospective analysis

In this phase, all data that have already been gathered from the teaching

experiment were analyzed. The result of the retrospective analysis is used to answer the research questions, to draw a conclusion, and to redesign the HLT.

B. Research Subject

The study involved 42 fifth grade students and one classroom teacher of *Pusri* Primary School, *Palembang,* South Sumatera academic year 2011/2012. The first cycle of this study was held in a small group which consisted of 5 students. These students were selected based on the teacher's suggestion and by their performance in the mathematics classroom. The second cycle was held in a classroom with 37 students participated.

C. Data Collection

In the preparation phase, there were some sorts of data that had been collected, namely classroom observation, interview with the teacher, studying the document needed, pre-test, and interview with some students. Meanwhile, data of pre-test, classroom observation, group observation, students' written works, video recordings, field notes, and post-test had been collected during teaching experiment.

D. Data Analysis

Analyzing data started from students' written pre-test. The written pre-test was collected from the first and second cycle. In the first cycle, the written pre-test gave information about pre-knowledge of students in learning percentage. The written pre-test from students in the second cycle gave more information of what students have already known and what they have not known about percentages. Data from observation - classroom observation and group observation- and students' written works had been analyzed using the video recordings and field notes during the teaching experiment. The written post-test had been analyzed and the result of this analysis had been compared with the result of students' written pre-test. The purpose of the comparing was to see what students have learnt during the experiment. The result of the analysis contributed to the conclusions of the present study.

III. Results and Discussion

The retrospective analysis of data collected from pre-test, the preliminary experiment, the teaching experiment activities, and post-test are described. The result of this study is the underlying principles explaining how and why this design works. The hypothetical learning trajectory served as a guideline in the analysis to investigate and explain students thinking in learning percentages utilizing a percentage bar.

A. Preliminary Teaching Experiment

In the written pre-test, generally, only 5 problems out of 8 could be solved by the students and from the 5, only 2 problems were answered correctly by all students. If we focus on the sort of problems, the two problems that students can solved correctly were the problems that they usually did from their text book. Fractions were given and students were asked to make it into percentage forms. This is the reason why students did not hesitate when

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they were interviewed to explain their answers. Not all students knew and understood that 100 percent is the total. It revealed by their answer in the first problem. Since most problems were the story problems, it needed time to be understood before answering it. However, based on the results, students mostly only paid attention to the number stated in the problem. Using the numbers as information, some students performed operations such as multiplication or division.

During the first activity, most students could give estimation for the shaded area with a given percentage. They made some sort of shapes, for example rectangle, circle, and some irregular shapes. One student seemed not understand percentage and the part-whole relationship yet. However, he had the basic understanding that his figure and percentage he made was not more than 100 percent. What this student did in this activity seemed like what had been predicted before. Students will find it hard to visualize the percent since they did not give a correct answer for the problem in the pre-test. Since they were given a chance to make their own figure and represented their own percent, students came up with the benchmark numbers of percent, such as 10 percent, 25 percent, 50 percent.

What was aimed to be grasped by conducting the next activity was that students could apply the model namely a percentage bar in solving the problem. After giving the problem, two students came up with a correct solution. However, they found it was really hard to explicate the meaning of percentage in the problem. Only one student could solve this problem using a percentage bar. He drew the figure and shaded the area according to the given percentage. He also showed the ability to correspond the percent and the shaded area. At this point, he developed his understanding about a part-whole relationship. He had already used the percentage bar as a tool for reasoning and also as a tool for calculating. The other two could not solve the problem and had hard time dealing with percentage bar in finding solution.

In the process of doing the next activity, all students used the percentage bar. Even though only one student could use it as a model for comparison, other students did their best in showing the representation of the percent asked in the percentage bar. They seemed to have a good estimation in shading the area in which they thought as the area that correspond with percent.

The last activity was designed as a conclusion for the whole activities. Still, only one student used the percentage bar in solving the problem. Other students used their text book method – a formal way to solve it. The interesting part was when they could not solve the problem using the formal way, they turned to the percentage bar.

In the post test, the number of students who could solve the problems increased. All problems could be answered this time. Even though no student could answer all

problems correctly, they showed better progress than the first time they worked with the problem.

B. Improvement of Hypothetical Learning Trajectory (HLT)

Since researcher worked with more students in the teaching experiment, the first activity should have to be rethought.

In activity one, students needed more time to work with different figures. It was aimed to make them realize the best shape to visualize the percentage as the main starting point of using percentage bar. The worksheet has to be added, so that students could work with different kind of shapes. Probably, it was not given as the main activity but as the enrichment activity in which students could practice that at home. This was also to make them sure and to realize themselves the best shape to represent the percentage. The homework had to be discussed in the beginning of the next lesson.

In activity two, the introduction of a percentage bar should be the main focus. Students who had already practiced with some sort of shapes will be guided to find the best figure to represent the percentage. It needed more attention from the students.

In activity three, there should be an introduction or an example of how to compare relatively since it was hard to make students realize the greater numbers with different basis.

The problem or question in the last activity had to be formulated. It needed more space for students to work themselves. It probably could be divided into three parts, namely the steps that students use to solve percentage problems, an example of a percentage problem that they made by their own, and the application of the rule in solving it.

C. Teaching Experiment

In this section, the improved HLT was compared with the students actual learning process during the teaching experiment phase. The result of the retrospective analysis in this teaching experiment would be used to answer the research question.

There were 37 students who participated in the pretest. Generally, students had difficulty to visualize the percent into the real objects. Percent should be taken into account of something; this characteristic was not found by the students, so that no one could give the reasons. They just did perform a calculation using some numbers given in the problem without knowing the meaning of it. Finding the whole part was the hardest problem since no one can come to the right answer. They seemed that they did not understand what should be found from the problem and they did not attained the concept of part whole relationship. In thirty-seven students who were tested, almost all of them could answer the text-book problem correctly. The text book problems here were problems they usually worked with, while no context was provided.

1. Activity 1

Almost all students drew not only the part of the audience but also drew the

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stages. Some of students works are represented here.

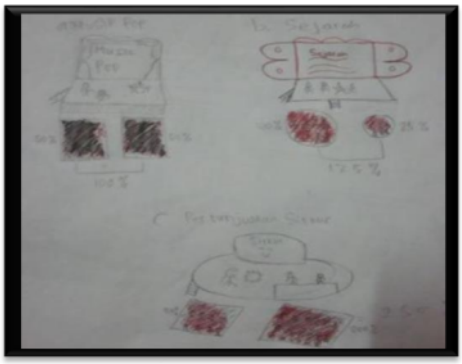

Figure 1. Student's work (a)

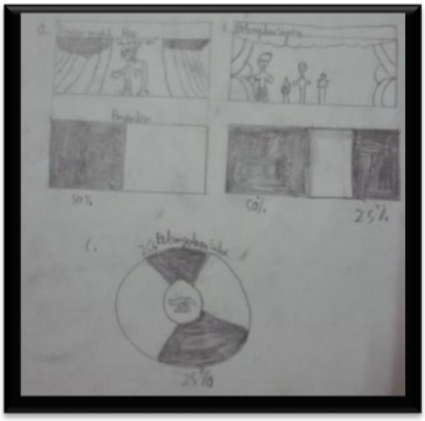

Figure 2. Student's work (b)

Figure 1 and 2 showed students' answers when they were asked to estimate the percentages using figures. Most students showed some benchmarks of percentages such as 25 percent, 50 percent, and 100 percent. It means that they had already been familiar with those numbers of percentage. This activity revealed that there was one student who could not show the relationship of figures and the percentages she stated. She did not know that the total should be 100 percent. Meanwhile, one student from the focus group could not connect the part and the whole of the figure to show the percent she chose to shade. This problem likely happened since she only knew the procedure of doing calculations but did not mastered the concept of percentages.

2. Activity 2

Before going to the problem, teacher and students made agreement about the best shape that can be used to represent the percent best. Since they all stated that the rectangle figure was the best shape to visualize the percent, it was generalized as the tool later in solving percentage problems. Subsequently the teacher introduced the use of the percentage bar.

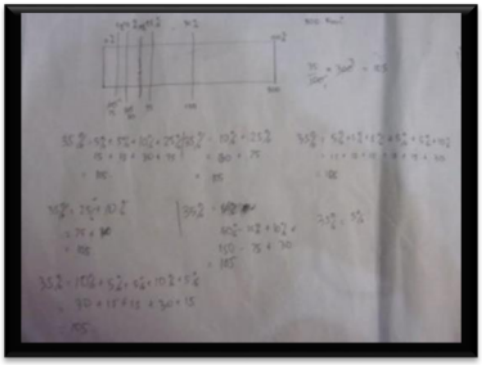

Figure 3. Student's work (a)

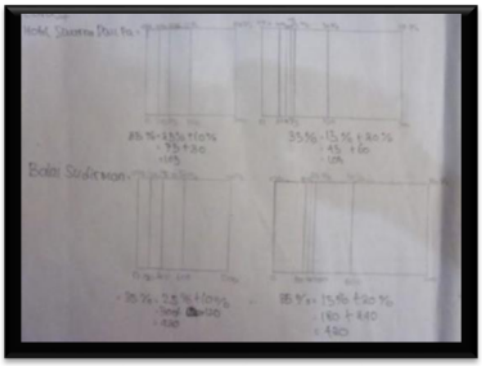

Figure 4. Student's work (b)

In Figure 3, there was only one percentage bar and some combination of 35 percent. The percent which were involved and used in the bar were 5 percent, 10 percent, 25 percent, and 50 percent. In Figure 4, there were two percentage bars where each percentage bar was a combination of the 35 percent. The percent that appeared in the bars were 25 percent, 10 percent and 15 percent. Figure 3.3 showed that students have already used the percentage bar as the calculating tool. If we focused on the bar they made, they did not state where the 35 percent was. They just tried to find the percent that could be combined to represent 35 percent. In fact, they successfully could do that. There were 6 combinations of a 35 percent. It was quite different from the work of group b (Figure 4). One student in group b, Fitra, who was interviewed to explain his work.

Researcher: How could you come up with 35 percent?

Fitra: **15 per 100**. 15 per 100 times 1200. it will be 180 **For 20 percent**. 20 per 100 times 1200. it will be 240. **35 percent** is 35 per 100 times 1200, it will be 420.

This small conversation urged us to give some remarks about his understanding of percent. First, he did not use the bar as a calculating tool. Different from the work in figure 3, Fitra used the bar as the tool for reasoning. He reasoned with the bar to show where we could write 35 percent, but he used the formal way to get the value of the percent asked. Second, he surely knew how to calculate in a formal way. However, here, he did not straightly go to the 35 percent. He divided it into two benchmark numbers of percent namely 15 percent and 20 percent.

Since this was the first time for students to use a model in learning percentages, they had not been comfortable using it yet. What they did was mostly using the bar as a tool for reasoning or using it as a tool for calculating. Some groups including the focus group have tried to apply the percentage bar as both tools. What the groups did in figure 3 and figure 4 were actually out of the conjecture that have been made. It has been predicted that students will solve the problem in different ways; even it was the formal way and the combination that can be made from the benchmark percent on the percentage bar. However, when we talked about the percentage bar, researcher predicted that its use as a calculating tool and a reasoning tool can be attained by the students.

3. Activity 3

It was hard to make students think relatively when comparing two things. They mostly used the absolute way before they moved to the activity.

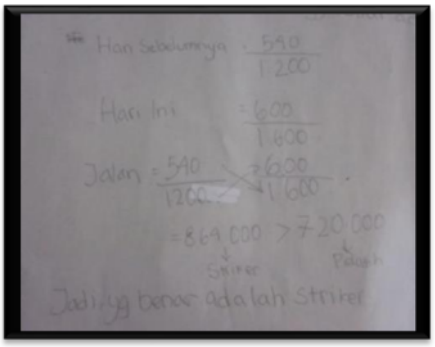

Figure 5. Student's work (a)

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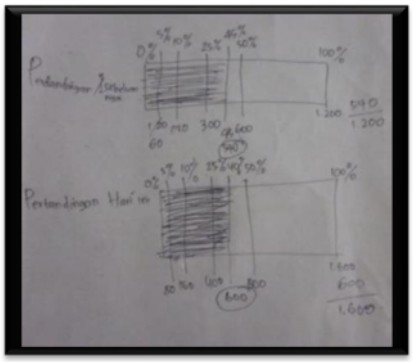

Figure 6. Student's work (b)

Figure 5 shows how students can compare two different numbers by using fractions. After making the numbers into fractions, they performed a cross multiplication. This was the common or usual strategy that had been taught already by the teacher in the classroom, when they started learning fractions.

Figure 6 shows students worked with the percentage bar. They wanted to use percent to compare relatively. This was exactly the relative nature of percent. Even though they did not solve the whole problem, only correct for the last day match (from the problem), they practiced to make estimation of percentage stated for today match. They came to a better conclusion in comparing the two.

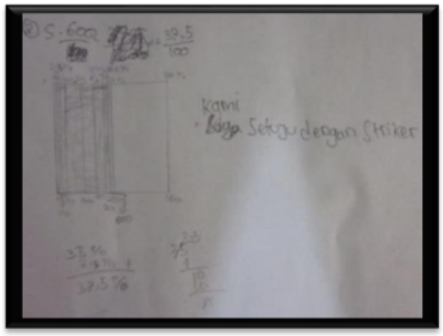

Figure 7. Student's work (c)

Figure 7 was the work of Fitra's group in solving the problem. They made two versions or two ways in solving this kind of problem. The first one, like stated above, was the proportion of two numbers, in which they change into the per-hundred fractions. The other way was the use of a percentage bar. They got the correct result for both matches. The interesting thing of the bar was the shaded area that they made to show the area that exactly the percentage asked.

From the three figures (5, 6, and 7) if we focused on one by one, figure 5 shows that students used fractions to compare as the simplest way to practice. However, there would be a problem for them to determine the part and the whole if they did not understand both. They tended to work with numbers and the fastest strategy. It also had a drawback since the numbers were not always simple and often needed a thorough calculation. The 3.6 was the point where the percentage bar used. They have already succeeded using the benchmark numbers of percent to help them find the percent asked. The last worksheet showed the understanding of using a model. They used the percentage bar as a tool for reasoning and at the same time also used it as a tool for calculating.

The strategies that students posed in the worksheet had already been predicted before. Since the students were given chances to solve it in their own. However, the one percent strategy that was predicted did not appear during the lesson.

It was probably because there was no introduction of using it.

4. Activity 4

There were some sorts of answers that came up from students in explicating their general rule in solving percentage problems.

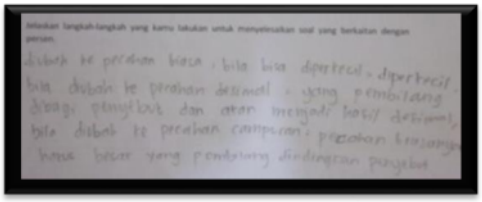

Figure 8. Student's work (a)

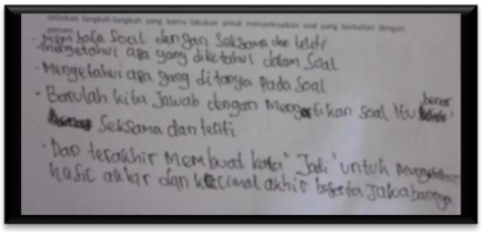

Figure 9. Student's work (b)

From Figure 8 and 9, we can see that 3.8 focused on the steps how to change the fractions, including proper and improper fractions, and decimal forms into percent. Meanwhile the 3.9 focused on the generalization of the way he could solve the problem. Different from what was predicted in HLT, students not only answered it based on their experiences in learning percentages but also, they made some kind of conclusion about how to solve mathematics story problem.

Below there are some percentage problems that made by the students using context. Some students made the story problem.

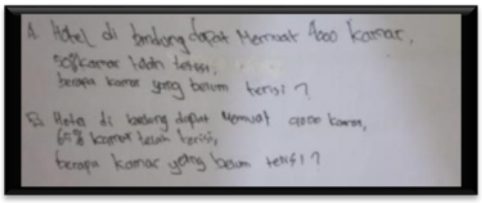

Figure 10. Student's work

Figure 10 shows that students did not have difficulty in designing percentage problems. Here, they use a "hotel" context. It is true that students have already used to deal with percentage in their daily life.

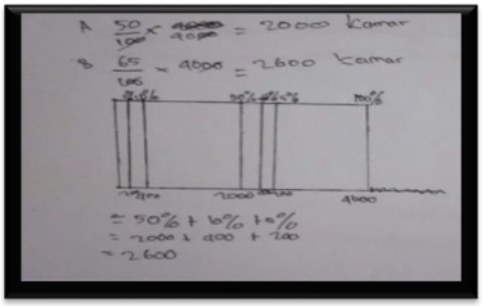

Figure 11. Student's work

Students strategies in figure 11 were the answer of the students work in figure 10. From figure 10 and 11, we conclude that students could design their own problems and were able to solve them. The answers that they gave were correct and in a systematic way even though most of them used the formal way. When they asked about this, they said that it was what they had learnt from the text book. The students who answered the problem using the percentage bar were the students in the focus group. In fact, they came to the answer using the bar.

However, students missed to understand the first question since they worked with the three of them separately.

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For example, when they were asked to write down their general rules in solving percentage problem, some students made the general rule for solving mathematics problems; it was different from what was expected.

The result of the posttest did not show better development of students thinking. However, from what they had done in their activities during the four activities, it can be concluded that they had learnt something and this was an important thing after all. Some students had used the percentage bar in solving problems. In the posttest, students again showed their ability to transform the fraction into percentages and vice versa.

IV. CONCLUSION

In this study, the construction of the percentage bar took place. The advantage of the bar is that it has —body – area. This body part was the visualization of the percent that students usually shaded. This model helped students in understanding the problems since the bar model has an area that makes it easier to talk about in terms of "the whole". Students learnt to use the percentage bar throughout solving problems. Since this was the first time for students to use model in learning percentages, they had not been comfortable utilizing it yet. What they did was mostly using the bar either as a tool for reasoning or using it as a tool for calculating. However, some groups including the focus group had tried to apply the percentage bar as both tools. They have already been succeeded using the benchmark numbers of percent to help them find the percent asked. The bar model gives a good hold for estimating an approximate percentage, especially in cases where the problems concern numbers that cannot be simply converted to a simple fraction or a percentage.

The bar gradually changes from a concrete context-connected representation to a more abstract representational model that moreover is going to function as an estimation model, and to model that guides the students in choosing the calculations that have to be made. In the process, percentages are written above the bar and the corresponding numbers below the bar, or the other way around. The bar model provides the students with more opportunity to progress. This also means that the bar model can function on different levels of understanding.

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