Analysis of Question Levels Design through Vertex-Edge and Graph Chapter for Prekindergarten-Grade

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Abstract. *This paper focuses on vertex-edge and graph topics in Prekindergarten to Grade 2, including an overview of the design level of the question and student's strategy in solving problems related to the topic. It discusses how the topic should be introduced in Prekindergarten to Grade 2 and the efforts to facilitate and support the level-question adoption of vertex-edge and graph topics for those graders. Fourteen students participated in this study from different schools in South Sumatra, Indonesia. This research was a development study using design research implementation with quantitative data analysis by testing, and qualitative by face-to-face interview. The results showed that students assessed a question categorized into easy, medium, and hard levels according to the questions' complexity. This study can be used as a guidance to teach vertex-edge and graph topics more interestingly.*

Keywords*: Discrete mathematics, Vertex-edge, Graph, and Question level*

Introduction

The development of mathematical proficiency begins in preschool, and individuals become increasingly mathematically proficient over their years in educational settings (Dooley, 2014). Discrete mathematics is the study of mathematical structures that are countable or otherwise distinct and separable. Discrete Mathematics provides an opportunity to focus on how mathematics is taught, giving teachers new ways of looking at mathematics and making it accessible to their students (DeBellis, 2004). In general, discrete mathematics is concerned with infinite processes and discrete phenomena. It is sometimes described as the mathematical foundation of computer science. However, it has even broader application since it is also used in the social, management, and natural sciences. Discrete mathematics can be contrasted with continuous mathematics, such as the mathematics underlying most of the calculus. However, this association (National Council Of Teachers Of Mathematics) gives the impression that discrete mathematics is only for advanced high school students. In reality, elements of discrete mathematics are accessible and important for all students in all grades.

NCTM dedicated its 1991 yearbook, Discrete Mathematics, across the K-12 Curriculum to provide a good understanding of what discrete mathematics is. Discrete Mathematics throughout the K-12 Curriculum provides some specific examples of applying ideas in the K-12 classroom. Prekindergarten to Grade 12 discrete mathematics has three content areas, one of which is vertex edge graphs which has four sections: Prekindergarten-Grade 2, 3-5, 6-8, and 9-12. In this research, the researcher will discuss vertex edge graphs Prekindergarten-Grade 2.

Vertex Edges Graph is a mathematical model consisting of vertices, represented by dots or small circles and edges shown by line segments that may be straight or curved, where each edge will connect two vertices. Vertex Edge Graph is a process of calculating and finding the best way systematically in solving a mathematical problem. Vertex Edge Graphs provide ideal learning where students can abstract mathematical topics, reason and communicate about mathematics, and connect mathematical ideas. In the Pre-Kindergarten Grade - Grade 2, students are introduced to points and lines and how to find the fastest path from one place to another (DeBellis, 2005). In this study, researchers designed an interesting question design regarding vertex edge graphs in Prekindergarten-Grade 2, making students more attractive and easier to understand the material. To design questions and find out which questions are right for the ability of Prekindergarten-Grade 2 students, the researcher needs to analyze these questions, which will be categorized into easy, medium, and difficult questions.

Problems that arise in mathematics are generally called problems (Hudojo, 2005). The question referred to in this study is a matter of the story. A story problem is defined as a question presented in the form of a story that describes events or occurrences in everyday life, where to solve it must be translated first into a mathematical sentence and not a question of giving opinions/statements. In solving math story problems, information or data is needed that is selected from information or data that is known in the problem or what is not known. Through this information or data, a satisfactory solution will be obtained. The more information or data needed, the students will find many responses.

In proposing questions, the teacher must pay attention to the suitability between the level of questions and students' cognitive level. This needs to be considered so that the maximum test will be produced. In a study, it can be seen that student learning outcomes are limited only to the cognitive domain, which includes: knowledge, understanding, analysis, synthesis, and evaluation. These learning outcomes can be measured using the tools of test descriptions and objective tests in multiple choices. Sudjana (1998) argued that the test as assessment tools are questions administered to get answers in the formal, written, or in form of an act. Meanwhile, according to Popham (1995), the test is used in-class assessments, and there are several forms of tests, namely: multiple-choice tests and essay tests with short answers and descriptions. Description test is a form of test that consists of one or several questions that demand specific answers from students individually based on their own opinions different from other students' answers. an essay test is a freedom to answer questions aimed at a person that demanded that he give his own, relatively free answer, how to approach the problem, what information to use, how to organize the answers, and how much emphasis is placed on every aspect of the answer (Grondlund, 1982).

Research conducted by Nuraulia, Uswatun, and Nurrochmah (2020) showed that there is still a lack of mathematical problem-solving ability for Grade 2 children caused by many inhibiting factors. So it takes away to improve problem-solving skills that can help teachers in educating their students. Research on students' mathematical problem-solving abilities through Grade 2 questions has been widely studied. However, the topics studied are only general math problems. They are not categorized and analyzed based on the level of questions to assist teachers in improving students' ability to solve mathematical problems, especially on vertex-edge and graphs. From this description, the problem formulation that needs to be answered in this study is how to design easy, medium, and difficult questions for prekindergarten-Grade 2 students. So, the title of this research is "Analysis of Question Levels Design through Vertex-Edge and Graph Chapter for Prekindergarten-Grade 2".

Method

This research is a development study by using design research implementation. Design research is relevant for educational practice (and therefore also for educational policy). It aims to develop research-based solutions for complex problems in educational practice or to develop or validate theories about learning and teaching processes. The flow chart of the framework of thought:

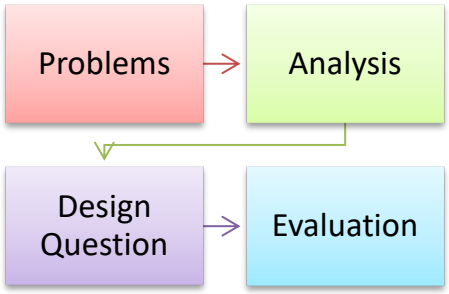

Figure 1. Flow chart thinking framework

National council of teachers on mathematics (NCTM) proposed the vertex-edge and graph topic should be taught from Prekindergarten to Grade 2. In order to appreciate the design of our model for professional development of Prekindergarten-Grade 2 teachers, one must first understand the population that it serves. The common problem is how to make this topic a fun topic for the students. By using the animation characters, they would like to know the concept easily. The authors made the four questions, three of which are multiple-choice, and the other is an open-minded question. The four-question will be analyzed to be three levels of question (easy, medium, and hard level). The questions were put on quizizz.com with the code is 56932912.

- Q.1 Let's help Dora get home! Which path should Dora choose to get home quickly?
- Q.2 Booth is in the forest to pick up bananas; there are three paths that Booth can take to get there, namely the watermelon, orange, and strawberry path. What path does Booth should choose so that he can gather the most fruit?
- Q.3 Booth wants to go to the playground. Before that, he will pick up Dora and go to the playground together. Which route is the shortest route that Booth will choose to go to the playground?
- Q.4 It is said to be neighbors when the path connects the two houses. How many neighbors does the red house have based on your work? Draw your answers on paper!

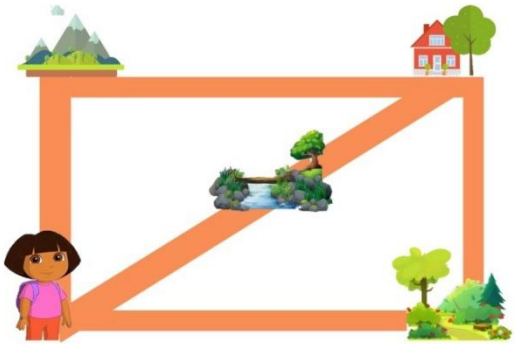

Figure 2. Question 1. finding the shortest path

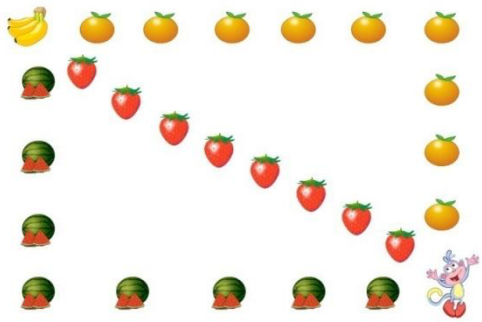

Figure 3. Question 2. Take the most fruit to reach bananas

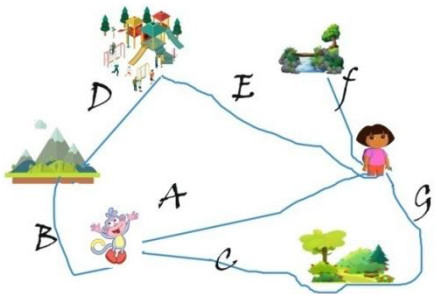

Figure 4. Question 3. Finding the best route

Figure 5. Question 4. Finding the neighbors

Decree of the Minister of Education and Culture RI Number 4 of 2020 Regarding the Implementation of Education Policy in Period Emergency Spreading Corona Virus Disease (COVID-19). The learning process starts from the level of Prekindergarten up to college doing online learning. In this research, Fourteen students participated in the study during the 2020-2021 academic year. Those students were taken randomly from under two graders. Five out of fourteen are prekindergarten students, and the rest are up to Grade 2 students in South Sumatera. Due to the COVID-19 pandemic, the participants in the study were not a random sample of the same school, which could limit the generalizability of the results.

The analysis used in this paper is a quantitative and qualitative descriptive analysis using game testing questions and face-to-face interviews.

- Quantitative

  Quantitative data analysis is characterized by the data that can be analyzed numerically, typically presented using statistics, tables, and graphs. In this paper, to analyzing level question by the percentage of the correct answer that student's get each question.

- Qualitative

  Qualitative data analysis, whether concerning the analysis of transcripts of conversations or interviews or sections from documents, is less standardized than quantitative analysis. In this paper face to face interviews will be used qualitative analysis method. A qualitative interview is a type of framework in which the practices and standards are not only recorded but also achieved, challenged, and reinforced.

Results and Discussion

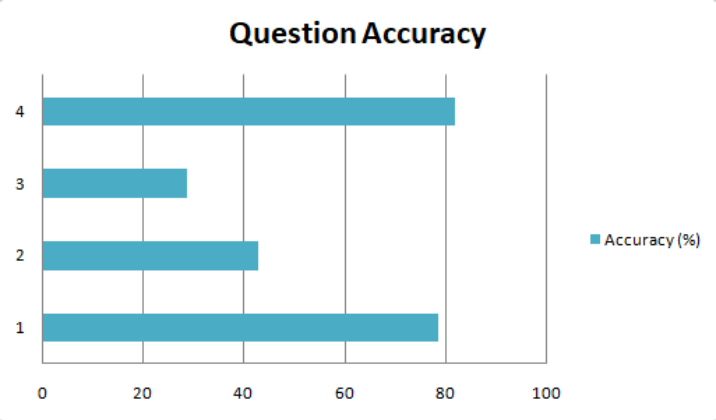

Figure 6. Question Accuracy.

First, the multiple-choice questions were answering by fun games. The results showed that question 1 (Fig.2) contained questions to take Dora's shortest path to get home, indicating that 78.6% of students answered correctly. In this question, students are expected to pay attention to the distance through the scale in the picture. 42.8% is shown for question 2 (Fig.3), which contains the path that Booth must take to pick up the bananas and collect the most fruit. In this question, students are asked to count to find out which paths have lots of fruit. And the last multiple-choice question, question 3 (Fig.4) shows a percentage of 28.6% containing the route that must be taken to reach the destination. In this problem, students are expected to understand the concept of vertex-edge and graph with the place symbol as the vertex and the path symbol as the edge forming a single unit into a graph. In addition, question 4 (Fig. 5) is an open-minded question that asks students to understand the problem and interpret the answer. As many as 81.8% of students were able to answer this question according to the questions presented. The following is an example of student work for question 4. Seen from the percentage of scores obtained by students, this proves that students will easily answer questions when the questions are presented simply. On the other hand, the more complicated the questions presented, the more students will assume that the questions are at a difficult level.

In question number 1, the questions are presented simply by letting students count the fruits in determining the shortest route from a path. Some children at an early age are very happy to count and love to learn interesting things. Question number 4 is presented with open-minded questions so that students are free to be creative by forming the route they want but stick to the conditions that have been set. Therefore, the percentage of students who answered these two questions correctly was high. For question number 2, students only need to determine the longest route by counting the most fruits from each route. Questions number 2 and 1 have the same concept, but many students still incorrectly answer question number 2 because they

count the wrong fruit. As a result, question number 2 has a lower percentage than the previous question. As for question number 3, the questions are presented with various routes and are symbolized by letters to determine the right route. But because the picture looks complicated, students do not understand the meaning of the question. In the end, the percentage for this question is lower than the other questions and is below the average.

Figure 7. Student's work

Then the research was continued by determining the level of difficulty of each question design. Based on the level of questions that have been stated by Rasyid, Harun & Mansyur (2008) that: (a) $p \leq 0.30$ = hard level; (b) $0.30 < p \leq 0.70$ = medium level; and (c) $p > 0.70$ = easy level. So, the questions that have been designed and tested on students are categorized as the easy level for Q.1, and Q.4, the mid-level in Q.2, and the hard level question is Q.3.

Based on the survey that we have conducted thorough testing the question design in answering and reasoning the vertex-edge and graph concept in answering questions, we also conduct face-to-face interviews. The interview data in this study were used to strengthen the question-level approach. Based on the interview results, students provide reasons for the answers to the vertex-edge and graph each question given. This is evidenced by the following student statements:

- Question 1:

  "I choose the answer for the path that is traversed by the river because the path has no curves and the distance is also shorter than the other paths".

  “I like to count the fewest fruits”.
- Question 2:

  "I counted the number of each fruit, but sometimes it was wrong with the number because there were quite a lot of them."
- Question 3:

  "I am confused by the path on this route".

"I don't understand what I should choose".

- Question 4:

"I like to draw paths to connect the house and its neighbors."

After knowing the student's answer, it can be described that the questions that the students consider easy level are Q.1 and Q.4, the medium level is Q.2, and the hard level is Q.3 because students have difficulty interpreting the problem.

The results of this study prove that the implementation for teachers, according to Winarni and Harmini (2016) to teach problem-solving to students is to present activities in solving mathematical problems without using numbers is already effective. Mathematics learning activities in games, such as grouping and sorting objects using pictures (Tatminingsih, 2020). Early childhood likes activities using pictures and games so that going through the question level can make it easier for them to learn.

Conclusion

Based on the analysis results, it can be concluded that students assessed a question categorized into easy, medium, and difficult levels according to the level of complexity of the questions they had. From the results we tested on Prekindergarten to Grade 2 students, it was found that the percentage of Q.1 and Q.4 was more than 70%, so, it was categorized as easy. Q.2 showed a percentage of 42.8%, so that it was categorized as medium level. Q.3 shows a percentage of 28.6%, so it is categorized as difficult. Based on this analysis, Prekindergarten to Grade 2 students will consider a question easy if it is simple, or a difficult question if it is complicated. With the topic of vertex-edge and graph, students must be introduced to the concept of vertex-edge of a graph through the symbols and road routes given. Students also like playing games and understand better if we use cartoon characters such as Dora, Naruto, SpongeBob, and others.

Using vertex-edge graph understanding for students is needed to be applied for them to solve the problems easily. The teacher is expected to finish the questions following the difficulty level of each question, from the lowest to the highest level. The hardest level of the questions also affects students' cognitive development in applying vertex-edges graph learning. We hope that there will be further research on problem analysis design on other discrete mathematics topics. The Authors hope vertex-edge and graph should be viewed not only as an interesting mathematical topic but, more importantly, as guidance for providing teachers with a new way to think about the strategies for engaging their students in the study of discrete mathematics.

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References

ACAPS. (2012). *Qualitative and quantitative research techniques for humanitarian needs assessment: An introductory brief.* Better Assessments Better Aid.

DeBellis, V. A., & Rosenstein, J. G. (2004). Discrete mathematics in primary and secondary schools in the United States. *ZDM*, *36*(2), 46-55.

De Bellis. (2009). *Navigating through discrete mathematics in pre-kindergarten–grade* 5. National council of teachers of Mathematics.

Dooley, T., Dunphy, E., Shiel, G., O'Connor, M., & Travers, J. (2014). Mathematics in early childhood and primary education (3-8 years). *Teaching and learning*, *18*, 164.

Makariem, N. (2020). *Circular of minister of education and culture no.4 year 2020 concerning implementation of education policy in emergency spread of corona virus disease (Covid-19).* Jakarta: Ministry of Education and Culture Republic of Indonesia.

Milati, N., dkk. (2013). *Analisis level pertanyaan pada soal cerita dalam buku teks matematika penunjang SMK program keahlian teknologi, kesehatan, dan pertanian kelas X terbitan erlangga berdasarkan taksonomi solo*. Pancaran, *2*(1), 83-94.

Nuraulia, N., Din Azwar Uswatun, dan Andi Nurrochmah, (2020). Analisis kemampuan pemecahan masalah matematika siswa melalui soal kelas II SDN Selabintana. *JIKAP PGSD: Jurnal Ilmiah Ilmu Kependidikan, 4*(3), 247-256.

Oakley A., Gender. (1998). *Methodology and people's ways of knowing: Some problems with feminism and the paradigm debate in social science*. *Sociology.*

Rasyid, Harun, & Mansyur. (2008). *Penilaian hasil belajar.* Bandung: CV. Wacana Prima.

Tatminingsih, S. (2020). *Belajar matematika yang menyenangkan untuk anak TK.* Universitas Terbuka. www.gurupintar.ut.ac.id. Accessed on 14 november 2020.

Winarni, E.S., & Harmini,S. (2016). *Matematika untuk PGSD*. Bandung: PT Remaja Rosdakarya.