The Implementation of Cumulative Learning Theory in Calculating Triangular Prism and Tube Volumes

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Abstract. This study aims at describing the application of cumulative learning theory in calculating the volume of a triangular prism and a tube as well as revealing the students’ responses toward the learning. The research method used was descriptive qualitative with elementary school students as the subjects of the research. Data obtained through observation, field notes, questionnaire, tests, and interviews. The results from the application of cumulative learning theory obtained positive students’ responses in following the learning and students’ learning outcomes was dominantly above the average. This showed that cumulative learning could be used as a reference to be implemented in learning, so as to improve the students’ achievement.

1. Introduction
Cumulative learning is one of learning model which is related to knowledge and skill development. In psychology education, cumulative learning is considered be able to consolidate knowledge gained through experience. Then, it is allowed to be reproduced and exploited for subsequent learning situations through cumulative interaction between prior knowledge and new information. Gagné [1] argues that "cumulative learning" is built by the previous learning and relies on a combination of previous and memorable entities as well as their potential. Through their potential, the students are trusted to do cumulative learning. According to Maton [2], cumulative learning means that students are able to follow the new learning method developed based on their previously acquired knowledge or skills. In addition, Wiegand [3] studied whether the performance of a complex science problem was similar to the one used by Piaget in his studies as well as whether Piaget’s task could be justified by Gagné’s cumulative learning model with children as the participants through providing needed subordinate capabilities in the interval between two times of test. The results indicated that the cumulative effects of the learning on concretely referenced intellectual skills are more conducive to intellectual development than to the adaptation of structures of intellectual growth. Thus, Wiegand [3] described “A cumulative effect of learning within varied stimulus situation deals with the acquisition of skills, strategies, and learning sets that make the individual have to deal with environmental contingencies in more effective way”.
Furthermore, cumulative learning has effects which offer the potency to investigate the differential impacts of early and later experiences on the formation of lexical and other mental representations [10].

Gagné [1] explains the main theory which proposes that there are eight essential steps of instruction. As the first step or phase, the motivation phase refers to the set of induction process including giving motivation to the students to learn. Motivation is conceptualized as a situational constructive dependence
on a one’s moment-to-moment experiences and the related interpretation [13]. The second one is the apprehending phase which refers to a phase in which the students pay attention to the stimulus provided by the teacher so that they can catch and interpret the information themselves. It means that the learning is a unique process for each student and it becomes the student’s responsibility towards their studies. The next one is the acquisition phase which is a phase in which the students acquire new knowledge by linking the information received from the previous knowledge. In other words, in this phase, the students form associations between the new information and the old information. The process emphasizes the student’s ability to construct knowledge rather than to learn through memorizing [15,16]. The next phase is the Storage phase in which, in this phase, the information is stored in the short-term and in the long-term memory. Through repetition of information in short-term memory can be transferred to long-term memory. Next, the recall or retrieval phase, is a phase of remembering or recalling information that has been stored in memory. Sometimes, the information may be lost in memory or there may be a loss of connection with long-term memory. Furthermore, to strengthen the memory, the new and the old information is needed to be arranged in an organized and well-regulated way by groupings into categories. Therefore, the concept will be easier to recall. The next one is generalization phase which is the phase in which the information is transferred into new situations. In order to furtherly improve the memory, students can be assigned to apply certain material with the new information. Generalization itself can be described as the occurrence of functional behavior in response to conditions that are different from the moment when the behavior is trained first [18]. The next one is the appearance phase which refers to the phase in which the students must show a visible appearance after learning something. The feedback phase is the next phase in which the students should be given feedback from what has been shown (reinforcement). In this research, the researcher uses eight phases of cumulative learning in accordance with the theory which has been explained by Gagne including motivation, introduction, acquisition, storage, recall, generalization, performance and feedback. The activities can particularly be conceptualized through productive stimulations in the form of teacher’s questioning and meaningful feedback [14]. Firstly, in the motivation phase, the teacher displays the geometrical pictures that are similar to triangular prism and tube. According Serio [20], motivation affects students in their learning process. Secondly, the introduction phase which uses teaching aids for the teacher in introducing the construction of triangular prism and tube. Third is the acquisition phase that is students gain new knowledge on how to calculate the triangular prism and tube volumes after the students do their worksheet. Fourth, the storage phase occurs through working on worksheet in which the students can find the formula of the triangular prism and the tube volume so that students will not forget it easily. Fifth, the recall phase is done when the teacher asks the students and they can answer the questions. Sixth, the generalization phase occurs when the teacher gives the students questions to calculate the volume of the triangular prism and the tube which relates to the real life. Seventh, the performance phase is when the teacher gives the students a chance to present their answers. Eighth, the feedback phase occurs when the teacher gives praise to the students who can show their answers. In order to make the students more active in learning and at the end of the lesson, the teacher gives a test. Cumulative learning means that students are able to use the new learning to develop previously acquired knowledge or skills. It means that students can apply what they have learn during their studies to unfamiliar workplace situations [11]. Although the students need to study in order to learn the subject matter, at school, it is the teacher’s job to make the cumulative learning process occurs and goes on productively. Therefore, the teachers need to integrate the subject matter in order to understand it, plan the lessons which relates to it, represent it, demonstrate it, and explain it [17].

Based on Kilpert [4], cumulative learning would be further enabled in the curriculum if the teacher who deals with students’ assessments is given more freedom to reward thinking and skills that are beyond the context of the students’ general learning⁹. From the statement above, the cumulative learning will be better applied in the learning process when the students are given more freedom to think and to create. However, this study tries to examine students’ responses to assessment for evidence of
cumulative learning. According to Aebli [5,6,7], the students should play an active role in the learning process by actively build new knowledge based on the existing or prior knowledge structures.

The purpose of this study is to describe the application of cumulative learning theory in calculating triangular prism and tube volume as well as revealing the students' responses toward learning mathematics using cumulative learning theory.

2. Method
This research was a qualitative descriptive research. The data collected was in the form of qualitative data which is a description of the nature of a symptom. The data was presented in accordance with the facts and phenomena that occur during the learning process [8]. The subjects of this research were the students of class VI of MI Subulussalam Blawe Kediri Indonesia. The method used to collect the data in this research was observation which is used to observe the students’ activities during the learning process. The test method was administered in order to measure the students' learning mastery. The data of the students’ learning result or achievement was obtained by giving test sheet to students. In addition, an interview was administered to confirm student's answer of the test. Moreover, questionnaire was used to know the students’ responses toward cumulative learning. According to Arikunto [9] questionnaire is a written statement used to obtain information from respondents in the sense of reports in relation to the person or things that the respondents know.

3. Results

3.1. Observation
The observation was conducted during the learning activities is done by the subject teacher. The observation is done by observing the activities of students during the learning activities took place. The result showed that, in the class, the students were active in the teaching and learning process conducted by the teacher. They followed everything that the teacher instructed and led them to study well.

3.2. Students’ responses
The students’ responses can be seen from the questionnaire responses that have been distributed and submitted. The researchers distributed questionnaire to 22 respondents, the result of which was shown in Table 1.

| Category                                                                 | Percentage |
|-------------------------------------------------------------------------|------------|
| Students are motivated to follow the learning.                           | 81.8%      |
| Students are happy in learning math using media.                        | 86.4%      |
| Students understand and remember easily the concept of mathematics by finding the concept themselves. | 77.3%      |
| Students are not bored.                                                 | 90.9%      |
| Students are happy to be able to discuss with their friends.            | 95.4%      |
| Students can express opinions in the process learning.                  | 81.8%      |
| Students feel that knowledge that has been learned is useful for the next subject material. | 86.4%      |
| Students find it easier to calculate prism and tube volumes after following the cumulative learning. | 72.7%      |
| Students are more confident in learning.                                 | 63.6%      |
| Students are more interested in doing exercises.                        | 77.3%      |
From the result of questionnaire of student responses, it is found that the highest percentage is on students feel happy because they can discuss with their friends and does not feel bored when following the lesson. In addition, they are able to follow the learning because it can exchange opinions with friends and not easily get bored. Meanwhile, the lowest percentage is on the students’ self-confidence because when in the process of learning, some students feel less confident when the teacher asks them to explain the results of their work.

3.3. Test
The test was conducted at the end of the lesson with twenty-two students. The result showed that the average score was 73.95. Hence, it can be concluded that the students are considered passing the test if the score was $\geq 65$. There were 4 of 22 students who did not pass the test.

3.4. Interview
There were five people or subjects who becomes the interviewee. The results are described as follows.
3.4.1. The first subject. The interview result stated that the subject felt very happy with the learning she got through. The subject felt free to express her opinions toward the learning process and the moment of discussing with friends. The subject did not feel difficult in learning and able to do the test by herself without any help.
3.4.2. The second subject. The subject preferred learning by discussion rather than listening to teacher’s explanation. The subjects did not find any difficulty in following the learning because students were free to ask directly to the teacher and his friend. In addition, the student was able to do the tasks by himself.
3.4.3. The third subject. The interview result showed that the subject felt happy toward the learning process. The subject felt confident because she could find the step in calculating the volume of prisms and tube herself as well as discuss their ideas. The subject did not find any difficulties in the learning process. She did the test without her friends’ help. The subject found the steps when she was joining the teaching learning process.
3.4.4. The fourth subject. The result showed that the subject felt happy toward the teaching and learning process. The subject wisely used their time very well for discussion in the process of learning by asking to the teacher and his friends. The subject could do the tests by himself. The steps were retrieved from the teaching and learning process.
3.4.5. The fifth subject. The result showed that the subject felt happy toward the teaching and learning process. The subject could freely ask a question if there was a problem although the teaching and learning process was overall fun. The subject did the test given by the teacher by herself. The steps used were as same as what she had revealed in the teaching and learning process.

4. Discussion
From the result of questionnaire, the students’ responses in following the cumulative learning were very good or positive. It was because when cumulative learning was implemented, the teacher used eight stages of cumulative learning theory, including when motivating the students and the other phases such as understanding, acquisition, storage, retention, generalization, appearance, feedback [1]. Based on Piaget’s Theory of Cognitive Development, children of elementary school age (11-12 years) have not fully been able to think abstractly, therefore, the presence of concrete objects are still needed in the learning [12]. The teacher used props in the form of triangular prism and tube miniatures at the beginning of learning process as a tool to bring students into concrete forms. In addition, based on the results of students’ learning achievement, it was found that eighteen students have completed the target while the other four students have not completed it yet. It was because the students made a mistake in performing
the operation of calculation. It is revealed from the yield of relatively good long-term retention after a single study session [19].

5. Conclusion
Based on the results of this research, it can be concluded that the implementation of learning by applying cumulative learning theory in calculating triangular prism and tube volumes on sixth grade students used eight stages or phases of the theory. The result of the questionnaire showed that the students’ responses toward the implementation of cumulative learning were very good or positive. Moreover, the result of the test showed that the students’ scores increased with the average score 73,95. There were 18 students who passed the test and only 4 students who failed. It showed that the cumulative learning theory can be implemented in teaching and learning process. Through that way, it is expected that the students’ learning achievement will improve.

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