Increase the hierarchy concept map score through the modification in the 2nd stage of problem-based learning

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Abstract. The research aimed to calculate the increase of student’s hierarchy concept map (CM) scores through the modification of problem analysis and learning issue (2nd stage of problem-based learning (PBL)) using question instructional techniques. The type of research is classroom action. Research subjects were 36 X grade students. Research procedures: planning, action, observation, and reflection. Research data is the percentage of hierarchy CM score which is calculated based on the Expert CM score according to the material in each cycle. Data validity is done by confirming the percentage of hierarchy CM score with the result of interviews and documentation of the learning process in each cycle. The analysis techniques use reduction, presentation, and drawing a conclusion. The results show that the average increase in hierarchy percentage scores from pre-cycles to cycle I was 25% and cycle I to II was 38%. The number of students who experienced an increase in percentage hierarchy scores from pre-cycle to cycle I was 83% and cycle I to II by 90%, thus the modification of instructional techniques in problem analysis and learning issues PBL increased the students’ CM hierarchy score.

1. Introduction
Concept Map (CM) is a graphic visualizing the inter-concepts relation using the linking word on a particular topic [1]. CM has two main functions: as an instructional technique and an assessment [2]. As an assessment, CM stimulates students to link new knowledge into the existing cognitive structure to create meaningful learning [3]. As an assessment, CM has 6 components of assessment, namely hierarchy, valid relationship, branching, cross-link, specific example, and pattern [4].

Hierarchy (H) is one of the component CM that visualizes students’ ability in making the level of concept [5]. The most common concept is put on the top-most level and the most specific concept is placed on the bottom-most level [6]. Students need to analysis the inter-concepts relation when constructing the H in the CM [7]. The analysis of the inter-concepts relation requires a stimulus that helps students to activate the knowledge they already have, improve concept understanding, and know the interrelation between concepts [8]. The stimulus that helps students to activate the knowledge, understand the learning, and improve understanding and the inter-concepts relation is a problem [9].

Complex/ill-structured problems make the acquisition and interconnection between concept more optimal [10]. Complex problems need to be formulated and solved [11] by involving a complex thinking process [12]. A complex thinking process makes complexes problem solving [13]. Complex problem solving needs several stages: meeting the problem, problem analysis and learning issue, discovery and reporting, solution presentation and reflection, and overview, integration, and evaluation owned by the PBL [14].
PBL helps students to solve the problem by connecting the descriptive and procedural knowledge, thus helping the students to organize the concept [8]. The observation results of the PBL learning process for CM construction at the end of the study show an average percentage of 20% for the H component. The percentage of the H component shows that the use of PBL has not been optimal in improving the students' ability to make the concept level, so there should be modifications at the PBL stage.

The PBL stages that accommodate the ability of students in making H are the problem analysis and learning issue stages. The problem analysis and learning issue stages help students to develop concepts about the problem, understand the relevant concepts and connect the concepts with the knowledge they have [15], so the problem analysis and learning issue stages need to be modified.

Modification of problem analysis and learning issue stages is done by adding instructional techniques [16]. One of the instructional techniques that help students to construct CM is the teacher's question because CM is constructed by focus questions [17]. Teacher questions attract students' interest and attention to the material being studied, help to reconstruct knowledge [18], activate thinking, motivate to seek new knowledge [19], and facilitate students to find answers in the form of concepts that are organized in a list [20]. Therefore, modifying the teachers' questions in the problem analysis and learning issue stages is assumed to improve the H component score in students' CM.

The research aimed was to calculate and analyze the increase in the percentage of H scores in the student CM in each cycle through the modification of problem analysis and learning issue (2nd stage) in problem-based learning.

2. Methods
This is a classroom action research which consists of pre-cycle, cycle I and cycle II actions. The pre-cycle uses PBL, while cycle I and II use PBL which has been modified in the problem analysis and learning issue stages using an instructional technique in the form of teacher’s questions. The research subjects were 36 students of 10th grade.

The research procedures consisted of planning, action, observation, and reflection. The planning was conducted by arranging the research instruments in the form of syllabus, lesson plan, syntax implementation in pre-cycle, cycle I and II, CM expert, performance assessment, teacher and students interview guideline. The action implementation was done by implementing the lesson plan, which was finished by submitting the assessment in the form of CM construction by students at the end of learning, and interviews of teacher and students. The observation was made using syntax implementation observation sheets, performance assessments for making observations and inferences, group work, oral presentations, and learning process-documentation. The reflection was carried out based on the analysis results of the H component scores in the students’ CM in each cycle.

The data collected were in the form of syntax implementation percentage, percentage of learning process assessment through performance assessment, interview results, documentation and the score of students’ concept map hierarchy. The students’ H & CM scores were calculated using percentages based on the expert concept map in each cycle that refers to Novak & Gowin's (1984) assessment rules. The calculation of the percentage of the students’ H component score is done using the formula below:

\[
\text{Percentage of H Score} = \frac{\text{Students' H Score}}{\text{Maximum H Score on CM Expert}} \times 100\%
\]

The calculation of students’ H score is done using the formula below:

\[
\text{Students’ H score} = \text{Number of hierarchies constructed in the students’ CM} \times 5 \text{ points}
\]

The maximum score of H component in CM expert pre-cycle, cycle I and cycle II actions are presented in Table 1.
Table 1. Maximum score of H component in CM expert pre-cycle, cycle I and cycle II

| Actions     | Number of Hierarchies | Point | H Score | H Score Percentage |
|-------------|-----------------------|-------|---------|--------------------|
| Pre-cycle   | 5                     | 5     | 5x5 = 25 | (25/25)x100% = 100% |
| Cycle I     | 5                     | 5     | 5x5 = 25 | (25/25)x100% = 100% |
| Cycle II    | 3                     | 5     | 3x5 = 15 | (15/15)x100% = 100% |

The validity test used data triangulation technique by confirming the percentage of H CM scores students with the results of teacher and student interviews, and learning process-documentation in each cycle. The data analysis was done using reduction, presentation and drawing a conclusion. The data of students that were incomplete in the three cycles were reduced, so the 36 students were reduced to 30 students. The achievement indicator in this study was an increase in H concept map scores of participants.

3. Result And Discussion

3.1. Result.

The research results in the pre-cycle, cycle I, and cycle II in the form of a percentage of the H score in the students’ CM who have been reduced to 30 students, are presented in Figure 1.

![Figure 1. The Percentage of Students’ H Scores from Pre-cycle, Cycle I, and Cycle II](image)

The average percentage score of the H component in pre-cycle is 20% with 3% of students having scores above the average, 94% is the average and 3% is below the average. The average percentage score of the H component and the number of students having scores above the average in the pre-cycle shows that students have not been able to make the concept level.

The average percentage of the H component score in cycle I is 45% with 40% of students having scores above the average and 60% having a value below the average. The average percentage of the H component score and the number of students having scores above the average indicate that there is an improvement of students’ ability to make the concept level from cycle I, but it has not been optimal. So, further observation needs to be done in cycle II.

The average percentage of the H component score in cycle II is 83% with 60% of students having scores above the average and 40% students below the average. The average percentage of the H component score and the number of students having scores above the average show that there is an improvement of students’ ability to make the concept level from cycle I, and the average score is above 80% with 50% of the students having scores above the average. Thus, the research stops at cycle II.

The results of the study in the pre-cycle, cycle I and II show an increase in the average percentage of the H component score by 25% from pre-cycle to cycle I, and 38% from cycle I to II, with 73.3% of students get a linear increase, 16.7% students experience a trend increase, and 10% of students get an
increase in cycle I, but experience a decrease in cycle II. Students who experience a trend increase are number 6, 15, 18, 25, and 32, students who get an increase in cycle I, but experience a decrease in cycle II (fluctuating) are number 4, 13, and 31, and other students experienced a linear increase.

The results of the H component scores in the CM of students are supported by an assessment of the learning process in each cycle by using performance assessment. The results of the average percentage scores of performance assessment making observation, group work, and oral presentation are presented in Figure 2.

![The Average Percentage of Students' Performance Assessment Scores](image)

**Figure 2.** The average percentage of students’ performance assessment scores

Figure 2 shows the average percentage of performance assessment scores making observation and inferences, group work, and oral presentations have increased linearly in each cycle, but the rate of increase is very small. The average percentage of performance assessment scores making observations and inferences from pre-cycle to cycle II ranged from 46%-52%. The average percentage of group work performance assessment scores from pre-cycle to cycle II ranged from 69% -79%. The average percentage score of performance assessment oral presentation from pre-cycle to cycle II ranged from 54% -60%, thus the rate of the increase in the average percentage of the performance assessment score from pre-cycle to cycle II cannot be directly assumed to be a factor affecting the increase in the score of component H. Other factors influencing the increase in H component scores still require further research.

3.2. Discussion

The average percentage score of the H component in pre-cycle is low because students experience misconceptions about the material and difficulties when analyzing the relationship between concepts and organizing thoughts [7]. Misconceptions about the material occur because of incomplete and confusing information got by students [22]. Students’ misconceptions are reduced by the addition of question instructional techniques in the form of teachers’ questions. Specific questions make students easier to gain an understanding of the concept material, and easier for students to construct H in the CM.

Analyzing the inter-concepts relation, students need to understand relevant concepts, and be able to connect the concepts with the knowledge they have [21]. The activities needed to analyze the inter-concepts relation and concepts organization are accommodated by the problem analysis and learning issue stage in PBL (2nd stage) [15], thus the addition of instructional techniques in the 2nd stage of PBL in cycles I and II prevents students’ misconceptions of the material being studied, makes it easier for students to analyzing the inter-concepts relation and increase in the percentage of H scores in the CM of students.

The results of cycle I and II actions showed an increase in the percentage of H scores in the CM of students. The increase occurred because of the addition of instructional techniques in the form of teachers’ questions at the stage of problem analysis and learning issues made students give opinions about a material, clarify the connection between ideas and terms [23], and look for various information to get answers [24]. Getting answers from teacher questions are used in problem analysis activities, so that the problem analysis activity becomes easier. The ease in conducting problem analysis helps students to build an understanding of the concept material.
Students' understanding of the material requires a process. Students’ cannot gain a comprehensive understanding if the students only understand the concept of material in general, so students need to understand the basic and specific concepts of a material [25]. Comprehensive understanding of the concept makes it easy for students to understand the position of the concept, so students can identify the most general to specific concepts [26]. The ability of students to identify concepts makes it easy to arrange the concept hierarchy [6], so that the modification of instructional techniques of teacher questions at the stage of problem analysis and learning issues increase the concept map hierarchy scores.

The Increase in the percentage of H scores in students’ CM on cycles I and II is not all linear. Some students experience increasing trends and fluctuations. Students who experience increasing trends and fluctuations show a lack of students understanding of the material in cycle I or cycle II [27]. Lack of understanding material makes it difficult for students to arrange concepts obtained from learning outcomes [25], so the level of concepts formed is not optimal.

The increase in the percentage of H scores in students' CM was supported by an increase in the average performance of group work assessment, making observations and inferences, and oral presentations, but the rate of increase was very small. A very small increase in performance assessment of students occurs because of the less optimal performance of students in observing, discussing, and oral presentations.

Group work performance assessment supports an increase in the linear, trend, and fluctuating students’ H scores in the CM that are influenced by the composition of group members [28]. The composition of group members consisting of members who have a lot of experience, varied expertise, high level of activity, and variety of fields of knowledge increases the chance for information exchange and acquisition of knowledge [29], so the discussion activities become more meaningful and optimal. Discussion activities that run optimally lead to the assimilation of more knowledge in each individual [30], thus students' understanding of the material will be more complex. Complex understanding makes it easy for students to improve their ability to construct H in the CM [31], thus the composition of members involved in the discussion affects increasing the H score in students’ CM.

Making observation and inferences performance assessment supports an increase in the linear, trend, and fluctuating students’ H scores in the CM that are affected by the use of tools and materials that support observation activities. The use of tools and materials for observation activities helps students to find appropriate and accurate concepts [32]. Therefore, the acquisition of concepts obtained from an observation on revealing facts is capable to activate and to reconstruct their knowledge. The reconstruction of knowledge makes students' understanding of the material taught increases. Thus, they can organize their thoughts [33] and are easy to constructs H in the CM.

Oral presentation performance assessment supports an increase in the trend, linear, and fluctuating towards an increase in students’ H scores in CM which is affected by the delivery of information from a person or group doing the presentation. The information delivery by using varying tones, emphasizing the keywords of the material, giving appropriate pauses, and not reading the book while doing the presentation shows a good understanding and mastery of the material presented by the presenter and makes the audience easily understand the material [34]. The information delivery in the tendency to read the book while doing the presentation shows the presenter’s less understanding of the material presented and makes it difficult for the audience to understand. Thus, it affects the synthesis of the knowledge structure of each student [8]. The optimal knowledge synthesis makes it easy for students to classify the concepts to generate H in CM. Consequently, if students' performance assessment scores are optimal, the knowledge gained is more complex, and the students are able to construct more complex concept levels.

Optimizing student performance assessment requires high motivation to be serious in following the learning process properly. Students in building cognitive abilities require actions that are motivated by themselves on the environment [30], thus causing optimal performance assessment and helping students to construct H in the CM.

4. Conclusion

Students’ H scores were improved through a modification of problem analysis and learning issue stage in the PBL using question instructional techniques with a percentage increase of 25% from pre-cycle...
to cycle I and 38% from cycle I to II and the instructional technique in this study was more impactful in increasing the percentage of H component scores in CM of students compared to the increase in the average percentage of performance assessment scores.

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