Application of the 5E learning cycle model to overcome misconception and increase student learning activities in learning chemical bonding

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Abstract. This research aims to determine the use of the 5E learning cycle (LC) model in reducing student misconceptions and increasing student learning activities in learning of chemical bonding. The research method used was experimental design with the research design was pretest-posttest control group design. The study population was high school class X students consisting of four classes, and the sample group was determined by purposive sampling technique in order to obtain two classes that became the study sample. The results showed the use of the LC 5E model can reduce student misconceptions, this is indicated from the initial analysis the average percentage of students in the experimental class was 50.66, after applying the LC 5E model to 18.30. Increased student activity in learning activities can also illustrate a decrease in misconceptions. Learning activities of students during the application of the LC 5E model in three meetings obtained by 88%, included in the excellent category. The conclusion in this study is the LC 5E model can reduce misconceptions and increase student learning activities because each stage in the learning process directs students actively and creatively.

1. Introduction
Chemistry is learned by students at the high school level, but basic knowledge about chemistry has been taught at the junior secondary level in natural science subjects. The process of learning chemistry is arranged systematically starting from simple concepts, into more complex concepts. The science or study of chemistry is continuous, meaning that between one concept and another is mutually sustainable and studied coherently [1], one example is chemical bonds. This material will be difficult if the lack of understanding of students on previous concepts, such as atoms, electron configurations, and periodic systems. This is due to the relationship between chemical bonds with the previous concept [2,3].

Chemical bonding is one material that is considered complicated by students, this is because the explanation of this concept is still abstract so it makes it difficult to understand it. The low learning outcomes of students can also be caused by incomplete understanding, or understanding that has formed contrary to scientific theories often called misconceptions [4]. This is what ultimately can hamper student learning [5]. Observations made at schools found in the learning of this material are explained
conventionally and at the last stage is given worksheet which contains questions as an evaluation of the material being taught. As a result, the activities of students become less active, where the learning process is only centered on the teacher and the involvement of students is only in filling the worksheet. Teacher-centred learning can make students not participate in learning and can cause misconceptions [6].

A misconception is concept interception through a statement that cannot be accepted in theory [7]. This happens because students store knowledge in accordance with the concepts they know, but the concepts they have do not correspond to scientific reviews [8]. The education of students is not only obtained formally but also through informal means of daily experience outside of school education, so they sometimes form their own views [9]. This is also consistent with the exposure of [10] which states students come to school with different learning experiences and this has an effect on learning.

Misconceptions can be remediated by applying student media, models, or worksheets. Teachers need to make changes in the teaching and learning process by changing the learning system into student-centred, fostering motivational attitudes, and trying to apply models and methods that can increase student learning activities [11]. Overcoming misconceptions using learning models has been done by [12] with the results of research showing a reduction in misconceptions and maintaining the correct concept for a long time. Another step that can be done by increasing the activities of students in learning activities. Increased activity in learning can affect student understanding [13]. Student activities are closely related to misconceptions, increasing learning activities can affect the understanding of concepts which can reduce misconceptions. The activity demanded is student-centered that expects active students and is not fixated on the teacher's explanation [14].

Learning models can function to increase the activity, motivation, level of understanding of concepts and creativity of students. One learning model that can improve understanding of concepts and activities is the learning cycle (LC) [15-17] states LC is a constructivism learning model and emphasizes conceptualism, where the teaching and learning process that is applied is centered on students (student-centered) and in accordance with the application of the 2013 curriculum [18]. Students in constructivism are required to be able to create their own understanding and knowledge so that an active learning process will be formed [19]. Learning like this can reduce misunderstandings experienced by students [20]. LC consists of several types, but according to [21] type 5E has more role in increasing the success of science.

LC 5E is learning that consists of 5 stages namely, engagement, exploration, explanation, elaboration, and evaluation. This model has a positive impact on learning science and creating critical thinking students [22]. The same thing was explained by [23,24] namely a significant increase in student achievement and attitudes towards science. The attitude of science in question such as being objective in conducting research, delighting in inquiry or discovery, cautious and appropriate [25]. The stages in LC 5E are also effective in increasing understanding of concepts [26], and building meaningful knowledge [27]. Based on the statement, this model can be used to reduce misconceptions [28], and is associated with student learning activities. Increasing learning activities means involving students in learning and this step can reduce misconceptions.

Similar research on LC 5E was carried out by [18], said the application of the LC 5E model can correct concept errors in redox material with a percentage of values of 78.78 and increase the retention of concept comprehension conducted two weeks after learning. The results of students' understanding of concept retention showed an excellent value with an average percentage score of 95.5. A similar study was also conducted by [29], remediating misconceptions with the LC 5E learning cycle model on style material. Based on the research conducted it can be concluded that LC 5E is able to reduce the proportion of students who experience misconceptions from a percentage of values of 46.0 to 2.8. Thus there is a decrease in the number of students experiencing misconceptions by 43.2, which shows that the LC 5E learning cycle model is able to increase the proportion of students who experience misconceptions. LC 5E model has several advantages, namely developing scientific attitudes, increasing motivation and activities because students play a role in every learning activity, and make learning to be more meaningful [30]. Based on these statements, the LC 5E model has a relationship in overcoming misconceptions and increasing student activity.
2. Method
This research uses experimental design method with pretest-posttest control group design. The population consists of 4 classes totalling 180 students, based on the percentage of misconceptions it is known that the two classes have the same average ability. The research sample was determined by purposive sampling technique. Data on students' misconception before applying the LC 5E model and students after applying the LC 5E learning model were compared to see the level of decrease in misconceptions.

The research was conducted with an initial stage, namely the students' misconception level test using questions in the form of four tiers, in the form of multiple-choice multiple-level questions totalling 20 questions. Each question is divided into 4 levels, namely for level one in the form of questions, the second level in the form of confidence in the face of the answer to level one, level three in the form of reasons in answering questions at level one, and the fourth level in the form of confidence in the reasons at third level [31].

The next step is to implement the LC 5E model in three meetings. The learning activities in the experimental class are adapted to the LC 5E model, namely the engagement stage (conveying apperception and motivation), the exploration stage (students observe the learning video, observe the worksheet shared by researchers), the explanation phase (look for sources or other learning information, make mind mapping), elaboration stage (completing worksheet, presentation of results) and evaluation stage (drawing conclusions and conducting tests to find out the achievement indicators of competency achievement). Learning activities of students was observed by observers based on LC 5E stages. The instrument for measuring student activity uses activity observation sheets that have been validated and adjusted to each stage of LC 5E. The final stage is to reexamine the students' level of misconception after applying the LC 5E model.

3. Result and discussion
3.1. Misconception
Analysis of the use of the LC 5E model in overcoming misconceptions can be seen from the hypothesis test data (t-test), which is obtained from the students' post-test scores in the experimental and control classes. The function of the t-test is to see the hypothesis accepted or rejected. T-test results were obtained with the help of SPSS software version 20, the data can be observed in Table 1

| Misconception score (Posttest) | Normality\textsuperscript{a} | Homogeneity\textsuperscript{b} | Test of Hypothesis\textsuperscript{c} | Conclusion |
|-------------------------------|---------------------------|---------------------------|-------------------------------|------------|
| Control | Experiment | Normal (0.517) | Normal (0.761) | Homogeneity 0.408 | t-count (7.234) > t-table (1.725) | Significant |

\textsuperscript{a} One-Sample Kolmogorov-Smirnov Test, if the value of sig> 0.05 (Normal)
\textsuperscript{b} Levene Test (Test of Homogeneity of Variance, if the value of sig> 0.05 (Homogeneous)
\textsuperscript{c} Independent Sample Test, if t-count>t-table (Significant)

Based on Table 1, the results of the normality test of the control class and the experiment are normally distributed, with the acquisition of each class is 0.517 and 0.761 significant> 0.05. The homogeneity test obtained 0.408 with a significance level of 0.05 concluded that the two sample variants were homogeneous. Based on these data obtained t-count (7.234)> t-table (1.725) at a significant level of 0.05 there is a significant difference between the control class and the experimental class, meaning that the
application of the LC 5E model can reduce students' misconceptions. Data on student misconceptions can be seen in Figure 1.

![Figure 1. Chemical bond misconception](image)

Based on Figure 1, the percentage of misconception pretest for each class is included in the medium category, this proves that chemical bonds are among the materials that have misunderstood students. If seen from the research of [2], chemical bonds are included in material that is susceptible to misconceptions, this is because this material is one of the difficult material so high understanding is needed. Misunderstandings experienced can be caused by student initial concepts, incomplete reasoning, and cognitive development [32]. Misconceptions that occur in students can also be caused by several factors such as assuming a concept is always the same as another concept, wrong intuition and low student interest in learning [33]. This last factor is related to learning activities, the lack of interest in participating in learning also impacts the absence of activities that occur in learning activities, students feel bored so they are more likely to play around and not listen to learning that takes place.

The percentage of students' misconceptions after being applied LC 5E has decreased, for the experimental class to 18.30 the category is low from the previous 50.66 category is being decreased by 32.36. Furthermore, in the control class, the average percentage was 44.35 with an initial misconception of 54.36, a decrease of 10.01. Each class decreased misconceptions, but students who applied LC 5E can reduce greater misunderstanding. This is because through this model students can relate new information to the knowledge they have, and avoid traditional learning methods that tend to memorize [34]. [18] in her research succeeded in correcting misconceptions with very good categories through the use of the LC 5E model, because the stages of learning activities in LC 5E can increase students' understanding of concepts systematically from basic concepts to more difficult concepts. Aside from the stages of the LC 5E model that can reduce misconceptions, this model is also supported by the worksheet provided in the learning process that is designed based on the LC 5E model. The superiority of the LC 5E model that is applied can make students play an active role in learning so that students more interpret each process for the process of learning. Research on the use of LC 5E-based worksheet was conducted by [35] can improve student learning achievement. LC 5E model itself is a learning model that emphasizes more in the process of student activities [36].

A worksheet which is designed follows the steps of LC 5E, namely exploration, explanation, and elaboration. Students respond to each question from the researchers listed in the lesson plan, this is included in the engagement stage. The task of the teacher at this stage is to arouse students' interest and curiosity about the topic to be studied by making questions related to the subject. In the next stage of
exploration, students observe the learning video and observe the worksheet that is distributed. At this phase, explanation of the role of students in developing mind map with work steps that have been listed in worksheet was included.

Mind mapping is designed in three meetings with each material, namely the stability of atoms and ionic bonds, covalent bonds, and metal bonds. The completed mind mapping was then presented to other groups. Other groups provide input or provide questions about the mind mapping that has been presented. All students were very enthusiastic to pay attention to mind mapping that had been prepared by other groups. The resulting mind mapping is also able to explain the level of understanding of students' concepts. Based on the t-test and previous explanations, it can be concluded that the LC 5E model can reduce students' misconceptions, this is indicated by the value of the posttest, work on worksheet and making mind mapping and presenting it makes students better understand the concept of chemical bonds. Creativity in designing mind mapping will help students to understand and absorb information quickly so that students' memories are more optimal [37,38].

Elaboration stage, students solve every problem in the worksheet by applying all the concepts obtained in learning in the questions given. This stage changes the conception of students into concepts in accordance with the opinions of scientists [29]. Some advantages of using the LC 5E model in overcoming misconceptions are, students understand the concept of chemical bonds systematically, where they learn the concept of chemical bonds from the most basic concepts to more complex concepts, in learning students have wider opportunities to express their opinions and students find concepts based on their own understanding through group discussions [39].

3.2. Learning activities
Observation of the activities of students observed during learning activities by the observer. Observer consists of 2 people, there are five stages observed, namely engagement, exploration, explanation, elaboration, and evaluation. These indicators are redefined in the LC 5E stage, the results of the percentage of student learning activities can be observed in Figure 2.

![Figure 2. Average learning activities of students based on the stages of the LC 5E model](image_url)

Based on Figure 2, a significant increase in activity occurred at the elaboration stage, where at each meeting the average activity of students was 100%. Likewise, if observed at the evaluation stage, each meeting received an average of 90%. Furthermore, the stage of engagement, exploration, and explanation increases the activity of students in each meeting. Conclusions that can be drawn based on
these data increase in activity occurs in elaboration activities, wherein this stage student works on the worksheet and design mind mapping. This design process students structure the concepts that they have obtained from the previous stage, while the work of worksheet is to apply the concepts that have been obtained in the problems described in the questions. The same thing was also obtained by [40] in his research, an increase in student activity in the LC 5E stages including exploration and explanation, at which stage the students read and worked on the worksheet.

The mind mapping is a supportive learning strategy by organizing information obtained both from books or other learning sources that are poured based on the imagination or creativity of students [41]. This can help students understand and absorb information quickly [37]. So that all participants in the group work together to complete mind mapping then present it and link the concepts that have been learned by working on all observations or problems in the worksheet. Learning activities of students are associated with a decrease in misconceptions, this is according to [26] that this LC model can increase the role of students in the learning process, which means an increase in learning activities and increase understanding so that it can reduce misconceptions. [42] also explains that student activities can support success in the learning process. Learning will not run well if there is no activity from the students. Activities are important in the learning process, meaning that increasing the activity of students will affect other aspects such as, understanding concepts or reducing misconceptions [43].

4. Conclusion
The results showed that the initial analysis of the average of students 'misconceptions in the experimental class was 50.66%, after LC 5E was implemented there was a decrease in students' misconceptions of 18.30%. This proves that the LC 5E learning model is more effective in reducing students' misconceptions on chemical bonding material. Student learning activities get an average of three meetings at 88%, included in the excellent category. Each activity meeting increases this because students are more enthusiastic in working on worksheet and mind mapping. So the LC 5E learning model can increase student learning activities.

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