Implementation of 4Es combined with drill and practice learning model by considering mathematics ability on the students’ learning achievement on the topic of solubility and solubility product

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Abstract. The object of the research was to investigate: (1) the effectiveness of the Learning Cycle 4Es combined with Drill and Practice and conventional learning models on the students’ learning achievement; (2) the effect of the ability in Mathematics on the students’ learning achievement; and (3) the interaction between the Learning Cycle 4Es combined with Drill and Practice and conventional learning models and the ability in Mathematics on the students’ learning achievement on solubility and solubility product. The samples of research consisted of 2 classes, experimental class and control class. Data analysis study used two way variance analysis (ANAVA) with unequal cells and Kruskal Wallis tests. The results of the research showed that (1) there was an effectiveness of the Learning Cycle 4Es combined with Drill and Practice and conventional learning models on the learning achievement in the knowledge and skill aspect, but there was not any effectiveness on the attitude aspects; (2) there was an influence of mathematics ability on learning achievement aspects of knowledge, but there was not any influence on attitude and skills aspect; (3) there was an interaction between the Learning Cycle 4Es combined with Drill and Practice and conventional learning model and the ability in Mathematics on learning achievement aspects of knowledge, but there was not an interaction on attitudes and skills aspect.

1. Introduction
Education is an essential aspect of nation-building as its role in creating characters of a nation. Improving and upgrading the curriculum has become one of the efforts conducted by the government to improve Indonesian education quality. 2013 Curriculum, the newest curriculum, implements student-centered learning which has been applied since long ago.

According to the students' perspective, chemistry is a challenging subject as it has several concepts and its vocabulary [1]. To make the learning process fun, the teacher should be able to choose an effective learning model so that students easy in acknowledging the subject matter. The selection of a good learning model should be adapted to the coming material. One learning model that can increase student interest and activeness is a cooperative learning model that requires students to actively work in small groups [2].

Learning Cycle 4Es is one type of learning cycle model which applies the concept discovery method. Practically, there is a more complex phase in each type of phase increasing. Besides, there are
four steps in the learning cycle 4Es model: exploration, explanation, expansion, and evaluation. Chemistry tends to contain concepts and calculations. The Learning Cycle 4Es helps students finding concepts but the model has not yet provided the maximum effect on the calculations material. The use of the learning cycle model has an effect on student learning outcomes in the solubility and its results where the influence of the model is equal to 28% [3]. Therefore, the researcher combined the Learning Cycle 4Es with drill and practice learning model.

Drill and Practice learning model trains students to be accustomed to the materials delivered [4]. This learning model can add accuracy, speed, perfection in doing something [5]. Moreover, the learning model can increase students’ activeness and achievement in the subject matter of salt hydrolysis [6].

The combination of the Learning Cycle 4Es and drill and practice learning model can be used in chemistry subject matter, especially solubility and solubility product where solubility and solubility product are materials in which there are concepts and calculations. Learning solubility and solubility product required good ability in mathematics. In contrast, each student’s mathematics competence is certainly different.

Based on the phenomenon above, the researcher carried out a research on the effectiveness of the Learning Cycle 4Es combined with Drill and Practice learning model in terms of mathematical ability on students’ achievement in solubility and solubility product for grade XI of Mathematics and Natural Science.

2. Research methods
The research was conducted on 11th Science graders of a senior high school in Boyolali. A quasi-experiment is implemented as the research method. The research design chart was presented in Table 1.

| Class | Learning Model | Math Ability |
|-------|----------------|--------------|
|       |                | High (B₁)    | Low (B₂)    |
| Experiment | Learning Cycle 4Es combined with Drill and Practice (A₁) | A₁B₁ | A₁B₂ |
| Control  | Conventional (A₂) | A₂B₁ | A₂B₂ |

The research subjects were 11th Science graders 1 as the control which applies conventional learning model and 11th Science graders 2 as the experiment class which applies the learning cycle 4Es combined with drill and practice learning model.

3. Results and discussion
Hypothesis testing is done by the analysis of variance (ANOVA) of two paths with unequal cells. Before conducting the ANOVA test, the data must meet the analysis prerequisite test, which includes normality test and homogeneity test. Normality test is done by the Lilliefors method, while the homogeneity test is done by the Barlett method. The prerequisite test is used to find out whether the research data is normally distributed and has the same variance or not. For data abnormally distributed and homogeneous, hypothesis testing is performed by Kruskal Wallis non-parametric statistical tests. The following results from the normality test and homogeneity test can be seen in Table 2 and Table 3.

| Students’ Groups | α | Knowledge | Attitude | Skill |
|------------------|---|-----------|----------|------|
|                  |   | Sig  | Conclusion | Sig  | Conclusion | Sig  | Conclusion |
| A1               | 0.05 | 0.069 | Normal | 0.00 | Abnormal | 0.020 | Abnormal |
| A2               | 0.05 | 0.235 | Normal | 0.00 | Abnormal | 0.140 | Normal |
| B1               | 0.05 | 0.052 | Normal | 0.00 | Abnormal | 0.113 | Normal |
Table 3. Homogeneity Test Results of Students’ Achievement of Experimental Class (Learning Cycle 4Es combined with Drill and Practice) and Control (Conventional).

| Homogeneity Test | Significance α Conclusion | Knowledge | Attitude | Skill |
|------------------|---------------------------|-----------|----------|-------|
| Homogeneity in terms of model | 0.549 | 0.130 | 0.553 | 0.05 Homogeneous |
| Homogeneity in terms of Math Skill | 0.093 | 0.718 | 0.575 | 0.05 Homogeneous |
| Homogeneity in terms of between cells | 0.358 | 0.174 | 0.538 | 0.05 Homogeneous |

Based on Tables 2 and 3, research data that fulfill the prerequisites for ANOVA analysis are data of knowledge achievement. While the data of attitudes and skills achievement do not meet the requirements of the analysis, as its distribution is not normal so the hypothesis testing uses Kruskal Wallis nonparametric analysis.

Table 4. ANOVA Test Results in Two Paths Knowledge Achievement

| Source | Significance α | Judgment Means |
|--------|----------------|----------------|
| Learning Model (A) | 0.009 | 0.05 | $H_{1A}$ accepted |
| Math Ability (B) | 0.009 | 0.05 | $H_{1B}$ accepted |
| Interaction (AB) | 0.000 | 0.05 | $H_{1AB}$ accepted |

| Hypothesis | Significance α | Judgment Means |
|------------|----------------|----------------|
| Learning Model (A) | 0.442 | 0.05 | $H_{1A}$ rejected |
| Math Ability (B) | 0.852 | 0.05 | $H_{1B}$ rejected |
| Interaction (AB) | 0.738 | 0.05 | $H_{1AB}$ rejected |

Table 5. Non-parametric Test Results of Students’ Attitude Achievement

| Hypothesis | Significance α | Judgment Means |
|------------|----------------|----------------|
| Learning Model (A) | 0.029 | 0.05 | $H_{1A}$ accepted |
| Math Ability (B) | 0.236 | 0.05 | $H_{1B}$ rejected |
| Interaction (AB) | 0.088 | 0.05 | $H_{1AB}$ rejected |

Table 6. Non-parametric Test Results of Students’ Skills Achievement

| Hypothesis | Significance α | Judgment Means |
|------------|----------------|----------------|
| Learning Model (A) | 0.029 | 0.05 | $H_{1A}$ accepted |
| Math Ability (B) | 0.236 | 0.05 | $H_{1B}$ rejected |
| Interaction (AB) | 0.088 | 0.05 | $H_{1AB}$ rejected |
3.1. This study aims to investigate the effectiveness of Learning Cycle 4Es combined with Drill and Practice learning model and conventional learning model on students’ achievement

ANOVA results of two cell paths are different in the first hypothesis, the results of the two models show that the significance value < significance level is 0.009 < 0.05 which means that H1 is accepted. This proves that there is effectiveness between the experimental class (Learning Cycle 4Es combined with Drill and Practice learning model) and the control class (Conventional learning model) on the learning achievement of students’ knowledge on solubility and solubility product where the experimental class is better than the control class. The average score of students’ knowledge achievement taught through implementing the Learning Cycle 4Es combined with Drill and Practice learning model is 3.07. While the average score of students’ knowledge achievement taught by conventional learning models is 2.84. This difference is due to learning by applying the Learning Cycle 4Es combined with Drill and Practice learning model, students get the opportunity to find concepts and practice questions compared to conventional learning model. According to Subaryana (2005: 9), conventional learning places the instructor as the sole source where students assume that the teacher is the only learning source so that students become passive [7]. Learning Cycle model is commonsense in increasing students’ achievement than conventional models [8]. Drill and Practice models affect the science process skills and student learning outcomes in salt hydrolysis material, in which the Drill and Practice learning model is more effective than conventional learning model [9].

The results of the Kruskal Wallis analysis of the attitude aspects of the two models show that the significance value of 0.442 is greater than the significance level of 0.05, then H1 is rejected. This proves that there is no effectiveness between the experimental class (Learning Cycle 4Es combined with Drill and Practice learning model) and the control class (Conventional learning model) on the learning achievement of students’ attitudes. The average amount of student achievement attitudes implemented with conventional learning models is 3.26. While the average amount of student achievement attitudes implemented with the Learning Cycle 4Es combined with Drill and Practice learning model is 3.30. There may be no differences in terms of attitudes achievement aspects as its factors are more influenced by internal factors that exist in students’ in the form of psychological factors such as attention, interest, self-concept, and students’ readiness of learning towards subject matter [10].

The results of the Kruskal Wallis analysis on the skills aspect show that the significance value of 0.029 is smaller than the significance level of 0.05, then H1 is accepted. This proves that there is effectiveness between the control class (Conventional learning model) and the experimental class (Learning Cycle 4Es combined with Drill and Practice learning model) on students’ skills achievement. As the average number of control class (conventional learning models) is 3.68 and the average experimental class (Learning Cycle 4Es combined with Drill and Practice learning model) is 3.78, they show that Learning Cycle 4Es combined with Drill and Practice learning model yield in better achievement psychomotor learning than conventional learning model. The learning cycle model improves students’ ability in understanding lessons and makes the lesson more meaningful [11].

3.2. This study aims to investigate the effect of mathematical ability on students’ achievement

The results of ANOVA two different cell paths of knowledge aspects show that the significance value < significance level is 0.009 < 0.05 which means that H1 is accepted. This proves that there is an influence between students’ mathematical ability in the high and low categories on students’ knowledge achievement aspect on the solubility and solubility product. Based on the average value of students’ mathematical abilities, it is known that students in the high mathematical ability group have an average value of 3.31 while students in the low mathematical ability group have an average value of 2.82. As the results obtained, it is stated that students with high mathematical ability have higher results than students with low mathematical ability. Mathematical ability provides a very important role in learning outcomes achievement, especially in science learning [12].

The results of Kruskal Wallis statistical test on the attitude aspect show that the significance value was 0.852 > the significance level of 0.05, then H1 is rejected. This shows that there is no influence
between students' mathematical ability in the high and low categories of attitudes towards learning achievement. Based on data of students’ mathematical ability average, it is known that students in the high mathematical ability group have an average value of 3.32 while students in the low mathematical ability group have an average value of 2.28.

The results of Kruskal Wallis analysis on students’ learning outcomes in terms of skill aspects obtain significance value > significance level of 0.236 > 0.05 which means $H_1$ is rejected. It can be concluded that there is no influence between the mathematical ability of students in the high category and the low category of students’ skill achievement. Consequently, the study shows that some students having high mathematical ability gain skill value of 3.68, while students having low mathematical ability attain skill value of 3.72.

3.3. This study aims to investigate the interaction between Learning Cycle 4Es combined with Drill and Practice learning model and conventional learning model and the ability in Mathematics on the students’ learning achievement

The results of two-way ANOVA with unequal cells obtain significance value < significance level that is 0.000 < 0.05 which means $H_1$ is accepted. It can be concluded that there is an interaction between the conventional learning model and the Learning Cycle 4Es combined with Drill and Practice learning model with mathematical ability to the learning achievement of students’ knowledge on the solubility and solubility product. From the results of the learning achievement in terms of knowledge in the control class (using conventional learning model), the average achievement of knowledge in students with high mathematical ability is 3.18 while students with low mathematical ability are 2.73. While the results of the learning achievement in terms of knowledge in the experimental class (using Learning Cycle 4Es combined with Drill and Practice learning model), the knowledge achievement average in students with high mathematical ability is 3.42 while students with low mathematical ability are 2.92.

In the implementation of the learning process applying conventional learning models as well as the Learning Cycle 4Es combined with Drill and Practice learning model, the role of mathematical ability is highly needed by students in improving learning achievement in terms of knowledge. Students with high mathematical ability in both classes have better learning achievement than students with low mathematical ability. It can be concluded that the students’ mathematical ability will have the same effect both those taught using conventional learning models and Learning Cycle 4Es combined with Drill and Practice learning model in which students with high mathematical ability having better achievement and students having high or low mathematical ability provides better performance than students taught using conventional learning models.

The results of Kruskal Wallis statistical test using attitude achievement values indicate that the significance value is 0.738 > a significance level of 0.05, which means that $H_1$ is rejected. This proves that there is no interaction between Learning Cycle 4Es combined with Drill and Practice learning model and conventional learning model with mathematical ability on the learning achievement aspects of students’ attitudes. The results of the achievement of attitude aspect in the control class (using conventional learning model), the average attitude achievement in students with high mathematical ability are 3.33 while students with low mathematical ability are 3.21. Whereas in the experimental class (using Learning Cycle 4Es combined with Drill and Practice learning model), the average attitudes achievement in students with high mathematical ability is 3.35 while students with low mathematical ability are 3.25.

The results of Kruskal Wallis statistical test using skills achievement scores indicate that a significance value of 0.088 > a significance level of 0.05, which means that $H_1$ is rejected. This proves that there is no interaction between Learning Cycle 4Es combined with Drill and Practice learning model and conventional learning model with the mathematical ability on the learning achievement aspects of students’ skill on the solubility and solubility product. The result of students’ skill achievement in the control class (conventional learning models) with high mathematical ability is 3.76 while students with low mathematical ability are 3.66. Whereas in the experimental class (using the
Learning Cycle 4Es combined with Drill and Practice learning model), the average achievement of skills in students with high mathematical ability is 3.78 while students with low mathematical ability are 3.70.

4. Conclusion
According to the findings, it can be concluded that (1) there is effectiveness in implementing Learning Cycle 4Es combined with Drill and Practice learning model and conventional learning model on students’ achievement in terms of knowledge and skills, but there is no effectiveness on attitude aspects, (2) there is influence of mathematical ability towards students’ learning achievement on knowledge aspects, but there is no influence on an attitude and skills aspects, (3) there is an interaction between Learning Cycle 4Es combined with Drill and Practice learning model and conventional learning models with mathematical ability on students’ achievement solubility and solubility product in knowledge aspects, but there is no influence on attitude and skills aspects.

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