Implementation of the inquiry model assisted with quick response code to improve students’ critical thinking skills

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Abstract. This research was aimed to study the influence of inquiry learning model with assisted quick response code (QR code) to students’ critical thinking skill (CTS) in the learning of salt hydrolysis in one of the senior high school in Banda Aceh. The sample was collected by purposive sampling. The quasi-experiment method was implemented in two classes, accompanied by nonequivalent control group design. Two groups of students from different chemistry class were selected as sample. The results showed that the CTS of students who are taught using inquiry model has higher posttest score compared to control class. Moreover, the results revealed that the comparison of average N-gain for all CTS indicators was 42.37% for control class and 73.57% for experiment class. Statistical analysis with t-test on all CTS indicators showed that the value of $t_{\text{count}} > t_{\text{table}}$ at $\alpha = 0.05$. The conclusion of this study is the implementation of inquiry model with assisted QR code improves student’ CTS.

1. Introduction
Learning chemistry focuses on the mastery of knowledge in the form of facts and concepts by finding and investigating systematically [1]. Students can get the opportunity to learn to find facts, concepts and principles through direct experience so that students not only memorize material from books or from the teacher's explanation but also get the opportunity to develop critical thinking skills [2,3]. The results of observations that have been conducted in SMAN 4 Banda Aceh, showed that students were still not independent in solving problems, less creative and less critical. Based on interviews on December 10, 2018 with chemistry teachers, who have been implementing several cooperative learning models, although they often found resistances in learning. Students were bored and not motivated in learning. The concepts of salt hydrolysis which is an abstract nature and must be understood by students in limited time, so make the material is still difficult for most students, to learn that many students have difficulty in understanding the concept [4]. In addition, the learning achievement on topic of salt hydrolysis was quite low. According to National examination results (UN) in the school, especially the thesaurus of the salt hydrolysis material in 2018 with average score was 45.45 [5].
In 2013 curriculum concerns to the student-centered learning, in which they are facilitated to be more active directly in teaching-learning process by implementation of 21st century that reflecting 4 sides, they are critical thinking and problem solving, creativity and innovation, communication and collaboration [6]. Thus, the teachers are permitted to conduct the learning by driving the student to be creative, innovative, collaborative, and able to think critically for problem-solving. An inquiry is one of learning models which is successfully lead the critical thinking skill for learning [7]. In addition, this model also developing the CTS with various steps, they are identifying the problem, creating the hypothesis, designing and conducting the experiments and making the conclusion from experimental results [8].

Inquiry model learning expects students to be braved to ask in any condition, collect and analyze the data until they find the proper answer for their questions [9]. Learning with the inquiry model is a series of activities which are forced on critical and analytical thinking in order to find the solution for the questions that have been asked [10]. CTS indicator consists of analyzing the argumentation, answering and clarifying the questions, creating and considering the deduction, making and considering the value of decision and determine an action [11]. The previous research explained inquiry learning by using android-based digital game improved learning achievement and student critical thinking skill [12]. Another research also showed that guided inquiry model has significant influences on the student CTS [13].

There are several steps of inquiry learning namely orienting student to start learning, formulating the problems, creating a hypothesis, collecting data, testing the thesis and making conclusion [9]. The implementation of this learning model must be supported by appropriate media or other sources which are interactive and innovative sources, so it improves student abilities to activate their critical thinking for solving the problems. One of formulated learning tools is digital-based media in form of video and teaching materials which are joined to be QR code. The QR code is two-dimensional barcode used to integrate and solve information code [14]. This code tells much information in form of text, URL link, automatic SMS, or other information that can be stored in this dimensional barcode [15]. Data which has been encoded can be decoded again by scanning the barcode through mobile phone assisted with camera and software to read the QR code. This code also excessively used in companies and libraries; however, it has not been used specifically in learning yet [16]. Moreover, the implementation of QR code was done in education sectors. Learning using this code will motivate students to be more active to use their mobile phone for benefits of education compared to traditional learning [17]. Based on these problems, the research about implementation inquiry model with assisted QR code had been done to improve CTS of student in learning salt hydrolysis at SMAN 4 Banda Aceh.

2. Methods

The research was conducted at SMAN 4 Banda Aceh from February to March in the academic year of 2018/2019. Sample selection was done based on homogeneous pretest score from all population, thus it selected class XI science 2 and XI science 3 as a sample with 34 students for each class. To determine class of control and experiment, it was done randomly. This research used nonequivalent control group design by distinguishing class of control and class of experiment without raking randomization. Research design can be seen in Table 1 [18].

| Classes   | Pretest | Treatment | Posttest |
|-----------|---------|-----------|----------|
| Experiment| O₁      | Xₑ        | O₂       |
| Control   | O₁      | X₉        | O₂       |

*O₁ : Pretest in the experimental and control groups

*O₂ : Posttest in the experimental and control groups

*Xₑ : Treatment by applying a guided inquiry model with QR code

*X₉ : Treat by applying the learning model commonly used in school
Data collection techniques include CTS test before treatment (pretest) and after treatment (posttest). Data analysis using normality, homogeneity and t-test with the help of SPSS 20. The normality test uses the Kolmogorov-Smirnov Test, the homogeneity test with the Levene’s Test and the t-test using the Independent sample Test. If the data is normally distributed and homogeneous then a t-test is carried out to see the difference / influence of the application of the inquiry model with QR code. Conversely, if one or both of the data is abnormal and homogeneous, the non-parametric hypothesis test is done, namely the Mann Whitney test.

3. Results and Discussion

3.1. Identification of CTS improvement

The Student CTS was measured using multiple-choice questions accomplished with reasoning questions in which 20 questions, according to CTS indicators. The improvement of student CTS was analyzed through item test which is performed by each score of item test. Every item test was assessed using 6 criteria namely: score 5 for right answer with appropriate reason, score 4 for right answer with less appropriate reason, score 3 for wrong answer with appropriate reason, score 2 for wrong answer with less appropriate reason, and score 0 for both answer and reason are wrong. The average score of CTS can be investigated based on each indicator developed for every item test. The result reached from inquiry model with assisted QR code is represented by N-gain for each CTS indicator and it can be seen in Figure 1.

![Figure 1. CTS comparison for each indicator between experimental and control classes](image)

Figure 1 exhibited that the score on each indicator of CTS performed by N-gain in class of control obtained moderate level for CTS 2, 4 and 5 and low level for CTS 1 and 3. But, class of experiment has N-gain with higher level, moderate and low which were CTS 2, 3, 1, 5 and 4, respectively. It can be seen that the overall improvement of CTS N-gain of student in class of experiment is greater than class of control. The improvement was clearly observed when students were seriously to follow the class, and they tried to be more active and independent. In addition, the learning trained the students to activate their critical thinking using basic knowledge and analyze the argumentations, presenting their perception to develop cohesive and logic analysis. Hence, they were able to find the relevant hydrolysis concept, and able to answer questions with reason during they took the posttest. This result is in line with the research which explained that students are able to improve their critical thinking for
all problems in their life and to improve their reasoning [11]. Another research showed that learning using QR code increased motivation, communication, collaboration and critical thinking skill of students [16].

Students in class of experiment were used inquiry student worksheet with assisted QR code, so they were able to find the best answer and give the proper reason for each item test. On the steps of inquiry model implementation, third phase was presented by students who creating the initial hypothesis to the problems and teachers supervised the group which found the difficulties to solve the problems. Teachers asked students to do collaboration and doing experiment to find the data in order to solve the problems. Then, the fourth phase showed the hypothesis test that have been made by students before, where students did experiment using inquiry model with assisted QR code to fulfill the student worksheet and made discussion in a group in order to sharing information each other independently and critically. It is related to the research concerned about the effect of laboratory experiment using guided inquiry method to develop positive attitudes at chemistry laboratory and to reduce student fears [10]. Then, QR code are used to stimulate the application of online-based materials for special topic using mobile phone, and to determine student perception to the combination of smartphone and QR code for learning tools [19]. It is influenced by student skill who have known the rules to do experiment using inquiry model and follow the general steps of scientific method

3.2. Analysis of CTS Improvement

Analysis of data on normality, homogeneity and hypothesis testing of increasing CTS of students at the first CTS indicator (analyzing and evaluating the argumentation) using an inquiry model with assisted QR code can be seen in Table 2.

Table 2. The results of the normality, homogeneity and CTS Z test results of students at the first CTS indicator (analyzing and evaluating the argumentation).

| Analyzing and evaluating the argumentation | Classes | Normality$^a$ | Homogeneity$^b$ | $Z_{test}^c$ | Conclusion |
|-------------------------------------------|---------|---------------|-----------------|---------------|------------|
| N-gain                                    | Exp.    | 0.14          | 0.01            | 5.43          | Significance |
|                                           | Ctrl.   | 0.10          | 0.01            | 0.99          | Significance |

$^a$ Kolmogorov-Smirnov Test, If Sig. > 0.05 (Normal)  
$^b$ Levene Test, If Sig. > 0.05 (Homogeneity)  
$^c$ Test = If $t$ count $>$ $t$ table (there are significant differences)

Based on analysis data of CTS between two classes and hypothesis results presented in Table 2, students who studied using inquiry model with assisted QR code have higher achievement in moderate level on indicator of argumentation analysis. The result was also found in Table 2 using z-test which showed the value of $Z_{count} > Z_{table}$ (5.43 $> 0.99$). Analysis of the data showed a significant difference between the control class and the experimental class. This exhibited that students in class of experiment are more able to analyze the argumentations than student in class of control.

Critical thinking skill is strongly related to abilities of identification and analysis. Analyzing argumentation is a fundamental thinking which must belong to every student; thus, they are able to train their initial ability concerned of the topics what they will be learned. Moreover, it trains the students to find information, it helps them to develop their thinking skill [20]. It is related to guide inquiry characteristic which leads students to do investigation in order to find knowledge, motivate them to be active and reflected on learning experiences. Students learns based on their previous knowledge, and they develop the series of thinking in learning through gradual guidance and each student within social interaction with others [21]. Besides that, QR code software was used in innovative and simple education quickly and ideally to analyze the argumentation by using cellular tools [22].
Results test for normality, homogeneity and hypothesis testing increasing CTS students at the second CTS indicator (Asking and answering clarifying and challenging questions) using an inquiry model with assisted QR code can be seen in Table 3.

Table 3. The results of the normality, homogeneity and CTS Z test results of students at the second CTS indicator (asking and answering clarifying and challenging questions).

| Asking and answering clarifying and challenging questions | Classes | Normality | Homogeneity | $Z_{test}$ | Conclusion |
|----------------------------------------------------------|---------|-----------|-------------|------------|------------|
|                                                          | N-gain  |           |             |            |            |
|                                                          | Experiment | 0.32      | 0.02        | 5.18       | 0.99       | Significance |
|                                                          | Control   | 0.68      |             |            |            |              |

a Kolmogorov-Smirnov Test, If Sig. > 0.05 (Normal)
b Levene Test, If Sig. > 0.05 (Homogeneity)
c $Test = If \ t_{count} > t_{table} (there are significant differences)$

Table 4. The results of the normality, homogeneity test and CTS t student test at the third CTS indicators (determining an action).

| Determining an action | Classes | Normality | Homogeneity | $t_{test}$ | Conclusion |
|----------------------|---------|-----------|-------------|------------|------------|
|                      | N-gain  |           |             |            |            |
|                      | Experiment | 0.47      | 0.07        | 6.43       | 2.03       | Significance |
|                      | Control   | 0.83      |             |            |            |              |

a Kolmogorov-Smirnov Test, If Sig. > 0.05 (Normal)
b Levene Test, If Sig. > 0.05 (Homogeneity)
c $Test = If \ t_{count} > t_{table} (there are significant differences)$

Hypothesis testing for the third CTS indicators in Table 4 shows the value of $t_{count} > t_{table} (6.43 > 2.03)$. The result of t-test shows that there was a significant difference between class of experiment and class of control, where the students at class of experiment were easier to determine an action than students at class of control. By this indicator, students explain their majoring topics in detail and specifically and appropriate with their ability which obtained during learning [25]. This inquiry learning model must have good and productive environment where they were productively trying to find and implement the inquiry process of experiment guided by teachers [26]. Inquiry learning can also stimulate students to raise questions, get knowledge and develop it into a concept to improve students’ CTS in cognitive, psychomotor and affective [27].
Analysis of data on normality, homogeneity and hypothesis testing of increasing CTS of students at the fourth CTS indicator (making and balancing the value of decision) using an inquiry model with assisted QR code can be seen in Table 5.

**Table 5.** The results of the normality, homogeneity test and CTS t student test at the fourth CTS indicator (making and balancing the value of decision).

| Making and balancing the value of decision | Classes | Normality\textsuperscript{a} | Homogeneity\textsuperscript{b} | Conclusion |
|------------------------------------------|---------|-----------------|-----------------|-----------|
| N-gain                                   | Experiment | 0.91 | 0.97 | 2.86 | 2.03 |
|                                          | Control  | 0.92 | 0.86 | 2.03 | 2.03 |

\textsuperscript{a} Kolmogorov-Smirnov Test, If Sig. > 0.05 (Normal)

\textsuperscript{b} Levene Test, If Sig. > 0.05 (Homogeneity)

\textsuperscript{c} Test = If z count > z table (there are significant differences)

The result of t-test on Table 5 to the indicators and showed the value of t \textsubscript{count} > t \textsubscript{table} (2.86 > 2.03), its mean that students at class of experiment are more bale to considering the decision value than class of control. By this indicator, students are hoped to explain their problems, even though not all students are competent to reveal the problems, and most of students are difficult to follow the learning. Student with a good CTS are able to announce the difficulty in learning and will solve the problems.

Inquiry learning model with assisted QR code helps students to solve problems through several phases which began with problem formulation, hypothesis, investigation, and conclusion based on the result that has been proved during learning. Learning was conducted by dividing into groups heterogeneously. It aimed to create collaboration between students and others, help each group members, and they will be active in a group. So, the problems obtained in learning will be solved well, and it improved student CTS. Critical thinking is a kind of skill which has various objectives to process, analyze, and evaluate the information in order to create the solution from new ideas of problems [28]. The use of inquiry learning model with assisted QR code also polish student CTS, indicated by providing a lot of figure content in student worksheet in order to train student skill.

CTS students at fifth CTS indicator (inducting and considering the induction results) using an inquiry model with assisted QR code were also analyzed by normality, homogeneity and t-test which can be seen in Table 6.

**Table 6.** The results of the normality, homogeneity test and CTS Z student test at the fifth CTS indicator (inducting and considering the induction results).

| Inducing and considering induction results | Classes | Normality\textsuperscript{a} | Homogeneity\textsuperscript{b} | Conclusion |
|------------------------------------------|---------|-----------------|-----------------|-----------|
| N-gain                                   | Experiment | 0.19 | 0.01 | 2.90 | 0.99 |
|                                          | Control  | 0.35 | 0.00 | 2.90 | 0.99 |

\textsuperscript{a} Kolmogorov-Smirnov Test, If Sig. > 0.05 (Normal)

\textsuperscript{b} Levene Test, If Sig. > 0.05 (Homogeneity)

\textsuperscript{c} Test = If z count > z table (there are significant differences)

The result of t-test on Table 6 to the indicators and showed the value of Z \textsubscript{count} > Z \textsubscript{table} (2.90 > 0.99). Z-test result revealed that there is a significant difference between class of experiment and class of control. Students at class of experiment are easier to make induction and considering the final induction result than student at class of control. By this indicator, students are able to formulate the hypothesis and making conclusion individually without teacher helps based on reality and facts what they have been learned and examined. This skill is only belong to students who has good CTS, thus the implementation of inquiry learning model with assisted QR code was successful to enhance student skills. Making conclusion is done by students based on facts obtained from student worksheet.
and able to gain new ideas to solve the problems. Students were trained to make decision according to topics what they have been learned in class. CTS aspects are collaboratively conducted in group to find ideas and principles as student cognitive development [28]. The teacher as an active facilitator, information provider, and be able to inform the various relationships of students’ thinking in detail, thus bringing out the student’s CTS in concluding a concept [29].

4. Conclusions
Based on the research results, it can be concluded that CTS students can be improved by applying the inquiry model with assisted QR code. The average N-gain experimental class 73.57% while the N-gain control class is 42.37%.

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