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Research-Oriented Collaborative Inquiry Learning (REORCILEA) Model: Improvement of Students' Critical Thinking Ability and Collaborative Skills in Thermochemistry of Materials

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Abstract: This quantitative quasi-experimental study with a posttest-only control group design aimed to analyze differences in critical thinking ability and collaborative skills between students using a research-oriented collaborative inquiry learning model and those using a scientific approach in thermochemistry materials. Conducted with four classes XI MIA students in Pekanbaru, divided into experimental and control groups, the study used essay tests and observation sheets as instruments, with data analyzed via MANOVA. The research findings indicate that: (1) there are differences in critical thinking ability and collaborative skills between students using the research-oriented collaborative inquiry learning model and students using the scientific approach in thermodynamics material; (2) there is a difference in critical thinking ability between students who followed the research-oriented collaborative inquiry learning model and students who followed the scientific approach in thermodynamics material; (3) there is a difference in collaborative skills between students who followed the research-oriented collaborative inquiry learning model and students who followed the scientific approach in thermochemistry material.

Keywords: Critical Thinking Ability; Collaborative Skills; Research-Oriented Collaborative Inquiry Learning Model; Scientific Approach; Thermochemistry

Introduction

The 21st century is known as the knowledge age, where all alternative efforts to meet life's needs in various contexts are based on the principles of knowledge (Mukhadis, 2013). However, due to changes in technology, society, and culture, the education system is undergoing transformations to meet current and future needs (Kuloğlu & Karabekmez, 2022). This has led educational institutions to be required to ensure that students possess learning skills, literacy skills, and life skills (van Laar, van Deursen, van Dijk, & de Haan, 2020).

The shift in the education system in the 21st century has significantly impacted the learning process, particularly in the field of chemistry education. Boholano (Boholano, 2017) explains that the curriculum must be designed in such a way as to create a collaborative environment that actively centers on students, enhancing cognitive, affective, and psychomotor dimensions. This aims to produce graduates who not only master knowledge but also possess soft skills and are able to combine both (Knox &

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Stone, 2019). With the hope that students will become productive graduates capable of competing in universities and the global community (Coleman, Baker, & Stephenson, 2019).

Chemistry is a science that studies phenomena, such as interactions between atoms, molecules or ions that cannot be directly observed by the human senses with various levels of conceptual representation, including macroscopic, sub-microscopic and symbolic concepts (Gkitzia, Salta, & Tzougraki, 2020). Representation of concepts such as chemical phenomena that can be touched, smelled, and seen, (macroscopic level) requires knowledge of molecular structure and interactions between atoms, molecules, and ions (submicroscopic level) (Taber, 2013). Due to the need to describe, explain, communicate and visualize chemical phenomena, chemists create special symbol systems such as element symbols, chemical formulas, chemical equations, molecular models, and graphical representations (symbolic level) (Nyachwaya & Wood, 2014). As a result, studying chemistry requires a high level of conceptual understanding and abstraction skills, so many students have difficulty learning chemistry (Falconer, 2013).

Magwilang (Magwilang, 2016) stated that the difficulties experienced by students in learning chemistry are generally due to the delivery of chemical material that is less relevant to everyday life coupled with complex chemical content. This makes students feel less interested and passive in learning activities. Veiga, Luzardo, Irving, Rodríguez-Ayán, & Torres (2019) reports that many students enter higher education with inadequate initial knowledge and laboratory skills. Thus, chemistry learning needs to be designed to develop student competencies which include general skills, specific skills and integrated knowledge management. Students must not only follow practical techniques, but students must be encouraged to actively participate in the learning process to build knowledge and develop skills effectively.

Educators have a responsibility to find effective teaching methods to transfer skills and support student success (Irwanto, 2023). This cannot be separated from the ultimate goal of the learning program which is to evaluate and improve learning outcomes (Belsito, 2016). However, the reality that occurs in the field is that most learning activities use teacher-centered learning and rely on conventional methods (Sumardi, Rohman, & Wahyudiati, 2020). This condition is still reflected in the dominance of educators in learning and the lack of stimulating students to be motivated towards active learning (Dina & Nugraheni, 2017). As a result, it can result in low hard skills and soft skills of students, which has implications for the profile of graduates and the needs of higher education levels and the general public.

Based on previous research, research oriented collaborative inquiry learning can create a conducive learning environment for students and encourage discussions, questions and answers, sharing information from various sources, and drawing conclusions. In this way, it is hoped that the research-oriented collaborative inquiry learning model can improve students' critical thinking and collaboration skills in the future.

Method

This research was carried out by applying a quantitative approach using the quasi experiment method. Meanwhile, the type of research design is posttest-only control group. In this study four classes were used, two classes each as an experimental group and a control group. The sample in this research came from MAN 2 Pekanbaru City, totaling four classes, with details of two control classes and two experimental classes. The sampling technique was carried out by random sampling (Cohen, Manion, & Morrison, 2018) through random number drawing from 7 classes of XI MIA MAN 2 Pekanbaru City. The research sample involved students consisting of 4 classes of XI MIA MAN 2 Pekanbaru City, namely students of classes XI MIA 2 and XI MIA 9 as the experimental class and students of classes XI MIA 1 and XI MIA 6 as the control class.

The techniques used to collect data in this research are test and observation techniques. The data analysis technique in this research was carried out using inferential statistics and descriptive statistics. The research data analysis technique used in this research is multivariate analysis using the MANOVA (Multivariate Analysis of Variance) technique using a significance level of 0.05. The following will explain several data analysis techniques used in this research.

Multivariate significance tests were conducted to evaluate the first hypothesis, which examines whether there is a significant difference in critical thinking abilities and collaboration skills between students engaged in the research-oriented collaborative inquiry learning model and those using a scientific approach to thermochemical material.

The univariate significance test was employed to assess the differences in each dependent variable, specifically critical thinking ability and collaboration skills, between students participating in the research-oriented collaborative inquiry learning model and those using a scientific approach to thermochemical material. This test was performed using the test of between-subject effects.

The effect size in MANOVA was determined by examining the partial eta squared value found in the MANOVA test results within the test of between-

subjects table, using SPSS 25. The partial eta squared value ranges from 0 to 1, indicating the percentage of the effect of group differences on the dependent variable.

Table 1. Partial Eta Squared Interpretation

Partial Eta Squared Value (η^2)	Interpretation
$0.01 > X \geq 0.06$	Little Influence
$0.06 > X \geq 0.14$	Medium Influence
> 0.14	Big Influence

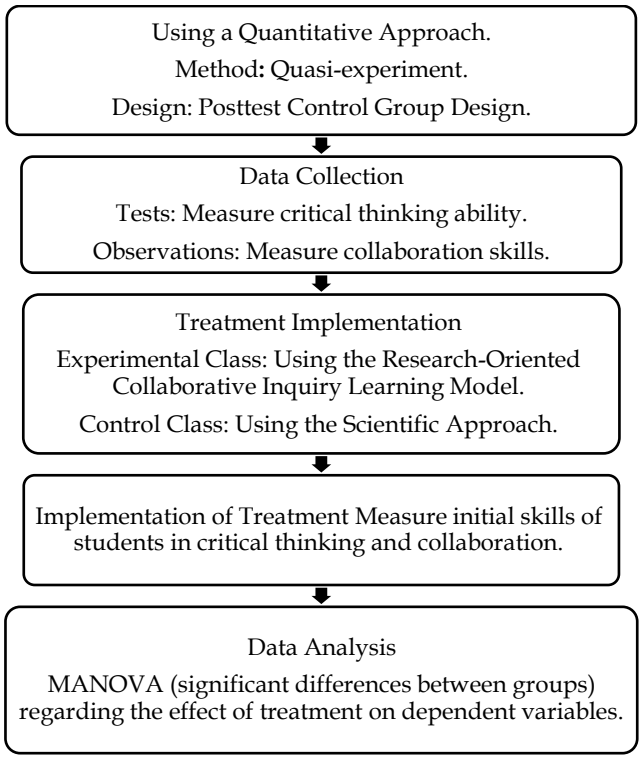

Figure 1. Research flow

Result and Discussion

The Differences in Critical Thinking Abilities and Collaboration Skills Between Two Groups

In this study, to see whether there are differences in critical thinking abilities and collaboration skills between students who take part in learning using the research-oriented collaborative inquiry learning model and students who take part in learning using a scientific approach simultaneously on thermochemical material.

Table 2. Manova Test Results

Test Analysis	F Price	Sig.	Partial Eta Squared
Hotelling's Trace	111.494	0.000	0.644

Table 2 describes that the significance value obtained from the Hottelling's Trace test analysis is 0.000, which is smaller than 0.05, so $H0_{is}$ rejected. Students' perceptions about chemistry subjects being too abstract and difficult then gradually changed with students' increasing cognition of concepts and students' attitudes becoming more interested, happy, interested and motivated to develop their positive attitudes towards chemistry (Magwilang, 2016). Ozkanbas and Kirik (2020) stated that learning with collaborative inquiry supports students to connect macroscopic and symbolic level understanding with submicroscopic representations through active participation in collaborative discourse, which provides opportunities for students to engage in the construction stage with scientific explanations. The research-oriented collaborative inquiry learning model is a constructivist learning model that places students as learning subjects.

The Differences in Critical Thinking Abilities Between Two Groups

In this study, was carried out to determine whether or not there were differences in critical thinking abilities between the experimental class which implemented *research-oriented collaborative inquiry learning* and the control class which used scientific approach learning on thermochemical material.

Table 3. Results of Test of Between Subject Effect Critical Thinking Ability

Dependent Variable	F Price	Sig.	*Partial Eta Squared*
Critical Thinking Ability	143.707	0.000	0.537

The results of the Test of Between Subject Effect show that the significance value for critical thinking ability of 0.000 is smaller than 0.05, so $H0_{is}$ rejected. The results of the analysis show that the indicators mastered by students are breadth indicators, namely expressing reasons or arguments related to phenomena from various points of view. Cigdemoglu, Arslan, & Cam (2017) stated that argumentation contributes to critical thinking ability. Chemistry learning based on research-oriented collaborative inquiry learning makes lesson content more relevant to students' lives because it connects daily life activities with chemical concepts (Magwilang, 2016) therefore students will more easily solve questions involving problems in everyday life. their day. The application of research-oriented collaborative inquiry learning based learning is the right way to integrate basic chemistry concepts as an illustration needed to transfer knowledge. This proves that students' knowledge of thermochemical material can provide meaningful learning and benefits in students' daily lives.

Critical Thinking Abilities Profiles in The REORCILEA Study Group

The description of critical thinking ability and collaboration skills scores aims to support the findings

in this research. Data were obtained from two classes, namely the experiment class with the implementation of the REORCILEA learning model and the control class with the implementation of the scientific approach to learning. The data obtained consisted of post-test scores of critical thinking abilities and the average scores of collaboration skills over four learning sessions. The description of the average scores of students' critical thinking abilities and collaboration skills can be seen in Table 4.

Table 4. Categorization of students' Critical Thinking Abilities

Aspects of Critical Thinking Abilities	Experiment Class	Control Class
Very Good	13%	0%
Good	87%	28.6%
Fair	0%	57.1%
Low	0%	14.3%
Very Low	0%	0%

Based on Table 4, it is evident that the average scores of critical thinking abilities and collaboration skills in the class implementing the Research-Oriented Collaborative Inquiry Learning Model (REORCILEA) are higher than those in the control class implementing the scientific approach. This finding is consistent with previous studies, such as Smith, Johnson, & Lee (2020), which demonstrated that collaborative learning models significantly enhance students' critical thinking and collaboration skills compared to traditional instructional methods.

The Differences in Collaboration Skills Between Two Groups

In this study, was carried out to see whether or not there were differences in collaboration skills between students who were taught using the research-oriented collaborative inquiry learning model and a scientific approach to thermochemical material. This hypothesis test can be seen from the results of the between subject effect test.

Table 5. Results of Test of Between Subject Effect Collaboration Skills

Dependent Variable	F Price	Sig.	*Partial Eta Squared*
Collaboration Skills	145.097	0.000	0.539

The results of the Test of Between Subject Effect for the collaboration skills variable obtained a significance value of 0.000 which is smaller than 0.05, so H0 was rejected. Yusuf (2014) revealed that when students work in groups, they tend to foster a collaborative attitude, support each other, and take responsibility for their learning processes and outcomes. In addition, they also apply social skills relevant to group dynamics and critically assess the collective progress of learners.

Collaboration Skills Profiles in The REORCILEA Study Group

The achievement of collaboration skills in the experiment class using the REORCILEA learning model and the control class using the scientific approach to learning can be compared by analyzing collaboration skills descriptively using ideal assessment categories. The data used are the averages from the observation sheet scores over four sessions. The results of the analysis of collaboration skills achievement can be seen in Table 6.

Table 6. Categorization of students' Collaboration Skills

Aspects of Collaboration Skills	Experiment Class	Control Class
Very Good	56%	0%
Good	44%	73%
Fair	0%	27%
Poor	0%	0%
Very Poor	0%	0%

Based on Table 7, it can be seen that there are differences in the achievement of collaboration skills between the experimental class and the control class. Students in the "very good" category were predominantly from the experimental class. Meanwhile, the highest percentages in the "good" and "fair" categories were predominantly from the control class. This aligns with findings from previous research by Johnson and Johnson (2019), which indicated that collaborative learning models significantly improve student engagement and collaborative skills compared to traditional teaching methods.

Conclusion

There are significant differences in critical thinking abilities and collaboration skills between students who take part in research-oriented collaborative inquiry learning models and students who take scientific approach learning in thermochemical material. The research-oriented collaborative inquiry learning model has proven to be more effective in improving these two abilities compared to the scientific approach. The effective contribution of applying this model to critical thinking abilities and collaboration skills is 0.644, which is included in the category of having a large influence. In particular, the effect on critical thinking ability is 0.537, and on collaboration skills is 0.539, both of which are also included in the category of having a large influence.

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