



Ethical Aspects of Implementing Experimental Research Design in Science Education

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Abstract

Science education aims to convey science to students so that science can be transmitted according to its nature. Various scientific studies have been conducted to develop better teaching strategies. The research was conducted with the principle of the scientific method, experimental research design. In principle, it aims to test a treatment of research objects. In educational research, the tested treatment or learning model will be applied to the experimental group while the control group will not receive the additional treatment. Methodologically, the design is certainly in accordance with the purpose of the hypothesis. However, this will certainly be contradictory to ethical issues if the involved research objects are humans. The principle of fairness needs to be considered between the experimental group and the control group. It is guaranteed that all participants receive the same benefits. Therefore, it is necessary to study the ethical aspects of experimental research design in science education

Keywords: *information technology, christian religious education, learning.*

INTRODUCTION

Science is a science that is based on the scientific thinking process. The laws, concepts, and theories contained are representations of scientific discoveries made by scientists. The scientific method is the main instrument in obtaining this knowledge. This step ensures that science is a science that explains nature according to its actual state. Science is a science that relies on objectivity, not subjectivity. Scientists must be honest and objective (Firman, 2019). Therefore, the transmission of scientific knowledge must be conveyed according to its substance and not deviate.

From a contextual perspective, the deviation that occurs can be considered as a gap between science and society. The goals to be achieved in the context of science become less than ideal when entering the area of social context. The social context is responsible for the success of achieving the context of science. In this case, the social context should be a support system for the context of science. According to Gascoigne et al. (2020), Toomey (2016), and Vincent, (2001), gaps can occur because: (1) the context of science is not in line with the dynamics that occur in the social context and (2) the social context is not in an ideal position as a support system for the context of science. The interaction between the context of science and the social context should be synergistic. In this case, communication is needed that bridges the context of science and the social context. Ideal science communication is expected to reduce the gap that occurs between the context of science and the social context. The hope that the goal of science as a tool to improve human welfare will be increasingly achieved if science communication can be carried out properly.

One of the means of science communication is the field of education. In the field of education, science broadly covers three groups of sciences, namely physics, chemistry,



and biology. As we know, one of the important components in science education is teaching science according to its essence. Learning strategies applied in schools are expected to be able to convey physics, chemistry, and biology to students according to their substance. Learning activities should be able to help students understand science optimally. Macroscopic, microscopic, and abstract representations that require comprehensive understanding in students are challenges in developing science learning strategies (Jansoon et al., 2009). Various studies have been conducted to explore the best learning strategies. One of the methods used is experimental research design.

Pring (2015) explains that the discovery of learning strategies is part of science that is valuable for progress in the field of education. However, the process of discovering a science should consider the potential benefits and losses that will be felt, especially for the participants involved. There are ethics that should be considered so as not to deviate from the purpose of knowledge, namely human welfare. Ethical rules need to be considered in determining research procedures to avoid negative impacts on students. Ethics direct that knowledge must be universal, communal, without interests, and skeptical. Universal nature demands knowledge free from race, color, citizenship, and religion. Communal refers to the obligation of a researcher to publish the results of the findings. In addition, research results should also not be influenced by interests. Research results must be free from external influences. The results of science must be a representation of validity in actual conditions.



Figure 1. Illustration of Experimental Research Design in Education

Based on the description above, the author conducted a study from a philosophical perspective on ethical issues in experimental research design applied in the field of science education. Is it fair if the control group gets different learning outcomes from the experimental group? Is it ethical if the two groups get different treatments? What happens to participants who enter the research group with lower learning outcomes? Are participants who enter a research group willing without coercion? Do all participants involved get the same benefits? These questions are interesting for us to study together as represented in Figure 1. The author feels the need to conduct a study on ethical issues in experimental research methods so that it is expected to be a consideration for further researchers if they want to conduct similar research. As stated by Cresswell and Cresswell (2018) that all participants involved in a study must get the same benefits without exception



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METHOD

The method used is a literature review on ethical issues in the application of experimental research design in science education. This article presents the argumentative side of ethical aspects that need to be considered in designing a research with an experimental research design based on related literature.

The research materials used include journals, books, and other literature sources that are relevant to the topic of this research. The basis of the research focuses on literature that discusses ethics in experimental research design, especially in the context of science education.

RESULT AND DISCUSSION

The main principle of experimental research design is the experimental group and the control group. The experimental group is treated as an object that is inserted with factors whose influence is to be known (independent variables) on the measured factors (dependent variables). The control group is generally given conventional treatment or does not receive additional treatment. The experimental research design is designed with the aim of empirically testing the effect of independent variables on dependent variables (Cressweell and Gueterrman, 2019). At the end of the study, the post-test results from the experimental and control groups were compared to determine the effect of the independent variables. The types of several experimental research designs can be seen in Table 1 (Cresswell and Cresswell, 2018).

Table 1. Experimental Research Model

Type	Participant	Sample Selection	Pretest	Treatment	Posts
<i>TRUE EXPERIMENTAL</i>					
<i>Pre-and Posttest</i>	Control Group	Random	√	Control	√
	Experimental Group	Random	√	Experiment	√
<i>Posttest-Only</i>	Control Group	Random	X	Control	√
	Experimental Group	Random	X	Experiment	√
<i>QUASI-EXPERIMENTAL</i>					
<i>Pre-and Posttest</i>	Control Group	Not Random	√	Control	√
	Experimental Group	Not Random	√	Experiment	√
<i>Posttest-Only</i>	Control Group	Not Random	X	Control	√
	Experimental Group	Not Random	X	Experiment	√
<i>CAUSAL-COMPARATIVE</i>					

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Intelektium adalah jurnal yang diterbitkan oleh Neolectura, diterbitkan dua kali dalam satu tahun. Intelektium adalah media publikasi ilmiah dalam bentuk makalah konseptual dan penelitian lapangan yang terkait dengan bidang pendidikan. Diharapkan Intelektium dapat menjadi media bagi akademisi dan peneliti untuk menerbitkan karya ilmiah mereka dan menjadi sumber referensi untuk pengembangan ilmu pengetahuan.

Pre-and Posttest	Group A	Not Random	√	Variable Group (without intervention)	√
	Group B	Not Random	√	Variable Group (with intervention)	√
Posttest-Only	Group A	Not Random	X	Variable Group (without intervention)	√
	Group B	Not Random	X	Variable Group (with intervention)	√

Experimental research design is a procedure or stage of quantitative research that is widely applied in science and social-humanities including in education. This design seeks to identify more deeply the causal relationship between independent variables and dependent variables. This means that this research method is chosen to determine the effect of treatment on the impact caused. In terms of design, this research is most qualified if the hypothesis implies testing of the causal relationship. The uniqueness of experimental research is the direct testing of the effect of one variable on another variable, and the testing of the causal hypothesis (Sukmadinata, 2013).

In several studies in the field of education, the most widely applied design is quasi-experimental design. This research design allows it to be applied in research involving humans as research samples. Quasi-experimental design is designed to overcome obstacles in controlling external variables that may affect the results of the study. This design can be applied in learning activities. Sample selection does not have to be done randomly so that the determination of the control group and experimental group can be adjusted to conditions in the field such as schools. Researchers can still conduct research even though the selected sample is difficult to determine randomly. This certainly makes it easier for researchers in school conditions that have sample characteristics that have been grouped into learning classes. Table 2 is a summary of several studies in the field of science education.

According to Pring (2015), one of the ethical things that should be considered in compiling educational research procedures is the method of data collection. Research procedures compiled by researchers should provide equal benefits to all participants. It is highly avoided if the research procedure has the potential to cause injustice, especially between the experimental group and the control group. Different treatments for the two groups and the follow-up that will be carried out by researchers need to be prepared. This is done to ensure equality of benefits that will be obtained by all participants (Cresswell and Cresswell, 2018).

Creswell and Guetterman (2019) argue that often in procedures that apply experimental research designs have the potential to sacrifice the rights of the control group. The research procedures that are designed tend to ignore treatments that are beneficial to the control group. This can unknowingly have a negative impact on participants. The control group is not accommodated to benefit from the treatment innovations provided by the researcher. Another thing that can happen is the opposite. In fact, the experimental group may be the victim because it gets no better influence than the control group. Hypothetically, a research design that is designed with different treatments will have different impacts. One research group will get no better treatment than the other research group. Therefore, further treatment after the research results are obtained is to provide



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treatment to the group that gets lower benefits.

Groups that get lower learning outcomes need to be given the same treatment as groups that get higher learning outcomes. Groups that do not get treatment with positive influences should also be accommodated to get the same thing. All participants have the right to get the same benefits at the end of the research, especially in science education. Researchers need to consider the principle of justice and not only focus on the objectives of the research. Researchers should also pay attention to the impact of science learning strategies applied to participants, especially in research groups with low learning outcomes. Recommendations that can be made to minimize the gap between the experimental group and the control group can be seen in Figure 2.

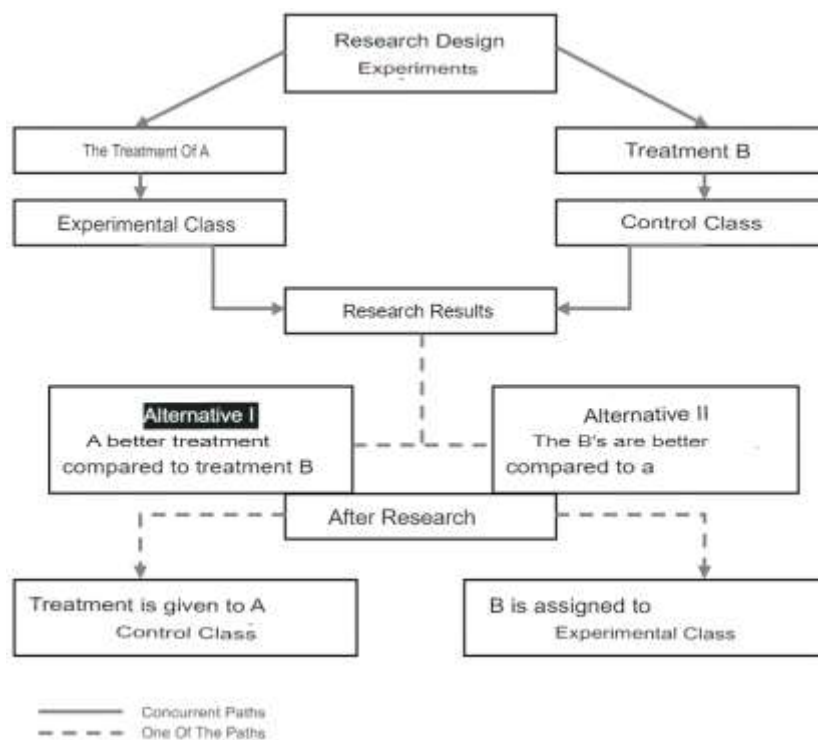


Figure 2. Follow-up Recommendations

Cresswell and Guetterman (2019) provide suggestions for addressing ethical issues that may arise from experimental research designs. So that all participants get the same benefits without reducing the essence of the research objectives, namely: (1) designing the same treatment for the control class when the research conclusions have been obtained and (2) providing treatment that has been proven to have a positive impact on research groups that have not received it. In more detail, Table 2 describes the ethical issues in the data collection process and what needs to be included in the research procedure (Cresswell and Creswell, 2018).

Table 2. Ethical Issues of Experimental Research Procedures

Ethical Issues	Things to Include in Research Procedures
As much as possible, do not cause	Establish communication and build trust at the research site.

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any disturbance to the research location.	Communicate the steps that will be taken to reduce potential disruptions during the data collection process.
Ensuring that all participants receive equal benefits.	Create details regarding the steps to be taken for the control group.
Be open about research procedures to participants.	Discuss the purpose of the research and how the data will be used.
Taking into account the proportions regarding the demands of participant involvement.	Positioning participants as partners and avoiding sensitive and overly personal questions if they are not related to the research objectives.
Don't just view participants as research objects.	Providing awards and appreciation to participants for being willing to be involved and assist in the research process.
Avoid collecting data outside the agreed context.	The data collection process does not deviate from the agreed context. There is no improvisation on the questions to be asked.

CONCLUSION

The design of experimental research in science education must prioritize the principle of justice, where all participants, both from the experimental and control groups, receive equal benefits. Researchers need to ensure that groups that do not receive treatment or whose learning outcomes are lower are given follow-up to improve their results. This step is the moral responsibility of researchers in ensuring that all participants benefit from the research.

This follow-up can be in the form of additional interventions for groups that are less advantaged in the study. This aims to ensure that all participants ultimately gain the same benefits from the learning strategies being tested. Thus, the study does not only pursue the results of the hypothesis, but also ensures that there is a balance of benefits for all parties involved.

Suggestions for further research are to expand the research variables by considering other factors such as socio-economic background, teacher support, and learning environment. In addition, the use of mixed methods can provide a more comprehensive view of learning effectiveness, so that research results are more useful and sustainable in the world of education.

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DOI PUBLIKASI

<https://doi.org/10.37010/int.v5i2>

SEPTEMBER

Vol. 5 No. 2

2024

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