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The Effect of Verification Experimental Methods on Science Process Skills and Chemistry Learning Achievement

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Abstract: Learning by using the verification experimental methods could improve students' cognitive abilities and science process skills. However, there are inconsistent results when applying this method of science process skills and learning achievement. This study was conducted to describe and explain: the simultaneous differences in science process skills and learning achievement between students taught by verification experimental and conventional methods; the differences in student science process skills taught by verification experimental and conventional methods; and the differences in the students' learning achievement taught by the verification experimental and conventional learning methods. This study was a quasi-experiment with a pretest-posttest design. The data analysis was conducted using descriptive analysis techniques and multivariate analysis (MANCOVA). The results of the study showed there are simultaneous differences in science process skills and students' learning achievement with an r square price of 0.743, or 74.3%; there are differences in the science process skills of students who studied using the verification experimental methods; and there are differences in students' learning achievement; the experimental class was is higher than the control class. The other inconsistent results of the study on this method were caused by the different characteristics and cognitive levels of students.

Keywords: Conventional learning methods; Learning achievement; Science process skills; Verification experimental methods

Introduction

The success and improvement of education quality are determinants of a nation's degree. Excellent quality of human resources are created through good education quality. Education in Indonesia is currently implementing the 2013 Curriculum. This curriculum focuses on improving and balancing attitudes, skills, and knowledge competencies (Andrian & Rusman, 2019; Kholik, 2019; Lubis, 2022; Redhana, 2019). In order to realize this, educators have an important role in creating an effective and meaningful learning system for students. However, the problem that occurs is that teachers still characterize conventional learning (Andrian & Rusman, 2019; Istyowati et al., 2017; Novika et al., 2020; Rosyad et al., 2021; Wahyuni & Taufik, 2016).

Science learning has an important role in preparing the quality of human resources. The science includes four elements, namely products, processes, applications, and attitudes (Wahyuningsih et al., 2019). All these elements form is a whole unified. The chemistry learning process, especially in high school, tends to be teacher-centered and less related to daily life (Anna et al., 2012). The characteristics of chemistry learning according to the 2013 Curriculum are not only limited to theoretical understanding related to facts, concepts, and theories but also a process of discovering and proving a concept through experimentation (Damayanti et al., 2019; Subagia & Wiratma, 2015; Subagia et al., 2019; Widayanti et al., 2019). Some researchers said that the problem is that teachers still apply expository methods or lectures throughout the chemistry learning process (Anna et al., 2012; Damayanti

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et al., 2019; Fatma & Utami, 2018; Lestari et al., 2014; Muna, 2018; Parmithi et al., 2018; Subagia & Wiratma, 2015; Subagia et al., 2019; Widayanti et al., 2019).

One of the factors that influences the achievement of learning objectives is the selection of learning methods used by teachers (Lestari et al., 2014). The learning method is a process that is easy to know, apply, and theorize, which helps students to achieve the learning outcomes (Lee et al., 2015). One of the methods that can be used is the verification experimental method. The main activity is trying-out the experiments to prove theories, concepts, principles, and laws that have been studied previously. After obtaining the experimental data, students will be required to carry out a data analysis, discuss findings, practicum results, and conclusions, and report their findings orally and in writing (Subagia et al., 2019). The steps of the verification experimental method includes opening, discussing material descriptions, discovering concepts through practice questions, proving concepts through the verification experimental method, applying concepts through work on applicative questions, and closing.

The use of the verification experimental method proves effective in increasing student activity compared with the inquiry experimental method (Lestari et al., 2014). The use of this method is effective in increasing students' cognitive, affective, and psychomotor abilities through a real orientation towards abstract chemistry learning, so that it succeeds in increasing students' learning achievement (Lestari et al., 2014; Yennita et al., 2012). The application of the verification experimental method involves skills, one of that is science process skills. This skill trains students to have the reasoning skills, thinking, and acting logically to build their science concepts (Akmal & Nargis, 2023; Astra & Wahidah, 2017; Fitriyani, 2017; Guritno et al., 2016; Juraini et al., 2017; Lepiyanto, 2017; Masus & Fadhilaturrahmi, 2020; Minasari et al., 2020; Putri et al., 2022; Royani & Imran, 2020; Subekti & Ariswan, 2016; Sumarti et al., 2018; Varadela et al., 2017; Wahyuningsih et al., 2019; Winarti, 2015). Science process skills are needed to develop and apply abstract chemical concepts (Saribas & Bayram, 2009). According to Karamustafaoğlu (2011) science process skills are special skills that can facilitate the learning process, activate students, develop students' sense of responsibility in the learning process, increase immortality, and teach research methods. The use of the verification experimental method helps in improving and training science process skills through the application of the scientific method to learn chemistry, which is in increasing in students' science process skills.

Refers to the success factor in learning, the application of innovative methods namely the verification experimental method, should be able to create a conducive and enjoyable learning atmosphere that leads to the achievement of learning objectives. However, several studies have found results that are inconsistent with some of the statements and facts above. Fatmawati (2010) found that there was a significantly higher increase in students' mastery of concepts taught by inquiry-based experimental methods compared to students taught by the verification experimental method. The results of Larashati's research (2010) were in contrast to Fatmawati's findings: students' cognitive learning outcomes with the verification experimental method are better than those of students taught using the inquiry experiment.

The inconsistency toward the findings may caused by the students' characteristic in every school and the different student learning conditions. Based on theoretical presentations and empirical study of verification learning methods, researchers are trying to investigate more deeply the effect of verification experimental methods by involving the variables of science process skills and high school chemistry achievement. The researchers hopes that this research can provide empirical justification regarding the influence of the verification experimental method so that it becomes material of study for other researchers, references, and sources of information for teachers and schools in choosing effective learning methods for improving science process skills and learning achievement.

Method

This research is a quasi-experimental research. The research design that used was the pretest-posttest design (the matching pretest-posttest design). This research design was choosed because, the quasi-experimental research is not possible to change existing classes. The subjects were taken by paring samples technique (matching) to the subject in control groups and experimental groups. Furthermore, a pretest and posttest were given after treatment in the both of study classes. The experimental class was taught using the verification experimental method and the control class was taught using conventional learning methods.

The population of this study was all 134 students of class XI at SMA Negeri 1 Kintamani, divided into four classes. The selection of samples as experimental and control classes used a matching group technique (Fraenkel, *et al.*, 1993). According to the design, it means that members in each class are matched but not randomly assigned to the class. Prior to sampling, a class equivalence test was carried out first using the existing class XI average; this was done to ensure that the existing classes were academically equivalent.

Results and Discussion

General Description of Studys' Results

The results of the students' learning achievemnent and science process skills tests obtained in this study were used as a basis for grouping students who had an increase in the dependent variable. Recapitulation of the results of initial learning avhievement (pretest) and the results of final learning achievement (posttest) are presented in Table 1.

Table 1. Results of Initial and Final Learning Achievement

Analysis results	Verification Experimental Methods		Conventional Learning Methods	
	pretest	posttest	pretest	posttest
Average	47.59	77.97	45.84	65.66
Standard deviation	1.29	9.93	1.21	1.04

The results of descriptive data analysis show that there was a significant increase in students who were taught using the verification experimental method, with a pretest score of 47.59 and a posttest score of 77.97. Students who were taught using conventional methods obtained a pretest score of 45.84 and a posttest score of 65.66.

Data from observations of students' science process skills are presented in recapitulation form in Table 2.

Table 2. Observation Results of Science Process Skills

Analysis results	Observation of Science Process Skills	
	Experiment Class	Control Class
Average	88.94	78.60
Standard deviation	4.77	5.39

The results of the descriptive data analysis show that the science process skills of students who were taught using the verification experimental method in the experimental class were higher than the science process skills in the control class with conventional learning methods.

Data Description of Student Learning Achievement Based on Learning Methods

The frequency distribution of students' learning outcomes in the verification experimental method is presented in Table 3. Based on Table 3 it shows the results of students taught using conventional methods: in the very low category, there were as many as 14 students (20.28%); in the low category, there were as many as 33 students (47.83%); in the moderate category, there were as many as 19 students (27.54%); in the high category, there were as many as 3 students (4.35%); and there were no students in the very high scores category. While the students' learning outcomes after being taught using the verification experimental method shows that 16 students (23.19%) were in the very high category, 36 students (52.17%) were in the high category, 17 students were in the moderate category (24.64%), and in the low and very low categories there were none or 0.00% students. These results show a significant increase from the treatment given.

Table 3. Distribution of Frequency of Learning Achievement in the Verification Experimental Method

Score Intervals	Category	Preliminary Test		Final Test	
		fo	Percentage (%)	fo	Percentage (%)
85–100	Very high	0	0.0	16	2.,19
70–84	Tall	3	4.35	36	52.17
55 – 69	Enough	19	27.54	17	24.64
40–54	Low	33	47.83	0	0.00
0 - 39	Very low	14	20.28	0	0.00
Amount		69	100	69	100

The frequency distribution of students' learning outcomes in conventional learning methods is presented in Table 4.

Table 4. Frequency Distribution of Student Learning Avhievement in Conventional Learning Methods

Score Intervals	Category	Preliminary Test		Final Test	
		fo	Percentage (%)	fo	Percentage (%)
85 – 100	Very high	0	0.00	0	0.00
70–84	Tall	0	0.00	22	33.85
55 – 69	Enough	18	27.69	32	4.,23
40–54	Low	33	50.77	11	16.92
0 - 39	Very low	14	21.54	0	0.00
Amount		65	100	65	100

Based on Table 4, it shows that there was no significant increase in students' learning outcomes taught using conventional learning methods used at schools. The initial students' learning outcomes material in the control class with conventional learning methods in the very low category was achieved by 14 students (21.54%); there were 33 students (50.77%) in the low category; there were 18 students (27.69%) in the sufficient category; and there were no students in the high or very high category. Furthermore, there were no students in the very low category of students' learning avhievement of the final material in the control group; there were as many as 11 students (16.92%) in the low category, 32 students (49.32%) in the sufficient category, 22 students in the high category (33.85%), and there were no students in the very high category. However, there was an increase in the initial and final students' learning achievement scores in the control class.

Description of Science Process Skills Data Based on Learning Methods

The frequency distribution and the percentage of students' science process skill scores in the evidentiary experimental method is presented in Table 5.

Table 5. Distribution of Frequency and Percentage of KPS Values in the verification Experimental Method

Score Intervals	Category	KPS Experiment Class	
		fo	Percentage (%)
85–100	Very high	56	81.16
70–84	Tall	13	18.84
55–69	Enough	0	0.00
40–54	Low	0	0.00
0-39	Very low	0	0.00
Amount		69	100

Based on Table 5 above, it shows that the science process skills of students taught by the verification experimental method had the highest frequency and percentage. In the very high category, there were 56 students with a percentage of 81.16%. There were 13 students in the high category with a percentage of 18.84%, and there were no students with sufficient, low, or very low percentages.

The distribution of frequency and percentage of KPS scores in conventional learning methods are presented in Table 6.

Table 6. The Distribution of Frequency and Percentage of KPS Scores in Conventional Learning Methods

Score Intervals	Category	Control Class KPS	
		fo	Percentage (%)
85–100	Very high	13	20.00
70–84	Tall	49	75.38
55–69	Enough	3	4.26
40–54	Low	0	0.00
0 - 39	Very low	0	0.00
	Amount	65	100

Based on Table 6, it can be seen that the science process skills of students taught using the proving experimental method have the highest distribution of frequencies and percentages in the very high category.

Results of Assumption Test and Hypothesis Testing

The data analysis technique used to test the hypothesis in this study is Multivariate Analysis of Covariance (MANCOVA). Prior to statistical testing with MANCOVA, an assumption or prerequisite test is carried out, which consists of (1) data distribution normality test, (2) variance homogeneity test, (3) variance matrix homogeneity test, (4) correlation test between dependent variables, (5) linearity test, and (6) homogeneity of regression line slope test. Following are the results of the assumption test in this study.

a) Data Distribution Normality Test

Based on Table 7, the sig values for the pretest, posttest, and KPS in each group are greater than 0.05, so that the data is said to be normally distributed.

Table 7. Data Normality Test Results

	Class	Kolmogorov-Smirnov[a]	
		df	Sig.
KPS	Experiment	69	0.200
	Control	65	0.181
Posttest	Experiment	69	0.200
	Control	65	0.093
Pretest	Experiment	69	0.200
	Control	65	0.185

b) Variance of Homogeneity Test

Based on the data in Table 8, it shows that the sig values for the pretest, posttest, and KPS are greater than 0.05. This means that the data has a homogeneous data variance.

Table 8. Result of Variance of Homogeneity Test

Test	F	df_1	df_2	Sig.
Pretest	0.079	1	132	0.666
Posttest	0.242	1	132	0.623
KPS	0.872	1	132	0.352

c) Homogeneity Test of Variance Matrix

Based on the results of the Box's M homogeneity test in the Table 9, it is known that the value of Sig. is 0.082, which means greater than 0.05. This means that data on mastery of the material and students' KPS between classes have a homogeneous variance.

Table 9. Result of Homogeneity Test of Variance Matrix

Box's M	0.905
F	0.297
Sig.	0.828

d) Correlation Test between Dependent Variables

Based on Table 10 , the value of Sig. is 0.068 greater than the significance price of 0.05. This means that there is no relationship between the learning outcomes variable and students' Science Process Skills.

Table 10. Result of Correlation Test between Dependent Variables

		Material Mastery
KPS	Pearson Correlation	0.158
	Sig. (2-tailed)	0.068
	N	134

e) Linearity Test

Based on Table 11, the sig. Deviation from Linearity value in each model is greater than 0.05. This shows that the relationship between pretest data, posttest data, and students' Science Process Skills data in each class as a whole is linear.

Table 11. Result of Linearity Test

	Model	Sig.
Deviation from Linearity	Pretest with Posttest	0.155
	Pretest with KPS	0.528

f) Homogeneity of Regression Line Slope Test

Based on Table 12, the value of *sig*. on the pretest* method path is equal to 0.945. This significance number is greater than 0.05, which indicates that there is no interaction between the pretest and posttest values in the experimental class and the pretest and posttest values in the control class. This means that there is no interaction that makes the pretest suitable for use as a covariate variable.

Table 12. Results of Regression Line Slope Posttest

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Method	8335.841[a]	28	297.709	2.992	0.00
Intercept	401873.847	1	401873.847	4.039E3	0.00
Pretest	2664.171	14	190.298	1.912	0.03
Method	1957.904	1	1957.904	19.676	0.000
Pretest* Method	587.821	13	45.217	0.454	0.945
Error	10448.159	105	99.506		
Total	713440.000	134			
Corrected Total	18784.000	133			

Table 13. Slope Test Results for KPS Lines

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Method	4860.353[a]	28	173,584	8.742	0.000
Intercept	547275.420	1	547275.420	2.756E4	0.000
Pretest	1220.218	14	87.158	4.389	0.000
Method	2159.956	1	2159.956	108.780	0.000
Pretest* Method	66.037	13	5.080	0.256	0.996
Error	2084.901	105	19.856		
Total	950770.000	134			
Corrected Total	6945.254	133			

Based on Table 13 above, the value of sig. on the pretest* method path is equal to 0.996. The significance value is greater than 0.05, which indicates that there is no interaction between pretest scores and KPS scores in the experimental class and pretest scores and KPS scores in the control class. This means that there is no interaction that makes the pretest suitable for use as a covariate variable.

Hypothesis Test

a) *Hypothesis Test I and II*

Based on Table 14, it is known that the sig. for the posttest is 0.000. This sig value is smaller than 0.05, so H_0 is rejected, or there is a simultaneous difference between the science process skills and learning outcomes of students taught using the experimental proof method and conventional learning methods on high school chemistry material. In hypothesis II, the value of sig. for science process skills of 0.000 is smaller than 0.05. Thus, H_0 is rejected, or there are differences in science process skills between students taught using the experimental method of proof and conventional learning methods in high school chemistry material. In addition, the value of r squared for the posttest value is 0.268, indicating the magnitude of the partial effect of the experimental method of proof on the posttest. While the value of r square for the value of science process skills is 0.541, which shows the magnitude of the partial influence of the experimental method of proof on science process skills.

Table 14. Results of Hypothesis Test I and II

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	Sig.	Partial Eta Squared
Method	Posttest	4803.101	1	4803.101	0.000	0.268
	Science Process Skills	3378.382	1	3378.382	0.000	0.541

b) *Hypothesis Test III*

Based on Table 15, it is known that the *Sig*. for *Pillai's Trace, Wilks' Lambda, Hotelling's Trace*, and *Roy's Largest Root* is smaller than 0.05. Thus, H0 is rejected, or there are differences in material mastery between students taught using the experimental method of proof and conventional learning methods on high school chemistry material. In addition, the r square value is 0.743, or 74.3%, which indicates the magnitude of the simultaneous influence of the proving experimental method variable on science process skills and chemistry learning outcomes in senior high school.

Table 15. Results of Hypothesis Test III

Model	Sig	Partial Eta Squared
Pillai's Trace	0.000	0.743
Wilks' Lambda	0.000	0.743
Hotelling's Trace	0.000	0.743
Roy's Largest Root	0.000	0.743

Discussion

There are several theoretical foundations and justifications for the claim that the experimental verification method gives better results in material mastery and science process skills. The verification experimental method is a learning method that trains students to prove the truth of a concept or theory that has been studied previously (Fernandes, 2014). Students are facilitated to find concepts to be proven through experiments as well as to apply concepts through applicative questions.

Reviewed by the activities in learning using the verification experimental method, which includes the discovery of concepts through material descriptions, literature, and textbooks; proof of concepts through experimentation; and application of concepts through applicative questions. Learning with this method is a form of strengthening the theories and concepts found by students. Reinforced by Puspasari (2022), the completeness of students taught using the verification experimental method reached a percentage of 81%. Practicum could improve science process skills and students' expertise in making observations, skills in using tools, strengthening knowledge or concepts of the previously studied material, being innovative, and fostering scientific honesty in students (Fitriani et al., 2021). This indicates an increase in students' learning achievement with this method.

The data on science process skills were obtained through observing learning in the two research classes by looking at two indicators and several sub-indicators. All indicators appear in both classes, with different percentages of sub-indicators. Indicators communicating the investigation results are more dominant in the experimental class because the necessary concepts that have been thoroughly discussed in the concept discovery strengthened by experiments. In addition, several intermediate variables emerged, such as learning independence and motivation. Student learning independence in carrying out practicums provides a positive response to improving science process skills (Dedi Rasdjo et al., 2017).

The implementation of learning using the verification experimental method packs the learning process, which begins with the discovery of concepts that cause students' curiosity and criticism of learning. After that, proof of concept is carried out through practicum, which encourages independence and motivation of students in carrying out the practicum stages, and then applied through applicative questions. This implementation stage causes students to gain a complete understanding of the material being studied. Learning with the verification experimental method improves students' science process skills through a learning process that is based on scientific methods, is systematic, and critical (Astra & Wahidah, 2017; Kurniawati, 2018; Sumarni, 2011; Winarti, 2015).

Conclusion

Based on the discussions that have been described, it can be concluded several things as follows. There are simultaneous differences in science process skills between students who are taught using verification experimental and conventional learning methods in senior high school chemistry material. The learning method works simultaneously with the verification experimental method, which contributes to students' learning outcomes. There are differences in the science process skills of students taught using verification experimental methods and conventional learning methods in high school chemistry material. The students' science process skills in the experimental class were higher than the students' science process skills in the control class. There are differences in the students' learning outcomes taught using verification experimental methods and conventional learning methods in high school chemistry material. Students' learning achievement taught using verification experimental methods was superior than groups of students taught using conventional learning methods.

Author Contributions

Ni Wayan Diah Purnami Dewi M conceptualization, which includes research ideas, design with methodology, and data analysis. I Wayan Subagia and I Wayan Redhana has been carried out by reviewing investigation research, literature review, and provided feedback on the manuscript.

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Conflicts of Interest

The author declares no conflict of interest.

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