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THE CORRELATION OF GREEN CHEMISTRY AND ENVIRONMENTAL KNOWLEDGE ON STUDENTS' ENVIRONMENTAL CARE BEHAVIOR

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Abstract

Green chemistry and environmental knowledge shape individual awareness and action towards environmental sustainability. The integration of both can become the basis for attitudes and behaviors more concerned about the environment. Based on this background, the objectives of this research is to analyze the level of green chemistry and environmental knowledge of students' SMA Kristen Harapan Denpasar and its correlation to environmental care behavior. The research was conducted using a random sampling technique with a sample size of 100 students. This research's independent variables are green chemistry (X1) and environmental knowledge (X2). In contrast, the dependent variable is environmental care behavior (Y). The research instrument is a test to measure the level of green chemistry and environmental knowledge and a questionnaire to measure students' environmental care behavior. Data analysis was done using descriptive statistics and Product Moment correlation analysis, followed by a t-test and F-test using Microsoft Excel. Based on the research results, it can be concluded: the level of green chemistry and environmental knowledge of students' SMA Kristen Harapan Denpasar in a good category, and there is a correlation between green chemistry and environmental knowledge on students' environmental care behavior.

Keywords: *Green Chemistry, Environmental Knowledge, Environmental Care Behavior.*

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Introduction

The relationship between humans and the environment is significant and complex; it is reciprocal and influences each other (Seif & Nematolahi, 2019). Humans are very dependent on the environment to fulfill their living needs. However, various human activities change the environment, such as decreasing environmental quality, increasing solid waste, decreasing green areas, and even resulting in global warming (Maesaroh et al., 2021). Therefore, humans need to maintain a balanced and sustainable environment to continue supporting human life in the future (Rusdiana, 2015). Continuous and sustainable efforts are needed to overcome these problems (Fitriani & Sugiyono, 2018).

Environmental damage can influence environmentally conscious behavior in several ways (Supangkat & Herdiansyah, 2023). Witnessing or experiencing the negative impact of environmental damage can influence attitudes and behavior toward the environment (Adliyani, 2015). In this case, psychological effects such as personal experience when witnessing the negative impacts of environmental damage, such as floods, forest fires, and pollution, will result in a tendency to be more aware of the importance of protecting the environment. (Sari, 2021) . This can cause emotional responses such as sadness, anger, or worry about the environment's future. It can influence individual attitudes and actions to become more concerned about the environment.

Previous studies (Seif & Nematolahi, 2019) revealed that environmental concerns, attitudes, and knowledge significantly influence environmental care behavior. Research by (2022) reveals that students' attitudes towards green chemistry in public and private high schools are satisfactory, while the practice towards green chemistry is satisfactory. Research (Mufidah, 2017)

revealed a significant relationship between individual characteristics and students' environmental care behavior. Based on this background, I am interested in researching "The Correlation of Green Chemistry and Environmental Knowledge on Students' Environmental Care Behavior at SMA Kristen Harapan Denpasar."

The problem formulation is as follows: (1) What is the level of green chemistry knowledge of students at SMA Kristen Harapan Denpasar, and how is it correlated to environmental care behavior? (2) What is the level of environmental knowledge of students at SMA Kristen Harapan Denpasar, and how is it correlated to environmental care behavior? The aims of this research are: (1) To analyze the level of green chemistry knowledge of students at SMA Kristen Harapan Denpasar and how it correlates to environmental care behavior. (2) To analyze the level of environmental knowledge of students at SMA Kristen Harapan Denpasar and how it correlates to environmental care behavior.

The formulation of the hypothesis in this research is as follows: There is no relationship between green chemistry knowledge (X1) and environmental care behavior (Y) and there is no relationship between environmental knowledge (X2) and environmental care behavior (Y)

Based on several studies that have been conducted previously, it is found that environmental awareness, attitudes, and knowledge have a significant direct influence on environmental care behavior. Meanwhile, related to green chemistry, research was conducted among university students and it was found that the level of knowledge and practice of green chemistry was high, while the level of awareness of green chemistry was very high. Based on these findings, the position of this research is to develop from studies that have previously been conducted. Some previous studies have connected knowledge about the environment with students' environmental care behavior, but researchers have not found research related to the relationship between green chemistry knowledge and students' environmental care behavior.

The benefits of this research are: (1) this idea can be implemented so that students have environmental care behavior; (2) the integration between green chemistry and environmental knowledge can increase awareness of environmental sustainability, so as to increase environmental care behavior; (3) the application of green chemistry and environmental knowledge can arouse individual awareness to behave care for the environment so as to have a positive impact on the environment.

Research methods

This research uses a quantitative approach to analyze the level of green chemistry and the environmental knowledge of students at SMA Kristen Harapan Denpasar and analyze how it correlates to environmental care behavior. It was conducted from June to November 2023. The data collection techniques used in this research are literature study, testing, and questionnaires. Using the *random sampling technique*, the total sample was 100 people, with 50 samples of 11th grade and 50 samples of 12th grade students.

The data processing technique used is descriptive analysis with the calculation of *mean*, *median*, *mode*, and standard deviation, as well as minimum and maximum values. Hypothesis testing is carried out using the *Product Moment correlation formula* to determine the relationship between the independent variables (X 1 and X 2) and the dependent variable (Y), with the formula:

$$Ry.x1x2 = \frac{\sqrt{(ryx1)^2 + (ryx2)^2 - 2.(ryx1).(ryx2).(rx1x2)}}{1 - (rx1x2)^2}$$

Information:

Ry.x1x2	= correlation variable X 1 with X 2 to Y
ryx1	= correlation simple (product moments person) between X 1 with Y ryx2
	= simple correlation between X 2 with Y
rx1x2	= correlation simple between X 1 with X 2

Testing significance next with a t-test, using the formula:

$$t = \frac{r\sqrt{n-2}}{\sqrt{1-r^2}}$$

The withdrawal conclusion was made by comparing the t-count with the t-table.
If t-count > t-table, H_0 is rejected, H_1 is accepted, and vice versa.

Results and Discussion

Green Chemistry Knowledge

The green chemistry knowledge of 11th grade students at SMA Kristen Harapan Denpasar was determined from scores from 18 questions with 50 respondents. The level of green chemistry knowledge is classified as follows.

Table 1 Classification of Green Chemistry Knowledge Levels

No	Total score	Level of Green Chemistry Knowledge
1	1-6	Poor
2	7-12	Fair
3	13-18	Good

The following results were obtained based on the results of descriptive calculations.

Table 2 Descriptive Statistical Analysis of Green Chemistry Knowledge Level

No	Level of Green Chemistry Knowledge	Frequency	Percentage
1	Poor	0	0%
2	Fair	13	26%
3	Good	37	74%
	Total	50	100%
	Mean	14.36	
	Median	15.00	
	Mode	17.00	
	Standard Deviation	3.23	
	Minimal	8.00	
	Maximum	18.00	

The green chemistry knowledge variable of students' SMA Kristen Harapan Denpasar was mainly in grades 13-18, with as many as 37 people (74%). The remaining with grades 7-12 were 13 people (26%). These results show that green chemistry knowledge is in good category. Green chemistry knowledge refers to the 12 principles of green chemistry (Mustafa, 2016). Overall, the correct student answers were in principle 10, namely design chemicals that degrade and can be discarded easily, with 49 samples (98%) answering correctly. Meanwhile, the lowest student answers (most incorrect) were in principle 3, namely design chemical reactions and synthetic routes to be as safe as possible, with 21 samples (42%) who answered correctly or 29 samples (58%) who answered incorrectly.

Knowledge Environmental

The environmental knowledge of 11th grade students at SMA Kristen Harapan Denpasar was obtained from a score of 17 items questions with respondents totaling 50 people. The level of environmental knowledge is classified as follows.

Table 3 Classification of Environmental Knowledge Levels

No	Total score	Level of Environmental Knowledge
1	1-6	Poor
2	7-12	Fair
3	13-17	Good

The following results were obtained based on the results of descriptive calculations.

Table 4 Descriptive Statistical Analysis of Environmental Knowledge Level

No	Level of Environmental Knowledge	Frequency	Percentage
1	Poor	0	0%
2	Fair	20	40%
3	Good	30	60%
	Total	50	100%
	Mean	12.78	
	Median	13.00	
	Mode	13.00	
	Standard Deviation	1.85	
	Minimal	8.00	
	Maximum	16.00	

The environmental knowledge variable for most students is in grades 13-17, as many as 30 people (60%), and the remaining students with grades 7-12 are 20 people (40%). These results show that students' environmental knowledge is in a good category. Environmental knowledge of students at SMA Kristen Harapan Denpasar with indicators of waste management and energy utilization. Based on the waste management and energy utilization indicators, overall, the majority of students' answers were correct to the question "Efforts that can be made to reduce waste is..." with all samples (100%) answering correctly; meanwhile, the lowest student answer (most wrong) was found in the question "The biggest contributor to the earth's waste is..." with 24 samples (48%) who answered correctly or 26 samples (52%) who answered incorrectly.

Environmental Care Behavior

The environmental care behavior of students at SMA Kristen Harapan Denpasar was determined from the scores of 9 questions with 50 respondents. The level of students' environmental care behavior is classified as follows.

Table 5 Classification of Levels of Environmental Care Behavior

No	Total score	Level of Environmental Care Behavior
1	1-3	Poor
2	4-6	Fair
3	7-9	Good

The following results were obtained based on the results of descriptive calculations for 11th grade students at SMA Kristen Harapan Denpasar.

Table 6 Descriptive Statistical Analysis of the Level of Environmental Care Behavior of 11th grade students

No	Level of Environmental Care Behavior	Frequency	Percentage
1	Poor	3	6%
2	Fair	18	36%
3	Good	29	58%
	Total	50	100%
	Mean	6.50	

Median	7.00
Mode	7.00
Standard Deviation	1.73
Minimal	3.00
Maximum	9.00

The following results were obtained using descriptive calculations of 12th grade students of SMA Kristen Harapan Denpasar.

Table 7 Descriptive Statistical Analysis of the Level of Environmental Care Behavior of 12th grade students

No	Level of Environmental Care Behavior	Frequency	Percentage
1	Poor	1	2%
2	Fair	19	38%
3	Good	30	60%
	Total	50	100%
	Mean	6.70	
	Median	7.00	
	Mode	7.00	
	Standard Deviation	1.39	
	Minimal	3.00	
	Maximum	9.00	

The environmental care behavior variable of SMA Kristen Harapan Denpasar students was mainly in the range of scores 7-9 for as many as 30 people (60%), with scores of 4-6 for as many as 19 people (38%), and with a score of 1-3 as many as 1 person (2%). These results show that students' environmental care behavior is good. Environmental care behavior of students at SMA Kristen Harapan Denpasar with indicators of action on waste management and energy utilization (Setiajaya, 2019). Based on the indicators of waste management and energy utilization, overall, the highest number of student answers reflecting environmentally caring behavior was in the statement "I always use water sparingly," with all samples (100%) answering "yes." meanwhile, the lowest student answer was in the statement "I sort the waste for reuse and before the waste is disposed of at the TPS/TPA" with 17 samples (34%) who answered "yes."

Overall, the level of knowledge of green chemistry, environmental knowledge, and environmental care behavior are shown in the following table and graph.

Table 8 Level of Green Chemistry Knowledge, Environmental Knowledge, and Students' Environmental Care Behavior

	Poor	Fair	Good
Level of Green Chemistry Knowledge	0%	26%	74%
Level of Environmental Care Behavior (11th grade)	6%	36%	58%
Level of Environmental Knowledge	0%	40%	60%
Level of Environmental Care Behavior (12th grade)	2%	38%	60%

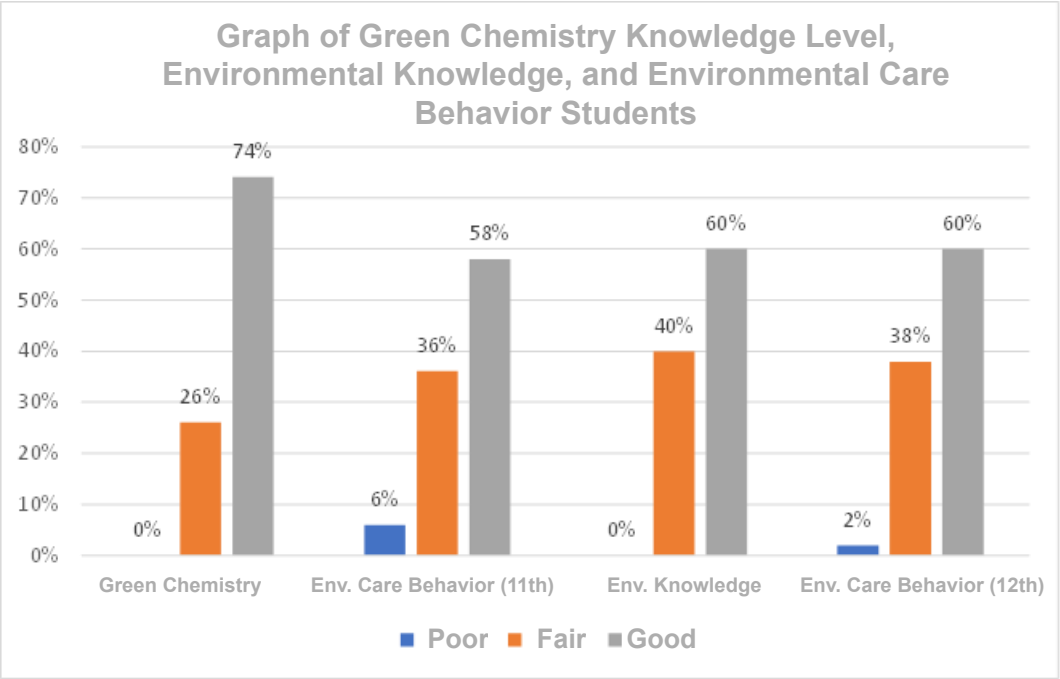

Figure 1 Graph of Green Chemistry Knowledge Level, Environmental Knowledge, and Environmental Care Behavior Students

Hypothesis test

To test the hypothesis, multiple correlation was used, and based on the calculation results, the following results were obtained.

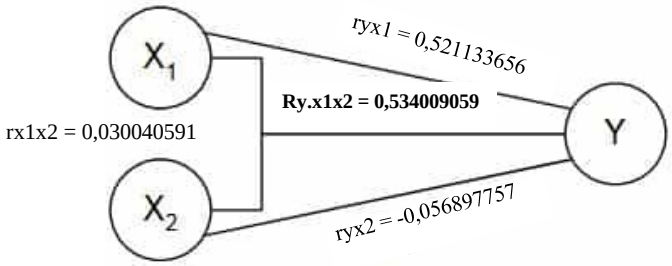

Figure 2 Multiple Correlation of Variables X1, X2, and Y and Correlation Calculation Results

The calculation was continued using the t-test, and the following results were obtained.

$$t = \frac{0{,}521133656\sqrt{50-2}}{\sqrt{1-\ 0{,}521133656^2}} = 8{,}117639742$$

$$t = \frac{-0{,}056897757\sqrt{50-2}}{\sqrt{1-\ (-0{,}056897757)^2}} = 6{,}939445059$$

The calculated t-value is then compared with the t-table value. For a 5% error in a two-tailed test and dk = n-2 = 48, we obtain t=table = 2.021. It turns out that the t-calculated value > t-table so that H0 is rejected and H1 is accepted, meaning (1) there is a correlation between green chemistry knowledge (X1) and environmental care behavior (Y), and (2) there is a correlation between environmental knowledge (X2) and environmental care behavior (Y).

The Relationship between Green Chemistry, Environmental Knowledge, and Environmental Care Behavior

Green chemistry knowledge is closely related to environmental awareness, which is related to understanding environmentally friendly chemical practices in the production process and using chemicals to increase individual awareness of the impact of chemicals on the environment. (Yandi, Muklhlis, & Zagladi, 2023). Apart from that, the principles of green chemistry also aim to increase the efficiency of chemicals, reduce waste, and use fewer resources in the production

process, including using more efficient catalysts, using raw materials that can be recycled, and reducing hazardous waste. (Widodo, 2017).

Environmental knowledge and awareness of the use of chemicals can also influence environmental care behavior (Sarkawi, 2015). Knowledge of environmental issues, such as the impact of pollution or environmental damage caused by the use of chemicals, can influence individual awareness of the need to use green chemistry, thereby increasing awareness of the environment.

Environmentally caring behavior results from green chemistry and environmental knowledge (Julianti & Pramudana, 2017). Combining knowledge about green chemistry and environmental knowledge influences individual behavior in choosing to use environmentally friendly products or supporting more sustainable practices. Thus, green chemistry and environmental knowledge are essential in shaping environmental care behavior.

Environmentally caring behavior is caused by various factors that involve interactions between individuals and their environment (Darmawan & Fadjarajani, 2016). From an environmental psychology perspective, several factors can influence environmental care behavior: environmental perception, personal and cultural values, awareness of personal impacts, emotions towards the environment, cognition and knowledge, and environmental identity.

The way individuals perceive their surrounding environment can influence environmental care behavior. In this case, if the environment is considered essential and valuable, there will be a tendency to care more about the environment (Gifford & Nilsson, 2014). Individual values and the culture in which individuals live can also play an essential role in environmentally conscious behavior. A culture that encourages concern for nature and the environment will influence individual behavior to become more concerned about the environment (Clayton & Myers, 2015). Awareness of an individual's environmental impact also plays an important role. Suppose someone realizes that their actions have consequences for the environment. In that case, there will be a tendency to care more about the environment and take sustainable action. Emotions triggered by certain environmental conditions, such as a love of nature or concern about environmental damage, can also influence environmental care behavior (Brügger & Höchli, 2019). In this case, individuals who love nature will have a high level of concern for the environment so they will have good environmental care behavior. Another factor is the individual's identity with the surrounding environment. Suppose someone feels they have a strong connection with the environment. In that case, they will tend to care more about and act to protect the environment to have good environmental care behavior.

The environmental psychology theory related to environmental care behavior is *the Norm Activation Model* (NAM). NAM is influenced by personal awareness, affective responses, personal responses, social responses, and cognitive responses (Simanungkalit et al., 2021). Based on researchers' observations of students, students gave *effective responses* when shown pictures of living creatures that were threatened/died due to environmental damage. In this case, students' emotional feelings towards environmental problems provide a sense of sympathy for the environment, which can lead to environmentally caring behavior. Apart from that, students also show *a cognitive response*, which can be seen from their belief that their environmentally conscious behavior, such as sorting waste, can significantly impact the environment. When we have high environmental awareness, strong emotional responses to environmental problems, strong personal norms for action, and belief that the actions taken can lead to a better environment, we will be more likely to carry out environmentally caring behavior.

Conclusion

Based on the research results, it can be concluded that: (1) the level of green chemistry of students' SMA Kristen Harapan Denpasar is 74% in the good category and there is a correlation between green chemistry and environmental care behavior; (2) the level of environmental knowledge of students' SMA Kristen Harapan Denpasar is 60% in the good category and there is a correlation between environmental knowledge and environmental care behavior.

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