

# Analysis of Heating Temperature Using Refrigerators in Mountainous Areas With Ethnoscience Approach

Ahmad Khoiri<sup>1</sup>, Widha Sunarno<sup>2</sup>, Sajidan Sajidan<sup>3</sup>, Sukarmin Sukarmin<sup>4</sup>

<sup>1</sup>Doctoral Program of the Department of Natural Science Education, Universitas Sebelas Maret Surakarta and Lecture of Universitas Sains Al Qur'an Central Java, Indonesia.

<sup>2</sup>Professor of Department of Physics Education, Universitas Sebelas Maret Surakarta, Indonesia

<sup>3</sup>Professor of Department of Biology Education, Universitas Sebelas Maret Surakarta, Indonesia

<sup>4</sup>Assoc Professor of Department of Physics Education, Universitas Sebelas Maret Surakarta, Indonesia

e-mail: <sup>1</sup>akhouri@student.uns.ac.id <sup>2</sup>widhasunarno@staff.uns.ac.id,

## ABSTRACT

The study of ethnoscience in cold and extreme environmental conditions requires heating, so the study aims to analyze the room heater using an ethnoscience approach refrigerator. The experimental method used a heater room simulator at 3 different temperature locations, with regression analysis techniques to test the magnitude of the influence between variables. The results showed that the longer the room heater operating time, the higher the temperature produced, and vice versa. In the use of 2 heating elements, regression analysis is carried out and it produces  $y = 0.0105x + 27.575$  where the greater the X value, the greater the Y value. Resulting in a room temperature of approximately  $\pm 28.2^\circ\text{C}$  at sixty minutes with R2 of 0.9953. In the use of 4 heating elements, regression analysis is carried out and produces  $y = 0.02x + 28.3$  where the greater the X value, the greater the Y value with R2 of 0.9991. Produces a room temperature of approximately  $\pm 29.5^\circ\text{C}$  for sixty minutes. The characteristics of the room heater after 5 hours of operation are smoke and odor. The smoke that appears is caused by the burning elements of the painted ram wire. While the smell that appears is the result of the burning. When 2 heating elements operate, the only effect within 10 minutes is the smell of burning paint. Meanwhile, when 4 heating elements operate, the effect within 10 minutes will only cause a little smoke and the smell of burning paint but not sharp. Furthermore, in 15 minutes it creates smoke that is thick enough and the smell of burning paint is quite sharp. Meanwhile, in 60 minutes it creates thick smoke with a sharp burning smell using ram wire that is not coated with paint or using other equipment provided that it is not easy to melt or burn because the temperature generated by the heating element is quite high. Especially in cold environmental conditions, it will accelerate the healing process because it is directly related to the surrounding air pressure. The ethnoscience approach provides an understanding of original science that develops in society through scientific.

## Keywords

Ethnoscience, Refrigerator, Room Heater, and Temperature

Article Received: 10 August 2020, Revised: 25 October 2020, Accepted: 18 November 2020

## Introduction

Challenging geographical conditions and problems with limited access to resources, poor transportation, and environmental health problems. In some areas with cold temperatures, there is no heating system as long as the temperature reaches  $18^\circ\text{C}$  which causes problems for humans living in cold regions. Some areas of Wonosobo have temperatures that are quite cold. Especially in the districts of Garung to Dieng with temperatures up to  $13^\circ\text{C}$  [1]. July enters a cold month with temperatures drastically minus for that part of the region. Therefore, research is aimed at overcoming the problems in winter, especially for middle-class people who are identified as having enough income for their daily needs only. Of course, buying a space heater requires a lot of money. Warming the room at a low cost is an alternative to buying a space heater in general [2]. The purpose of this study was to determine: 1) To determine the effect of time on the temperature of heating using 2 elements and 4 elements in cold areas. 2) Knowing the characteristics of a room heater using a refrigerator element. The ethnoscience study was explored through the conditions of the area which differed in temperature which would affect the room heater work system in each area. Several studies on temperature performance will be different for each region [3], [4] Analysis using time, temperature, and element

replacement treatments to respond to the system and environment [5], [6]. Thermodynamic studies discuss the relationship between the system and environment [7], [8]. Heating using electricity or combustible fuels, the presence of resistance can improve energy transfer performance as in photocatalysts [9]. Electric room heating is divided into three main categories, namely: a) Convection heaters use electricity with heat generated from the heating element, causing the heating element to become hot due to the influence of space heat [10], [11]. These elements are made of metal or ceramic, and the whole process is called Joule heating. Furthermore, this heat is transferred to the air in the room by convection. Some heaters include fans to increase air circulation, while others do not. b) The infrared heater also uses electricity via a conductive wire, which causes the wire to become very hot. Heat wires emit infrared light which transfers heat directly to the solid surface, not the surrounding air. and c) The heat pump uses the same process as the refrigerator and air conditioner, but vice versa. Whereas convective and infrared heaters create more heat from electricity, the heat pump only removes the heat location. The heat pump transfers heat from outside the room to the room and warms it which triggers better energy transfer [12]. Based on the problem of space heating, cold conditions will be different from hot temperatures, so the importance of designing a space heater that is suitable for

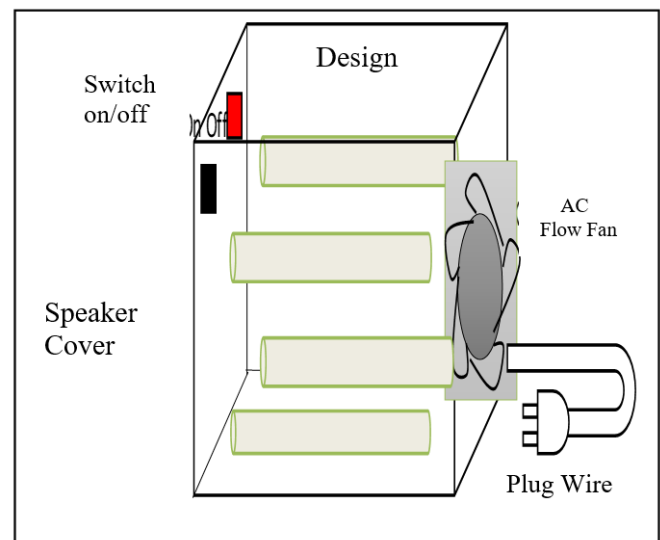
cold areas and analyzing the characteristics of the components used will be different.

### Materials and Methods

This research was conducted from 12 October 2019 to 30 January 2020 in the Dieng Plateau Mountain Range, Wonosobo, Central Java, Indonesia. 3 locations are the measurement places in the heater room work, namely: Garung (Location 1), Kejajar (Location 2), and Dieng (Location 3). The research targets are: 1) Reducing costs for space heating devices, 2) It can be enjoyed by the middle class in cold temperature areas, 3) Innovation in heating elements using a refrigerator. The main composition used is the refrigerator element as a tool that generates heat and is conveyed out through the AC fan which has the function of removing air. Experiments were carried out 3 times, and in the first and second experiments, measurements were taken 12 times with a vulnerable time of approximately 60 minutes. Temperature measurements were made in each experiment using a thermometer. The tools and materials used in the manufacture of heating devices:

- ✓ Refrigerator: As a heat source for space heating.
- ✓ AC fan: As a spreader of warm air from the elements.
- ✓ Plug wire: As a connection to electricity.
- ✓ Digital thermometer: To measure the room temperature when the heater is turned on.
- ✓ Speaker cover: As an outer cover of a space heater.
- ✓ Switch on-off switch: To turn on the heating element.
- ✓ Connecting cable: To connect one cable to another cable.
- ✓ Wooden framework: As a framework for space heating.
- ✓ Seng sari: As a cover from a wooden frame.
- ✓ Wire ram: To cover the inside of a wooden frame.
- ✓ Red paint: To paint the sides of the wooden frame to make it look neat.

The working principle of the tool, the room heater made by the researcher is the heater produced by using the refrigerator element as a heat source as presented in Figure 1.



**Figure 1.** Design of a Heating Device Circuit

The working mechanism of the room heater is by plugging a plug wire into the power source, the on-off switch, which when it is on the heater immediately turns on with 2 refrigerator elements that produce heat which will then be spread out of the room with an AC fan. And to increase the voltage or increase the heat turn on the add element switch and then the elements that turn on the number of 4 which will produce heat. In this study, data collection was carried out with 3 trials. The first and second experiments were carried out in multiples of 5 minutes to 12 measurements for 60 minutes. The third experiment was measured for 5 hours to determine the characteristics of the heater room simulator. The data analysis technique used in this research is a simple linear regression analysis. The specification of the tool used is the refrigerator as a heating element with the specifications of the Mitsubishi refrigerator 220 V / 140 Watt, length 30 cm (13 "). And an AC fan with specifications 120 x 120 x 38, AC 220/240 V, 50/60 Hz 0.14 amperes.

### Results and Discussion

#### Results

The results of making room heaters are expected to be used for the development of further experiments. From the experiments that have been carried out 3 times and in experiments 1 and 2, measurements were made 12 times. The third experiment carried out measurements with a 5-hour vulnerability at location 1 presented in Figure 2.

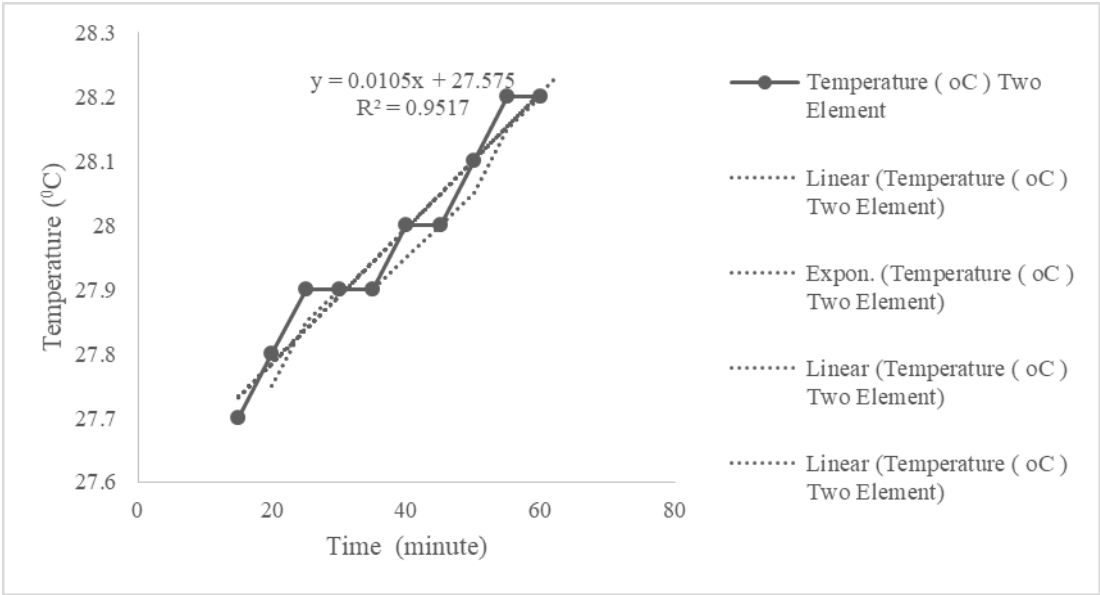


Figure 2. Experiment using 2 refrigerator elements

Based on Figure 2, it shows that the temperature increases during the 2 element room heater process gives the constantly and continues to increase, the temperature state response as presented in Table 1.

Table 1. Room heater 2 refrigerator elements

No	Time (minute)	Temperature (°C)	Criteria
1	5	± 26,6	Temperature rises
2	10	± 27,2	Temperature rises
3	15	± 27,7	Temperature rises
4	20	± 27,8	Temperature rises
5	25	± 27,9	Constant temperature
6	30	± 27,9	Constant temperature
7	35	± 27,9	Temperature rises
8	40	± 28,0	Constant temperature
9	45	± 28,0	Constant temperature
10	50	± 28,1	Temperature rises
11	55	± 28,2	Constant temperature
12	60	± 28,2	Constant temperature

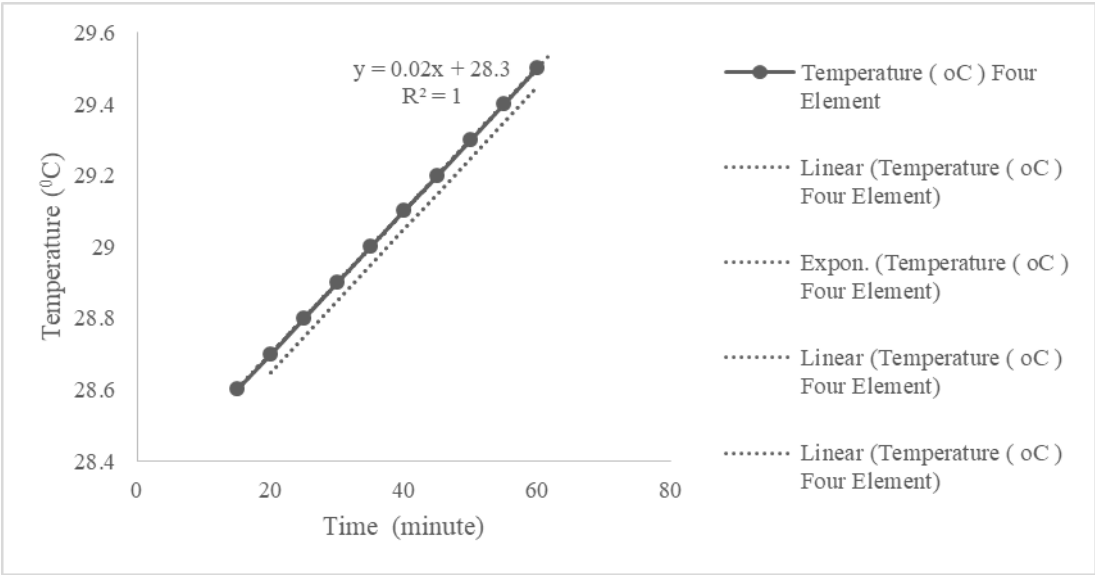


Figure 3. Experiment using 4 refrigerator elements

Figure 3 shows the room heater experiment with 4 refrigerator elements in cold areas, where the temperature continues to increase over a certain period, the duration of

60 minutes, the maximum temperature is up to 29.5°C which is presented in Table 2.

Table 2. Room heater 4 elements refrigerator

No	Time (minute)	Temperature (°C)	Criteria
1	5	± 27,1	Temperature rises
2	10	± 28,1	Temperature rises
3	15	± 28,6	Temperature rises
4	20	± 28,7	Temperature rises
5	25	± 28,8	Temperature rises
6	30	± 28,9	Temperature rises
7	35	± 29,0	Temperature rises
8	40	± 29,1	Temperature rises
9	45	± 29,2	Temperature rises
10	50	± 29,3	Temperature rises
11	55	± 29,4	Temperature rises
12	60	± 29,5	Temperature rises

Based on Tables 1 and 2, Figures 2 and 3 as comparison materials for the use of different refrigerator elements are

presented in the comparison diagram in the experiment presented in Figure 4.

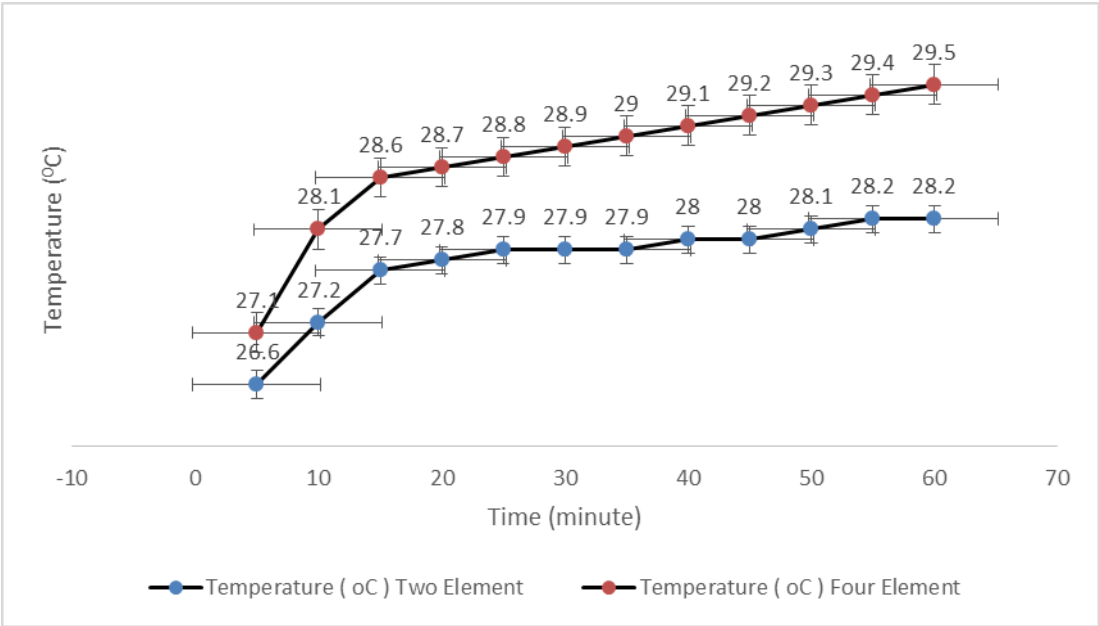


Figure 4. Comparison of the temperature of 2 and 4 refrigerator elements

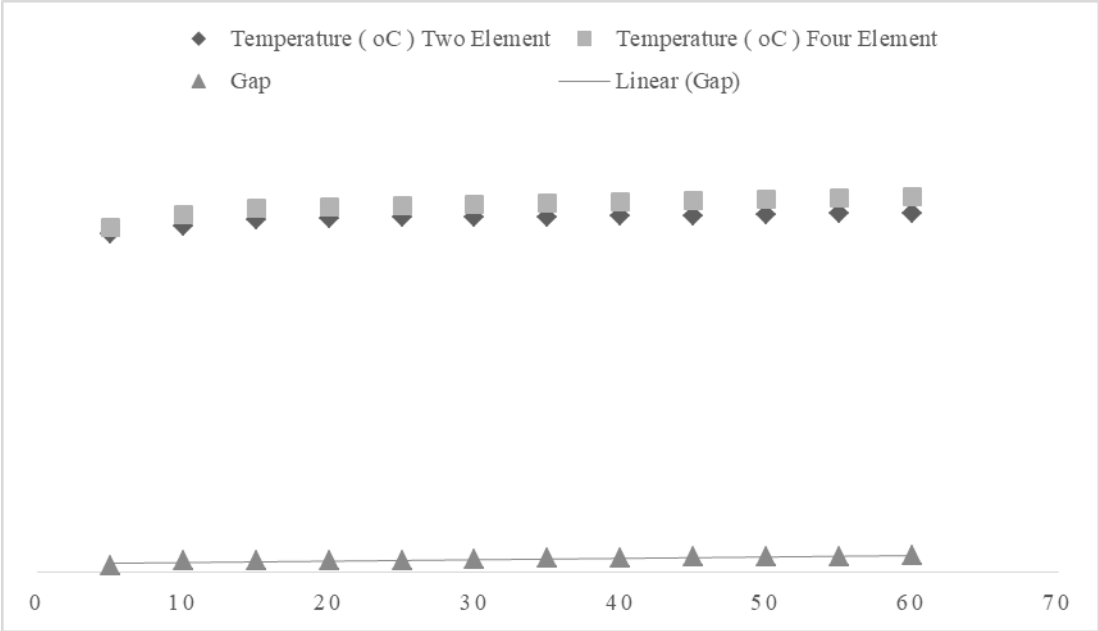


Figure 5. Gap analysis of temperature in room heater 2 and 4 refrigerator elements

The gap between the two different treatments is presented in Figure 5.

Based on the results of Gap analysis that with the same experiment time can produce a constant temperature when it is 30 minutes is presented in Figure 6.

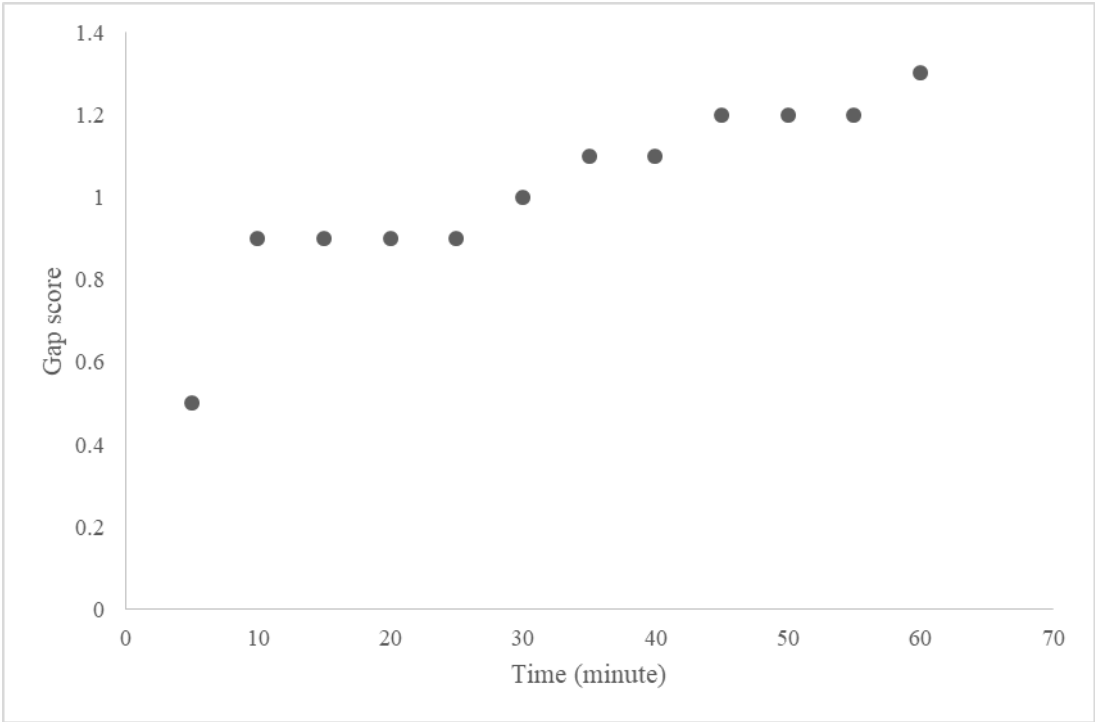


Figure 6. Gap scores on different elements

Based on the gab score, then comparing measurements at different locations according to different temperature points is presented in Table 3.

Table 3. Comparison of location temperature and maximum heather room temperature

	Garung (Location 1)	Village	Kejajar (Location 2)	Village	Dieng (Location 3)	Village
Height (mdpl)	1019		1378		2306	
Location temperature °C)	26		20		15	
Maximum temperature (°C)	33		31		29,5	

A comparison of location temperature and maximum temperature is presented in Figure 7.

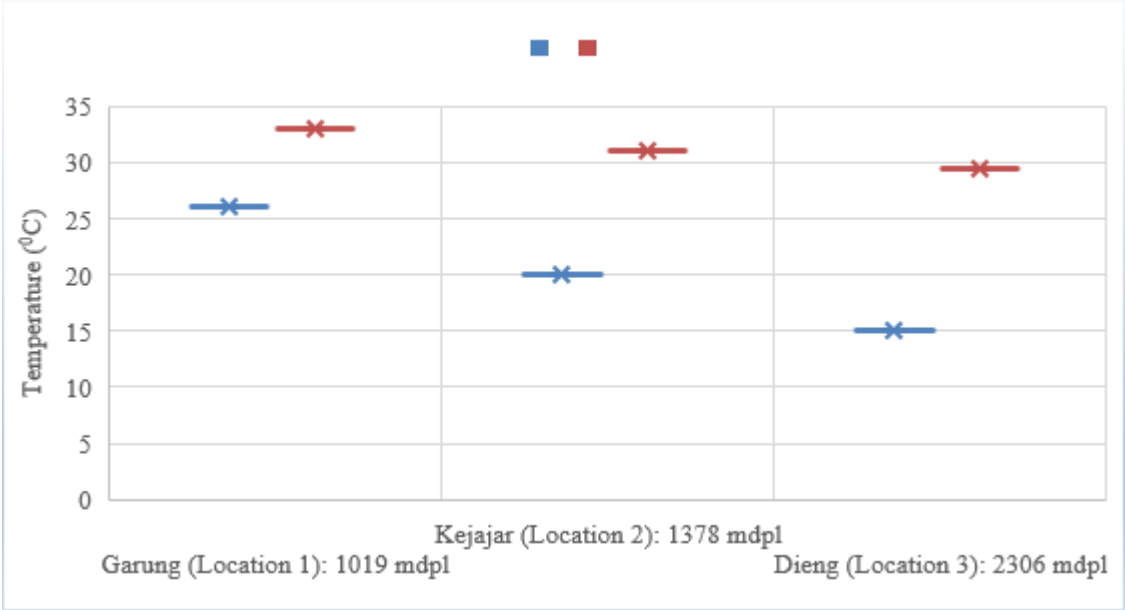


Figure 7. Maximum temperature difference for each location

## Discussion

In general, space heating uses the principle of a fan to carry heat away from the device, which can be made smaller without overheating. However, a relatively large amount of electricity is used to operate the fan and the elements. As for this heater, the fan carries heat away from the device, which can be made smaller without overheating. The relatively small amount of electricity used to operate the fan is partially converted to additional heat, so efficiency is not an issue. All heaters without external ventilation are nearly 100% efficient, meaning that all energy input enters the room as heat. Most heating elements use nichrome material with 80% nickel and 20% chromium. This element is ideal in the manufacture of elements because it has a relatively high resistance and forms a chromium oxide layer when the element is heated. It does not oxidize and prevents the wire from breaking or burning out. So that the use of the refrigerator element can replace the function of the heating element in the room in general.

When the refrigerator is in a state of defrosting, the refrigerator functions to raise the temperature to above room temperature so that the icicles melt. This is what inspired researchers to use it with a different function, namely as a room heater. Because the refrigerator element has the same function as the heating ROD and has a wire resistance for fire-resistant heating elements in the form of a straight or circular wire or ribbon. Used in heating devices such as toasters, hairdryers, furnaces for industrial heating, floor heating, space heating, heaters for defrosting, dryers, etc. Commonly used materials are Kanthal (FeCrAl), Nichrome Wire and Strips, Cupronickel (Cuni) Mixture for low-temperature heating. The manufacture of room heaters is made with the main tools and materials, namely: refrigerator elements, ac fans, connecting cables. The most important component in a refrigeration machine is the refrigerant. The refrigerant absorbs heat from one location and dissipates it to another through evaporation and condensation mechanisms [13].

Based on the results of experimental data (Table 1), a regression analysis was carried out to determine how long it affected temperature using two elements of the equation  $y = 0.0105x + 27.575$  where time is expressed in X and temperature is expressed in Y. From this graph, it is known that the greater the value of X, the greater the value of Y, and vice versa. And the longer the time it takes, the higher the temperature produced and vice versa, the less time it takes, the lower the resulting temperature. However, only up to a temperature of  $\pm 28.2^{\circ}\text{C}$  does not exceed  $100^{\circ}\text{C}$ . And it is known that the value of the coefficient of determination from the graph above is  $R^2 = 0.9517$ , which means that the contribution of the influence of variable X to variable Y is large or close to one. Where the R square value approaches one, the model fit is said to be better or 95.17% of the independent variables influence the dependent variable.

Based on the results of experimental data (Table 2), a regression analysis was carried out to determine how long it affected temperature using two elements of the equation  $y = 0.02x + 28.3$ . where time is expressed in X and temperature is expressed in Y. From this graph, it is known that the greater the value of X, the greater the value of Y, and vice versa. And the longer the time it takes, the higher the

temperature produced and vice versa, the less time it takes, the lower the resulting temperature. However, only up to a temperature of  $\pm 29.5^{\circ}\text{C}$  does not exceed  $100^{\circ}\text{C}$ . And it is known that the coefficient of determination (R square) from the graph above is  $R^2 = 1$ . This means that the contribution of the influence of variable X to variable Y is large or close to one. Where the R square value approaches one, the model fit is said to be better or 100% of the independent variables influence the dependent variable. The characteristics of the room heater after 5 hours of operation are smoke and odor. The smoke that appears is caused by the burning elements of the painted ram wire. While the smell that appears is the result of the burning. When using 2 heating elements it only creates odors in the 5th minute. Whereas when using 4 heating elements it causes odor in the 5th minute then it causes odor and a little smoke. But in the 15th minute, the smoke is thick until the 25th minute. Cold environmental conditions with maximum heating of  $29.5^{\circ}\text{C}$  are not yet maximal for normal room temperatures.

In (Figure 4) shows the difference in treatment between two and four refrigerator elements with a duration of 60 minutes. This condition shows that the additional elements in the room heater component will produce a higher temperature. Cold conditions show that the study of ethnosience in thermodynamics is a branch of physics that deals with the laws of heat movement and the change of heat from other forms of energy. This case also discusses the relationship between heat (heat) and the work done by the heat. The concept of thermodynamics in essence focuses its attention on the understanding or understanding of energy. Heat transfer and work effort provide two methods regarding adding energy or reducing energy from a system. Free convection is heat transfer caused by a temperature difference and a tight difference only and there is no external force to push it. Meanwhile, forced convection is the heat transfer of a gas or liquid flow caused by external forces. Forced convection can also occur driven by a mechanical device. Free convection occurs when the motion of the fluid is caused by the buoyancy force that comes from differences in density due to differences in temperature in the fluid. Dependent convection is the term used when the flow in a fluid is induced by external objects, such as fans, stirrers, and pumps, causing artificially induced convection. Most of the heating elements use nichrome material with 80% nickel and 20% chromium as found in refrigerators. This element is ideal in the manufacture of elements because it has a relatively high resistance and forms a chromium oxide layer when the element is heated. They will not oxidize and prevent the wire from breaking or burning out.

The gap score analysis (Figures 5 and 6) shows the existence of the same temperature at 30 minutes where the difference between the two and four elements of the refrigerator is  $1^{\circ}\text{C}$ , meaning that the temperature will increase every certain time interval which takes 30 minutes to get the temperature that continues to increase. The resistance component of the wire part of the fireproof heating element can be wire or ribbon in the form of straight or circular. Used in heating devices such as toasters, hairdryers, furnaces for industrial heating, floor heating, space heating, heaters for defrosting, dryers, etc. Commonly used materials are Kanthal (FeCrAl), Nichrome Wire and Strips, Cupronickel (Cuni) Mixture for low-temperature



heating. So that the refrigerator can be used as a heating element for the room. To transfer heat from the refrigerator element to the indoor air, use a fan here with an AC type. Because it is easier to apply. Meanwhile, the DC fan will increase funds because to run it must be assisted by a compressor. Thermodynamic studies on the concept of temperature and the relationship between the air pressure in cold areas, it is proven that the heater room system shows that there is a closed system that is influenced by the surrounding environment. The higher the temperature inversely proportional to the surrounding air pressure [5], [6]. Based on (Figure 7) shows the difference in maximum temperature is different, this is the height of a place on the earth's surface affects the high and low temperature and pressure of an area [14]. The higher an area, the lower the air temperature, every 100m of land elevation will experience a decrease of 0.61 °C but for dry air the air temperature drops 100 °C.

Based on ethnoscience studies at three different location points, it shows different results for each area with the maximum temperature produced by the room heater. The results indicate that each area requires a room heater with different specifications with maximum temperature requirements. The temperature that takes into account environmental conditions will affect the component elements in the refrigerator used [15]. The amount of heat transferred by the air conditioning system over time. The cooling load consists of the heat coming from the room and the additional heat. The refrigeration cycle and performance analysis of refrigerants in refrigeration machines can be observed in the refrigeration machine installation scheme [16], [17]. The research recommendation is that in making room heaters it is necessary to analyze the environment with various temperature conditions so that it will be more effective in its use.

The scientific reconstruction on the temperature analysis of the refrigerator used in the heater room provides more meaningful content. Ethnoscience has the potential to be used as a source of learning physics through the concepts of temperature and heat in exploring creative ideas or other scientific skills [18], [19]. Source of contextual and meaningful learning through practicum activities, working scientifically through explanation of data proven by experiments [20], [21].

## Conclusions

The ethnoscience of cold temperature areas determines the characteristics of the room heater components that are used differently in general. The elements used to give the effect of heating faster in cold areas than in hot areas. The longer the room heater operating time, the higher the temperature produced, and vice versa. In the use of 2 heating elements, regression analysis is carried out and it produces  $y = 0.0105x + 27.575$  where the greater the X value, the greater the Y value. Resulting in a room temperature of approximately  $\pm 28.2$  °C at sixty minutes with R2 of 0.9953. In the use of 4 heating elements, a regression analysis is carried out and produces  $y = 0.02x + 28.3$ , where the greater the X value, the greater the Y value with R2 of 1. Producing a room temperature of approximately  $\pm 29.5$  °C at sixty minutes. The characteristics of the room heater after 5 hours

of operation are smoke and odor. The smoke that appears is caused by the burning elements of the painted ram wire. While the smell that appears is the result of the burning. When 2 heating elements operate, the only effect within 10 minutes is the smell of burning paint. Meanwhile, when 4 heating elements operate, the effect within 10 minutes will only cause a little smoke and the smell of burning paint but not sharp. Furthermore, in 15 minutes it creates smoke that is thick enough and the smell of burning paint is quite sharp. Meanwhile, within 60 minutes it creates thick smoke with a sharp smell of burning paint. To overcome the smoke and odor, you can use uncoated ram wire or use other equipment provided it is not easy to melt or burn because the temperature generated by the heating element is high enough. The use of a room heater will have different performance in 3 locations with different temperatures, the maximum temperature obtained will also be different.

## Acknowledgements

Researchers would like to thank the managers of the Physics Laboratory of the Alquran Science University, Central Java, Wonosobo, and the Research Grants for Beginner Lecturers of the Ministry of Research, Technology, and Higher Education Indonesia.

## References.

- [1] A. Khoiri and W. Sunarno, "How Is Students' Creative Thinking Skills? An Ethnoscience Learning Implementation," *J. Ilm. Pendidik. Fis.*, vol. 08, no. October, pp. 153–163, 2019, doi: 10.24042/jipfalfbiruni.v0i0.4559.
- [2] D. Singh, S. P. Singh, M. Agnihotri, K. Palley, and A. K. Singh, "An Experimental and Economic Study of room heating through Solar Evacuated Tube Collector," *Int. J. Res. Advent Technol.*, vol. 7, no. 1, pp. 516–519, 2019, doi: 10.32622/ijrat.71201998.
- [3] Hermawan, E. Prianto, and E. Setyowati, "Thermal comfort of wood-wall house in coastal and mountainous region in tropical area," *Procedia Eng.*, vol. 125, pp. 725–731, 2015, doi: 10.1016/j.proeng.2015.11.114.
- [4] Hermawan, E. Prianto, and E. Setyowati, "The Difference of Thermal Performance between Houses with Wooden Walls and Exposed Brick Walls in Tropical Coasts," *Procedia Environ. Sci.*, vol. 23, no. Ictcred 2014, pp. 168–174, 2015, doi: 10.1016/j.proenv.2015.01.026.



- [5] Douglas C. Giancoli, *Physics Principles with Applications*. America: Pearson Education Inc, 2005.
- [6] M. Abdullah, "Basic Physics 2," vol. 53, no. 9, Bandung: Institut Teknologi Bandung, 2019, pp. 1689–1699.
- [7] E. W. Lemmon, "Reference Fluid Thermodynamic and Transport Properties—REFPRO.," in *Department of Commerce, Maryland, U.S: NIST*, 2010.
- [8] F. W. dan M. W. Z. Sears, "Physics for University 1," Jakarta: Yayasan Dana Buku Indonesia, 1962.
- [9] T. Matuska and B. Sourek, "Performance Analysis of Photovoltaic Water Heating System," *Int. J. Photoenergy*, vol. 2017, 2017, doi: 10.1155/2017/7540250.
- [10] B. I. Darshandee, R. Sivakumar, G. Sakthivel, S. Subramaniam, and J. Oksanen, "Design and analysis to analyse the heat transfer of a space heater for a boat," *Int. J. Ambient Energy*, vol. 39, no. 4, pp. 414–423, 2018, doi: 10.1080/01430750.2017.1303641.
- [11] A. H. Naser and K. I. Abaas, "Solar Water Heating for Space Heating Purposes Solar Water Heating for Space Heating Purposes," *Int. J. Civil, Mech. Energy Sci.*, vol. 2, no. 4 August, 2016, pp. 57–63, 2016.
- [12] A. Teskeredzic and R. Blazevic, "Transient radiator room heating-mathematical model and solution algorithm," *Buildings*, vol. 8, no. 11, 2018, doi: 10.3390/buildings8110163.
- [13] A. Amrullah, Z. Djafar, and W. H. Piarah, "Performance Analysis of Household Refrigeration Machines With Refrigerant Variations," *JTT (Jurnal Teknol. Ter.)*, vol. 3, no. 2, pp. 7–11, 2017, doi: 10.31884/jtt.v3i2.55.
- [14] M. Abdullah, "Basic Physics 1," Bandung: Institut Teknologi Bandung, 2016, p. 1068.
- [15] S. Siagian, "Analysis Of Condensor Performance Analysis Of A Cooling System Using Freon R-134 A Based On A Cooling Fan Running Variation," vol. II, no. 124–130, p. 126, 2015.
- [16] M. Rizal, "Effect of Variations in Load Engine, Cooling of Work Performance LPG, Refrigerant R12 and LPG," *J. ROTOR*, vol. Volume 6, no. 1, 2013.
- [17] I. Taukhid, D. Daniel, and B. R. S., "Analysis of the Work of Fish Vendor Table Refrigeration System," *J. Kelaut. Nas.*, vol. 9, no. 3, p. 121, 2014, doi: 10.15578/jkn.v9i3.6208.
- [18] A. Khoiri and W. Sunarno, "Ethnoscience Approach in a Philosophical Review," *SPEKTRA J. Kaji. Pendidik. Sains*, vol. 4, no. 2, p. 145, 2018, doi: 10.32699/spektra.v4i2.55.
- [19] W. Sumarni, Sudarmin, Wiyanto, and Supartono, "The reconstruction of society indigenous science into scientific knowledge in the production process of palm sugar," *J. Turkish Sci. Educ.*, vol. 13, no. 4, pp. 281–292, 2016, doi: 10.12973/tused.10185a.
- [20] Parmin, Sajidan, Ashadi, Sutikno, and F. Fibriana, "Science integrated learning model to enhance the scientific work independence of student teacher in indigenous knowledge transformation," *J. Pendidik. IPA Indones.*, vol. 6, no. 2, pp. 365–372, 2017, doi: 10.15294/jpii.v6i2.11276.
- [21] A. Khoiri, M. S. Kahar, and R. T. Indrawati, "Ethnoscience Approach in Cooperative Academic Education Programs (COOP)," *J. Phys. Conf. Ser.*, vol. 1114, no. 1, 2018, doi: 10.1088/1742-6596/1114/1/012018.