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Farenheat: A House Heat Reducer from Acrylic Mirrors and Packed Water against Solar Radiation

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Abstract. As climate change intensifies various environmental crises, health is also affected. One of the negative effects is the abnormally high temperatures during the daytime. Heat strokes, stress, and other health concerns related to extreme temperatures have gotten worse. Therefore, the study's primary purpose was to determine the effectiveness of "Farenheat" in reducing the heat experienced inside the house during the daytime, which was tested on a 60cm x 60cm x 70cm house model. A digital thermometer was used to gather the initial and final temperatures of the nine trials from the two samples of Farenheat: A House Heat Reducer from Acrylic Mirrors and Packed Water Against Solar Radiation. The statistical tools sum, mean, standard deviation, and one-tailed paired-sample T-test at a 0.05 significance level were used in this study, which were important in analyzing the data from the two samples. The results showed that the average change in the temperatures of the house model after applying the "Farenheat" is lower than the mean of the sample before applying the product. In addition to this, the analsysis showed that there is a significant difference between the changes in the temperatures of the house model before and after applying the "Farenheat." Therefore, the product is effective in reducing the rate of increase in the temperature inside the house model.

Key words: Farenheat, House Model, Solar Radiation, Acrylic Mirrors, Temperature.

Introduction

"By polluting the oceans, not mitigating CO2 emissions, and destroying our biodiversity, we are killing our planet. Let us face it, there is no planet B." -Emmanuel Macron, President of France (Wentworth, 2018).

Thermodynamics studies the relationship between heat, temperature, and energy

(Davidovits, 2013). According to Boechler et al. (2013), thermal energy is the energy contained in an object that can transfer to another location through particles that bounce into each other. On the other hand, the temperature is the degree of coldness or hotness of an object and is measured through degrees Fahrenheit, degrees Celsius, or Kelvin which describe the energy present in an object (National Geographic Society, 2011).

Heat is the energy transferred from one substance to another due to the temperature difference (Lucas, 2015). In relevance to this, Electronics Hub (2018) stated that a heat sink is a device that reduces or absorbs heat. On the other hand, a heat source is a mechanism that loses heat to a heat sink. The sun is the primary source of light, heat, and warmth for the living things on the planet (Designing Buildings, 2021) since it delivers a wide quantity of energy and a source of different types of energy (Rhodes, 2010).

Mackenzie and Lerman (2006) stated that when the longwave radiation is absorbed in the atmosphere, it induces a greenhouse effect. This phenomenon leads to climate change and causes extreme temperatures, which affect most public health and results in heat exhaustion, heat stroke, cardiovascular illness, kidney disease, and aggravated allergies. In addition to that, extreme heat affects various aspects: health, agriculture, work, and resources; it also affects socio-economic development, such as increased energy consumption and migration (Cartalis et al., 2014; Missirian & Schlenker, 2017).

According to So (2012), 75% of the heat that enters your home passes through the roof. It is especially true in the Philippines, where around 90% of homes have metal roofs and low ceilings. Based on the findings of a study, the average outside air temperature in hot conditions when temperatures are over 30ºC is 34ºC. In contrast, the average temperature inside the house in hot conditions over 30ºC is 31ºC (Healthhabitat, n.d.). Because of extreme temperatures, people rely on expensive materials to run cooling and heating systems to make their houses more habitable during different conditions. While some individuals can afford the luxury of buying an air conditioner, few people may not have that choice. One of the options is passive cooling, which utilizes heat sinks and vents to maximize heat dissipation (PCMag, n.d.).

Roof cooling systems are one of the alternatives since the most exposed part of a building to solar radiation is the roof. A mirror can be used to reflect heat that enters the building, by reflecting the solar radiation. Acrylic mirror is a type of mirror that is lightweight and is ten times more break-resistant than glass (US Plastics, n.d.), it is also usually coated with aluminum, a cheaper option than silver (LibreTexts, 2021). Aside from the space as a heat sink, the mirror needs another thermal reservoir. Water has the highest heat capacity than other liquids because its hydrogen bonds are separated when heat is absorbed, causing the water molecules to flow freely (Roenamaloku, 2017).

The primary purpose of the study was to develop “Farenheat,” a low-cost alternative to existing cooling systems. Its effectiveness in reducing the heat experienced inside the house during the daytime was determined by testing on a 60 cm x 60 cm x 70 cm house model.

Statement of the Problem and Hypothesis

The study's primary purpose was to determine the effectiveness of "Farenheat" in reducing the heat experienced inside the house during the daytime, which was tested on a 60cm x 60cm x 70cm house model.

Specifically, the study aimed to answer the following questions:

1. What are the changes in the temperatures of the house model before and after applying “Farenheat”?
2. Is there a significant difference between the changes in the temperatures of the house model before and after applying “Farenheat”?

Based on the statement of the problem mentioned above, a hypothesis was tested:

1. There is no significant difference between the changes in the temperatures inside the house model before and after applying “Farenheat”. It is represented as: $\mu_d \geq 0$.

Methodology

Experimental Research Design and Layout

The experimental research design of the study was a two-group design. According to Boyd (2013), a two-group design is when a researcher divides their subjects into two groups and compares the results. JoVE Science Education (2021) stated that the most straightforward technique to establish a cause-and-effect link between two variables is to employ a two-group design. The two groups, one treatment, and one control are ideal for evaluating the effects of a single independent variable that can be manipulated as a treatment (Bhattacherjee, 2012).

In this study, the before and after results were gathered from the nine trials of the house model to determine the effectiveness of “Farenheat”. The data was collected accordingly from one control group (before applying "Farenheat") and one experimental group (after applying "Farenheat"). The samples in the experimental group were considered successful if there is a significant difference between the changes in the temperatures inside the house model before and after applying “Farenheat.”

The independent variable of the study was the product “Farenheat,” and the dependent variable was the house temperature. In addition, the statistical tools: Sum, Mean, Standard Deviation, and One-Tailed Paired Sample T-test were used in this study.

The difference between the final and initial temperatures of the two samples, before and after applying “Farenheat”, which represents the change in the temperatures, is tabulated in Table 1.

Table 1. Two-Group Experimental Research Design Layout: Changes in the Temperatures Inside the House Model Before and After Applying “Farenheat.”

Trial	Sample	
	Change in the temperature before applying “Farenheat”	Change in the temperatures after applying “Farenheat”
1	x	x
2	x	x
3	x	x
4	x	x
5	x	x
6	x	x

7	x	x
8	x	x
9	x	x
Mean	X	X

Data Collecting Tools

Observation was the data-gathering instrument in obtaining results from the experiment. According to Shamaa (2014), observation may be characterized as a systemic viewing of a concrete phenomenon in its proper setting or the specific purpose of gathering data for a particular study. This collection method includes two senses such as "seeing" and "hearing," accompanied by perceiving well. Therefore, the instrument was utilized for the study as it allows the researchers to gather information by measuring specific data of a particular phenomenon.

A scientific type of observation was used in experimenting. This involves using the tools of measurement (Shamaa, 2014). In this study, the following measuring tools were utilized for the collection of data:

a) Digital thermometer – was used to measure the initial and final temperatures of the two samples, before and after applying “Farenheat" on the house model.

b) Pen, paper, and laptop – was used to tabulate data gathered from the observation.

c) Camera – was used for the documentation of the experiment and other activities regarding the study.

Results and Discussions

Descriptive Data Analysis

Changes in the Temperatures Before and After Applying “Farenheat”

Table 2 presents the paired samples statistics of the changes in the temperatures before and after applying “Farenheat.” The results showed that the mean of the change in the temperatures after applying “Farenheat” (M2= 0.12667°C) is lower than the mean of the change in the temperatures before applying “Farenheat” (M1= 0.91111°C).

Table 2. Paired Samples Statistics of the Changes in the Temperatures Before and After applying “Farenheat”

Test	Mean (℃)	Mean Difference
Before applying “Farenheat”	0.911	-0.784
After applying “Farenheat”	0.127	

The mean of the sample before applying “Farenheat” (M1=0.911°C) is greater than the mean of the sample after applying “Farenheat” (M2=0.127°C), 0.911°C > 0.127°C. Therefore, the changes in the temperatures before and after applying “Farenheat” indicated that the product reduced the rate of increase in the temperature inside the house model, for the reason that the acrylic mirrors reflected the solar radiation and the water absorbed some of the unreflected radiation.Inferential Data Analysis

Paired Differences of the two samples: Before and After Applying "Farenheat"

Table 3 below presents the result of the one-tailed paired samples T-test between the changes in the temperatures of the two samples: before and after applying "Farenheat." It depicts that the significance level is less than 0.001.

Table 3. Paired Differences Between the Changes in the Temperatures of the two samples: Before and After applying "Farenheat"

Test	t	df	Sig.	Interpretation
Before applying "Farenheat" After applying "Farenheat"	-5.825	8	0.000	Significant

p-value at 0.05 alpha level

The null hypothesis was rejected because there is a significant difference between the changes in the temperatures of the two samples, before and after applying "Farenheat" for the reason that the p-value is less than 0.001 which is lower than the alpha level.

This is because after the product "Farenheat" was applied on the roof of the house model, the increase in the temperature was decelerated, and some trials even showed a drop in the temperature. For that reason, the product was successful in reducing the heat inside the house as the acrylic mirrors reflected the solar radiation and the water absorbed some of the unreflected radiation.

The result of this study is congruent to the study of Chen and Lu (2021), the "cool roof" which is usually associated with high reflectance and high-emissivity coatings, it showed that it has reduced the indoor overheating of the attic by 4.7 °C during the peak summer. As stated by Lubis and Koerniawan (2018) a roof is a building surface with the most exposed area to the sun which provides most of the heat gain in the structure. In a review study by Abuseif and Gou (2018), it is revealed that increasing the solar reflectance lowers a surface's temperature because solar radiation is reflected rather than absorbed. As a result, the amount of heat that enters the facility is reduced.

Additionally, the result of this study is similar to the study conducted by Berliner and Pearlmutter (2017) wherein a psychrometer pond system was utilized to reduce the temperature inside the house. The psychrometer roof pond placed in hot and dry conditions was observed to lessen the internal surface of the roof by 15°C compared to a controlled roof. Roof ponds are puddles of water found on top of the roof used for passive evaporative cooling (McGraw-Hill Dictionary of Architecture and Construction, 2003).

Conclusions

Based on the findings of the study stated above, the following conclusions were drawn:

1. The result showed that the average change in the temperatures of the house model after applying "Farenheat" is lower than the mean of the sample before applying the "Farenheat". Therefore, the product is effective in reducing the rate of increase in the temperature inside the house model. This may lessen the energy consumption for electrical cooling devices such as air-conditioners and electric fans. Additionally, this may decrease the number of health issues that may arise due to extreme temperatures, through the use of the product.

2. The null hypothesis was rejected because there is a significant difference between the changes in the temperatures of the two samples, before and after applying “Farenheat.” Therefore, the results determined that the product "Farenheat" is effective in reducing the heat experienced inside the house during the daytime. This may aid in developing more tolerable living conditions for dwellers. Moreover, this may be applied to houses and other infrastructures that are in need of cooling systems without the use of electrical energy.

Recommendations

1. For households, it is recommended for them to learn more about solar radiation and its effects on health. Furthermore, knowledge about the importance of using reflective material and water in reducing the heat inside the house might be beneficial to the household members, in terms of energy consumption and health. Awareness about this issue may help prevent various holistic health issues such as cardiovascular diseases, heat stress, poor concentration, and heat strokes.

It is recommended for civil engineers to further investigate “Farenheat” and its factors that may aid in decreasing the temperatures inside infrastructures. Information from this study may help them develop more effective products and efficient procedures which may guide them in creating a more convenient and comfortable place for their clients.

To the community, it is recommended to launch programs or seminars regarding passive cooling systems. As stated above, awareness plays an important role in addressing issues. Information may be propagated through these programs which may prevent the negative health impacts of extreme heat and may assist in reducing electrical consumption. Through the use of passive cooling systems, electrical consumption may be reduced.

2. For households, it is recommended for them to use the product “Farenheat.” By using this, it may not only reduce the heat temperature but it may also reduce heat-induced illnesses. The heat experienced inside the house may also be lessened by reducing the use of electrical appliances that may contribute to heat gains.

For civil engineers, it is recommended for them to create a more ergonomic design for passive cooling systems for their clients. They may improve the following factors on the product “Farenheat”: (1) types of transparent substrates and metallic coatings, (2) the optimal angle placement of the mirrors, (3) types of heat sinks that may be used aside from water, and (4) container for the heat sink.

For the community. They may apply the product “Farenheat” on public establishments and may modify its size to determine its effect on energy consumption. Given that it does not require electricity to function, this product may be useful in reducing the electrical usage of people. Through this, it may lessen the hydrofluorocarbons (HFCs) and chlorofluorocarbons (CFCs) emission that leads to ozone depletion and global warming.

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