Enjoy science and wear it too: sunscreen research with UV-sensitive bracelets

David Kumar and **Rachel S. K. David** have devised a research project for developing knowledge and skills by evaluating sunscreens with beads

Enjoying the sunshine safely

To protect ourselves from the harmful effects of the Sun's rays, it is common and advisable to make judicious use of sunscreen (World Health Organization, 2017; Skin Cancer Foundation, 2023). This protects from the harmful effects of two damaging types of ultraviolet rays: UVA and UVB. The Sun Protection Factor (SPF) of sunscreens indicates how long UVB rays would take to redden the human skin after application of the sunscreen exactly as directed. Thus an SPF 30 product indicates that it would take 30 times longer for the skin to burn than without using the sunscreen. Sunscreens absorb or reflect UV rays, and protect the skin from sunburn. Clear understanding and thus appropriate selection of a good sunscreen is important in protecting the skin from the harmful effects of UV radiation. It is advisable to choose a sunscreen that offers protection against both UVA and UVB rays.

The project: Investigating sunscreen

In this project students use the scientific method to learn about how to select a good effective sunscreen through a simple fun experiment with a UV-sensitive beaded bracelet.

UV beads can be used to sense the presence and intensity of UV radiation and thus the type of protection needed. Embedded in the UV beads is a chemical containing a pigment that is sensitive to UV radiation. In unexposed

A brief summary of UV radiation

Ultraviolet rays from the midday Sun consist of about 95% UVA and 5% UVB radiation. UV has a wavelength between about 380 nm and 10 nm and a frequency in the range of 8×10^{14} Hz to 3×10^{16} Hz. The classification of UV is as follows: UVA (315–400 nm), UVB (280–315 nm), UVC (180–280 nm). Thanks to the ozone layer, UVC along with a good portion of UVB radiation capable of causing serious skin damage is mostly filtered out.

Out of the total solar UV radiation that reaches the Earth's Equator, 95% is UVA, which is the primary cause of immediate tanning and sunburn and, unlike UVC and most of UVB radiations, this is not absorbed by the ozone layer. UVB rays cause delayed tanning, sunburn, blistering and cellular damage in living organisms. UVB radiation is reported to be absorbed by DNA, leading to DNA damage and weakened immunity. In the long run, this leads to cell mutation and results in skin cancer. According to the Skin Cancer Foundation, the chance of occurrence of melanoma, the deadliest form of skin cancer, is doubled for people who have suffered repeated sunburn. Hence use of protective measures against UV radiation is essential.

Ultraviolet radiation ● **Sun protection factor** ● **Scientific method**

conditions, the beads appear colourless or almost white, but change colour depending upon the intensity of UV radiation when they are exposed to it. Once the exposed beads are no longer exposed they revert to white. This cycle of colour change takes place for up to about 50,000 times before the pigment becomes insensitive to UV light (ASTC Science World Society, 2022).

UV beads are available online costing around 15 dollars (approximately £10) for a packet of a few hundred beads. The colour of UV beads after exposure to sunlight will vary depending upon the selected brand of sunscreen, maintaining other factors constant. The authors have found it is better to select and experiment with beads showing violet or blue colour after sunlight exposure, and opaque with no sunlight exposure.

Worn around the wrist, the UV-sensitive beads look like a normal bracelet and are so sensitive that they will detect the presence of UV rays, even on a cloudy day (ASTC Science World Society, 2022). The beads are convenient to use in a variety of outdoor settings and conditions to engage school pupils in an affordable experiment in a real-world context. In this project the pupils use scientific method and get direct hands-on experience by investigating the effect of three different kinds of sunscreen. They learn how to assess the quality of the sunscreen and so how to select the best one for personal use.

Exemplar procedure

Purpose

The purpose of this research project is to determine which of three brands of sunscreen blocks is best at blocking UV rays.

As a result of participation in this research project, several science concepts could be addressed. It is best to start by discussing scientific concepts and principles related to the project: UV rays, the effects of exposure to the Sun's rays, sunscreens and their varieties, and so on. Then, summarize this to help develop a research question and hypothesis.

Hypothesis

State a hypothesis: for example, 'Sunscreen brand A will block the most UV rays'. Care should be taken to avoid using brand names and references to manufacturers, distributors and stores in any part of the research.

Variables

- **Independent variables:** The three types of sunscreens (anonymised to A, B and C) used.
- **Dependent variable:** The resultant colour of the UV beads bracelet photographs following UV exposure, ranked 1–5 (Likert Scale advised).
- **Constants:**
  - Amount of sunscreen used (e.g. 1 teaspoon per trial).
  - Surface background where UV beads and sunscreen are set up for sunlight exposure each time.
  - Length of time of each exposure (e.g. 15 seconds).
  - Digital camera.
  - Location where the UV beads and sunscreen set-up is exposed to sunlight.
  - Time of day of the experiment.

It is essential that these factors are kept the same.

Materials

- sunscreens x 3 brands (anonymised as A, B and C)
- UV beads and string for bracelet x 1
- teaspoons x 3
- clear zip lock plastic bags, x 17
- timer x 1
- digital camera x 1
- marker pen x 1

Safety

For safety during the project the following should be ensured:

- wearing of safety goggles;
- use of sunscreen protection for pupils and teachers;
- check for potential sunscreen allergies and use gloves if necessary;
- relevant measures to prevent heat exhaustion;
- responsible and authorised adult supervision.

Creating reference standards

No exposure to sunlight

1. Make one UV bead bracelet.
2. Label one clear bag 'No exposure to sunlight'.
3. Place the UV bead bracelet inside the clear bag.
4. Keep the bag with the UV bead bracelet indoors in a room far away from windows for 15 seconds; take a photograph and label it 'No exposure to sunlight' (Figure 1a).

Full exposure to sunlight

5. Place the UV bead bracelet inside a clear bag.
6. Place the bag with the UV bracelet outdoors in a sunny position with full exposure to sunlight for 15 seconds; take a photograph and label it 'Full exposure to sunlight' (Figure 1b).

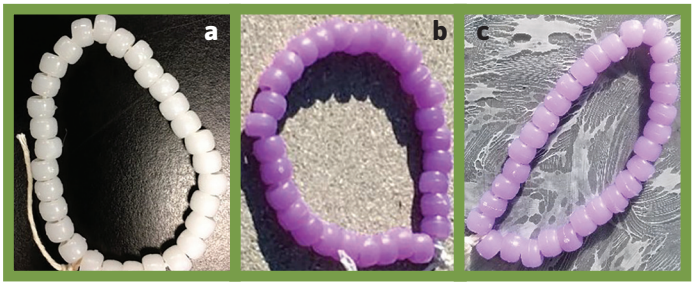

Figure 1 A sample UV bead bracelet (a) after no exposure to sunlight; (b) after full exposure to sunlight; and (c) after exposure to sunlight with a particular sunscreen

Testing brands of sunscreens

1. Label one clear bag 'A1' for sunscreen brand A.
2. Place the UV bead bracelet inside the labelled bag.
3. Coat one side of the bag with 1 teaspoon of sunscreen brand A.
4. Place the labelled bag (with UV bead bracelet inside) outdoors on a flat surface in direct sunlight with the sunscreen-coated side facing the Sun.
5. Record changes to the colour of the UV beads bracelet after 15 seconds in direct sunlight by taking a photograph of the bracelet (in the bag) (Figure 1c).
6. Repeat steps 1–5 for sunscreen brand A four additional times.
7. Repeat steps 1–6 for sunscreen brand B and sunscreen brand C.

Data generation

1. Bring all 15 photos (A1–5, B1–5, C1–5) to class for peer ranking (1–5 Likert scale).
2. Place the two reference standard photographs on a table with 'No exposure to sunlight' on the left and 'Full exposure to sunlight' on the right, one metre apart from each other.
3. Place photograph A1 in between the reference standard photographs.
4. Using a Likert scale (e.g. 5 = no exposure and 1 = full exposure to sunlight) rank photograph A1 and record the rank number in the data table (Table 1).
5. Repeat steps 3 and 4 for the rest of the photographs.
6. Calculate the average rank for each sunscreen brand.

Table 1 Data table for recording exposure ranking

Rank of UV bead photo (Likert scale 1–5)			
Trial no.	**Brand A**	**Brand B**	**Brand C**
1			
2			
3			
4			
5			
Average rank			

Results

The results can be plotted as a bar graph with 'Brand of sunscreen' on the *x*-axis and 'Average rank' on the *y*-axis.

Conclusion

Pupils summarize the results of their research, indicating whether they accept or reject their prediction/hypothesis. They should briefly mention difficulties if any were encountered during the research and discuss any suggestions for improving their research. Finally, they state an overall conclusion of their research to determine which brand of sunscreen blocked UV rays the best so that they can use the brand.

Positive aspects of UV radiation

Pupils' attention may also be drawn to the beneficial aspects of UV radiation:

- Both UVA and UVB are beneficial for plants.
- UV waves are visible to some insects, such as bees.
- UV lamps are used to kill germs in water purifiers.
- UV rays help in LASER-assisted eye surgery.
- Limited UV radiation is essential for the human body as it stimulates the production of vitamin D.
- Under medical supervision, UV radiation is used to successfully treat a number of diseases, including rickets, psoriasis, eczema and jaundice.
- In astronomy (NASA, 2010).

Summary

Sunscreen is meant to protect human skin by blocking UV light to a specified extent. This project can be used to inform pupils about the harmful effects of ultraviolet radiation and a discussion can be initiated about the care to be taken to prevent skin damage caused by the Sun's rays. Ultimately, pupils can be guided to read more about the uses and harmful effects of UV radiation from sunlight.

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