Use of Electronic UV Dosimeters in New Zealand School-based Primary Skin Cancer Prevention Programmes – *Kara Chameleon's Sun Smart UV Lab*

'Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand' – Confucius ~450 BC

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Abstract. A New Zealand adapted primary skin cancer prevention initiative is presented, in which school children investigate the nature of solar UV radiation for themselves using small, lightweight, electronic UV dosimeters. The key premise is that SunSmart behaviours are significantly reinforced when students self-discover their effectiveness in reducing harmful UV exposure.

Introduction

New Zealand has recently overtaken Australia as the owner of the highest per capita rates of melanoma in the world, despite having an overall less-harsh UV climate (Whiteman et al. 2016, McKenzie 2018). This is most likely due to a higher commitment to primary prevention programmes in Australia compared to New Zealand.

School-based interventions represent a significant opportunity for changing this unwanted statistic and improving life-long knowledge, attitudes, and behaviour towards solar UV radiation. New Zealand Schools are open for at least 190 days a year, with an outdoor lunch break of up to 50 minutes close to the solar noon when the summer-time UV Index can reach extreme levels, a morning interval of up to 25 minutes, and a curriculum requirement for outdoor physical education classes. As such, a significant proportion of childhood UV exposure occurs on school days, making school-based UV education programmes a significant primary skin cancer prevention opportunity.

In 2013, Dr Kimberly Miller and Prof. Myles Cockburn developed a 1-hour 'UV Dosimetry Laboratory' to provide a 'hands-on' experiential element to the University of Southern California's SunSmart Health Education Programme that teaches elementary school students (9-11 years old) in the Los Angeles Unified School District about sun safety, through interactive lessons and group activities (Miller at al. 2015). This experiential element involved students carrying out their own investigations, with guidance where required from trained facilitators, collecting UV exposure data from their school environment and comparing the results with their own predictions. These activities provided students with an opportunity to investigate the nature of UV radiation for themselves rather than just being told about it.

The UV dosimeters were designed and produced by Assoc. Prof. Martin Allen of the University of Canterbury and MacDiarmid Institute for Advanced Materials and Nanotechnology. They are small (35 mm × 13 mm), lightweight (19 g), with a long battery life (> 6 months) and have been verified in a wide range of research studies, including investigating the UV exposures of skiers, school children, outdoor workers, marathon runners, and elucidating the photo-production of Vitamin D among the general public (McKenzie et al. 2005, Wright et al. 2007, McKenzie et al. 2013, Scragg et al. 2017).

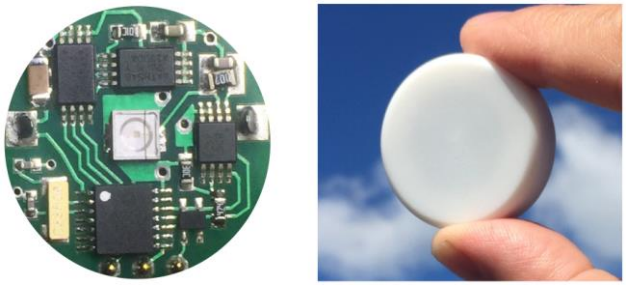

Figure 1. Electronic UV dosimeter produced at the University of Canterbury for use in the SunSmart UV Lab.

New Zealand tailored 'SunSmart UV Lab'

To tailor the programme for New Zealand primary schools we have focused on a student-led experimental verification of New Zealand's sun safety messages. In simple words, students are encouraged to investigate the recommended NZ SunSmart behaviours: Slip *on a shirt*, Slip *into the shade*, Slop *on sunscreen*, Slap *on a hat* and Wrap *on sunglasses*. This is done in the **UV SunSmart Lab** in which students use UV dosimeters to verify the effectiveness of these behaviours in reducing the risks of harmful UV exposure. Specifically, they will directly measure the reduction in sunburning UV radiation (measured in UV Index units) produced by different types of shade, sunglasses, school clothing, and sunscreen. The SunSmart UV Lab represents a real scientific experiment with learning outcomes that can be directly linked to the mathematics, science, and health curricula.

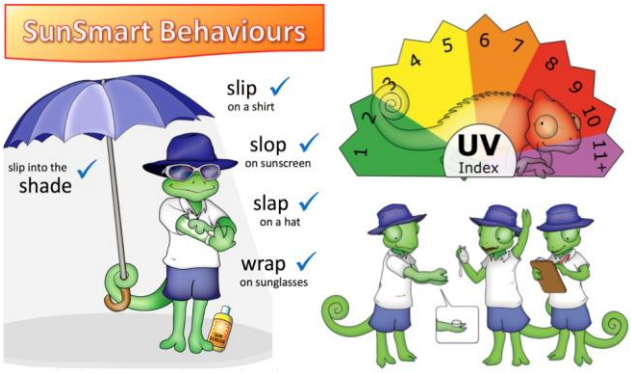

Figure 2. Kara Chameleon – cartoon vehicle for delivering SunSmart messages and the SunSmart UV Lab.

A cartoon character called **Kara Chameleon** has been designed by Dr Alana Hyland at the University of Canterbury to demonstrate New Zealand's recommended SunSmart behaviours and also show students how to carry out the SunSmart UV Lab. Chameleons are remarkable creatures that can sense UV light and rapidly change colour in response to their environment by changing the spacing between nanocrystals in their skin. They are therefore an appropriate vehicle to explain how the UV Index and its coloured warning categories work.

SunSmart UV Lab - Programme Delivery

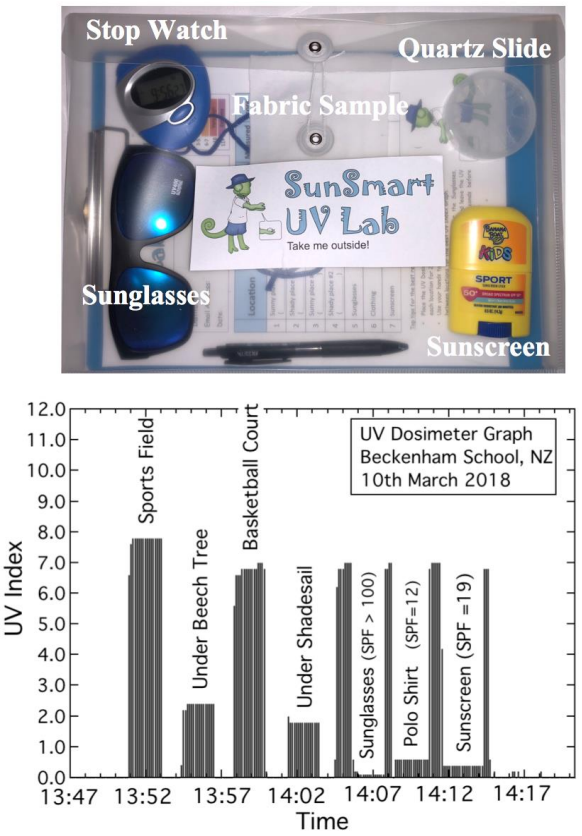

Figure 3. (a) SunSmart UV Lab resource pack containing the student worksheet, stopwatch, sunglasses, polo-shirt fabric sample, sunscreen and quartz slide; and (b) an exemplar UV Dosimeter Graph with sunny/shade locations and sun protection items.

The basic SunSmart UV Lab consists of two main parts: the first is an investigation into the effectiveness of shade in reducing the intensity of sunburning UV radiation. This involves placing the dosimeter on a flat surface (to directly measure the UV Index) for two minutes in two sunny and two shady locations around the school environment. Suggested choices include the sports field, play ground, under a tree and a shade sail. The name of each location and the time that the dosimeter was deployed are recorded on a student worksheet. The second part is an investigation of the UV protection provided by sun protection items such as sunglasses, clothing, and sunscreen. The students return to a sunny location and re-measure the UV Index in direct sunlight. The dosimeter is then covered by each of the items allowing their ability to reduce harmful UV exposure to be directly measured.

The outdoor data collection takes about 20 minutes to complete, after which the students return the dosimeter to their teacher/facilitator who downloads the dosimeter data and provides each student with a printed graph of the results, see Figure 3(b). The students then label their UV Dosimeter Graph with the locations and sun protection items that they have investigated by comparing the times recorded on the worksheet with those on the graph. The students are instructed to keep the dosimeter covered between measurements as this produces a very clear 'Manhattan-style' graph that can be easily labelled. The students then discuss their results and make conclusions about the effectiveness of shade, sunglasses, clothing, and sunscreen in reducing the risk of harmful UV exposure.

There is significant scope for extension activities such as measuring the sun protection provided by a range of different clothing materials and sunscreen products, and investigating the differences in sun protection provided by baseball and bucket hats. In addition, the dosimeters can be placed outside on a clear-sky day to produce a graph of the daily variation in UV Index on which the students can mark their morning interval and lunchtime breaks.

SunSmart UV Lab - Pedagogical Issues

The USC 'UV Dosimetry Laboratory' was originally designed to be carried out in teams of four students with each member taking on a specific role: These are **The Dosimeter Holder** (carries the dosimeter and makes sure it is covered up between measurements to produce the best data); **The Location Scout** (chooses the sunny and shady locations in discussion with the rest of the team and carries the sunglasses, clothing, sunscreen); **The Time Keeper** (operates the stopwatch to make sure that the dosimeter is uncovered for 2 minutes in each location); and **The Note Taker** (records the locations and measuring times on the worksheet). However, depending on the class size and availability of resources, the team can be reduced to three or even two students by combining these roles.

Wherever possible, activities and learning outcomes should be linked to the health, science, and mathematics curricula, so that the SunSmart UV Lab can be fully credited as teaching and learning time. For example, mathematical activities can include calculating the sun protection factors (SPF) of different types of sunglasses, clothing, sunscreen, and graphing exercises plotting the daily variation in UV Index (the appropriate dosimeter data can be provided in table form at 30 min intervals).

Figure 4. A student Note Taker and a polystyrene head used in extension activities comparing the effectiveness of baseball and bucket hats.

UV Colour Change Chameleon Models

In a further extension to the SunSmart UV Lab, a range of 3-D models of 'Kara Chameleon' demonstrating different SunSmart behaviours have been designed and printed using UV colour changing PLA filament by Dr Alexander Salkeld of the University of Canterbury. PLA is a biodegradable polylactic acid polymer derived from corn or potato starch. These models rapidly change colour from white to blue/purple on exposure to UV radiation, with a recovery time of approximately 1-2 minutes. These colour change models can be used to visually illustrate the UV protection provided by hats and other sun protection items and can even be used indoors using a UVA LED torch to mimic the sun.

Figure 5. Kara Chameleon UV colour change 3-D printed PLA models.

Conclusions

A powerful school-based, hands-on primary prevention intervention in which students use small, lightweight, electronic UV dosimeters to verify the effectiveness of SunSmart behaviours for themselves has been developed with the objective of reducing New Zealand's world leading rates of skin cancer.

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