

Raffles Institution  
Year 2 Research Education  
Final report

How to harness green roof technology in schools to encourage Singaporean students, through CCAs, to play an active role in reducing carbon footprints and controlling the negative effects of greenhouse gases?

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### **Abstract**

In Singapore, many students do not see the need to protect the environment. Thus, this study seeks to investigate the feasibility of educating Singapore youth about the environment and encouraging them to play an active role in environmental protection through the use of green roofs in schools. Surveys were conducted, and most respondents were secondary school students. Two interviews were also conducted with two interviewees from secondary school to gain insight into the matter. After further analysis, it was observed that most did not really know about green roofs, but had a positive perception of green roofs. They also had moderate environmental awareness. Thus, active participation in environmental protection through the use of green roofs should be possible with more education about green roofs and the severity of climate change, and how to play an active role in minimising their carbon footprint.

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# 1 Introduction

## 1.1 On green roofs

### 1.1.1 Definition

Green roofs involve growing plants on roofs, which can be sorted into muscinal roofs, herbaceous roofs and arbustive roofs (Madre et al., 2013).

## 1.2 Benefits

### 1.2.1 Summary

They can reduce energy demand on space conditioning, help in purifying air, and if widely adopted, could reduce the urban heat island effect, among other benefits (Liu, 2002).

### 1.2.2 Economic

Research on green roof technologies has so far proven them beneficial, with Liu, 2002 mentioning that they can reduce energy demand on space conditioning and decrease temperature fluctuations. This is agreed on by Mithraratne, n.d. who states that increased roof insulation could reduce space conditioning required in the building. Other sources also mention the decreased carbon emissions due to lower energy consumption from improved thermal performance (Wilkinson et al., 2014) which reduces cost of energy as there will be up to a 75 percent decrease in energy usage for cooling the building, with daily averages dropping from 7.5kWh to 1.5kWh (Liu, 2002). Liu, 2002 also mentions that daily temperature fluctuations on roofing membranes are significantly reduced, which can increase the lifespan of the roof.

### 1.2.3 Environmental

Liu, 2002 states that if green roof technologies are widely adopted, they could reduce the urban heat island effect (a situation where an urban area has higher temperatures than surrounding rural areas) by having the plants on the green roofs absorb some of the heat. Hui, 2010 also suggests that it “mitigates the urban heat island effect”. It is also said that green roofs can increase the aesthetics of urban landscape, reduce glare for surrounding buildings, showing its importance and relevance in today’s highly urbanised society. Additionally, Hui, 2010 found that green roofs can mitigate air quality issues, which are important for the wellbeing of all. Therefore, we find that there is a need to educate students, especially those in secondary institutions (as they are mature enough to understand the gravity of global warming and climate

change and the need to take immediate action, and are more likely to have time to undertake this project than those in tertiary institutions) about green roofs. Vegetation on green roofs help purify the air and convert carbon dioxide into oxygen, which reduces the amount of greenhouse gases in the air. (Liu, 2002) mentions this, and Wilkinson et al., 2014 goes a step further, even suggesting that green roofs help achieve zero carbon footprints. The plants also take in rainwater, reducing the water in the sewage system which needs to be purified and discharged to the sea, helping to stabilize the groundwater level and reducing the possibility of the sewer clogging and malfunctioning.

## 1.3 Purpose and significance of research question

### 1.3.1 Purpose

To find ways to, through green rooftop technology, increase Singapore students’ awareness of climate change and how they can play a part in reducing it. See below for more information as to how this topic is relevant to today’s dynamic and modern society.

### 1.3.2 Significance

Climate change is of significant importance. According to NASA, n.d., at the rate of climate change we are at, the sea levels worldwide would increase by 1–4 feet. This leads to the question of whether Singapore would truly be safe in the future. This thus draws the necessary attention and action of the Singapore Government and the citizens. Actions required includes educating the youth of the society of the consequences of climate change and the possible course of action. However, students in Singapore have “major gaps in their understanding [of climate change]” (Chang & Pascua, 2016), and thus will not see the need to protect the environment and prevent it. Therefore, it is necessary for us to research methods that can be used to raise awareness of climate change in Singaporean students. At the same time, we believe that green roofs can be an effective measure in fulfilling its purpose in combating climate change and in motivating the Singaporean youth to play an active role in it. Green roofs are a potential way to not only encourage the next generation of Singaporeans to take climate action, when the country is in their hands. Proper education of the youth would, hopefully, eventually lead to a rise in green technology and build a greener, healthier world for everyone to live in, one that is possibly freed of the grasps and struggles of climate change. Even in Singapore, green roofs have been

utilised on buildings such as the Nanyang Technological University’s School of Art, Design and Media. According to Berardi et al., 2014, green roofs not only play a part in helping to slow climate change, they also help create a better environment for residents.

## 1.4 Target Audience

We chose secondary school CCAs as our target audience as they are old enough and mature enough to understand the implications of global warming and climate change, and global warming. They will also be the leaders of tomorrow, so it is even more important for them to understand this.

## 1.5 Adoption

If adopted in schools by having students to take care of and keep up the green roofs, the students would then build this habit of caring for and maintaining a green roof, something they would hopefully continue to do upon reaching adulthood in the future when they would be able to realise human impact on the environment. This is even more important should they become national leaders, who have the power to influence the lives of other people. Having this influence from young, they would then turn to such technologies which can affect climate change for the better.

# 2 Methodology

## 2.1 Purpose

We believe that green roofs are severely underused in Singapore despite the advantages, and think that schools are a great place to have them implemented. The surveys and interview we conducted were in order to find out Singaporean students’ awareness and perception of green roofs, as well as the viability of, and their willingness to assist in green roof projects in schools.

## 2.2 Interviews

Two interviews were conducted. To have more accurate and fair data, we chose two interviewees from two different schools and different genders. We carried out the interview on 28 June 3pm. As both interviewees were unable to use Microsoft Teams due to a lack of access, we used other means to conduct the interview, such as Zoom or Discord video calls. The first interviewee was a girl studying in Nanyang Girl High, and the second was a boy studying in West Spring

secondary. This is to ensure diversity and fairness as both parties may have certain bias held against green roofs.

## 2.3 Surveys

The survey respondents came from two different age groups: primary and secondary school students. In total, we received survey responses from 21 students, one of which was not a serious response (evident from the options selected, which were all falling in the “Strongly disagree”, “False”, or similar categories, even disagreeing to the PDPA clause). Hence, we chose to omit the data gathered from that respondent and focus on the other 20 respondents. However, 19 of the remaining 20 respondents indicated that they were of 13–17 years of age, and hence the demographics of our survey were quite limited and the data collected may (unfortunately) not be representative of the entire student population in Singapore.

# 3 Results

## 3.1 Summary and results

In general, we found that the majority of Singaporean students are supportive of the concept of green roofs, from Fig. 1. Furthermore, as is shown in Fig. 2, respondents with more knowledge of green roofs were, on average, more environmentally aware and showed more support, and thought they were more effective in general.

We also think that more education to students about green roofs is necessary in order for them to fully understand their benefits. As shown in Section 3.1, students were generally more supportive of green roofs if that had more knowledge of them. However, Fig. 3 clearly shows that most students are lacking in knowledge of green roofs. Therefore we view further education on green roofs essential to achieving greater support for green roofs amongst students, thus making it more likely for them to be willing to participate actively.

## 3.2 Interpretation

These results showed that in general, teenagers in Singapore were supportive of the idea of green roofing. When asked about the practical usage of green roofs, 95% of respondents agreed on all aspects that they believed green roof systems being implemented would be a good idea. The one respondent that did not

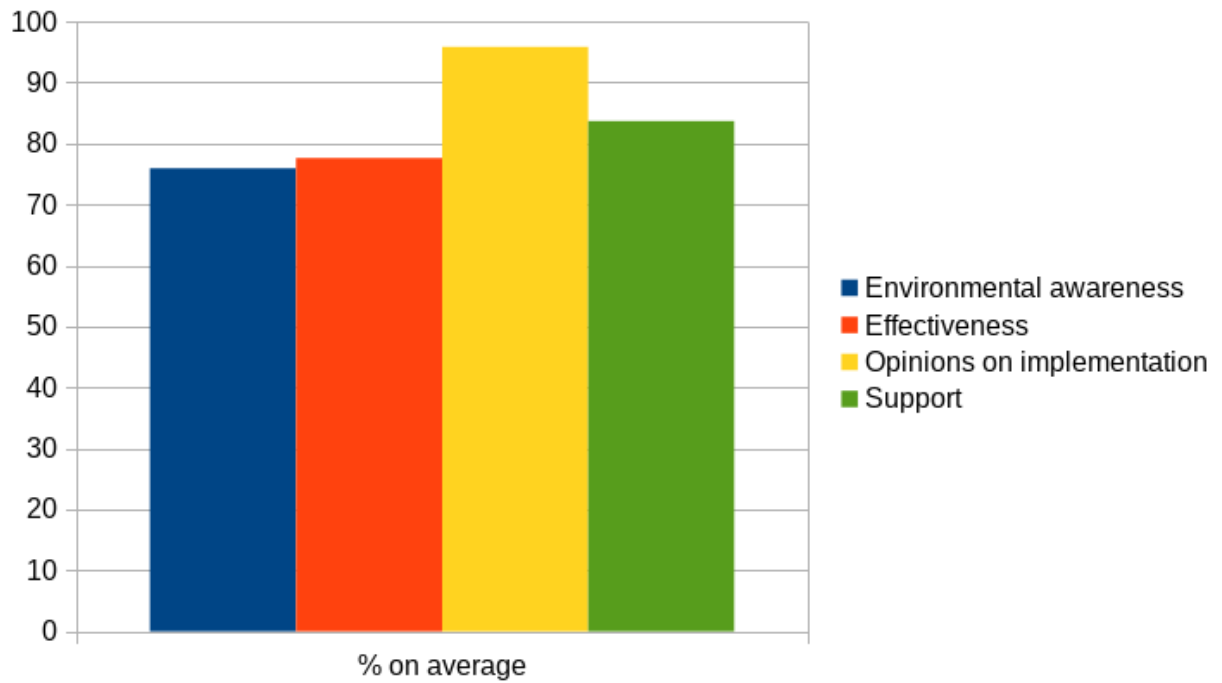


Figure 1: What respondents think of green roofs on average

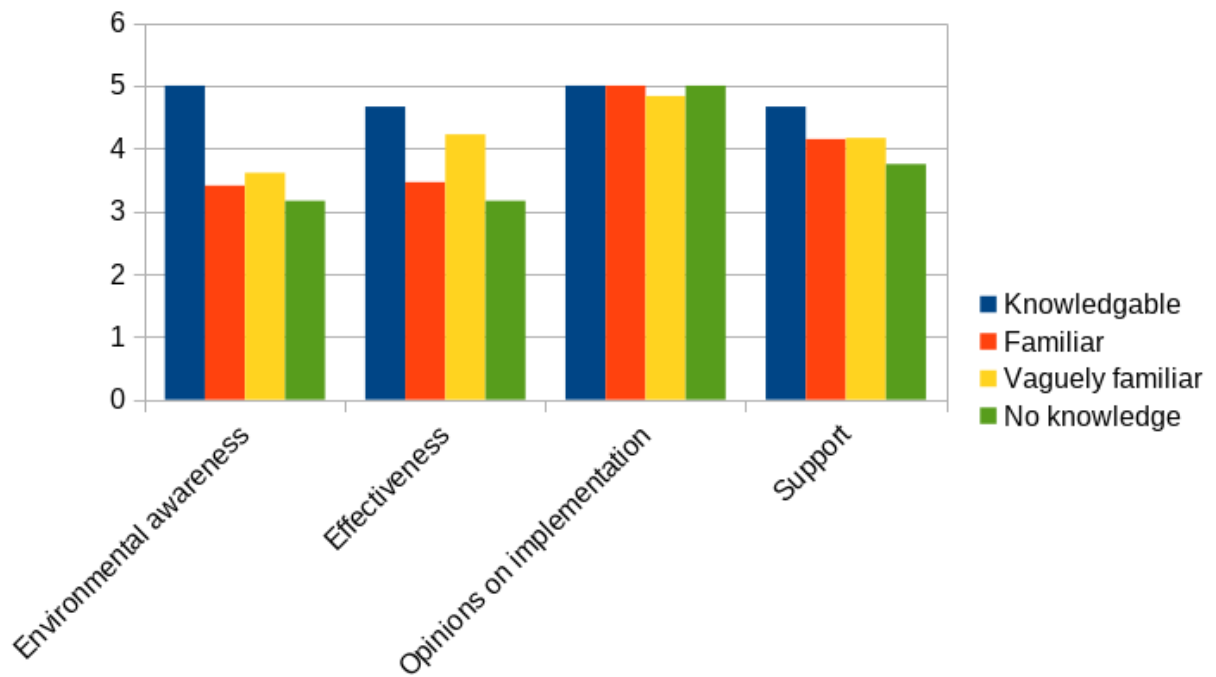


Figure 2: Subgroup analysis of Fig. 1: knowledge of respondents against what they think of green roofs

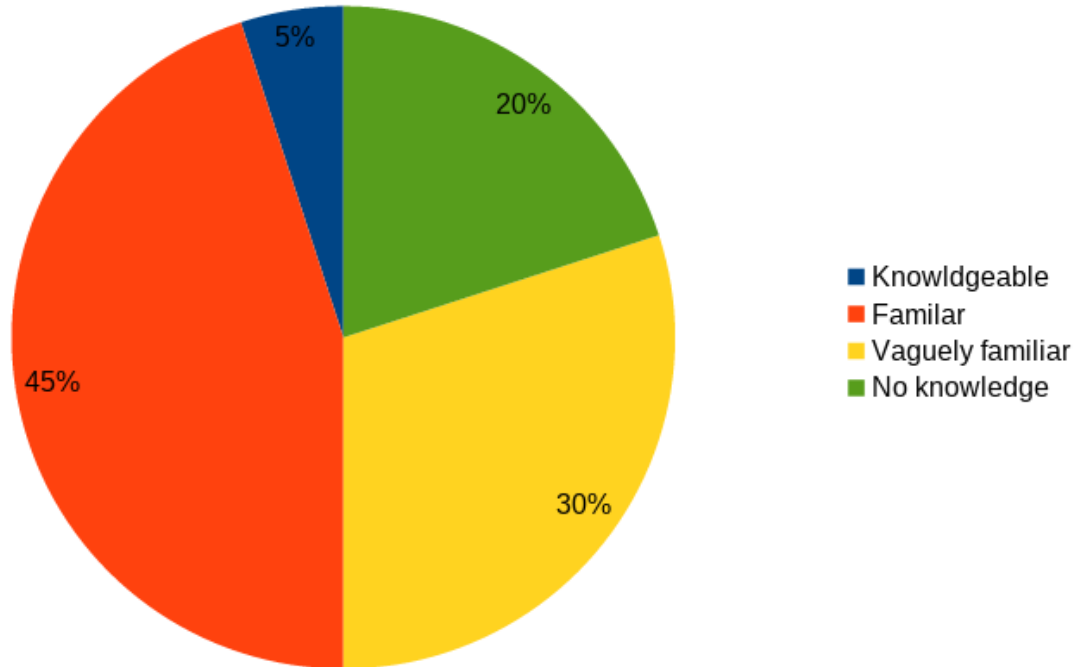


Figure 3: Knowledge levels of respondents

agree on every aspect noted that building green roofs was a waste of effort, but agreed on all other parts.

### 3.3 Analysis

We noticed that despite the varying levels of understanding of green roof systems, there was no clear and specific pattern where acceptance and questions regarding the use of green roofs was concerned. The questions to gauge their understanding were based on two research papers by Hui, 2010 and Liu, 2002, but respondents often showed varying degrees of agreement across those aspects listed. This suggests that despite their indication of their understanding of green roofs, their actual understanding may be different, or due to their individual perceptions. Hence, it was difficult to come up with sub group analysis. Interestingly however, we also noticed that when comparing the responses of people who indicated that they were only 'vaguely familiar' with green roofs were generally more optimistic about than ones who indicated that they were 'familiar' with them. Unsurprisingly, though, the single respondent who indicated that he was "knowledgeable" about green roofs was the most optimistic, fully agreeing to most of the statements.

## 4 Discussion

### 4.1 General perception of green roofs

Wilkinson et al., 2014 found that 55 percent of respondents to a survey conducted "strongly agreed" that greenery was important and its benefits outweighed its additional costs, showing public support of this idea suggesting that our idea may be quite welcome. This is supported by Mithraratne, n.d., who said that with therapeutic value of greenery in reducing stress already established, green roofs are used commonly in Singapore to soften the harsh urban environment and to improve the quality of life. Modern green roofs are now mainly based on cost, energy, water savings and carbon reduction Mithraratne, n.d. 71.8 percent of respondents in a survey conducted by Wilkinson et al., 2014 stated that greenery would make a place more attractive to live in meaning that greenery could have a positive impact on people's lives, especially for students who spend time in school. However, Castleton et al., 2010 also found that 33.8 percent of respondents to their survey had less than a general understanding of the concept of green roofs—with the oldest(76+) and youngest(12–17) age groups showing the least understanding, further stressing the need to educate students about green roofs, although this may be inaccurate due to the small sample size. However, Chang and Pascua, 2016, also found that

students in Singapore do not fully understand climate change.

## 4.2 Raising awareness of green roofs

Currently, as

## 4.3 Possible implementations

We propose that students be grouped according to three different CCA groups: sports, performing arts and uniformed groups, with each group doing its own part. The students in sports CCAs and uniformed groups will carry out the physically more demanding tasks (e.g. doing the actual planting itself and taking part in maintenance with the assistance of professionals, etc.) since they are more used to carrying out such physical tasks than the students in performing arts CCAs. The students in performing arts CCAs can manage the logistics (planning projects, budgets, etc.) seeing that they are likely to be less physically

inclined while everyone still keeping to the recommended guidelines by Hui, 2010.

## 5 Limitations

As we only had a limited amount of time, we may have collected insufficient data to fully justify our conclusion, hence the conclusion may not be entirely reliable.

## 6 Conclusion

Current research has shown that green roofs can be beneficial by maintaining a stable temperature, reducing space conditioning, amongst other benefits. However, there is still a knowledge gap where Singaporean students' perceptions of green roofs and its viability in schools are not addressed which is why our research is relevant and necessary.



## References

- Berardi, U., GhaffarianHoseini, A., & GhaffarianHoseini, A. (2014). State-of-the-art analysis of the environmental benefits of green roofs. *Applied Energy*, 115.
- Castleton, H., Stovin, V., Beck, S., & Davison, J. (2010). Green roofs; building energy savings and the potential for retrofit. *Energy and Buildings*, 42.
- Chang, C.-H., & Pascua, L. (2016). Singapore students' articleonceptions of climate change.
- Hui, S. C. M. (2010). Development of technical guidelines for green roof systems in hong kong. *Proceeding of Joint Symposium 2010 on Low Carbon High Performance Buildings*, 01.
- Liu, K. (2002). Energy efficiency and environmental benefits of rooftop gardens. *Construction Canada*, 44.
- Madre, F., Vergnes, A., Machon, N., & Clergeau, P. (2013). A comparison of 3 types of green roof as habitats for arthropods. *Ecological Engineering*, 57.
- Mithraratne, D. N. (n.d.). Carbon footprint of green roofs in singapore. *Proceedings of the Sustainable Buildings - Construction Products and Technologies*.
- NASA. (n.d.). The effects of climate change.
- Wilkinson, S. J., Osmond, P., Heller, A., Manion, J., Sumich, M., & Sharman, L. (2014). Community awareness of green roofs in sydney. *Community awareness of green roofs in Sydney Conference Proceedings*.

# Appendices

## A Research project timeline

Table 1: Our Timeline

Time	Goal
T1W5–T1W9	Group Project Proposal
T1W9–T2W3	Literature review
T2W3–T2W7	Finish finalised survey
T2W7–T3W1	Administer survey
T3W1–T3W4	Data analysis
T3W3–T3W9	Prepare for oral assessment
T3W4–T3W10	Finalise written report