Landscapes of Participatory Making, Modding and Hacking
Landscapes of Participatory Making, Modding and Hacking: Maker Culture and Makerspaces

Edited by Kenneth Y T Lim

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# Table of Contents

List of Tables and Figures ................................................................. vii

Preface ................................................................................................ ix

Chapter One .................................................................................... 1
Doorways to Making
Kenneth Y T Lim

Chapter Two ................................................................................... 13
Establishing a FabLab in a School
Susan Just

Chapter Three ................................................................................ 35
Bridging Transboundary Spaces through Making
Michael Vallance

Chapter Four .................................................................................. 55
Making Knowledge and Surfacing Intuition through a Citizen Science Game
Ladan Cockshut

Chapter Five .................................................................................. 83
Journeys in the Making: Supporting Thinkering through Maker Motes
Kenneth Y. T. Lim

Chapter Six .................................................................................... 107
FabLearn, FabLab, MakerEd, Experimental Laboratories:
Towards a Discussion of a Theory of Maker Education from a Brazilian Perspective
Rodrigo Barbosa e Silva and Luiz Ernesto Merkle

Contributors ................................................................................... 131

Index ............................................................................................... 135
LIST OF TABLES AND FIGURES

Table 1 Initial brainstorming key words .......................................................... 18

Figure 1 A puzzling photograph .................................................................... 1
Figure 2 A closed unmarked door ................................................................... 3
Figure 3 Access protocols .............................................................................. 3
Figure 4 Noisebridge .................................................................................... 4
Figure 5 Dim Sum Labs ................................................................................. 4
Figure 6 Novice trainees practicing on a flight simulator ............................. 6
Figure 7 Repairing a crashed kite .................................................................. 6
Figure 8 Cannibalisation of aeromodelling parts to craft a land-based go-kart .................................................................................................... 7
Figure 9 An early blueprint for the improvised go-kart................................. 7
Figure 10 Refined chassis with a low centre of gravity ................................. 9
Figure 11 Makers on parade ......................................................................... 10
Figure 12 The basic wooden structure the first STEM class (Semester 2, 2013) was required to improve ................................................................. 20
Figure 13 Reversing switch to drive 3V motor and gearbox (Semester 2, 2013) ........................................................................................................ 21
Figure 14 Finished houses from first cohort of students in Year 10 STEM elective (Semester 2, 2013) ............................................................................. 22
Figure 15 Students’ initial design approach (Semester 2, 2014) .................. 25
Figure 16 More innovative design approaches (Semester 2, 2014) .......... 26
Figure 17 More innovative design approaches (2015 & 2016) ................. 28
Figure 18 Innovation (2016) ......................................................................... 28
Figure 19 Constructing NXT robot program blocks in Second Life .......... 29
Figure 20 An example of a control station in OpenSim ............................... 40
Figure 21 LEAP Motion controller being used for the remote manoeuvring of an EV3 robot via the OpenSim Training Area ....................... 43
Figure 22 Interactions in OpenQwaq ............................................................. 44
Figure 23 Interface and controls ................................................................... 46
Figure 24 Robot retrieving a radioactive bin in virtual Fukushima .......... 46
Figure 25 Tsunami flooding in virtual Fukushima ......................................... 47
Figure 26 Maneuvering a robot in Oculus Rift ............................................. 48
Figure 27 Virtual craft using LEAP and Oculus Rift .................................. 49
Figure 28 A 3D object created in virtual space .......................................... 50
Figure 29 A 3D object printed using a 3D printer ........................................ 50
Figure 30 Screen capture of the Zooinverse citizen science portal ............. 64
Figure 31 Low-cost environmental sensor and hub .................................. 85
Figure 32 Placing a self-contained low-cost environmental sensor ........... 91
Figure 33 Example of how the intervention lends rich spatial context to environmental data ................................................................. 94
Figure 34 Teachers having hands-on experience with Maker Motes ........... 95
Figure 35A Overview of crowdsourced potential of Maker Motes ............. 98
Figure 35B Framing the curriculum within a crowdsourced model .......... 99
Figure 35C Crowd-based data sourcing in the cloud ................................ 99
Figure 35D Maker Motes for the wider social good .............................. 100
The impetus to write this book came in the summer of 2014, when some of the authors represented within these pages had just participated in a lively panel discussion during the annual conference of the Royal Geographical Society that year.

Entitled *Geographies of making: the jazz of participatory fabrication, improvisation and hackerspaces*, its Call for Proposals read as follows:

The Industrial Revolution of the nineteenth century introduced the world to mass production and to Fordist production flows. In the late twentieth century, phenomena such as jet travel, the internet, and outsourcing prompted some pundits (e.g., Friedman, 2005) to propose metaphors of a flattened world, with concomitant implications on space, geography and the (supposed) death of distance.

As our present century unfolds, technologies and socio-cultural phenomena such as the internet of things, crowd-sourcing, digital fabrication, and wearable computing are not only democratizing the potentialities of participatory design, prototyping and production, but are also becoming increasingly enmeshed with – and breathing new life into – ways of making more associated with cottage industries than with how production has been studied and understood for at least the past hundred years.

As circuits mashup with woodcraft and beadwork, as the clothes we wear identify themselves with their own unique digital signatures, and as interest-groups carve out fabricative spaces of their own across major urban centres worldwide, what might the implications to all we have studied and known about the geographies of industrialization, of industrial location, of urbanization, of regional divides be? What might some of the narratives be behind the emergence of maker cultures and hackerspaces?

This call is still relevant today. These pages represent an assemblage of such stories, and it is hoped you will draw your inspiration from them, as you seek to chart your own journey in the making.

The chapters in the remainder of this book develop these preceding themes in a myriad of ways.
Reference

In January 2013, a new school year was beginning in Singapore. My team of research assistants and I were at a state-funded school, helping a geography teacher with her lesson, using an immersive environment that we had co-designed. I was heartened to see the Grade Ten students in animated conversation during the discussion, until I realised that what they were so excitedly talking about was not their experiences from the lesson. Instead, I found them sharing pictures from their phones. I squinted to try to make out what the pictures were depicting, but I could not. Have a go at making this one out:

![A puzzling photograph](image)

**Figure 1** A puzzling photograph
It turned out that this was a photograph of radio-controlled kites. The students were very excited about this and similar photographs because they had spent the better part of their December holidays modifying / “modding” / “hacking” these kites with light-emitting diodes (LEDs) and trying to improve their flying characteristics. The students were showing a lot more interest in sharing these photographs than in discussing their experiences of our carefully designed formal curriculum lesson.

It turns out that there was a fascinating story behind this simple photograph, which – at first glance – shows something quite unintelligible. And therein lies a metaphor, which runs throughout the chapters in this book. Namely, attempting to describe the landscapes of making, maker culture, and makerspaces is an endeavour which requires intentionality and keen observation while rewarding patience and respect. And one never knows when Schrödinger’s Cat might show up.

As serendipity would have it, January 2013 marked my introduction to maker culture and makerspaces in a fairly elaborate way for even before the aforementioned geography lesson, I was fortunate enough to spend a week in early January visiting makerspaces on both the East and West Coasts of the United States. If I learned anything from these visits, it was that cultures of making dialectically evolve from their respective local socio-cultures. Since that first visit, I have also had the privilege of visiting makerspaces in East Asia, such as in Hong Kong and Singapore. Whether it be Dim Sum Labs or HackManhattan, Noisebridge or hackerspace.sg, a great many cultures of making still – for better or worse – situate themselves along the periphery of (what might loosely be constituted as) the “mainstream”; in fact, such peripheries are not only metaphorical but quite literal in terms of their siting within urban morphologies.

Closely coupled with such peripheral situations is the question of access. It is not uncommon for makerspaces to not only situate themselves behind closed doors but behind such doors with elaborate – and sometimes deliberately obfuscated – protocols of access. Take, for example, the following figure.
This innocuous unmarked door in a school in Singapore represents the sole means of access to the magic of the student-initiated makerspace described later in this chapter. One can imagine how easy it is to walk past it. In fact, that is precisely what adults are supposed to do; on the obverse of this door, inside the actual space, one finds this sign:
Across the landscapes of making, such issues of periphery and access are more common than one would think. Thus, for example, we have the façade of Noisebridge in San Francisco:

![Figure 4 Noisebridge](image)

And the façade of Dim Sum Labs in Hong Kong:

![Figure 5 Dim Sum Labs](image)
It can therefore be seen that from their origins in the polytechnic and vocational cultures of Germany, makerspaces have crossed oceans and emerged and/or attempted to be nurtured in countries such as South Korea, Thailand and Singapore (Endgadget, 2004). The story of the students and their modded kites transcends the boundaries of both the formal and non-formal curricula. Specifically, schools in Singapore oblige students to participate in at least one so-called co-curricular activity (CCA). The CCAs organize after-school activities with the aim of building character and leadership qualities among the students.

One example of a uniformed CCA group is the National Cadet Corps (Air) (NCC (Air)). The NCC (Air) curriculum has two main components: foot drills and aeromodelling. To build a healthy sense of competition and esprit de corps across the various NCC (Air) units placed in schools in Singapore, annual aeromodelling competitions are organized on an inter-school basis.

A corollary of the training as student-cadets prepare for such tournaments is that their remote-controlled scale-model aircraft will crash and will need to be repaired or replaced. Each school-based NCC (Air) unit is given autonomy with regards to crafting the curricular enactments in order to best prepare the cadets to fly the aircraft skilfully. At the school described in this study, the NCC (Air) student-cadets designed a scaffolded curriculum spanning the four years of secondary school. The novice trainees (typically aged twelve to thirteen) are introduced to the principles and concepts of flight through flight simulation software (see Figure 6). They then progress to practicing on remote-controlled powered-kites, and finally to the scale-model aircraft.
Chapter One

Figure 6 Novice trainees practising on a flight simulator

What distinguished the student-cadets at the school from their counterparts at other schools in Singapore is that they had developed a strong “can do” / improvisational spirit within themselves, and this was primarily evident in how they approached tinkering with and repairing the design of the stock, off-the-shelf kites and model aircraft they flew (see Figure 7).

Figure 7 Repairing a crashed kite
Of equal interest is how some of the more senior student-members within the team went beyond just tinkering with the design of flying models, and cannibalized parts to diversify into land-based (Figure 8), and even prototype water-based, craft.

Figure 8 Cannibalisation of aeromodelling parts to craft a land-based go-kart

To elaborate, six of the senior student-members began to iterate designs and prototypes. A blueprint for an early design is shown in Figure 9.

Figure 9 An early blueprint for the Improvised go-kart
In focus group discussions with the students, they described this initial design as follows:

The RC Car V1’s body was to have been made of wood. The car would have been propelled forward by the two motors driving its back wheels. The rotation of the wheels would depend on the plastic servo located at the front of the car. However, the RC Car V1 was not built as there were various safety concerns and budget issues.

The number of bespoke parts needed for their first iteration led them to look for possible sources to cannibalise. They described their thinking thus:

The RC Car V2 was conceptualised and subsequently built but there is no image available as it was dismantled on the same day it was constructed. The car’s body was made of wood. The car was made with two sets of Cessna (aircraft) landing gear. It was intended to showcase how Cessna parts could be readapted to serve a different function as a demonstration of creativity. One of the landing gear was glued at the back of the car while the other landing gear was attached to a servo, allowing the car to turn. A motor was attached to the back of the car in order to propel the car forward.

The students shared that during the course of their iterative attempts, they appropriated – with the permission and supervision of teachers – parts, materials and machining tools from the school’s metalworking workshop managed by the Design and Technology Department, even though they were not necessarily taking Design and Technology as an academic subject.

In fact, they went even further, because in some cases they found the soldering tools “not precise enough”. In these cases, they leveraged their social capital with the proprietor of the local kite-supplier to gain access to the better-maintained and up-to-date tools found in the proprietor’s personal workshop, even though this entailed a half-hour bus journey beyond their local estate.

Of particular interest was that – as they continued iterating the design, and because they were personally invested in a task which was both authentic and meaningful – the student-cadets gradually appropriated the epistemic frame (Shaffer, 2007) of the designer and the engineer; thus, for example, they were able to describe a subsequent iteration of the go-kart (Figure 10):
The RC Car V3 reuses the same wooden car body used by RC Car V2. However, a major design alteration involves wheels connected by carbon rods instead of the Cessna landing gear. This alteration was made to lower the centre of gravity so that the car would be more stable. A Karbonite servo was used to turn the wheels instead of a plastic servo as the plastic servo will vibrate the moment the wheels are attached.

![Figure 10](image.png)

**Figure 10** Refined chassis with a low centre of gravity

In these and other ways, the maker culture that has spontaneously emerged within the NCC (Air) at the school found enactments through seamlessly negotiating formal and non-formal structures of time and space within and without the schooling curriculum of an East Asian society more often associated with rules, laws, fines and regimented prescription.

To summarise, learners engaging in participatory performances in which they derive authenticity thrive on – and look forward to – having their respective creative processes critiqued by social others; one only needs to look at trust-based online communities – such as Flickr, YouTube, eBay, Amazon and fan-authored wikis – for evidence of this. This can be thought of as akin to a shift from a quasi-Cartesian “I am what I own / I am what I control” to “I am what I share with others to build upon”.

For example, Figure 11 shows a more stereotypical conception of what might be expected from a uniformed CCA group, and is all the more remarkable because it depicts the same student-cadets (on parade) as those who are active participants in their local makerspace.
This case example suggests that the student-cadets were successfully able to negotiate formalized regimental protocols as well as leverage – often informally through their own social networks – seemingly peripheral actors and structures such as kite-sellers, metal-working workshops and tools. They were able to operate fluently across what might initially come across as hard boundaries because they derived meaning and authenticity from their membership and participation in interest-driven communities. No one needed to tell them to persevere and improve; instead, they engaged in a complex series of performances encompassing goal-setting, resource evaluation and self- and peer-assessment according to both personal and socially moderated standards.

Fabricated using funds initially pool ed from their own savings, and using scrap materials and tools from the metal- and woodworking workshop in the school, the go-karts and subsequent craft represent authentic examples of remix and thinking that reflect the kinds of students East Asian societies will have to increasingly depend upon in order to stay relevant, adaptive and responsive in the 21st century. Going forward, it would do well for state-funded initiatives to consider how passion-driven street-craft communities might be encouraged through the provision of infrastructure, and access to shared resources, tools and expertise. The role that schools could potentially play in this process – in more structured ways – is taken up in the next chapter.
References


CHAPTER TWO

ESTABLISHING A FABL LAB IN A SCHOOL

SUSAN JUST

In the preceding chapter, a case study was shared on how a makerspace spontaneously emerged from within a co-curricular activity in a school in Singapore. This chapter focuses on how attempts to nurture such maker dispositions in a more intentional manner have resulted in a success story in a school in the Australian state of Victoria.

Lauriston Girls’ School is an independent non-denominational girls’ school founded in 1901. It has an enrolment of approximately 1000 students, spread between Kindergarten, Junior School and Senior School. The school is co-educational in the Kindergarten, three- and four-year-old classes, and all girls from Prep to Year 12.

Students from the Lauriston Girls’ School meet peers from a wide range of cultures. Their families exemplify life and work in a global community. Lauriston families come from a range of ethnic backgrounds which include students from China, Singapore, New Zealand, Malaysia, the United Kingdom and the United States of America.

Year 9 Lauriston students attend a rural campus – Howqua – which is situated near the township of Mansfield, approximately three hours from Melbourne. Attending school from Monday to Sunday, the students complete their academic curriculum and an outdoor programme, which is run two days of each week. The students undertake the programme in five-week blocks and return to their families in Melbourne for an exeat at the conclusion of each five-week block.

The Howqua campus was established on 250 hectares of bushland, and includes classroom facilities, a dining hall and kitchen, a library, art and music rooms, a performing arts building and nine Houses for students.

Lauriston Girls’ School is a non-selective school. Both the Victorian Certificate of Education (VCE) and the International Baccalaureate Diploma programmes are offered in Years 11 and 12. Most students enter into a tertiary course of study. Students choose a broad variety of tertiary

**The vision, mission and values of Lauriston Girls’ School**

At the heart of the Lauriston Girls’ School is a vision for girls’ education that encompasses pedagogical, environmental and pastoral considerations. Central to the success of this vision is the ability of the school staff to think beyond the “now” to plan for an ever-changing and complex future.

**Vision:** The school for life.

**Mission:** It is our mission to enhance the lifelong learning capabilities of all students.

**Values:** The values of the school are:

1. **Relationships:**
   The most effective learning occurs when the teacher / learner relationship is well established. Developing tolerant relationships irrespective of status, race or culture is a fundamental life skill.

2. **Courage:**
   Developing the courage to ask, act independently, think differently, face physical and moral challenges and make decisions.

3. **Creative Reflection:**
   This is a combination of the rational and the aesthetic. This is the key to music, visual arts, dance and higher order thinking skills.

4. **Intellectual Inquiry for Understanding:**
   We all learn but may not understand. To be a lifelong learner, one must value how and why, not only what.

5. **Engagement in Life:**
   Engagement with:
   - Projects and play
   - Teams and games
   - Community issues and giving
   - A sense of national spirit
   - International awareness
   - An ethical and moral life
Why digital fabrication?

The vision, mission and values of the school gave us the impetus to investigate digital fabrication and making. Our school is proud of the broad range of opportunities we provide to our students to not only learn across a range of disciplines but also to undertake experiential learning activities. Through participation in experiential activities, our students have the opportunity to develop their intellectual inquiry skills, build relationships with peers and teachers, and use their creative and critical thinking skills. We endeavour to provide opportunities which will enable our students to be courageous with their learning, expand their interests and develop their repertoire of skills. One example of experiential learning is our Howqua curriculum for Year 9 students. While at the Howqua campus, our Year 9 students participate in full academic and outdoor programmes. Through their participation in the Howqua programme, our students participate in hands-on activities and learn how to collaborate in teams and solve problems. They become more independent as thinkers and decision makers, particularly when they are given responsibility for planning all aspects of the hikes they participate in.

As a school we have come to value experiential or hands-on learning, and there is strong anecdotal evidence of students’ improved self-confidence and ability to collaborate with others as a result. Our intention through this investigation of digital fabrication and making was to first determine ways in which we could further develop the experiential learning activities for our students, and second, consider how we might address the concern that girls are less likely to choose tertiary studies and careers related to science, technology, engineering and mathematics (STEM). We believe that using hands-on equipment and new technologies in a cross-disciplinary approach will assist our students in their learning and help them engage more effectively with STEM. Indeed, through teaching our students how to use and apply these technologies in innovative ways, we are supporting them in participating in a broad range of future careers and interests.

In 2013, while on study leave, I visited the Transformative Learning Technologies Lab at Stanford University’s Graduate School of Education and met with Assistant Professor Paulo Blikstein. Professor Blikstein developed the concept of the Fablab@School, which supports project-based, student-centred learning; this is elaborated on in Chapter Six. The focus on invention, innovation and collaborative problem-solving was evident, and Professor Blikstein believes that students have the capacity to create inventions to solve real-world problems. I was able to visit the
Castilleja School for Girls in Palo Alto, where I observed a Fablab@School in action and students engaging in cross-disciplinary projects. Our school believes that students need to be exposed to hands-on activities in which they have the opportunity to solve real-life or authentic problems. Girls are good collaborators and they have the ability to solve problems, but they are not always exposed to hands-on activities. Our students already had the opportunity to undertake hands-on activities such as robotics, construction and tinkering-tables in classrooms, particularly in our Junior (Primary) School. The Fablab@School would enable us to further develop this work and progress current work into the Senior (Secondary) School, which begins in Year 7.

Lauriston Girls’ School secured an arrangement with Stanford University’s Graduate School of Education to establish a Fablab@School at our school; and with funding provided by the Lauriston Foundation, we opened the FabLab at the end of term 1 in 2014. Our FabLab coordinator is a teacher in our science faculty, and he has both teaching responsibilities within this faculty and a time allowance during the school day for collaborating with teachers and faculties on digital fabrication activities and projects.

**A cross-disciplinary approach**

We determined early in the establishment phase of the FabLab that this would be a cross-disciplinary space which would be available to students and teachers from Prep to Year 12. We firmly hold the view that our students need to be exposed to digital fabrication, design thinking, making and experiential activities from the early years of their primary education, in the same way they are exposed to science, mathematics and technology. We will be better able to engage students with these technologies and ways of thinking when they move into the secondary years of schooling and we provide broad access and multiple opportunities to undertake hands-on learning activities in the early years of a student’s education journey.

As students move through Years 10 to 12, there are more constraints on teachers to maintain a content-rich curriculum and this can result in teacher concerns that cross-disciplinary activities, experiential and hands-on activities may take time away from ensuring that students have been taught all of the required content within a subject discipline. We have found that our Junior (Primary) School teachers and students have more flexibility within their curriculum to redefine units of work so that these include hands-on learning experiences in the digital fabrication laboratory.
Our primary school students engage with the equipment in the digital fabrication laboratory and the design thinking process being introduced to them with enthusiasm. We have observed similar levels of engagement and interest with our Year 7 and 8 students, who enjoy activities which offer broad, real-life problems or situations. These activities are less structured in terms of teacher-directed learning, with only limited guidance provided and a preference for students to resolve design issues and solve problems for themselves. The students are able to collaborate in groups, and our observations reveal their growing ability to manage when provided with a problem or situation with which they are not familiar and where failures are likely to arise. The digital fabrication laboratory provides an environment where our students will more than likely make mistakes, and these situations are both opportunities for learning and persevering to determine whether a workable solution can be found.

Our Visual Communication and Design students and our Art students in Years 11 and 12 use the digital fabrication laboratory equipment and this has expanded their creative capacity in design work and art pieces. Over the last two years, we have observed that students have been able to produce more refined design products and art works with multiple dimensions and new materials, which can be used in the laser cutter or 3D printer. For both primary and secondary students, we have observed the importance of the design element within all of the projects completed in the digital fabrication laboratory. Our students give equal value to the functionality and design features of the artefacts they produce.

Formal school curriculum

The following outline of the Year 10 STEM subject titled "Innovation Design Engineering" offers an insight into how our work in the digital fabrication laboratory has progressed. Our science teachers, including the teacher who became our FabLab coordinator, collaborated in the development of the elective, and with the opening of the FabLab, the elective has been able to progress. The elective subject began in Semester 2 in 2013 and was offered to students in Year 10 with the initial aim of increasing engagement in maths and science (in particular, physics and higher level mathematics) in Years 11 and 12.

Planning for the course began in November 2012 with the objective of developing an elective that would offer girls in Year 10 the opportunity to participate in a practical-based STEM course which would be linked to their classroom curricula in mathematics and science. The key ideas from
an initial brainstorming meeting that formed the basis for the development of this course are listed below in table 1.

<table>
<thead>
<tr>
<th><strong>Innovation Design &amp; Technology</strong></th>
<th><strong>Sustainability: Address issues affecting people’s lives</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goals: Enjoy, GET Curious</strong></td>
<td><strong>Engage: Robots-Programming-Hands on; simple; build; trial and error.</strong></td>
</tr>
<tr>
<td><strong>TimeLine: 15 weeks (35 lessons)</strong></td>
<td><strong>Explore: Use technology; characterise; robotics challenge; higher level robotics</strong></td>
</tr>
<tr>
<td><strong>Stages: Robots, Analysis, Design (Engage, Explore, Extend)</strong></td>
<td><strong>Extend: Term 4 receive topic in term 3 to think through over the break. Design technology to address issue relevant to communities at the scales of the school, the state of Victoria, and internationally</strong></td>
</tr>
<tr>
<td><strong>Activity based – Present final project at assembly</strong></td>
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<tr>
<td><strong>Trips</strong></td>
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<td><strong>Resources</strong></td>
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<tr>
<td><strong>Achievement / Assessment Portfolio, Projects-progressive, Presentation-final, Competency checks?</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Connect with Math, Science, CAS.</strong></td>
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</tbody>
</table>

**Table 1** Initial brainstorming key words

From this meeting, the teachers developed a draft course outline and lesson plan. After many discussions, a final lesson plan was developed and rolled out in Semester 2, 2013.
First delivery of the Year 10 STEM elective
(Semester 2, 2013)

The initial delivery of this course was a highly structured sequence with an emphasis on skill development through a series of predetermined activities for students. Only after these activities were completed was the major project introduced. The major project required the students to modify a prebuilt structure which would improve its ability to insulate against all forms of heat transfer using passive and active approaches. The passive approach involved using insulation the students developed from recycled materials while the active approach required the students to create a motor-driven window that could open and close using a switch they designed. The students could have as many switches as they needed to make the window open and close but the aim was to develop a reversible switch. A solar-powered circuit was also required to operate a fan to assist with cooling of the building.

Initially, all electric circuits were required to be run from a solar cell but due to the limited size and capacity of the solar cells available, this requirement was changed to having the solar cell running only a fan. The concept, however, was incorporated as an important aspect of sustainable house design.

The initial delivery of the course was conducted in the science classrooms. These rooms, purpose-built for conducting scientific experiments, were not the most suitable for the delivery of this type of practical-based course. The lab benches and student desks were not suited to the types of activities and building required for this course. To compensate, the students were supplied with a basic wooden structure (figure 12), and they were required to improve its capacity to control heat transfer. At this stage in the delivery of the course, the lack of suitable equipment, space and skill (in the teaching staff) to allow students to design and build their own house design necessitated this approach.
Figure 12 The basic wooden structure the first STEM class (Semester 2, 2013) was required to improve.

The structure was made from 6mm plywood held together with metal brackets. A hinged window was present on one wall (not shown in this picture) and the roof was also hinged to allow access. The structure was attached to a larger wooden base (houses were designed by a science teacher in his home garage). An important phase of this project was to create an electrical circuit and switch that could open and close the window (Figure 13). The students were allowed to create any number of circuits and switches to ensure this could happen.