Stage 2 Electronic Systems

Assignment 1 – Materials Application

Evaluation of Electronic Circuit Design Media

Word count: 777

Government of South Australia

SACE
Board of SA

Subject: **Systems and Control Products I** Variant: ______ School: ______ Contact Teacher: ______

ASSESSMENT DETAILS

Use the table below to provide details of the assessments designed to provide opportunities for the range of students in the cohort to show evidence of their learning against the performance standards.

Name of Assessment (Assessment Type)	Description of Assessment (a description of the flexible, and where appropriate, negotiable, ways in which students show evidence that demonstrates their learning against the performance standards, including to the highest standard)	Assessment conditions as appropriate (e.g. task type, word length, time allocated, supervision)
Material application	Using appropriate components, materials and systems and BOTH the breadboard and Yenka simulation software to investigate the operation of AND and NOT gate chips and how they could be used to create an electronic 'lock'. Compare and contrast the two prototyping systems and speculate about how each could be used separately and in combination when designing a major project.	Results and findings presented as a report.800 max including appropriate annotated graphics and photographs.
Specialised skills application 1	Using a circuit diagram and component layout they have developed students construct an electronic lock circuit with a minimum 5 switch input and LED output and designed and constructed using AND and NOT gates chips. Circuit to be soldered onto stripboard.	Evidence must included computer generated graphics of the circuit and layout and an annotated photostory of the construction and testing – minimum 20 photographs
Specialised skills application 2	Students use their own electronic lock circuit to design and construct an appropriate housing for the circuit. The design needs to display appropriate attention in the design solution to LED and switch mounting, interstage wiring, battery and board security, maintenance access and output display.	Evidence must included working drawing with parts and material list and an annotated photostory of the construction, fitting and testing– minimum 20 photographs
Major project	Students produce an assembled stripboarded circuit linked to a theme of oscillating output.	Evidence annotated photostory and/or video of the construction, fitting and testing– minimum 30 photographs
Minor project	Students design and construct an appropriate housing for the oscillating circuit which converts it to an advertising display. Design needs to include consideration of interstage wiring, remote component mounting, flashing display properties, board and battery mounting and housing materials, dimensions and properties.	Evidence must include details specifications for the housing and an annotated photostory and/or video of the construction, fitting and testing of the product – minimum 20 photographs

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1. Introduction

This report compares and contrasts the use of circuit simulation software and a breadboard to experiment with and investigate digital gates and design a circuit for an electronic combination lock.

The resources that I have available to me are the *Crocodile Technology v401* circuit simulation software and the *Faystar SH-21* breadboard, therefore these will be used in my investigation and experimentation.

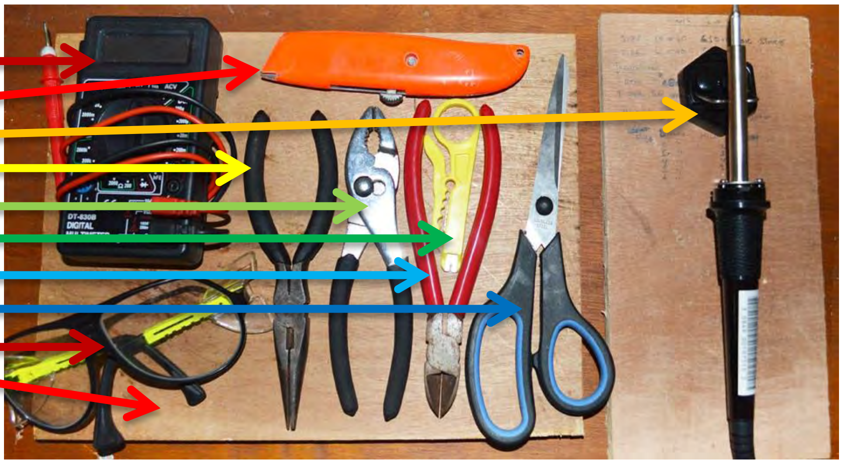
Experiments using gates will be carried out on both platforms. Screenshots with accompanying truth tables will be provided for each experiment conducted using the simulation software, and annotated photographs will show each experiment on the breadboard.

Evaluation of Electronic Circuit Design Media

2. Safety Considerations

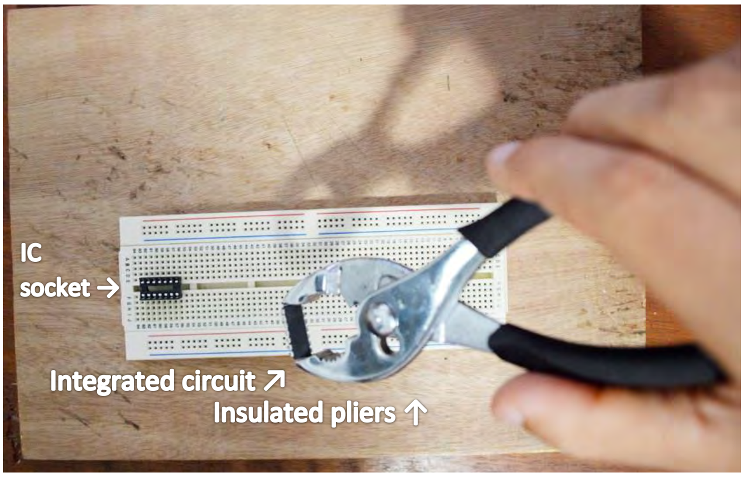
Care was taken throughout the experimentation and investigation process to minimise the risk of causing personal harm to myself or to the components. See Figures 1 and 2.

Figure 1



A photograph showing the safe equipment that was used to reduce danger to myself and the componentry.

Figure 2



A photograph showing my use of insulated flat-nose slip-joint pliers when handling sensitive integrated circuits (ICs), to reduce the risk of causing damage to the component through static electricity. Also, the black object to the left of the IC is an IC socket, which is used as a holder to facilitate easier insertion, removal and exchange of ICs during experimentation.

3. Evaluation of Media for Experimentation and Circuit Design Solutions

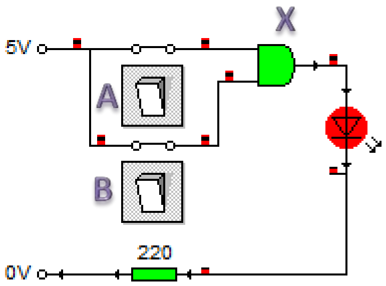
3.1 Crocodile Technology Software Experiments

The Crocodile Technology circuit simulation software allows for circuit design and testing with virtual components, and thus poses no danger to actual components or the designer.

3.1.1 AND Gate Experiment

AND gates require that all inputs be high to achieve a high output (see Figure 3).

Figure 3



Truth Table:

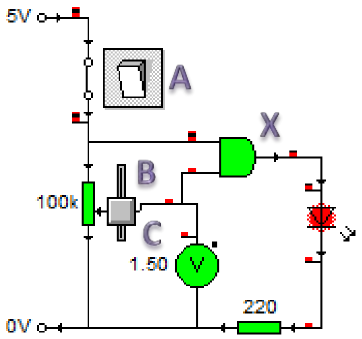
Input A	Input B	Output X
0	0	0
1	0	0
0	1	0
1	1	1

The screenshot and truth table above show that in the case of an AND gate, a high output (X) can only be achieved with high inputs for both A and B.

3.1.2 AND Gate and Potentiometer Experiment

By including a potentiometer in an AND circuit, we can see that AND gate inputs are high at 1.5 volts and higher (see Figure 4).

Figure 4

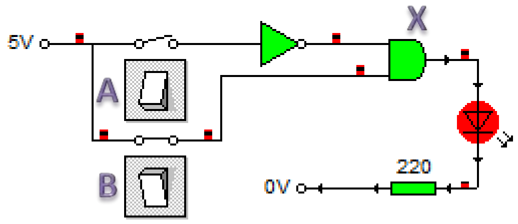


The voltmeter (C) in the screenshot above shows that in the case of an AND gate, a high input signal is recognised at 1.5 volts and higher, as the LED begins to glow at 1.5V on the voltmeter. So a high output at X is achieved by inputs A and B carrying more than or equal to 1.5V.

3.1.3 AND and NOT Gates Experiment

With a NOT gate (invertor) between a switch and an AND gate, the switch must be supplying an initial low input to produce a high output from the NOT gate (see Figure 5).

Figure 5



Truth Table:

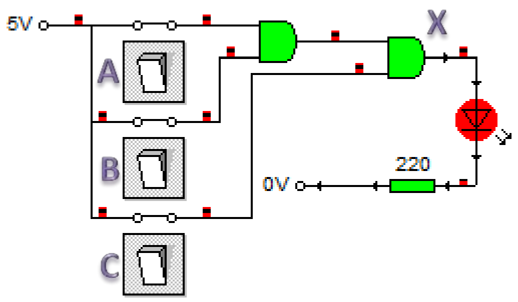
Input A	Input B	Output X
0	0	0
1	0	0
0	1	1
1	1	0

The screenshot and truth table above show that in the case of a NOT gate connected prior to an AND gate, a high output (X) can only be achieved with a low input for A and a high input for B.

3.1.4 Linked AND Gates Experiment

Linked AND gates require that all inputs be high to achieve a high output (see Figure 6).

Figure 6



Truth Table:

Input A	Input B	Input C	Output X
0	0	0	0
1	0	0	0
0	1	0	0
0	0	1	0
1	1	0	0
1	0	1	0
0	1	1	0
1	1	1	1

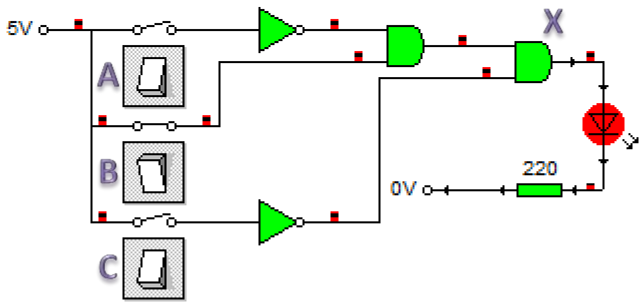
The screenshot and truth table above show that in the case of linked AND gates, a high output (X) can only be achieved with high inputs for A, B and C.

The use of tables and images provides evidence of students' high level of understanding of systems function.

3.1.5 Two AND and Two NOT Gates Experiment

With two AND gates and two NOT gates, two inputs must be low and one input high, in the order of low-high-low, to achieve a high output (see Figure 7).

Figure 7



Truth Table:

Input A	Input B	Input C	Output X
0	0	0	0
1	0	0	0
0	1	0	1
0	0	1	0
1	1	0	0
1	0	1	0
0	1	1	0
1	1	1	0

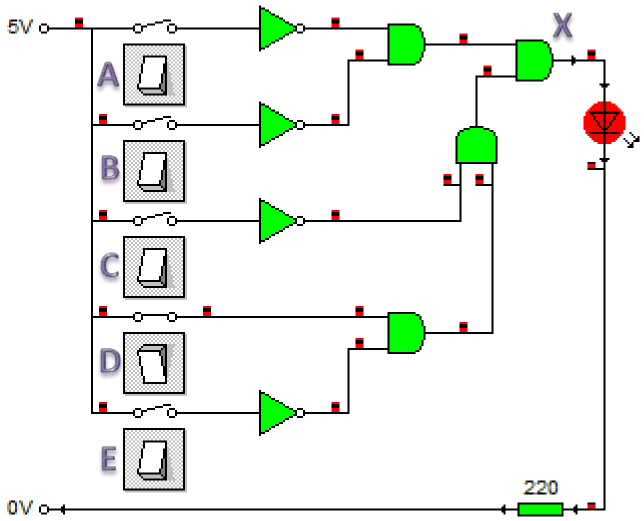
The screenshot and truth table above show that when two AND gates and two NOT gates are connected in the above configuration, a high output (X) can only be achieved with low inputs for A and C and a high input for B.

Comments provide evidence of in-depth understanding of system.

3.1.6 Four AND and Four NOT Gates Experiment

With four AND gates and four NOT gates, only the exact combination of low-low-low-high-low for the inputs will achieve a high output (see Figure 8).

Figure 8



Truth Table:

Input A	Input B	Input C	Input D	Input E	Output X
0	0	0	0	0	0
1	0	0	0	0	0
0	1	0	0	0	1
0	0	1	0	0	0
0	0	0	1	0	1
0	0	0	0	1	0
1	1	0	0	0	0
1	0	1	0	0	0
1	0	0	1	0	0
1	0	0	0	1	0
0	1	1	0	0	0
0	1	0	1	0	0
0	1	0	0	1	0
0	0	1	1	0	0
0	0	1	0	1	0
0	0	0	1	1	0
0	1	1	1	1	0
1	0	1	1	1	0
1	1	0	1	1	0
1	1	1	0	1	0
1	1	1	1	0	0
0	0	1	1	1	0
1	0	0	1	1	0
1	1	0	0	1	0
1	1	1	0	0	0
0	1	0	1	1	0
0	1	1	0	1	0
0	1	1	1	0	0
1	0	1	0	1	0
1	1	0	1	0	0
1	1	1	1	1	0

The screenshot above and the truth table to the right show that in the case of four AND gates and four NOT gates, a high output (X) can only be achieved with low inputs for A, B, C and D and high input C. This can alternatively be written as $\overline{\mathbf{A}}\ \overline{\mathbf{B}}\ \overline{\mathbf{C}}\ \mathbf{D}\ \overline{\mathbf{E}}$ where low inputs are overlined.

3.2 Breadboard Experiments

Experimentation on breadboards allows for a more 'hands-on' experience of circuit design, as well as a more accurate planning and layout platform. The layout that is used on a breadboard is much more realistic than that in a simulated circuit, as real components must be used, bringing limitations of size and proximity, among others.

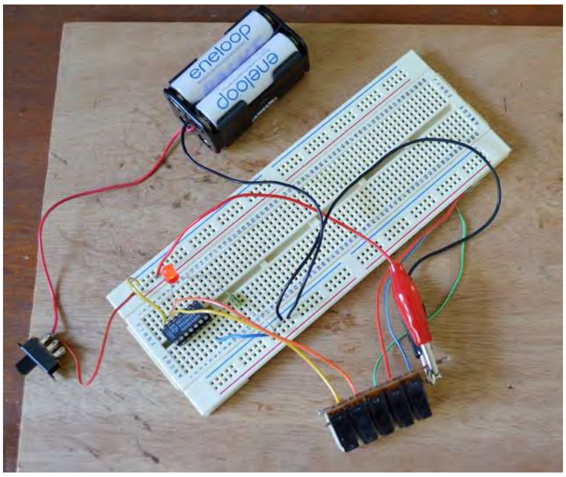
Some special equipment and components were constructed and used in the breadboard experimentation. These are listed and described in Appendix 1.

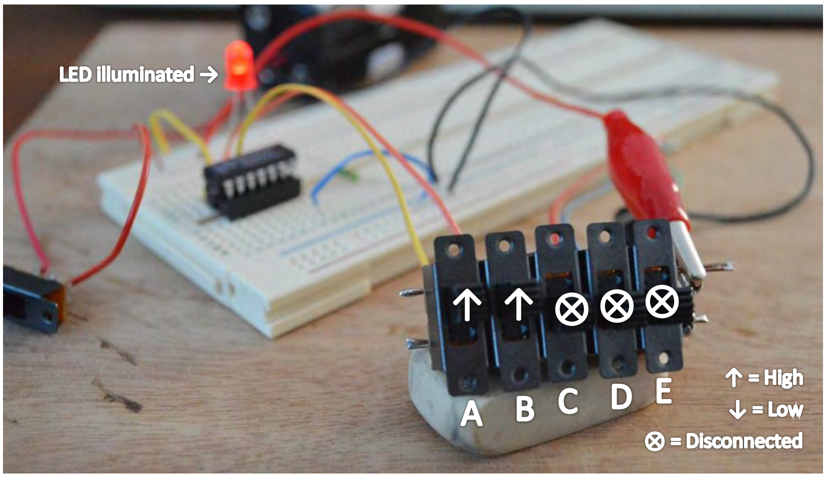
Discussion demonstrates insightful and informed understanding of system capabilities.

3.2.1 AND Gate Experiment

AND gates require that all inputs be high to achieve a high output (see Figure 9).

Figure 9



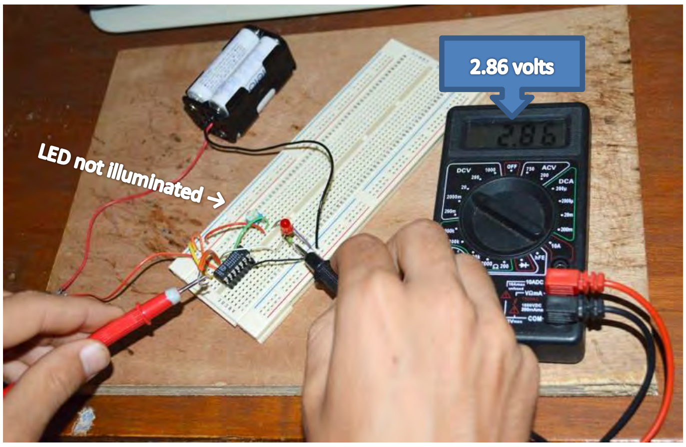


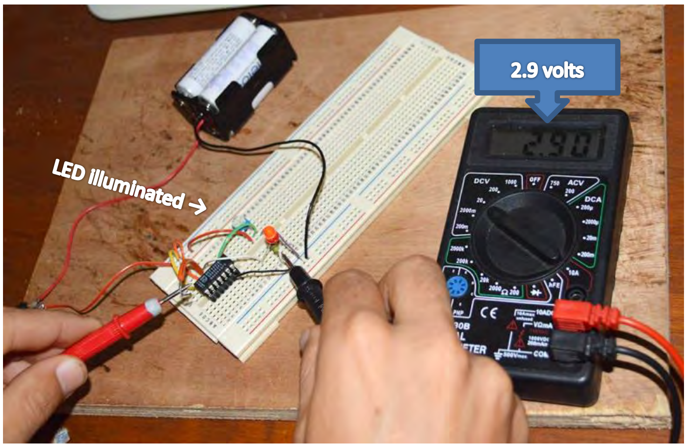
The above photographs show the AND Gate Experiment on a breadboard using physical components. Similarly to the results of the software-based experiment with the same circuit (see section 3.1.1), we can see from the image on the right that the LED is illuminated only when switches A and B are high.

3.2.2 AND Gate and Potentiometer Experiment

According to experimentation using the breadboard, AND gates require a minimum voltage of about 2.88V for a high input.

Figure 10



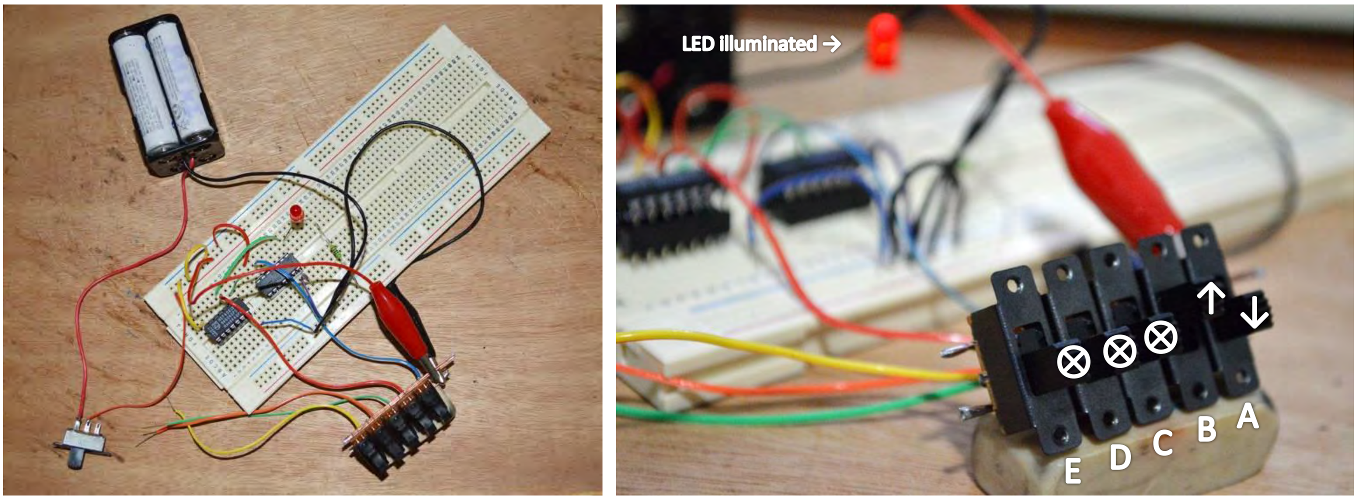


The photographs above show that the minimum voltage an AND gate requires to register a high input signal is between 2.86V and 2.9V.

3.2.3 AND and NOT Gates Experiment

When there is a NOT gate included in a single AND gate circuit, one of the inputs must initially be low to produce a high output (see Figure 11).

Figure 11

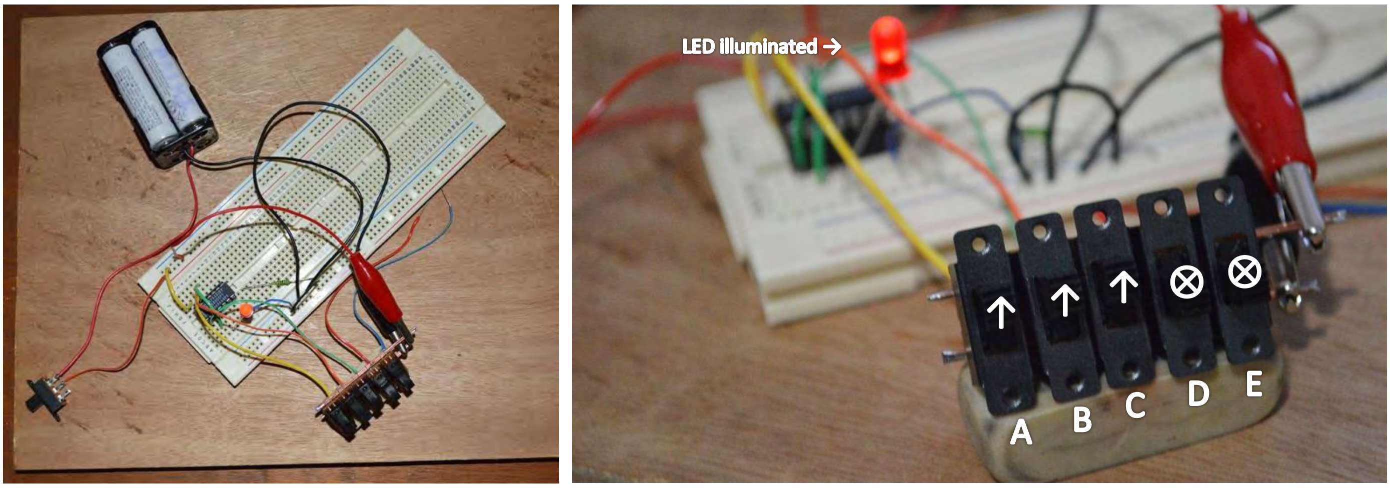


In the photographs above, we can see that the combination required to produce a high output (illuminated LED) in this AND gate circuit with one NOT gate, is switch A set to low and switch B set to high.

3.2.4 Linked AND Gates Experiment

A circuit containing only AND gates requires that all inputs be high to achieve a high output (see Figure 12).

Figure 12

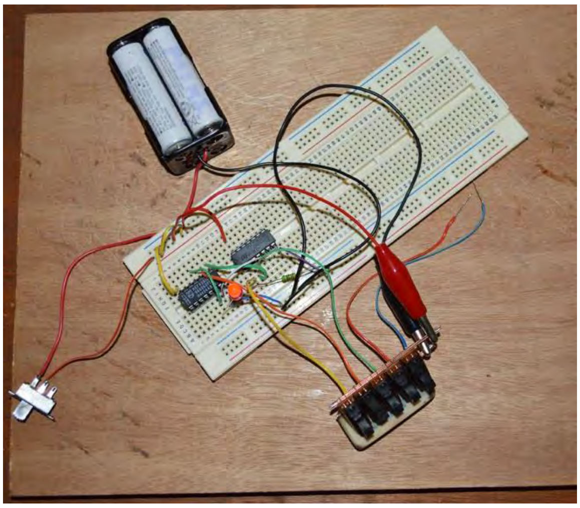


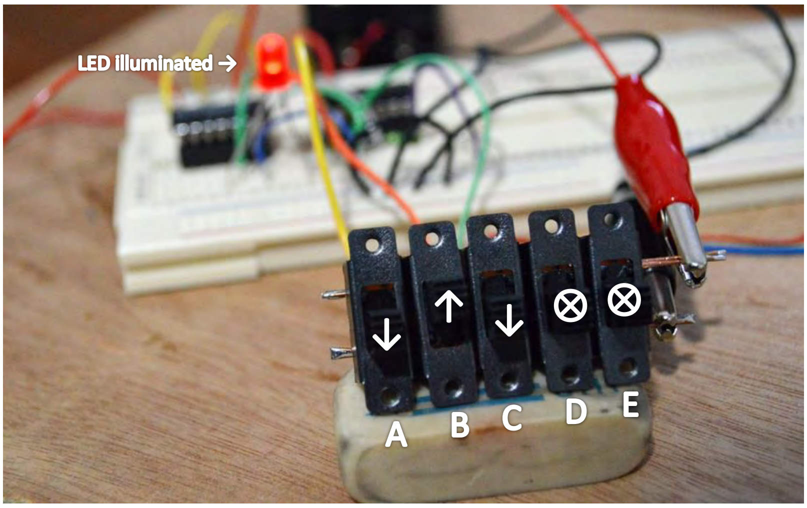
As can be seen in the images above, a circuit in which the only logic gates are AND gates requires all inputs (A, B and C) to be high in order to produce a high output.

3.2.5 Two AND and Two NOT Gates Experiment

The combination required for a high output in a circuit with two AND gates and two NOT gates is switch A set to low, switch B to high and switch C to low (see Figure 13).

Figure 13



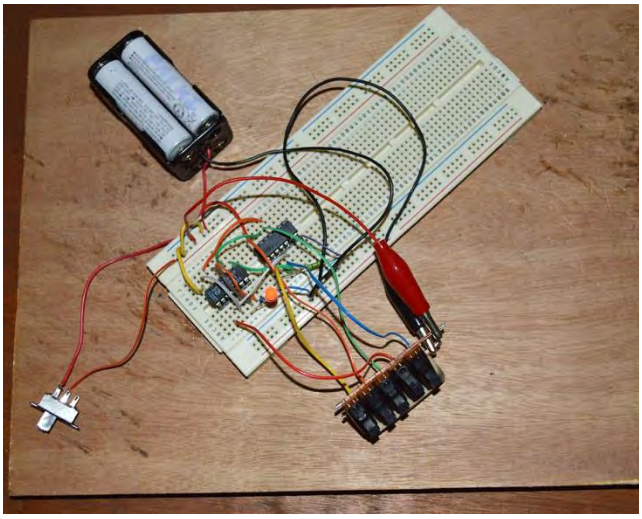


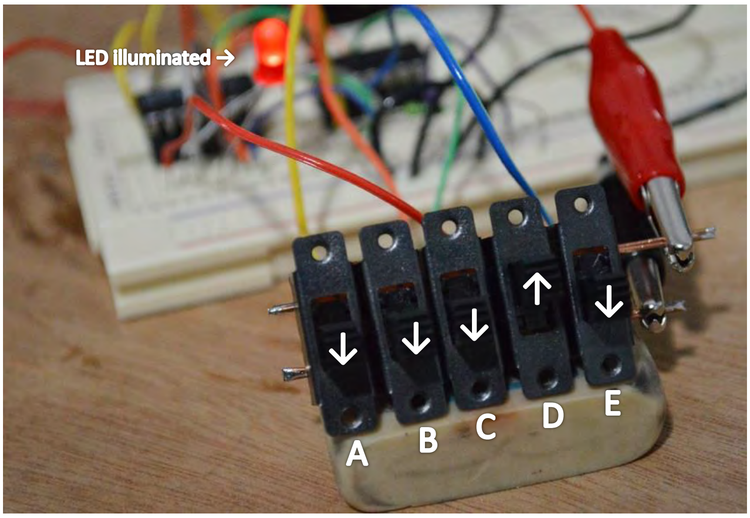
As seen above, the combination used to produce a high output in a circuit with two AND gates and two NOT gates is switch A as low, switch B as high, and switch C as low.

3.2.6 Four AND and Four NOT Gates Experiment

The combination to produce a high output in a circuit with four AND gates and four NOT gates is, in order from switch A to E, low, low, low, high, low (see Figure 14).

Figure 14





The combination for the circuit pictured above is A low, B low, C low, D high, E low. This circuit is essentially a basic electronic lock.

Sequence of tests conducted demonstrates accomplished communication of ideas, with consistent use of technical language.

4. Conclusions

In conclusion, when designing an electronic circuit with logic gates, it is much easier to use circuit simulation software such as *Crocodile Technology* to develop the design. The circuit and components are virtual simulations, rendering no danger to sensitive physical components such as integrated circuits. Also, logic gates are presented as 'stand-alone' components in simulation software, aiding in a simplified design platform. Whereas real logic gates (which are used on breadboards and printed circuit boards [PCBs]) are packaged in integrated circuits, which require more wiring to provide power and restrict positioning of the gates to a specific area. This makes the layout more complex on breadboards than in simulations.

Conversely, designing and constructing circuits on a breadboard provides an accurate, real-world understanding of how components perform in real-life. This gives a much more hands-on experience, which is helpful in developing practical skills.

Well considered analysis and evaluation of tests reflects perceptive analysis with sophisticated recommendations.

5. Recommendations

A combination of circuit simulation software and breadboard-based experimentation could be used to provide the best experience when designing circuits. Preliminary theoretical concept design could be carried out in the simpler interface of simulation software, before transferring the design onto a breadboard for further development, referring back to the simulation for guidance in layout.

6. Summary

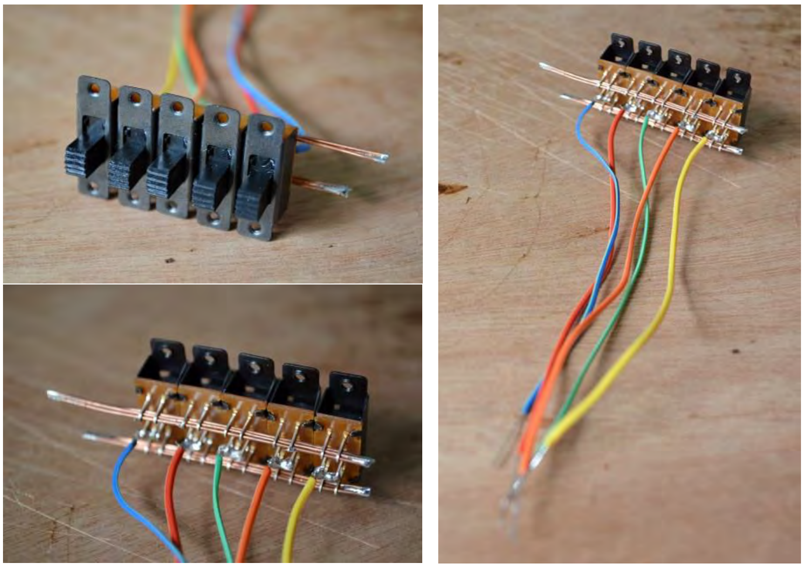
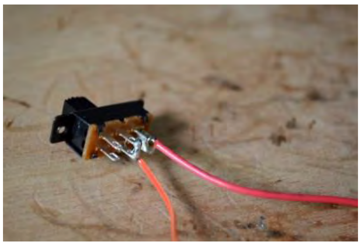
In summary, circuit simulation software is a helpful tool for initial development of circuit design ideas; however it is not a perfect solution, as it never ventures beyond the theoretical aspects of a circuit. Therefore, in order to further develop component layout and verify simulated circuit behaviour, it is more effective to use a breadboard.

Additional Comments
This task was assessed at an A+ level.

Appendix 1 – Supporting Equipment for Breadboarding

The three supporting components that were used in the breadboard-based experimentation are listed and described in Table 1 below.

Table 1

	**Switch Array** This was constructed using five mini slide switches, six 5.5cm lengths of copper wire, and five 10cm lengths of insulated multi-core electrical wire. Three lengths of copper wire were threaded through all the terminals on each side of the five switches (as visible in image bottom left) to make positive and negative power rails. The ends of the copper wires were soldered together to form solid tips. Five insulated electrical wires were then soldered to the remaining middle terminals, one on each switch. This switch array could then be connected to the circuit, with the positive rail being wired to the power supply and the negative rail being connected to ground.
	**4 × AA Battery pack** Provides 4.8V power supply, as four rechargeable AA batteries with 1.2V ratings were used.
	**Power supply master switch** Simply a mini slide switch installed as a safety to turn the power supply on and off.

Performance Standards for Stage 2 Design and Technology

	Investigating	Planning	Producing	Evaluating
A	Clear, comprehensive, and well-considered identification of a need, problem, or challenge. Thorough and insightful creation and validation of initial design brief based on needs analysis and task identification. Purposeful investigation and critical analysis of the characteristics of a broad variety of existing products, processes, systems, and/or production techniques. In-depth investigation into product material options and focused and thorough critical analysis for product use. Focused and perceptive investigation into the impact of products or systems on individuals, society, and/or the environment.	In-depth analysis of information to develop imaginative, innovative, and enterprising solutions to an identified design brief. Accomplished communication of a variety of refined product design ideas, consistently using relevant technical language. Purposeful testing and refined modification and validation of ideas or procedures.	Sophisticated application of appropriate skills, processes, procedures, and techniques to create a product or system to a precise or polished standard and specification. Accomplished use of resources, equipment, and materials to create a product or system safely and accurately. Accomplished and resourceful development of solutions to technical problems that may arise during product or system realisation.	Insightful and well-considered evaluation of product success against design brief requirements. Insightful and detailed evaluation of the effectiveness of the product or system realisation process. Refined and well-considered reflection on materials, ideas, and procedures, with sophisticated recommendations. Resourceful and well-informed analysis of the impact of the product or system on individuals, society, and/or the environment.
B	Well-considered identification of a need, problem, or challenge. Well-considered creation and validation of an initial design brief based on needs analysis and task identification. Thoughtful investigation and analysis of the characteristics of a variety of existing products, processes, systems, and/or production techniques. Detailed investigation into product material options and thorough analysis for product use. Some depth of investigation into the impact of products or systems on individuals, society, and/or the environment.	Thoughtful analysis of information to develop enterprising solutions to an identified design brief. Capable communication of different quality product design ideas, using relevant technical language. Thoughtful testing, modification, and validation of ideas or procedures.	Capable application of appropriate skills, processes, procedures, and techniques to create a product or system to a mostly precise or polished standard and specification. Capable use of resources, equipment, and materials to create a product or system safely and mostly accurately. Thoughtful development of solutions to technical problems that may arise during product or system realisation.	Well-considered evaluation of product success against design brief requirements. Well-considered and detailed evaluation of the effectiveness of the product or system realisation process. Well-considered reflection on materials, ideas, and procedures, with thoughtful recommendations. Well-informed analysis of the impact of the product or system on individuals, society, and/or the environment.
C	Considered identification of a need, problem, or challenge. Considered creation and validation of an initial design brief based on needs analysis and task identification. Competent investigation of the characteristics of some existing products, processes, systems, and/or production techniques. Competent investigation into product material options and analysis for product use. Generally thoughtful investigation into the impact of products or systems on individuals, society, and/or the environment.	Analysis of information to develop appropriate solutions to an identified design brief. Competent communication of product design ideas, using appropriate technical language. Competent testing, modification, and validation of ideas or procedures.	Competent application of skills, processes, procedures, and techniques to create a product or system to an appropriate standard and specification. Competent use of resources, equipment, and materials to create a product or system safely and generally accurately. Development of appropriate solutions to technical problems that may arise during product or system realisation.	Considered evaluation of product success against design brief requirements. Considered evaluation of the effectiveness of the product or system realisation process. Considered reflection on materials, ideas, and procedures, with appropriate recommendations. Informed analysis of the impact of the product or system on individuals, society, and/or the environment.
D	Identification of a basic need, problem, or challenge. Creation of a basic initial design brief with some consideration of a needs analysis. Identification of the characteristics of some existing products, processes, systems, or production techniques. Some basic description of material options. Some description of the impact of products or systems on individuals, society, or the environment.	Some identification of information to attempt basic solutions to an identified design brief. Basic communication of some product design ideas with some use of appropriate technical language. Partial testing and some modification of ideas or procedures.	Partial application of skills, processes, procedures, and techniques to make one or more articles to a limited standard and specification. Some use of basic resources, equipment, or materials to create a product or system, with some consideration of safety aspects. Partial development of some basic solutions to technical problems that may arise during product or system realisation.	Description of product progress, with elements of basic testing against design brief requirements. Some description of the effectiveness of the product or system realisation process. Superficial reflection on or description of materials, ideas, or procedures, with basic recommendations. Some consideration of the impact of the product on individuals, society, or the environment.

	Investigating	Planning	Producing	Evaluating
E	Limited identification of a need, problem, or challenge. Creation of a very basic initial design brief, with support. Statement of one or more characteristics of an existing product, process, system, or production technique. Limited description of one or more product material options. Identification of one impact of a product or system on individuals, society, or the environment.	Attempted identification of some information to develop limited solutions to an identified design brief. Limited communication of one or more product design ideas. Some attempt at testing and limited modification of an idea or procedure.	Attempted application of one or more skills, to follow an appropriate process, procedure, or technique. Attempted use of resources, equipment, or materials, with emerging awareness of safety issues. Some attempted description of problems that may arise during product or system realisation.	Identification of some product progress, with limited testing. Identification of some aspects of the effectiveness of the product or system realisation process. Identification rather than description of materials, ideas, or procedures, with one or more recommendations. Emerging recognition of one or more of the impacts of the product on individuals, society, or the environment.

Stage 2 Electronic Systems

Specialised Skills Application Task 1

Constructing an Electronic Lock

Word count: 754

Government of South Australia

SACE Board of SA

Subject: Systems and Control Products I Variant: ______ School: ______ Contact Teacher: ______

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Contents

1. Introduction

The purpose of this report is to evaluate and discuss the processes used to design a layout for and construct an electronic lock circuit. The report will also detail problems that were encountered and steps that were taken to overcome them, as well as an evaluation of the procedures used to determine whether they could be improved.

2. Parts List

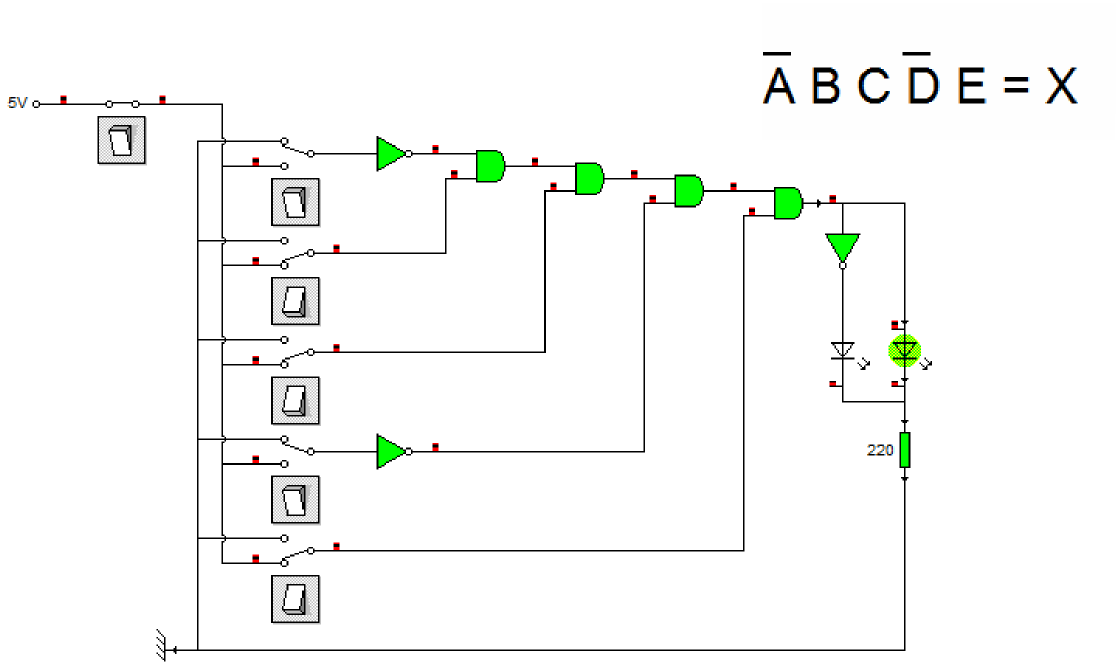
Quantity	Part
1	Strip board
1	5mm Red LED
1	5mm Green LED
1	220Ω resistor
1	4081 Quad 2-input AND gate IC
1	4069 Hex NOT gate (Inverter) IC
5	SPDT switch
1	AA 4-battery holder
2	14-pin IC socket
1	1m multi-core jumper and connecting wire
1	27cm insulated solid wire
1	7cm insulated wire-ribbed plastic tie

Task requirements clearly stated.

3. Diagrams

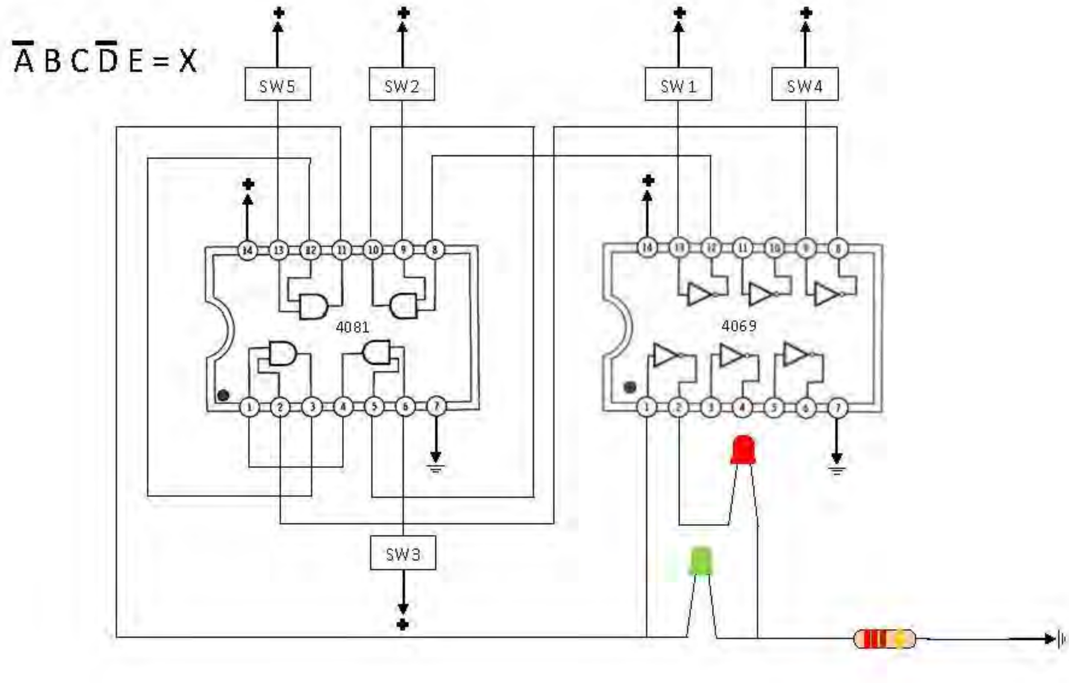
The diagrams that I created to aid me in designing and constructing the circuit are included below. See Figures 1-3.

Figure 1



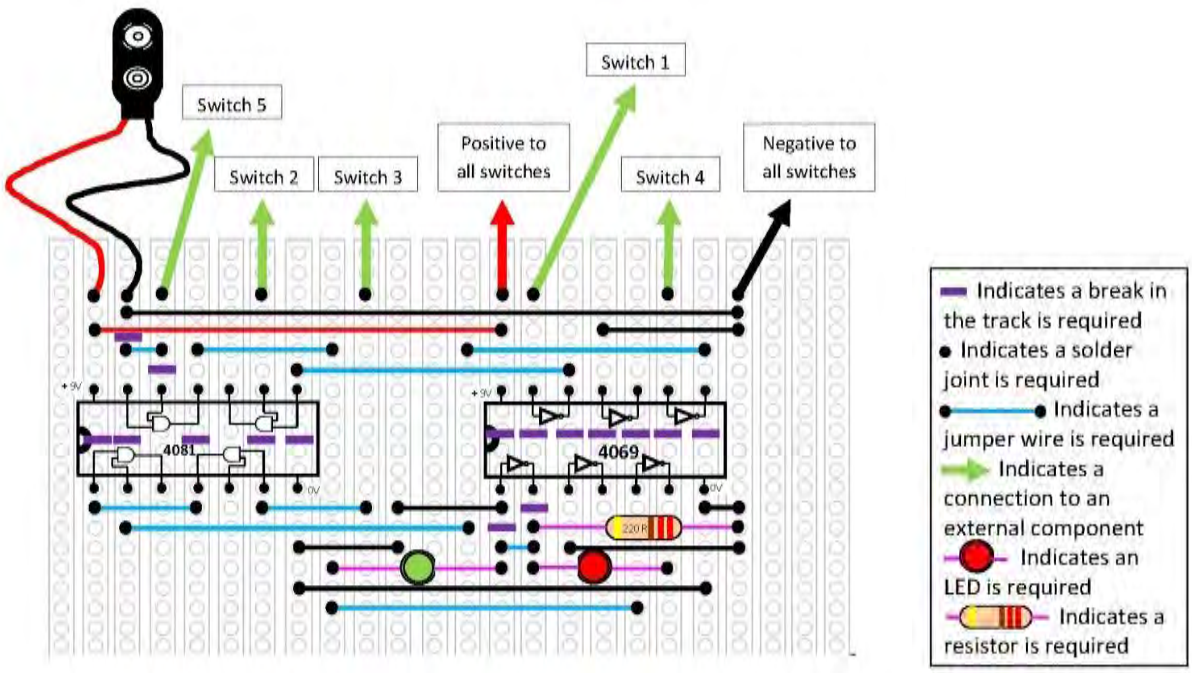
This is the circuit diagram that I created using circuit simulation software, called Crocodile Technology. The formula I have used for the electronic lock is shown in the top right.

Figure 2



This is the wiring diagram that I created to show the power and signal connections between the components. The formula I have used for the electronic lock is shown in the top left.

Figure 3



This is the component layout diagram that I designed to aid me in the construction of the circuit by providing a clear reference layout for the componentry, jumper wires and circuit board modifications (i.e. solder joints and track breaks).

The above diagram indicates the sophisticated level of understanding of procedures to create a locking system.

4. Photographic record of construction

I took photographs of many of the steps in the construction of the electronic lock circuit. These are included below in Figures 4-16.

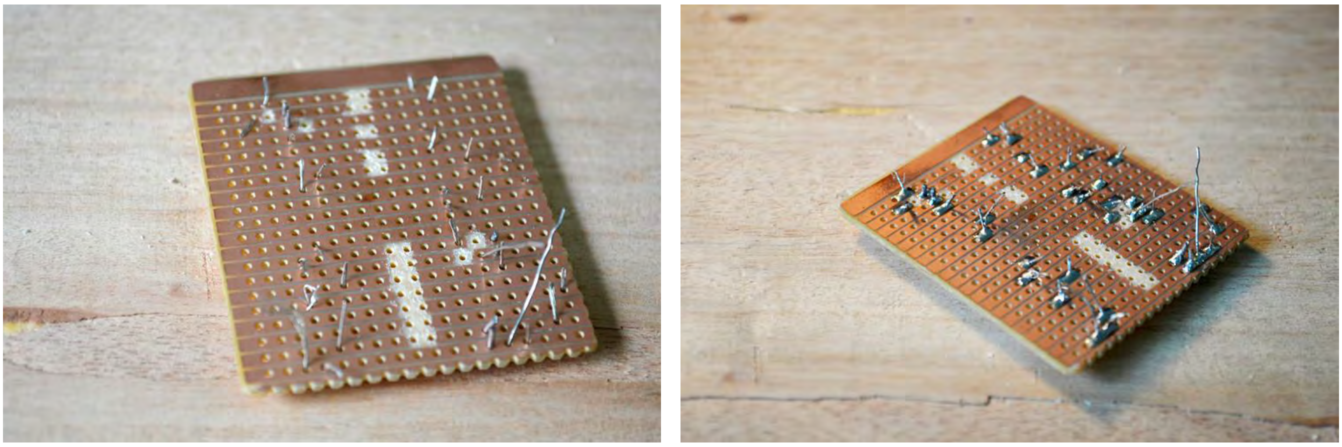
Figure 4

The photograph above shows the tools that I used when constructing the circuit.

Figure 5

The two photographs above showing the technique I used to resize the circuit board to the dimensions required for construction. Firstly, I used a ruler and a Stanley knife to score a line on the circuit board. Then I positioned the circuit board on the edge of a workbench with the ruler on top for stability, and snapped the extra circuit board off.

Figure 6

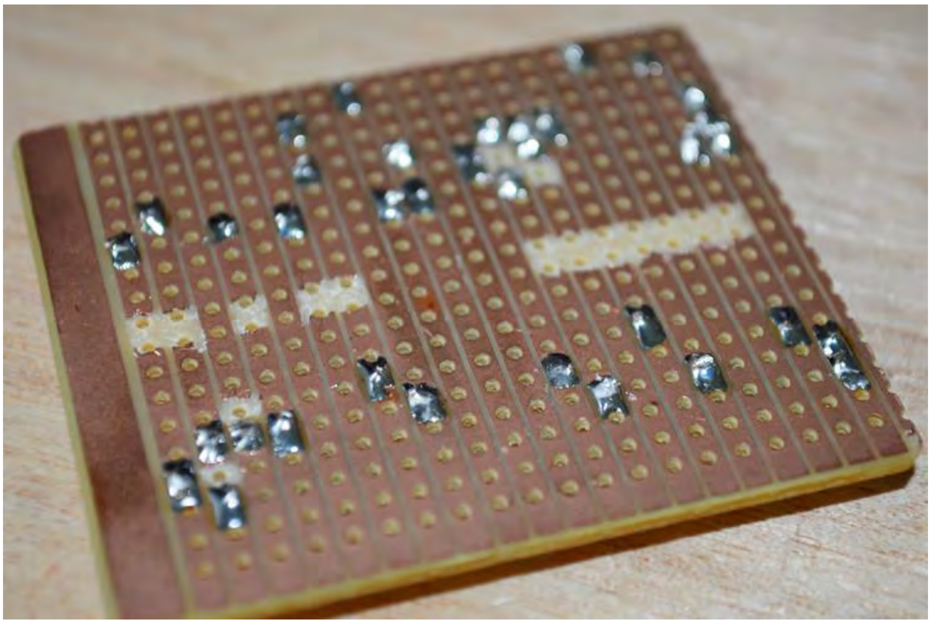


The photograph on the left shows the circuit board with jumper wires and resistor inserted and the intentionally broken copper tracks in accordance with the component layout diagram. The photograph on the right shows the soldered joints.

Figure 7

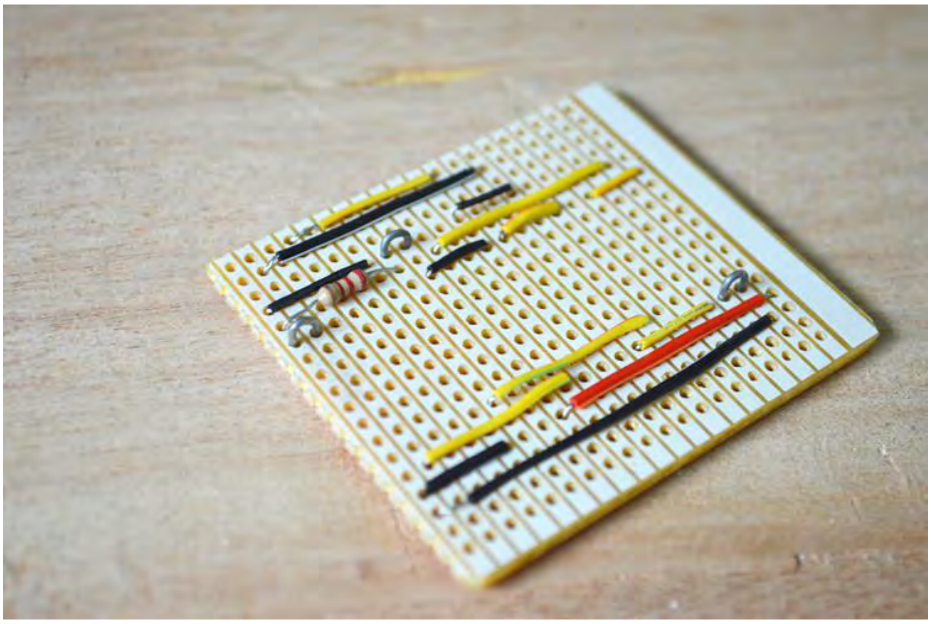
The photograph above shows me using wire cutters to trim protruding component leads on the underside of the circuit after soldering. Note the safety glasses being worn.

Figure 8



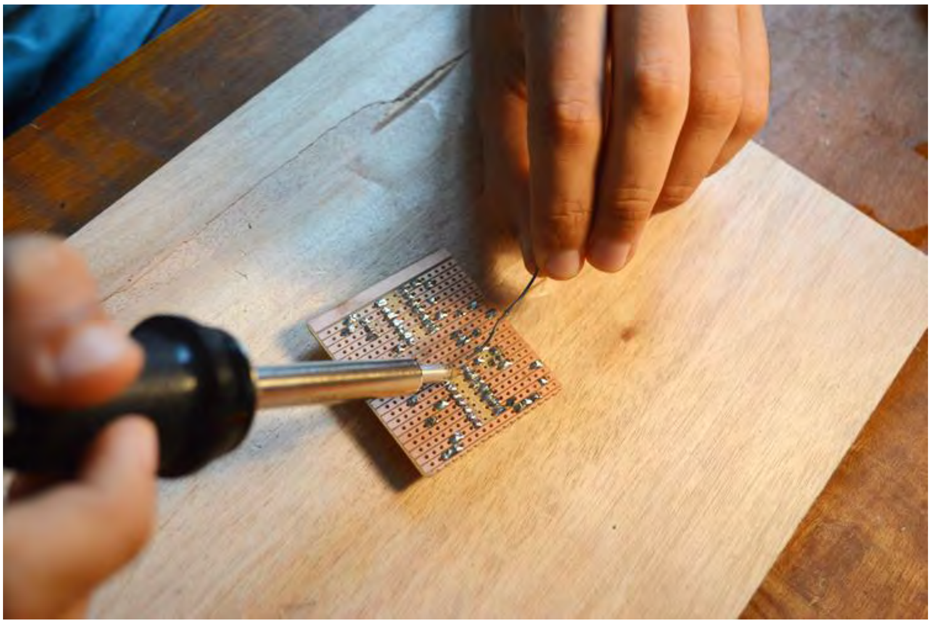
The solder joints on the underside of the circuit board are shown in this photo.

Figure 9



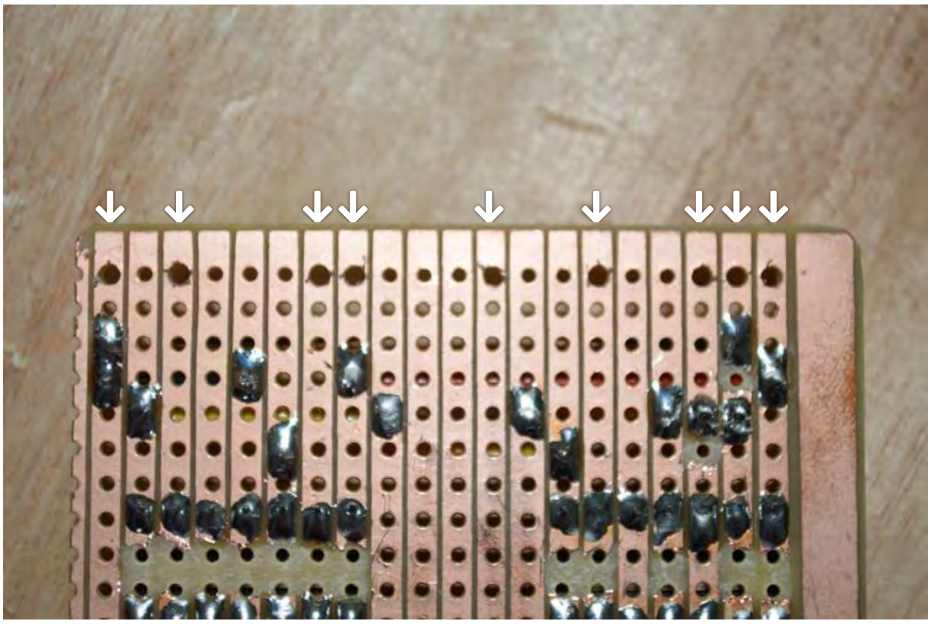
The jumper wires and the resistor on the top of the circuit board are shown in the photograph above. Note the use of colour-coded insulation; red for jumper wires connecting to the positive rail, black for wires to the negative rail and yellow for other connections. Also note the use of bent solid wire when connecting adjacent tracks.

Figure 10



This is a photograph showing the soldering of the integrated circuit (IC) sockets into the circuit board. These are used as holders to facilitate easier insertion, removal and exchange of ICs during construction.

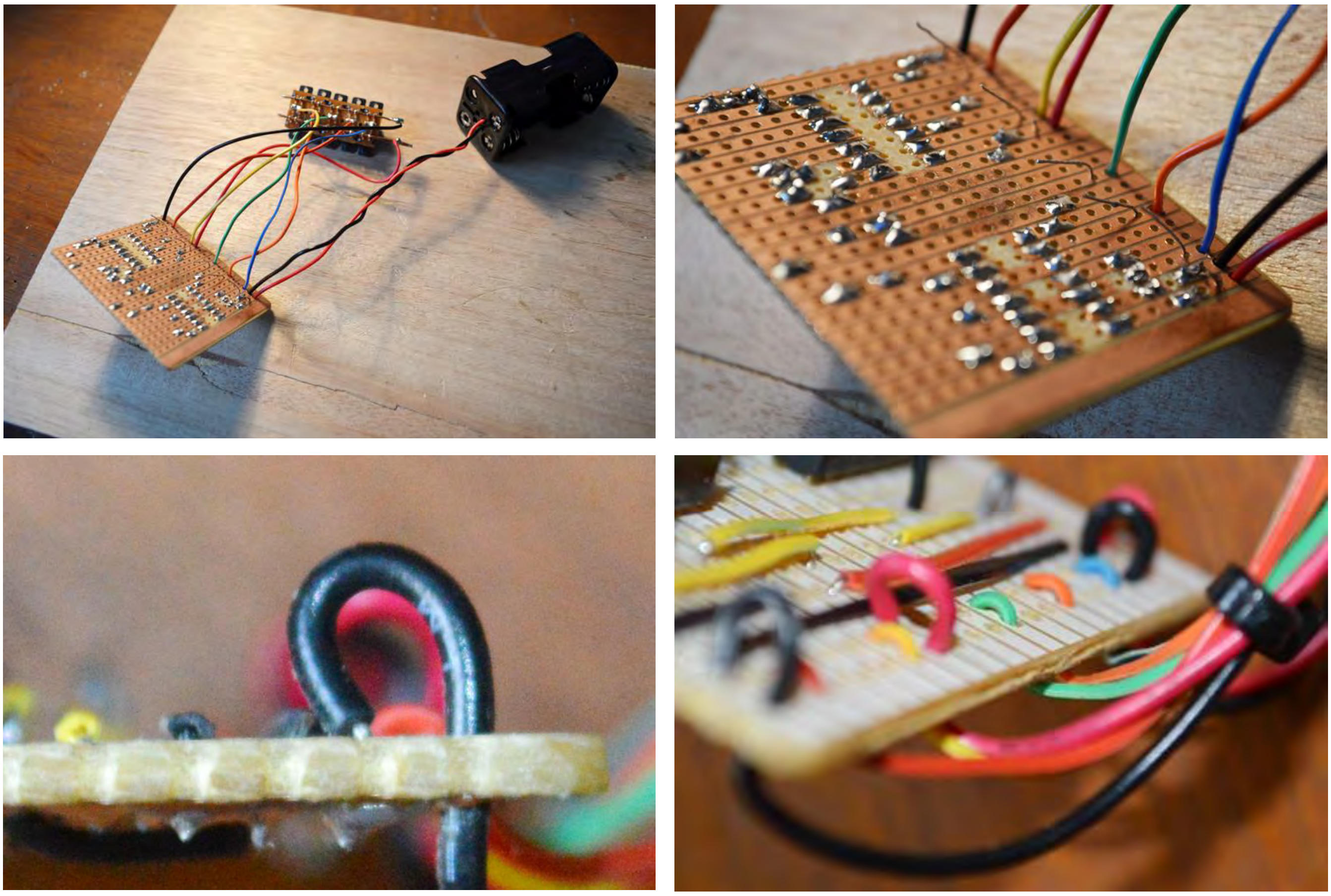
Figure 11



I used an electric drill and a narrow gauge drill bit to widen the holes through which the insulated wires for the off-board components (battery and switch bank) would be threaded to reduce stress on the solder joints. The photograph above shows the circuit board with the larger holes indicated with arrows.

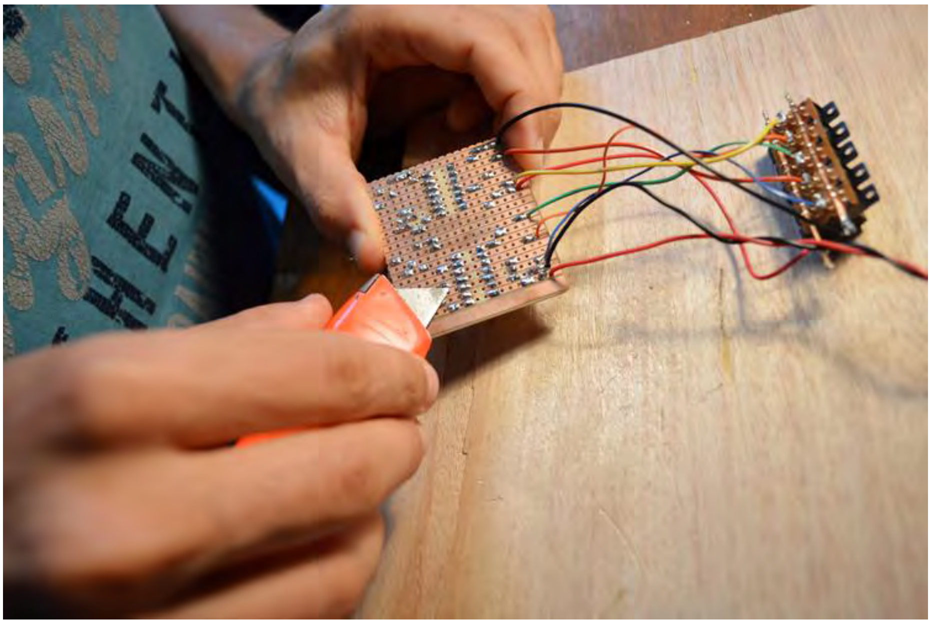
The images provided in these pages demonstrates an accomplished use of appropriate resources safely and accurately.

Figure 12



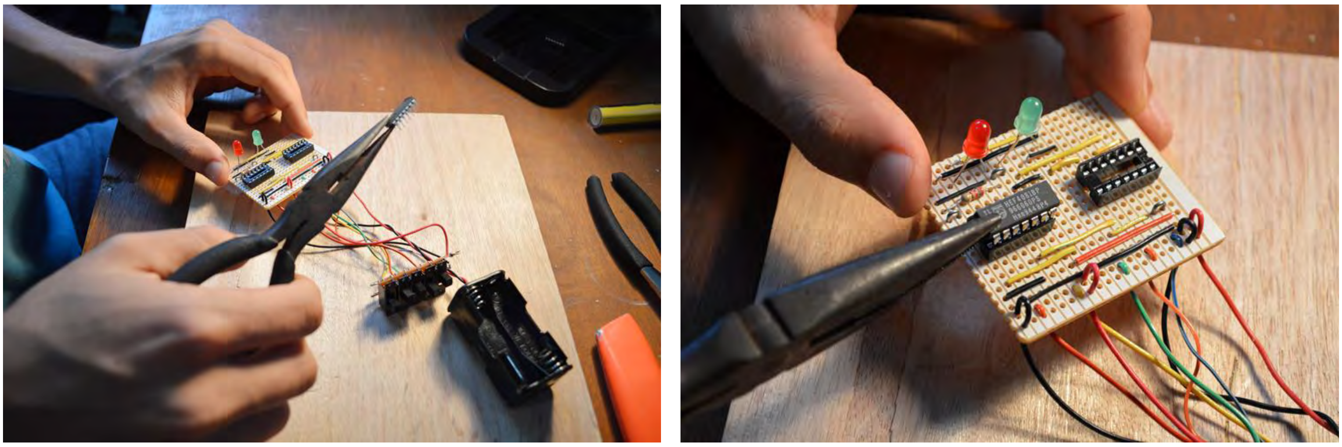
The off-board components are shown in the photograph at the top left. The wires that connect them to the circuit board are first threaded through widened holes from the copper track side before being soldered in, as can be seen in the picture at the bottom left. Thinner insulated wires were able to be bent at a more acute angle than the thicker power supply wires, as can be seen in the picture at the bottom right.

Figure 13



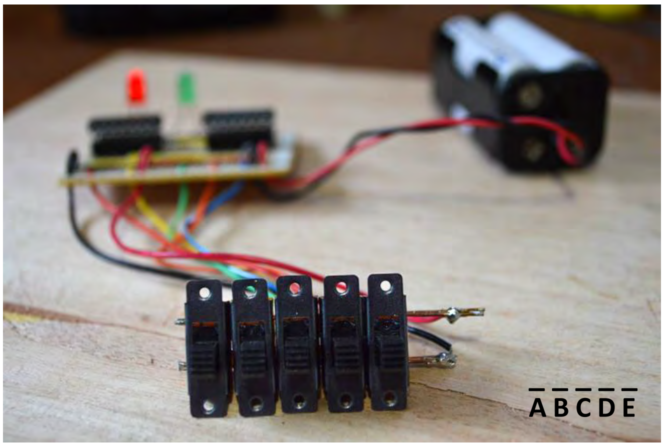
I used a Stanley knife to clean away excess flux from the solder joints and ensure track separation. Note that I am cutting with the knife blade angled away from my body so as to minimise the risk of personal harm.

Figure 14

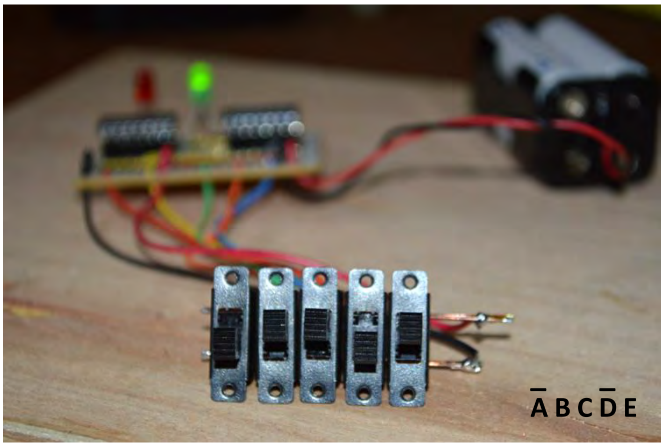


The photographs above show my use of insulated long-nose pliers when handling the sensitive integrated circuits (ICs), to reduce the risk of causing damage to the components through static electricity transference.

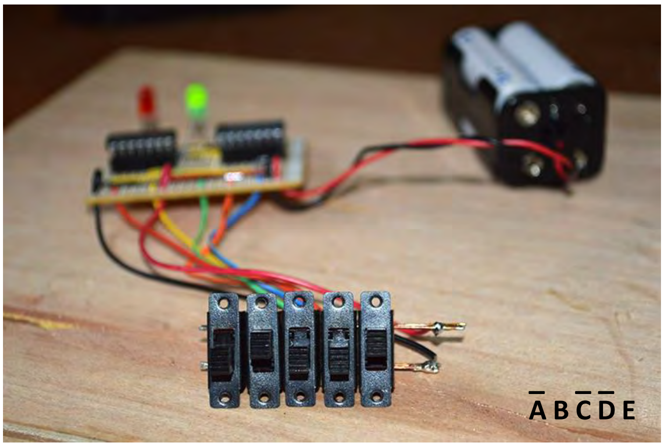
Figure 15



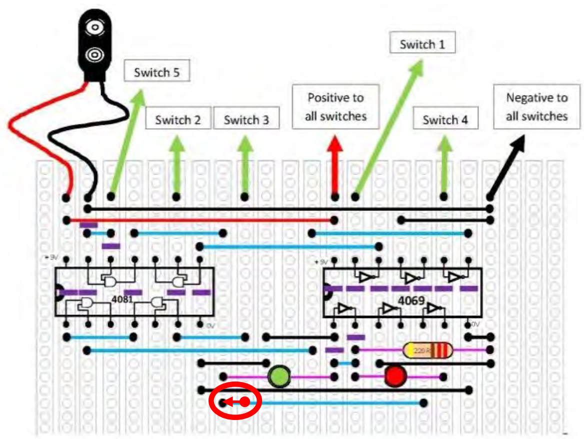
The photograph above shows an incorrect combination entered into the switch bank, causing the red LED to remain illuminated.



The photograph above shows the correct combination illuminating the green LED.



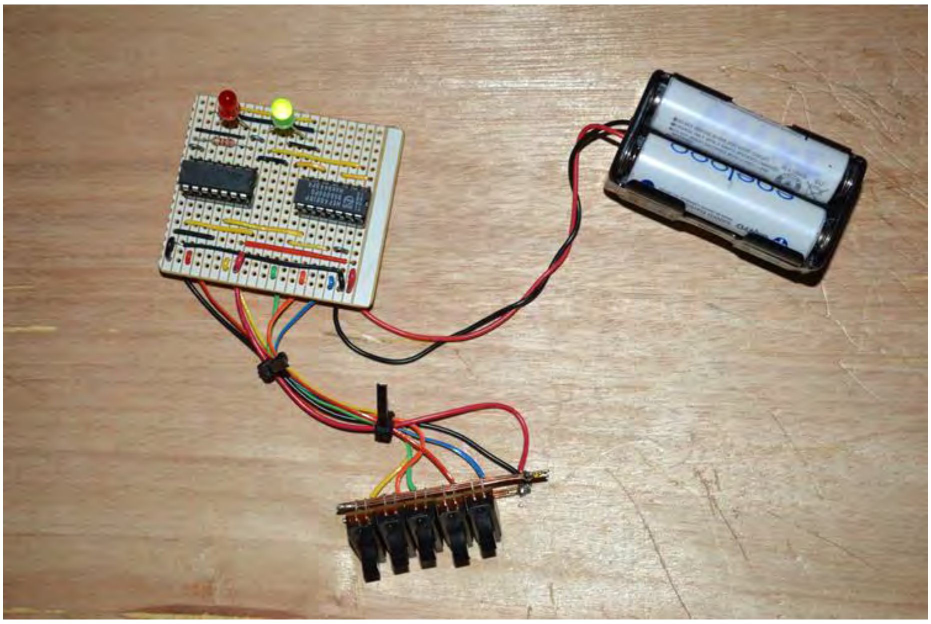
This photograph shows an incorrect combination illuminating the green LED. This indicates a fault in the circuit.



The circuit diagram above shows the fault in the construction of the circuit – I had accidentally soldered a jumper wire into the wrong hole, causing the wrong components to be connected.

The images and comments demonstrate accomplished solutions to a technical problem.

Figure 16



The completed functioning circuit is shown in the photograph above. Note the use of cable ties to loom the switch wires together.

5. Production evaluation

The construction of the electronic lock circuit was relatively straightforward. There were a few minor challenges that were encountered during the production of the circuit. These included the construction of the bank of switches, the sizing and positioning of multiple jumper wires, and the flexibility and strength of the wire used. When constructing the bank of switches, I decided to thread three 5cm lengths of solid wire through either side of the pins of the five switches to create positive and negative power rails and also to hold switches together. However, I found it difficult to thread three wires through on each side, as the holes were only just big enough for them. I also found it challenging and time-consuming to cut the jumper wires to size and position them correctly on the strip board, as there are multiple holes and tracks on the board. I discovered that the multi-core connecting wires that I used for the off-board components were not as strong and flexible as I had hoped. The wires broke a couple of times near solder joints, due to a small amount of movement and stress, requiring me to either resolder the wire connection or replace the wire altogether.

Example of coherent and fluent reflection on materials and procedures.

6. Production process evaluation

The production process is shown in the photographic record of the circuit construction. Firstly, I snapped off unnecessary parts of the circuit board to make it the smallest size possible that would still accommodate all of the on-board components and wiring. Then I inserted all of the low profile components: the jumper wires and the resistor – and soldered these into place, trimming off protruding wire on the copper side of the board. I also broke the copper track in the pre-determined locations using a Stanley knife. Next I installed the integrated circuit (IC) sockets and soldered them into place. I then constructed the switch bank and connected it to the circuit board, along with the battery holder, using connecting wires. The two LED lights were also soldered into the board. I used insulated pliers to insert the two ICs into their sockets. After that, the circuit was complete. I then inserted the four AA batteries into the battery holder and tested the circuit using different switch combinations.

Upon initial testing, I found that the red light remained illuminated as long as the combination did not comply with my pre-set solution, and when the correct combination was applied, the red light turned off and the green light turned on. This showed that the circuit was working correctly. However, after further testing, I discovered that when switch 3 was switched to low (incorrect position) after being high (correct position) and all the other switches remained in their correct positions, the green light stayed on and the red light stayed off, even though the combination was incorrect. I implemented numerous fault-finding techniques (including solder joint inspection, looking for unintentional track-bridging and component placement errors). After extensive analysis and review of the circuit wiring and construction, I realised that one of the jumper wires was incorrectly placed, bridging the wrong tracks. I fixed this by desoldering the wire and resoldering it to the correct tracks.

The tools that I used are shown in Figure 4 in the photographic record. Safety considerations were important during the construction of the circuit. For example, when soldering, I ensured that I was in a well-ventilated area with appropriate air flow and used a stand for the soldering iron to reduce the risk of bodily harm or damage to other objects from contact with the hot metal point. I also wore safety glasses whenever I was working with potentially dangerous materials and tools.

If I were to construct this circuit again, I would investigate the possibility of using a manufactured switch bank to simplify the process, and also obtain measurements of the final circuit housing so that I could calculate the required lengths of the connecting wires before cutting them to size.

Additional Comments
This task was assessed at an A+ level.

Performance Standards for Stage 2 Design and Technology

	Investigating	Planning	Producing	Evaluating
A	Clear, comprehensive, and well-considered identification of a need, problem, or challenge. Thorough and insightful creation and validation of initial design brief based on needs analysis and task identification. Purposeful investigation and critical analysis of the characteristics of a broad variety of existing products, processes, systems, and/or production techniques. In-depth investigation into product material options and focused and thorough critical analysis for product use. Focused and perceptive investigation into the impact of products or systems on individuals, society, and/or the environment.	In-depth analysis of information to develop imaginative, innovative, and enterprising solutions to an identified design brief. Accomplished communication of a variety of refined product design ideas, consistently using relevant technical language. Purposeful testing and refined modification and validation of ideas or procedures.	Sophisticated application of appropriate skills, processes, procedures, and techniques to create a product or system to a precise or polished standard and specification. Accomplished use of resources, equipment, and materials to create a product or system safely and accurately. Accomplished and resourceful development of solutions to technical problems that may arise during product or system realisation.	Insightful and well-considered evaluation of product success against design brief requirements. Insightful and detailed evaluation of the effectiveness of the product or system realisation process. Refined and well-considered reflection on materials, ideas, and procedures, with sophisticated recommendations. Resourceful and well-informed analysis of the impact of the product or system on individuals, society, and/or the environment.
B	Well-considered identification of a need, problem, or challenge. Well-considered creation and validation of an initial design brief based on needs analysis and task identification. Thoughtful investigation and analysis of the characteristics of a variety of existing products, processes, systems, and/or production techniques. Detailed investigation into product material options and thorough analysis for product use. Some depth of investigation into the impact of products or systems on individuals, society, and/or the environment.	Thoughtful analysis of information to develop enterprising solutions to an identified design brief. Capable communication of different quality product design ideas, using relevant technical language. Thoughtful testing, modification, and validation of ideas or procedures.	Capable application of appropriate skills, processes, procedures, and techniques to create a product or system to a mostly precise or polished standard and specification. Capable use of resources, equipment, and materials to create a product or system safely and mostly accurately. Thoughtful development of solutions to technical problems that may arise during product or system realisation.	Well-considered evaluation of product success against design brief requirements. Well-considered and detailed evaluation of the effectiveness of the product or system realisation process. Well-considered reflection on materials, ideas, and procedures, with thoughtful recommendations. Well-informed analysis of the impact of the product or system on individuals, society, and/or the environment.
C	Considered identification of a need, problem, or challenge. Considered creation and validation of an initial design brief based on needs analysis and task identification. Competent investigation of the characteristics of some existing products, processes, systems, and/or production techniques. Competent investigation into product material options and analysis for product use. Generally thoughtful investigation into the impact of products or systems on individuals, society, and/or the environment.	Analysis of information to develop appropriate solutions to an identified design brief. Competent communication of product design ideas, using appropriate technical language. Competent testing, modification, and validation of ideas or procedures.	Competent application of skills, processes, procedures, and techniques to create a product or system to an appropriate standard and specification. Competent use of resources, equipment, and materials to create a product or system safely and generally accurately. Development of appropriate solutions to technical problems that may arise during product or system realisation.	Considered evaluation of product success against design brief requirements. Considered evaluation of the effectiveness of the product or system realisation process. Considered reflection on materials, ideas, and procedures, with appropriate recommendations. Informed analysis of the impact of the product or system on individuals, society, and/or the environment.
D	Identification of a basic need, problem, or challenge. Creation of a basic initial design brief with some consideration of a needs analysis. Identification of the characteristics of some existing products, processes, systems, or production techniques. Some basic description of material options. Some description of the impact of products or systems on individuals, society, or the environment.	Some identification of information to attempt basic solutions to an identified design brief. Basic communication of some product design ideas with some use of appropriate technical language. Partial testing and some modification of ideas or procedures.	Partial application of skills, processes, procedures, and techniques to make one or more articles to a limited standard and specification. Some use of basic resources, equipment, or materials to create a product or system, with some consideration of safety aspects. Partial development of some basic solutions to technical problems that may arise during product or system realisation.	Description of product progress, with elements of basic testing against design brief requirements. Some description of the effectiveness of the product or system realisation process. Superficial reflection on or description of materials, ideas, or procedures, with basic recommendations. Some consideration of the impact of the product on individuals, society, or the environment.

	Investigating	Planning	Producing	Evaluating
E	Limited identification of a need, problem, or challenge. Creation of a very basic initial design brief, with support. Statement of one or more characteristics of an existing product, process, system, or production technique. Limited description of one or more product material options. Identification of one impact of a product or system on individuals, society, or the environment.	Attempted identification of some information to develop limited solutions to an identified design brief. Limited communication of one or more product design ideas. Some attempt at testing and limited modification of an idea or procedure.	Attempted application of one or more skills, to follow an appropriate process, procedure, or technique. Attempted use of resources, equipment, or materials, with emerging awareness of safety issues. Some attempted description of problems that may arise during product or system realisation.	Identification of some product progress, with limited testing. Identification of some aspects of the effectiveness of the product or system realisation process. Identification rather than description of materials, ideas, or procedures, with one or more recommendations. Emerging recognition of one or more of the impacts of the product on individuals, society, or the environment.

Stage 2 Electronic Systems

Specialised Skills Application Task 2

Constructing a Housing for an Electronic Lock

Government of South Australia

SACE Board of SA

Subject: Systems and Control Products I Variant: ____ School: ____ Contact Teacher: ____

ASSESSMENT DETAILS

Use the table below to provide details of the assessments designed to provide opportunities for the range of students in the cohort to show evidence of their learning against the performance standards.

Name of Assessment (Assessment Type)	Description of Assessment (a description of the flexible, and where appropriate, negotiable, ways in which students show evidence that demonstrates their learning against the performance standards, including to the highest standard)	Assessment conditions as appropriate (e.g. task type, word length, time allocated, supervision)
Material application	Using appropriate components, materials and systems and BOTH the breadboard and Yenka simulation software to investigate the operation of AND and NOT gate chips and how they could be used to create an electronic 'lock'. Compare and contrast the two prototyping systems and speculate about how each could be used separately and in combination when designing a major project.	Results and findings presented as a report.800 max including appropriate annotated graphics and photographs.
Specialised skills application 1	Using a circuit diagram and component layout they have developed students construct an electronic lock circuit with a minimum 5 switch input and LED output and designed and constructed using AND and NOT gates chips. Circuit to be soldered onto stripboard.	Evidence must included computer generated graphics of the circuit and layout and an annotated photostory of the construction and testing – minimum 20 photographs
Specialised skills application 2	Students use their own electronic lock circuit to design and construct an appropriate housing for the circuit. The design needs to display appropriate attention in the design solution to LED and switch mounting, interstage wiring, battery and board security, maintenance access and output display.	Evidence must included working drawing with parts and material list and an annotated photostory of the construction, fitting and testing– minimum 20 photographs
Major project	Students produce an assembled stripboarded circuit linked to a theme of oscillating output.	Evidence annotated photostory and/or video of the construction, fitting and testing– minimum 30 photographs
Minor project	Students design and construct an appropriate housing for the oscillating circuit which converts it to an advertising display. Design needs to include consideration of interstage wiring, remote component mounting, flashing display properties, board and battery mounting and housing materials, dimensions and properties.	Evidence must include details specifications for the housing and an annotated photostory and/or video of the construction, fitting and testing of the product – minimum 20 photographs

Contents

1. Introduction

The purpose of this report is to evaluate and discuss the processes used to design and construct a suitable housing for an electronic lock circuit. The report will also detail an investigation into the possible adaptation of existing containers and materials that could be used when constructing a purpose-built alternative. The design process is documented through a photographic record.

Task requirements clearly stated.

2. Investigation

2. 1. Purpose-built or modified pre-existing housing

I conducted an investigation into whether it would be more appropriate and/or efficient to design and construct a purpose-built container to house the circuit in, or just modify a pre-existing container to meet the requirements.

I analysed four pre-existing containers of different materials to determine the modifications that would need to be applied to each one to suit the task. See Table 1 below.

Summary provides evidence of critical analysis of information provided in the table below.

After investigating the option of modifying an existing container to use as the housing for the circuit, I have decided that it would be more effective to construct my own purpose-built container from scratch. I like the appearance of the container made from pine, however I also realise the benefits of the easy-to-manipulate cardboard.

Table 1

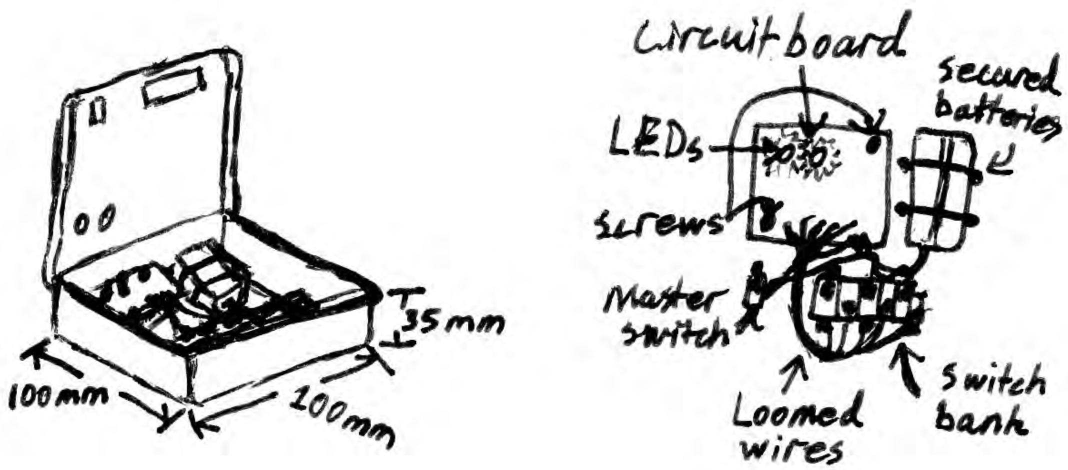
Pre existing container		Required modifications
Cardboard		• Add supports to secure circuit board and battery • Insert holes to make outputs (LEDs) visible and inputs (switches) accessible • Improve ventilation by removing section(s) of housing • Provide for looming of wires to improve neatness • Add labels for inputs (switches)
Tin		• Add supports to secure circuit board and battery • Insert holes to make outputs (LEDs) visible and inputs (switches) accessible • Improve ventilation by removing section(s) of housing • Insulate current-bearing components from contact with conductive housing • Provide for looming of wires to improve neatness • Add labels for inputs (switches)
Plastic		• Add supports to secure circuit board and battery • Insert holes to make inputs (switches) accessible • Improve ventilation by removing section(s) of housing • Provide for looming of wires to improve neatness • Possibly reinforce hinge joint to ensure durability • Add labels for inputs (switches)
Pine		• Add supports to secure circuit board and battery • Insert holes to make outputs (LEDs) visible and inputs (switches) accessible • Improve ventilation by removing section(s) of housing • Provide for looming of wires to improve neatness • Add labels for inputs (switches)

Information in the table is evidence of purposeful investigation of several possible options.

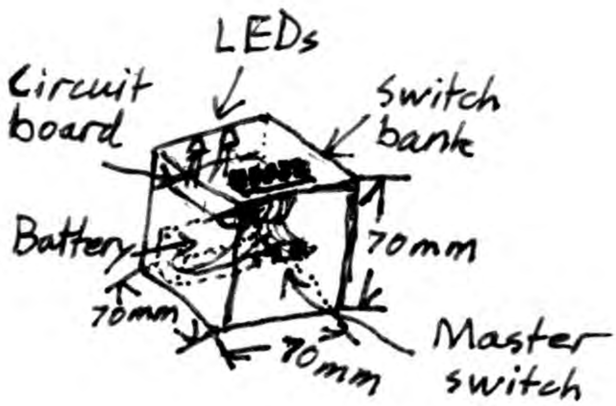
2. 2. Size, shape and layout

I drafted three designs for the housing – utilising different dimensions and layout for each. See Figure 1 below. I have decided to develop the third option, as I think it is the easiest to construct.

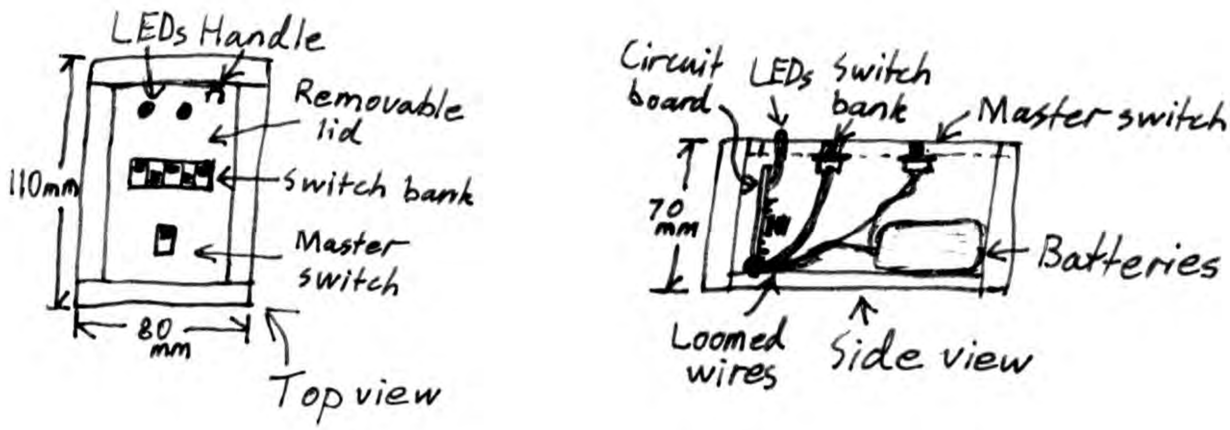
Figure 1



Dimensions: 100mm x 100mm x 35mm (l x w x d)



Dimensions: 70mm x 70mm x 70mm (l x w x d)



Dimensions: 110mm x 80mm x 70mm (l x w x d)

A series of sketches with comments indicates in-depth analysis of investigated examples, along with accomplished communication skills.

2. 3. Material

Comments reflect informed analysis of information provided in table below.

I investigated possible materials that were available to me to be used in the construction of my housing, evaluating the advantages and disadvantages of each. See Table 2 below.

I have decided to use pine as the main material for the housing base, especially because it is easy to work with, has an attractive finish and is durable.

Table 2

Material	Advantages	Disadvantages
Cardboard	• Non-conductive • Lightweight • Inexpensive • Easy to work with • Only simple tools required • Easy to add labels	• Fragile • Not waterproof
Tin	• Lightweight • Easy to work with	• Conductive • Requires special tools
Plastic	• Non-conductive • Transparent • Inexpensive • Lightweight	• Difficult to cut and machine • Is brittle and can shatter if not handled correctly • Scratches are easily visible
Pine	• Non-conductive • Very durable • Attractive finish • Inexpensive • Easy to work with	• Requires secure joins • Requires special tools • Heavy

Information in table is evidence of purposeful investigation of several materials options.

2. 4. Battery and board security

I will be using four 1.2V AA NiMH rechargeable batteries to supply power to my circuit. It is necessary to obtain a suitable battery holder that will be able to secure the batteries within the housing. Some options are detailed in Table 3 below.

Table 3

Battery security option	Comments	Battery security option	Comments
	This battery holder supports four AA batteries in series in a 4x1 configuration and uses a polarised snap connector. However, it does not provide any immediately obvious method of attaching to a solid surface.		This battery holder allows for four AA batteries to be connected in series in a stacked 2x2 configuration. It uses wire leads for connectivity and does not provide an easy way to be secured.
	Similarly to the one above, this battery holder supports four AA batteries in a 4x1 layout; however it uses wire leads and provides screw holes for easy fastening.		Four AA batteries can be connected in series in an elongated stacked layout using this battery holder. It provides for a snap connector; however it does not supply a way to be easily attached to a container.

The circuit board will also need to be secured in the housing. There are multiple options for doing this, including:

- Drilling holes for removable screws (either regular metal screws or plastic circuit board spacers)
- Using clips to lock the board in place
- Cutting slots into the housing material in which the board can be inserted and secured.

2. 5. Wire looming

As the housing will need to be as compact as possible, it is necessary to keep connecting wires tidy. This can be achieved by looming them together. Techniques include wrapping tape around the wires, threading them through a series of cable clips around the side of the housing to keep them out of the way of other components, or threading them all through a common larger hollow piece of wire insulation.

2. 6. Switch positioning and mounting

It is crucial that all inputs are easily accessible either on or through the housing. The SPDT switches that are being used in my electronic lock circuit include extensions on their extremities with screw holes for fastening to solid surfaces. The switches can either be mounted on the underside of a surface – protruding through to the front, or on the front of the surface itself, with the solder joints on the rear protruding back towards the inside of the housing. Either screws or glue could be used to secure the switches.

2. 7. Output exposure

Outputs must also be exposed when the device is in operation. In the case of my electronic lock circuit, the two LEDs must be easily viewable. This could be achieved through provision of holes in the housing for the LEDs to protrude through, or by placing a solid transparent material over the LEDs to let them be seen by the user.

2. 8. Labelling

It is important that all of the input components are labelled – as well as ambiguous outputs – to ensure that users are able to easily operate the electronic lock. Either purpose-specific adhesive labels or custom-made paper labels could be implemented depending on the type of material used in the housing.

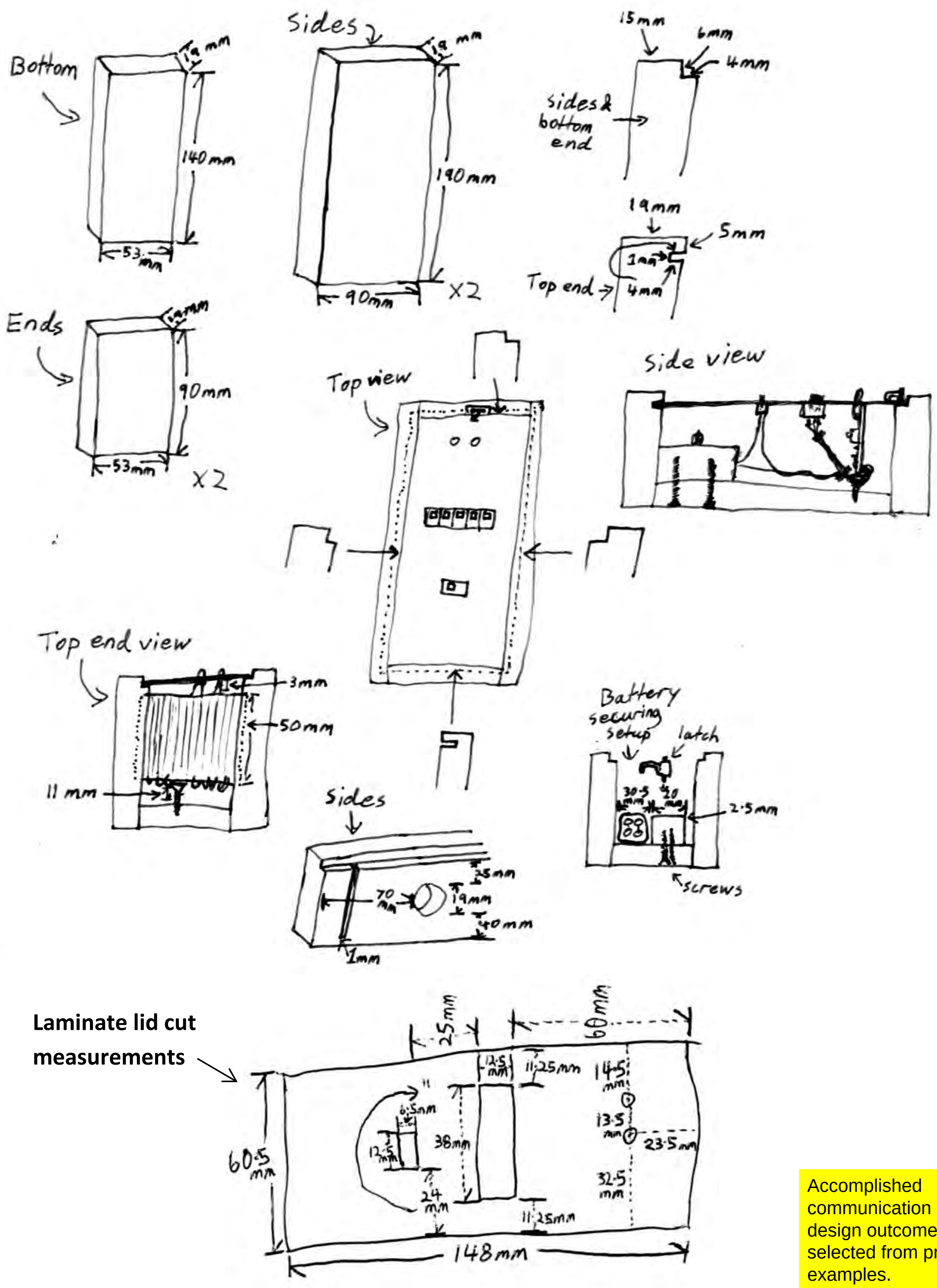
Further evidence of students purposeful investigation standards.

3. Specifications

3. 1. Working drawings

I created a series of hand-written diagrams to aid me in designing and constructing the housing. These are shown in Figure 2 below.

Figure 2



Accomplished communication of final design outcome, selected from previous examples.

3. 2. Materials list

Table 4	
Quantity	**Part**
1	Strip board
1	5mm Red LED
1	5mm Green LED
1	220Ω resistor
1	4081 Quad 2-input AND gate IC
1	4069 Hex NOT gate (Inverter) IC
5	SPDT switch
1	AA 4-battery holder
2	14-pin IC socket
1	1m multi-core jumper and connecting wire
1	27cm insulated solid wire
1	7cm insulated wire-ribbed plastic tie
1	50cm pine timber (90mm x 20mm)
1	Laminate (150mm x 65mm)

3. 3. Cut list

Table 5					
Item ID	**Description**	**Material**	**Stock size**	**Length**	**Number of pieces**
(a)	Base (bottom)	Pine	53mm x 20mm	140mm	1
(b)	Sides	Pine	90mm x 20mm	180mm	2
(c)	Ends	Pine	53mm x 20mm	90mm	2
(d)	Battery support piece	Pine	31.5mm x 20mm	57mm	1
(e)	Lid	Laminate	60.5mm x 1mm	148mm	1

3. 4. Battery and board security

I have decided to use a combination of techniques to secure the batteries and circuit board within my housing. As depicted in Figures 9 and 20 in the photographic record, a large cable clip and piece of pine will be used to keep the battery in place yet removable for maintenance or replacement. Also, the circuit board will fit into a pair of slots cut into either side of the housing, supported at the bottom by an adjustable screw and held in at the top by the lid of the housing.

3. 5. Wire looming

After using a pair of small cable ties as a temporary solution when testing the circuit, I have decided that they would work well once tightened and trimmed to size. So I will be using cable ties to loom the wires in the final product.

3. 6. Decisions

I have decided to use pine for the base of the housing, as it offers an attractive finish and a durable final product, and I have easy access to the tools required to machine it. The laminate that I will be using for the lid is of a high quality and also adds visual appeal to the housing. I think that the techniques that I have chosen for battery and board security are innovative and reliable – providing for easy maintenance and replacement of components – which, in my opinion, is a key feature of the housing.

4. Photographic record of construction

I took photographs of many of the steps in the construction of the electronic lock circuit. These are included below in Figures 3-24.

Figure 3

The photograph above shows me using a drop saw to cut the pine down to size. Note that my hands are well clear of the blade and that I am using ear protection and safety glasses to reduce the risk of personal harm while using this power tool.

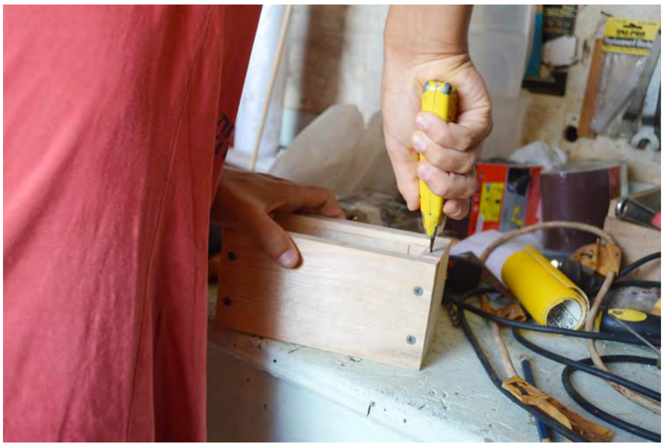
Figure 4

These are the pieces of pine after being cut down to size and bevelled according to my design plans. The two end pieces are on the left, the two side pieces are in the middle, and the bottom piece is on the right, with the battery support piece already screwed in place.

Figure 5

The photograph above shows me screwing the pieces of pine together.

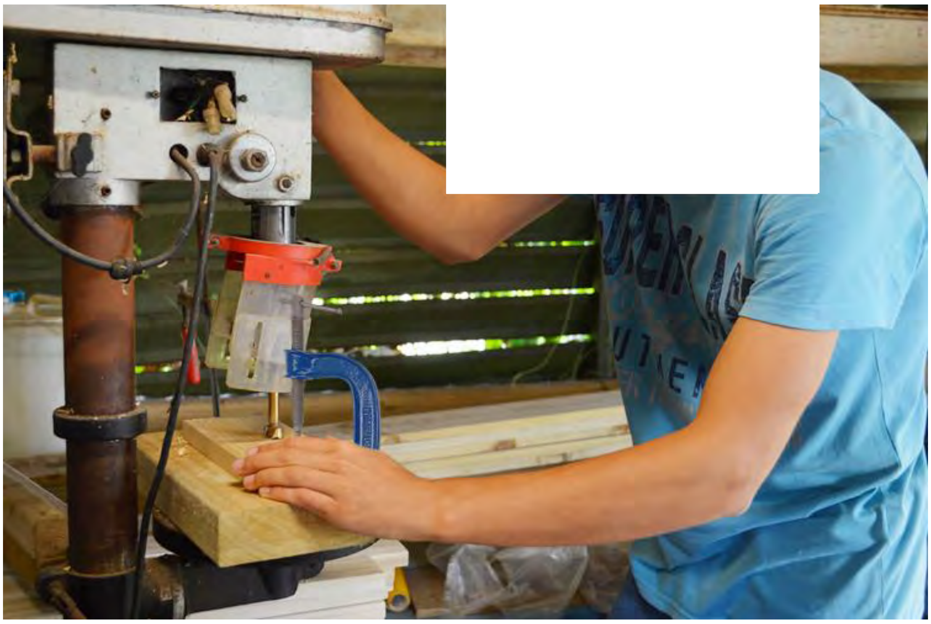
Figure 6



The two photographs above show me using a Stanley knife to cut the indented section in the top end piece of pine where the cable clip is to be inserted. Note that my fingers are well away from the knife blade and I am cutting at the safest angle possible.

Extensive range of images follows, providing infinite detail of sophisticated application of skills and procedures.

Figure 7



The photograph above shows me using a drill press to cut the circular ventilation holes in the side pieces. Note the safety glasses being worn, a clamp being used to keep the wood steady, and my hands being kept well away from the drill bit, which is shielded by a guard.

Figure 8

This photograph shows me hammering in the nail to secure the cable clip that holds the battery in place.

Figure 9

The photographs above show the completed housing base, with the two cable clips for securing the battery and the lid, and the screw for supporting the circuit board.

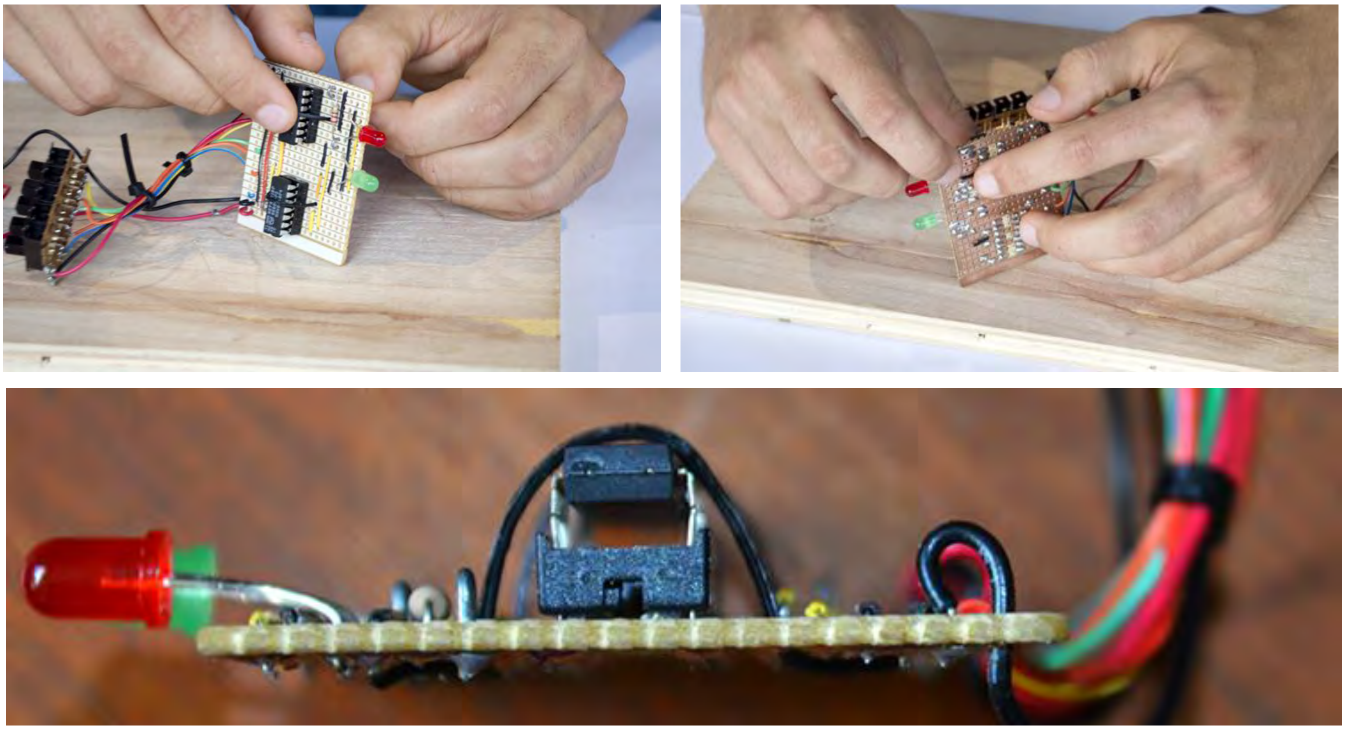
Figure 10

I used large and small drill bits and a cordless drill to cut the holes in the laminate, and then used sandpaper to smooth the edges of the holes and ensure that they were the correct sizes. Note the G-clamp being used to hold the laminate secure and steady, in lieu of my hands (which are being kept well clear of the drill bit). This reduces the risk of personal harm should the drill 'grab' the laminate material and spin out of control.

Figure 11

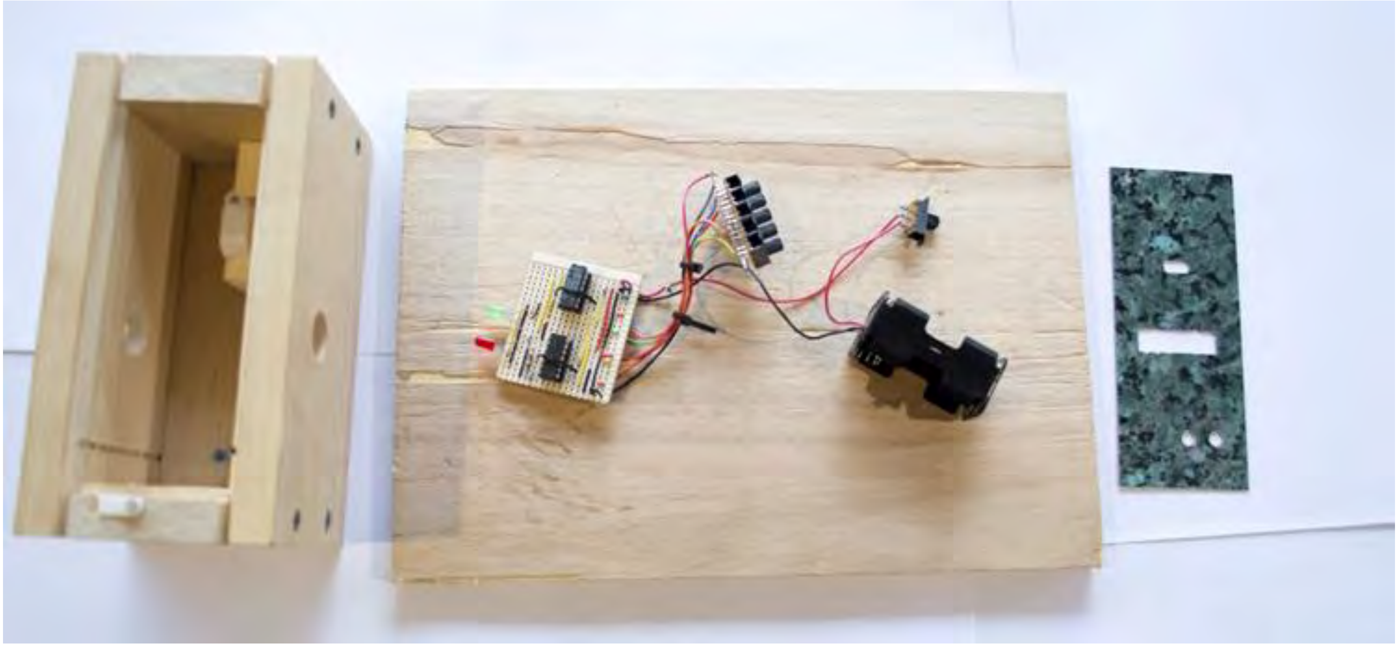
The photograph above shows me using sandpaper to smooth the edges of the laminate that forms the lid of my circuit housing.

Figure 12



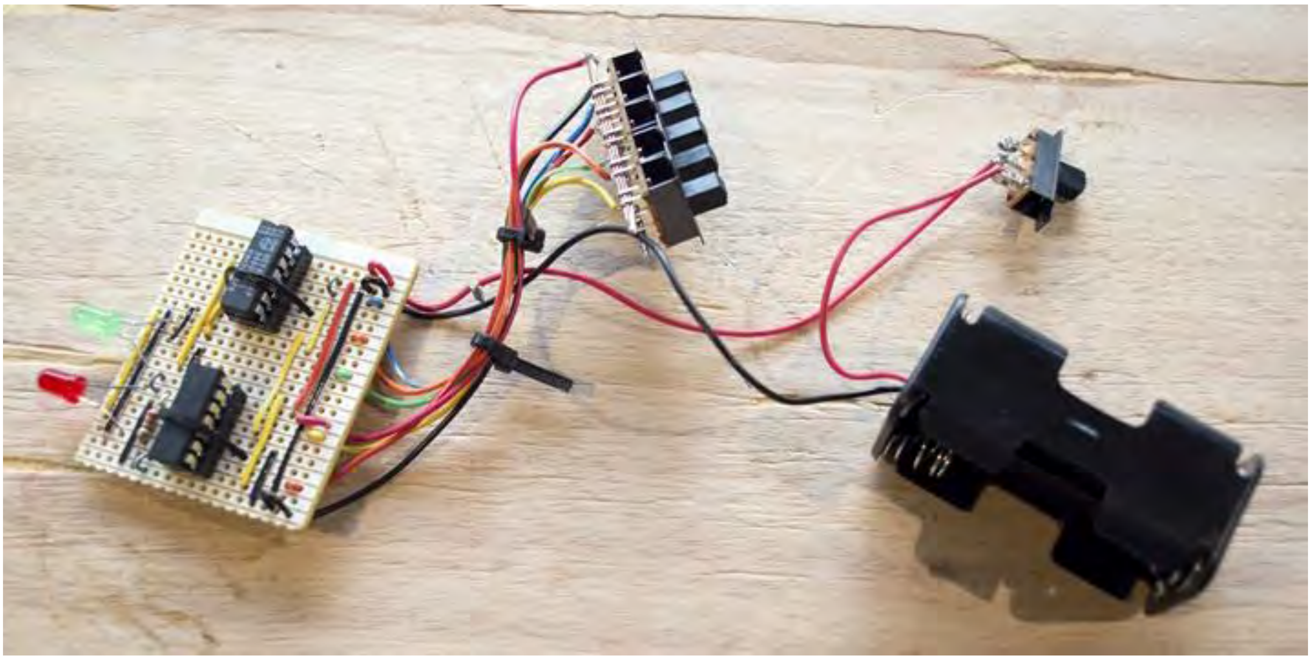
The pictures at the top show me fastening the insulated wire-ribbed plastic ties over the ICs and through the circuit board to secure the ICs in their sockets. The image below them is a close up of this.

Figure 13



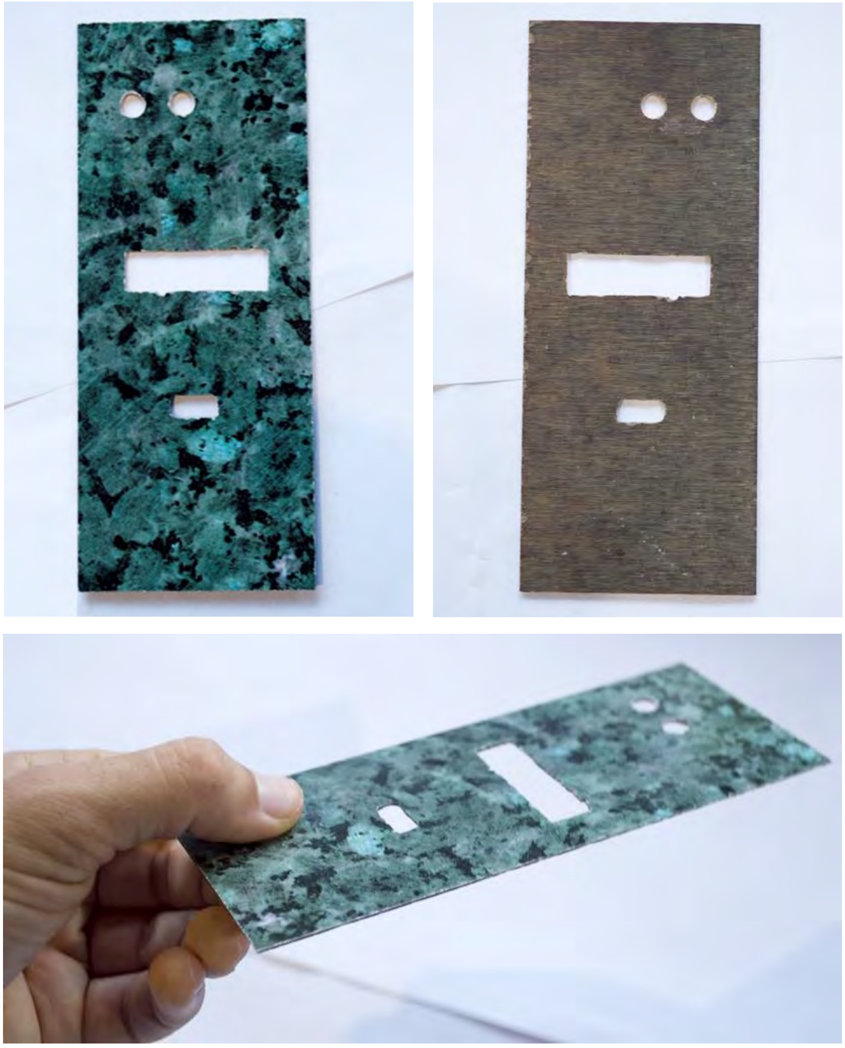
The housing, the circuitry and the lid are shown in the photograph above, prior to the switches being glued to the lid.

Figure 14



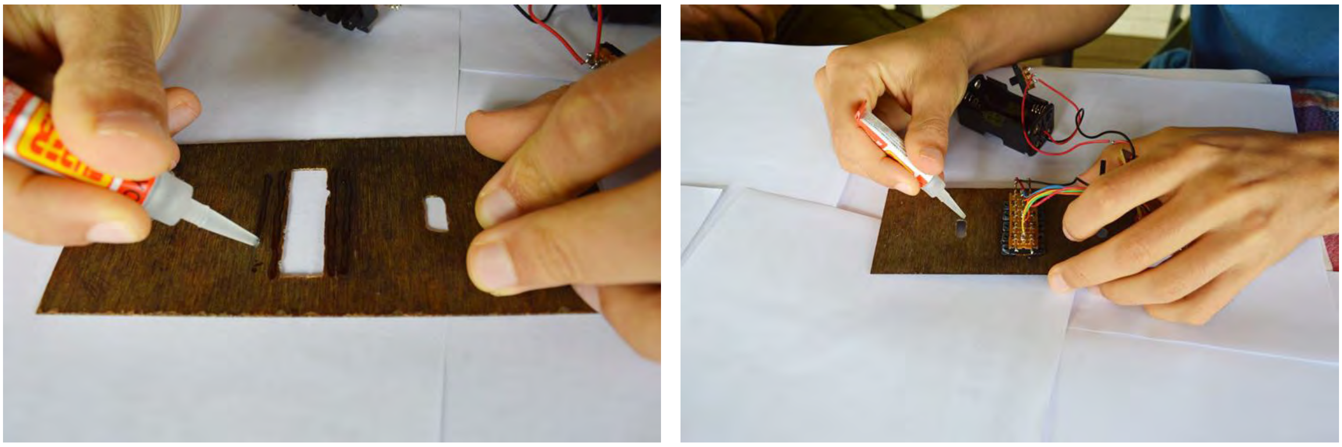
The circuit and off-board components are shown in the image above before being attached to the housing lid.

Figure 15



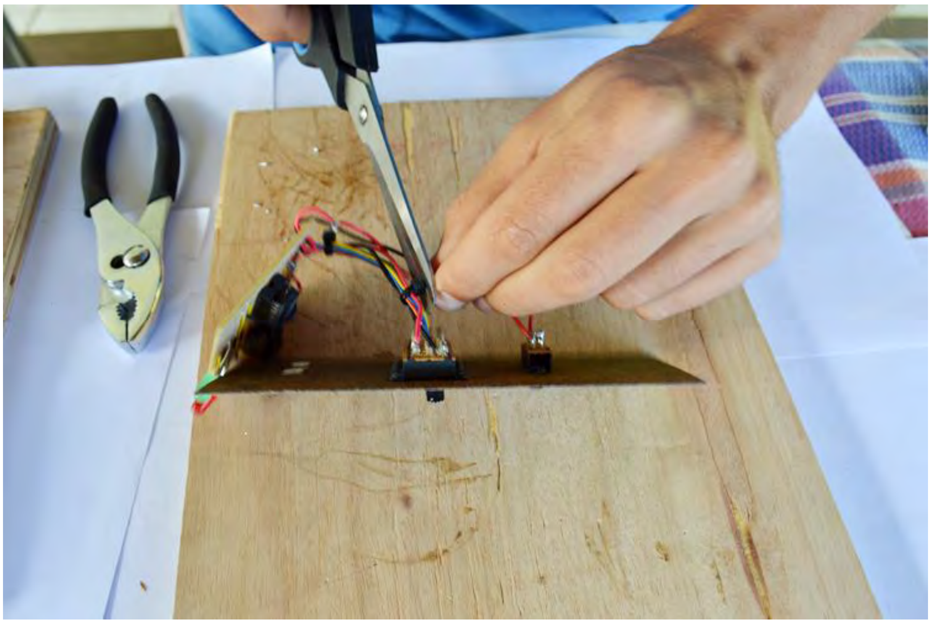
These photographs show the laminate lid before the switches were glued to it.

Figure 16



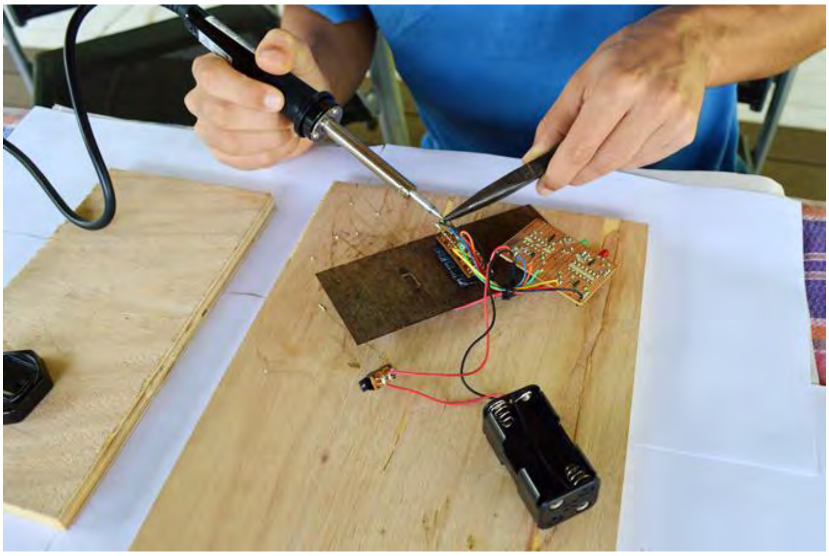
I used superglue to attach the switches to the underside of the laminate lid, as shown in the photographs above.

Figure 17



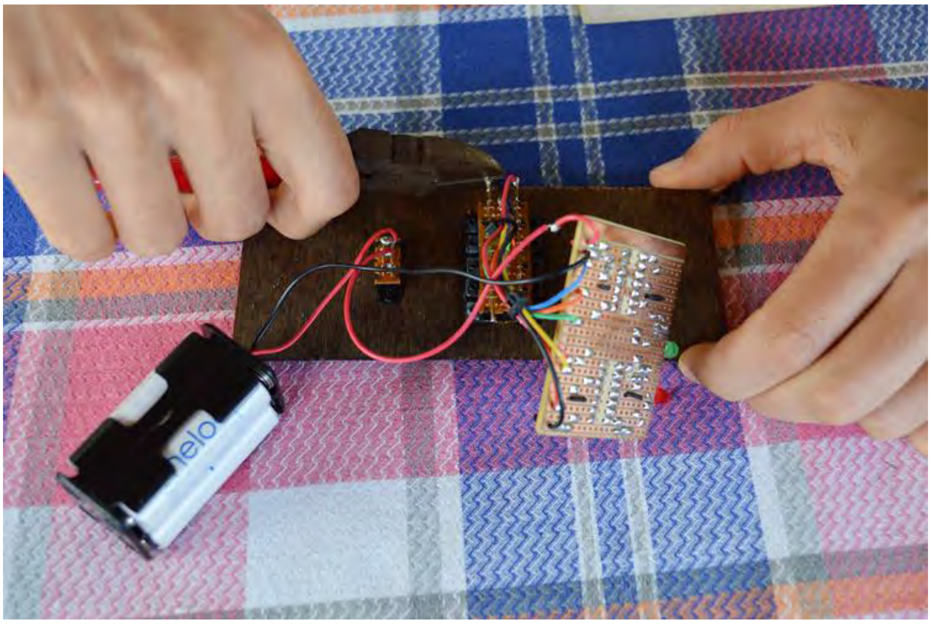
The photograph above shows me using scissors to trim off the ends of the cable ties used to loom the off-board components' connecting wires together.

Figure 18



Some of the solder joints connecting the off-board components were prone to failure and so I was required to repair these where necessary, aiming to make them stronger.

Figure 19



Evidence of solutions to technical problems.

After gluing the switches to the lid and attempting to fit it all into the housing base, I discovered that the power rails were about two millimetres too long to fit into the housing base after being attached to the lid – so I had to trim the necessary length of wire off the end of the wires using a pair of side cutters, as shown in the picture above.

Figure 20

The photograph above shows the four AA batteries in the battery holder, secured by a large cable clip and piece of pine.

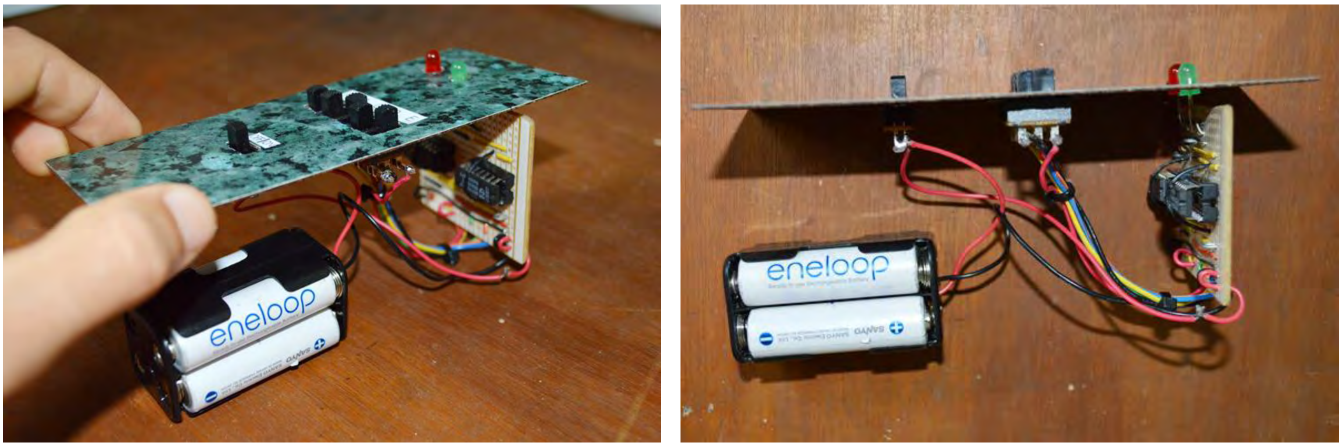
Figure 21

The photograph above shows the housing structure with the circuit inserted and functioning. The final step in completing the housing was to create and attach appropriate labels to the laminate lid.

Figure 22

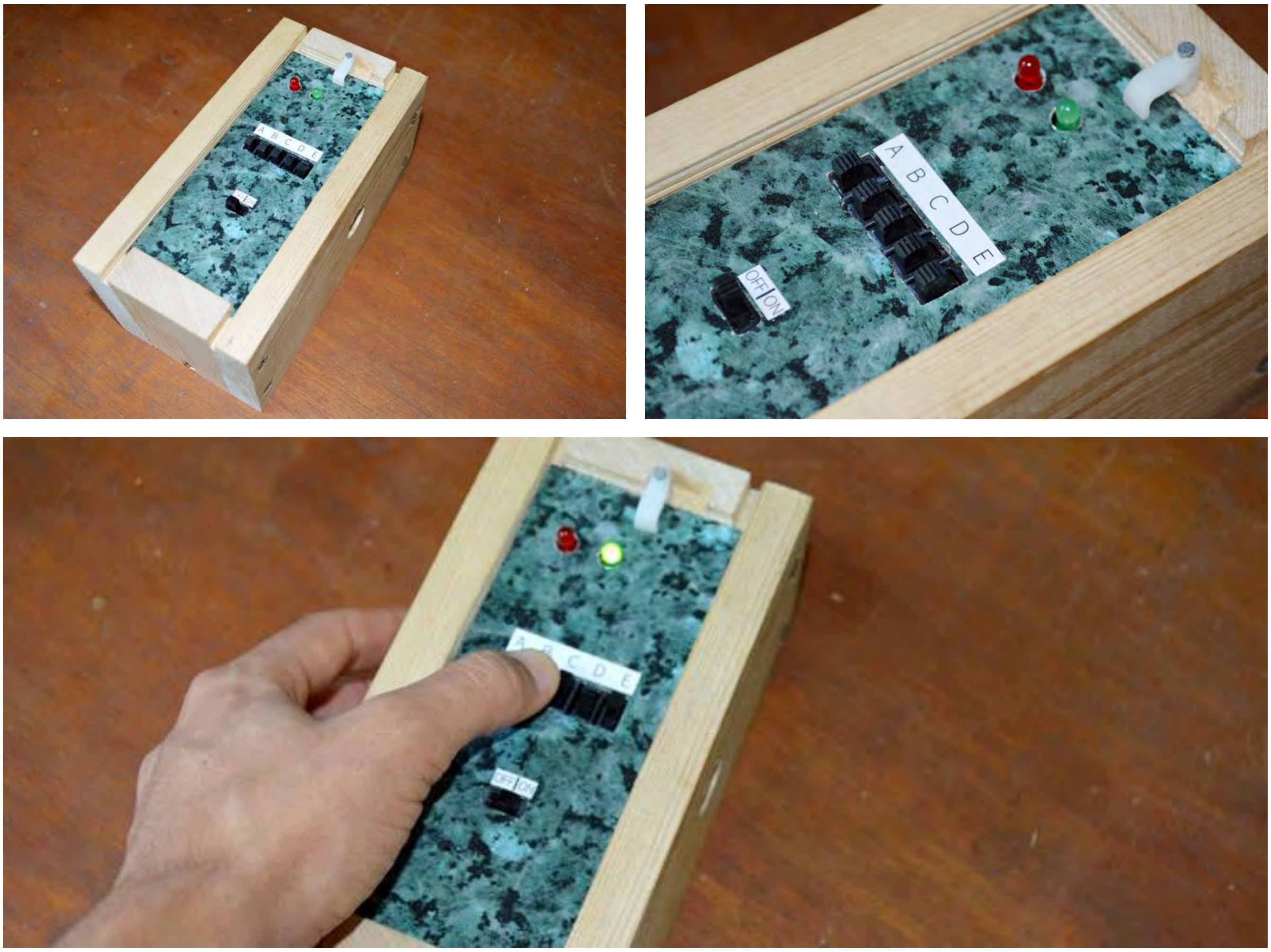
The photograph above shows me applying craft glue to a section of the surface of the laminate lid in preparation for attaching the 'ON | OFF' label above the master switch. The 'A B C D E' label can be seen above the switch bank.

Figure 23



The photos above show the approximate configuration of the on-board and off-board components as they would be when inside the housing. The looming of the connecting wires is visible in the picture on the right.

Figure 24



The three images above show the completed housing, with the circuit inserted and functioning.

5. Evaluation

Some aspects of the design and construction could be improved. A handle is not supplied to aid in lifting the laminate lid, making the lid difficult to remove from the base. The screw in the bottom piece of pine conflicts with the paths of connecting wires under the circuit board, making circuit board insertion tedious. This issue could be remedied through better coordination of off-board wiring and supporting components.

Overall, I am pleased with the final product. In my opinion, the slot systems used to secure the circuit board and lid are innovative and well-implemented.

Discussion demonstrates well considered evaluation of product success against design brief requirements.

Additional Comments
This task was assessed at an A+ standard.

Performance Standards for Stage 2 Design and Technology

	Investigating	Planning	Producing	Evaluating
A	Clear, comprehensive, and well-considered identification of a need, problem, or challenge. Thorough and insightful creation and validation of initial design brief based on needs analysis and task identification. Purposeful investigation and critical analysis of the characteristics of a broad variety of existing products, processes, systems, and/or production techniques. In-depth investigation into product material options and focused and thorough critical analysis for product use. Focused and perceptive investigation into the impact of products or systems on individuals, society, and/or the environment.	In-depth analysis of information to develop imaginative, innovative, and enterprising solutions to an identified design brief. Accomplished communication of a variety of refined product design ideas, consistently using relevant technical language. Purposeful testing and refined modification and validation of ideas or procedures.	Sophisticated application of appropriate skills, processes, procedures, and techniques to create a product or system to a precise or polished standard and specification. Accomplished use of resources, equipment, and materials to create a product or system safely and accurately. Accomplished and resourceful development of solutions to technical problems that may arise during product or system realisation.	Insightful and well-considered evaluation of product success against design brief requirements. Insightful and detailed evaluation of the effectiveness of the product or system realisation process. Refined and well-considered reflection on materials, ideas, and procedures, with sophisticated recommendations. Resourceful and well-informed analysis of the impact of the product or system on individuals, society, and/or the environment.
B	Well-considered identification of a need, problem, or challenge. Well-considered creation and validation of an initial design brief based on needs analysis and task identification. Thoughtful investigation and analysis of the characteristics of a variety of existing products, processes, systems, and/or production techniques. Detailed investigation into product material options and thorough analysis for product use. Some depth of investigation into the impact of products or systems on individuals, society, and/or the environment.	Thoughtful analysis of information to develop enterprising solutions to an identified design brief. Capable communication of different quality product design ideas, using relevant technical language. Thoughtful testing, modification, and validation of ideas or procedures.	Capable application of appropriate skills, processes, procedures, and techniques to create a product or system to a mostly precise or polished standard and specification. Capable use of resources, equipment, and materials to create a product or system safely and mostly accurately. Thoughtful development of solutions to technical problems that may arise during product or system realisation.	Well-considered evaluation of product success against design brief requirements. Well-considered and detailed evaluation of the effectiveness of the product or system realisation process. Well-considered reflection on materials, ideas, and procedures, with thoughtful recommendations. Well-informed analysis of the impact of the product or system on individuals, society, and/or the environment.
C	Considered identification of a need, problem, or challenge. Considered creation and validation of an initial design brief based on needs analysis and task identification. Competent investigation of the characteristics of some existing products, processes, systems, and/or production techniques. Competent investigation into product material options and analysis for product use. Generally thoughtful investigation into the impact of products or systems on individuals, society, and/or the environment.	Analysis of information to develop appropriate solutions to an identified design brief. Competent communication of product design ideas, using appropriate technical language. Competent testing, modification, and validation of ideas or procedures.	Competent application of skills, processes, procedures, and techniques to create a product or system to an appropriate standard and specification. Competent use of resources, equipment, and materials to create a product or system safely and generally accurately. Development of appropriate solutions to technical problems that may arise during product or system realisation.	Considered evaluation of product success against design brief requirements. Considered evaluation of the effectiveness of the product or system realisation process. Considered reflection on materials, ideas, and procedures, with appropriate recommendations. Informed analysis of the impact of the product or system on individuals, society, and/or the environment.
D	Identification of a basic need, problem, or challenge. Creation of a basic initial design brief with some consideration of a needs analysis. Identification of the characteristics of some existing products, processes, systems, or production techniques. Some basic description of material options. Some description of the impact of products or systems on individuals, society, or the environment.	Some identification of information to attempt basic solutions to an identified design brief. Basic communication of some product design ideas with some use of appropriate technical language. Partial testing and some modification of ideas or procedures.	Partial application of skills, processes, procedures, and techniques to make one or more articles to a limited standard and specification. Some use of basic resources, equipment, or materials to create a product or system, with some consideration of safety aspects. Partial development of some basic solutions to technical problems that may arise during product or system realisation.	Description of product progress, with elements of basic testing against design brief requirements. Some description of the effectiveness of the product or system realisation process. Superficial reflection on or description of materials, ideas, or procedures, with basic recommendations. Some consideration of the impact of the product on individuals, society, or the environment.

	Investigating	Planning	Producing	Evaluating
E	Limited identification of a need, problem, or challenge. Creation of a very basic initial design brief, with support. Statement of one or more characteristics of an existing product, process, system, or production technique. Limited description of one or more product material options. Identification of one impact of a product or system on individuals, society, or the environment.	Attempted identification of some information to develop limited solutions to an identified design brief. Limited communication of one or more product design ideas. Some attempt at testing and limited modification of an idea or procedure.	Attempted application of one or more skills, to follow an appropriate process, procedure, or technique. Attempted use of resources, equipment, or materials, with emerging awareness of safety issues. Some attempted description of problems that may arise during product or system realisation.	Identification of some product progress, with limited testing. Identification of some aspects of the effectiveness of the product or system realisation process. Identification rather than description of materials, ideas, or procedures, with one or more recommendations. Emerging recognition of one or more of the impacts of the product on individuals, society, or the environment.