Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Technology 2024

91612 Demonstrate understanding of how technological modelling supports technological development and implementation

EXEMPLAR

Excellence

TOTAL 08

AS91612 Demonstrate Understanding of how Technological Modelling supports Technological Development and Implementation

Technological modelling involves the testing and creation of design ideas to see if they induce the development of a technological outcome that is fit for a described purpose. Technological modelling falls under two categories: functional and prototyping. Functional modelling is the development, and testing of design concepts to see if the technological outcome will achieve its purpose. It comprises of research into the feasibility and practicality of an idea based off the context established. This involves research, testing, 2D and 3D modelling. Prototyping succeeds functional modelling and involves testing and necessary additional refinements to a physically produced outcome based on whether it meets its criteria. Prototyping considers potential social/physical environmental impacts and the testing of key factors affecting the technological outcome's functionality and fitness for purpose. This year we were given creative freedom to make anything we desired, provided that it addressed an issue within a self-determined context. To determine my context, I considered anything needed that would benefit me in the long term. This led to my need to store away valuable items such as money or sentimental objects for safekeeping, which is why I decided to make a safe. In my brief, I outlined that my safe would be able to store away valuable items safely through the use of an RFID based door lock access control system; a safe. My fitness for purpose was to make a safe that is secured, accessible (to me), and safe (hidden from unwanted others) by the use of an RFID based door lock access control system. Competing factors involve certain factors opposing each other where they are equally important, but the implementation or improvement of one involves the deterioration or disregard of another. It's moments in my modelling where I made a balanced decision to implement certain ideas at the expense of others or accommodate them in equal amounts for a better outcome. This includes the design, size, situation, time, and practicality (simplicity) of my build. Contestable factors are factors that are quite similar. It's moments in my modelling where I had made a decision and a new idea (or criticism from my stakeholders) arose that offered solutions that could have been better for my outcome. This includes the parts, material, and layout of my components. My report will discuss the decisions I made throughout technological modelling by testing competing and contestable factors in different parts of my build.

<u>Competing Factors:</u>

Electronic System – Once I had determined my context, I needed to decide on what type of electronic system I would use. This was between an electronic pin lock system and the RFID door lock system and the decision would be determined by what I deemed to be the most practical and effective for the security and accessibility of my safe.

Design – At the start of my build, I needed to determine a shape for my safe which was influenced by simple safe designs and a physical example given to me, as well as what was feasible. This was important as it would determine the structural integrity of my safe.

Size – This was important, because the larger the safe is, the more things it would fit, however, this was restricted by the workspace available (laser cutter size) and the area of situation. Thus, it needed to be big enough to fit my circuit components and valuable items, but small enough to fit in its area of situation.

Situation – This was important, as it would determine how secure and accessible my safe was from me and unwanted individuals – a big part of determining my safe's fitness for purpose physically. It needed to be safe and hidden from thieves, but also conveniently accessible by me.

Practicality – This refers to the feasibility of my ideas, an important part of functional modelling. It's how decisions were influenced by the competing factor of time – moments where I went for the simpler option that wasn't necessarily better but allowed me to finish my project on time.

<u>Contestable Factors:</u>

Parts – This consisted of plywood, battery holders, Arduino Uno circuit board, the LCD and IC2 module, Micro Servo, RFID module, breadboard, door hinges, door lock, servo-door-lock connector, and my 3D printed holders to construct my safe. These were the parts I decided I would need both before and throughout modelling, but there were other similar options that I could have chosen instead.

Material – The materials I would need ended up being hot glue, super glue, polyvinyl acetate (PVA) glue, nuts and bolts, pine wood (plywood), solder, and metal composite 3D print material filament, which were all used in different areas of my build as I deemed suitable. However, it is when I use particular materials in different areas of my build that induces contestability.

Layout of components – The way I arranged my different parts to complete my safe was also important, as it would ultimately determine the efficiency of my circuit, and strength/durability of the outcome.

Stakeholder feedback – Throughout modelling, I was constantly getting feedback and opposing opinions on decisions I implemented from my mum (Primary Stakeholder), and my classmate (Secondary Stakeholder). I asked my stakeholders important questions before making any decisions final. This was important as my mum is funding my project and my classmate is someone with a similar skill set, who would steer me in the right direction due to an unbiased view.

__Functional Modelling Used:__

Background Research:

The first factor that needed to be addressed was the electronic system. This was between a pin, mechanical wheel combination lock, or a Radio-Frequency Identification (RFID) based door lock access control system. I chose RFID because of the competing factor of practicality as I deduced the coding would be less complicated, and there were evident designs that used RFID in the past.

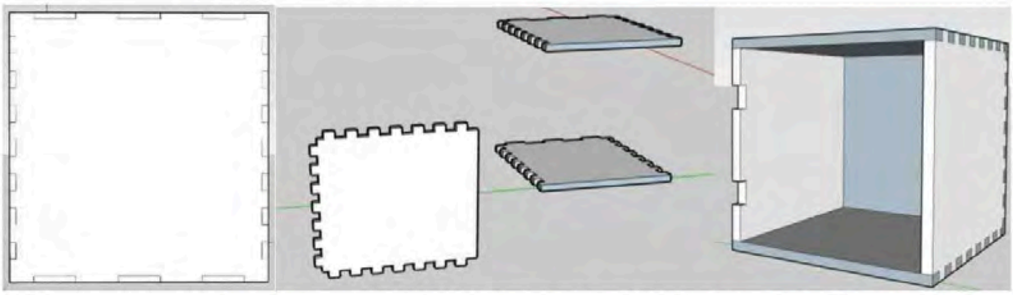
The next two competing factors were the design and size of my safe, which had to work with my chosen RFID system. For the design there are many different ways I could have made it, such as one which used LEDs and a protective covering around the receiver, but the one I deemed most practical was a proof of concept where, when the wrong card is presented, an alarm will go off and when right, a servo will shift the lock to lock or unlock the door, where a message on an LCD module will indicate this.

Physically speaking, I decided on a rectangular shape as most common safes are designed like this, making it more practical. Initially, I considered screwing my walls together where I could have made screw holes along the edges of the walls, but upon further consideration, using an example of a functioning box, I concluded that glueing the walls together would be stronger and easier to manage (can construct it for testing without having glued it in yet – can't do this with screwing option therefore more practical).

3D Design and Sketching:

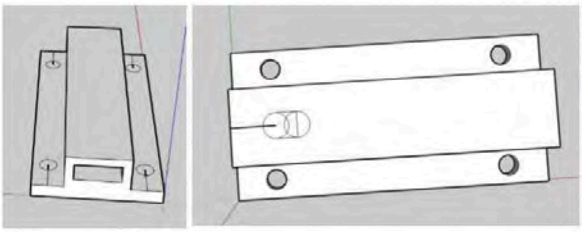
I decided to start my project with 3D modelling as I deemed it the most practical due to the complexity of my project's design – 2D format harder to visualise. I used SketchUp, a 3D modelling software, to first plan out what my safe could look like i.e. for visualization, and then design real parts for 3D printing. This allowed me to test the factor of size, which competed with the factor of situation and the contestable factor of stakeholder feedback.

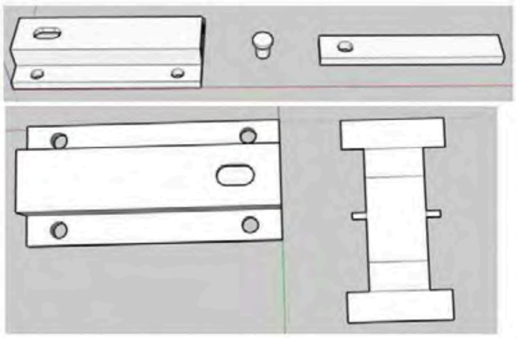
In my room, I had many options to choose from for situating my safe, but this was narrowed down to the 1st and 2nd levels of my drawers by my primary (chose the latter) and secondary (chose the former) stakeholders. My primary stakeholder thought I should put the safe in the 2nd level down from the top of my drawers, because there is a lot more space without being too exposed to external view. She believed that the lighting would also be darker, and compared with the other options, easily accessible without being too exposed. I fully agree with my mother for the same reasons as this corresponds with balanced security and accessibility. My secondary stakeholder said that he believes I can make the front of the safe look like a bookshelf by making it blend in with the surrounding books, but this competed with the factor of practicality, as there is little space and difficulty surrounding printing, where the LCD module and RFID reader would still be visible.

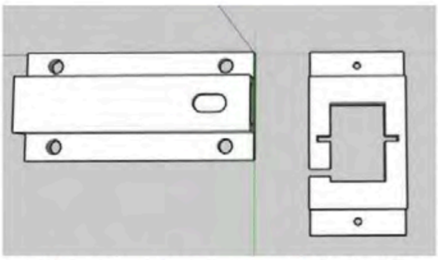


With my area of situation determined, I could now decide on a size. The area of situation has dimensions of approximately 25.4 cm(L) x 26cm(H) x 29.5cm(D). Thus, I settled on dimensions of 24.4cm x 25.4cm x 28.7cm, slightly smaller, so that it could fit. My initial thickness for the walls was 1.2cm, but I decided on 0.9cm upon being informed that the laser cutter cannot handle a large thickness.

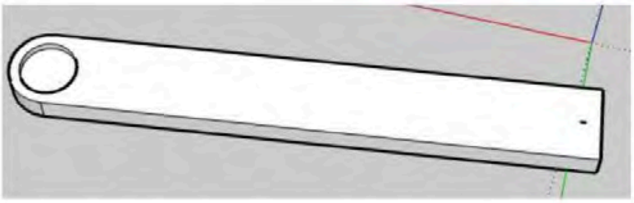
The next factor that needed to be addressed was my 3D printed parts. I started with my door hinges which I was going to base off of the idea of a pin hinge. This required more sophisticated software as the design was more complex, so I used another 3D modelling software known as [redacted]. The problem arose in the design not because of its structure, but due to its dimensions. Removing supports was difficult such that the pin snapped under pressure. This made the pin hinge a contestable factor as I was left with 3 options: alter my dimensions, alter my design, or change the design completely making it compete with the factor of practicality due to time. Feedback from my secondary stakeholder influenced my decision to keep the design but remove the pin, separating the two parts, which also coincided with practicality as I would be saving time. Instead of a 3D printed pin, I would use nails which, as a material, are stronger.



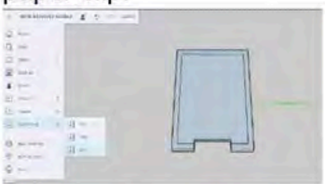


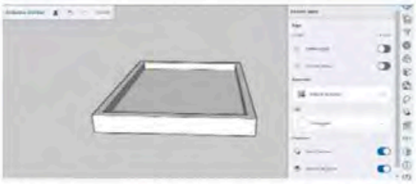


Next came the door lock, and servo holder. The decision to 3D print a door lock came down to practicality. Previously I had asked my stakeholders whether I should use a 3D printed or store-bought door lock and hinge. My primary stakeholder supported the idea of both due to their benefits (flexibility of 3D print and durability of store-bought), but my secondary stakeholder was convinced I buy a hinge and door lock, as the purpose of my safe was security. This made the 3D print material filament a contestable factor, as the outcome's fitness was being deterred by the alternative factor, steel. My final decision came down to the competing factor of practicality. A bought door lock and hinge is stronger and more durable, but because my dimensions are so specific, it would be difficult to find a hinge and door lock of the approximate size and design. Thus, I believe the slight deterioration in security was necessary to model a successful outcome. The decision to 3D print a door lock was also influenced by earlier modelling where my research depicted a lock of similar construct. In my research, the door lock and servo were connected by a paper clip-like filament where the servo was glued onto the back of the door. The decision to create a servo holder came down to the stability of my servo and the contestable factors of my layout of components and the parts themselves. Had I glued it on, the effects of angular momentum may have loosened the glue over time, breaking the functionality of my safe as my lock would no longer work and thus competing with its purpose by hindering security. Furthermore, to reduce the torque required to move my lock, I made sure to design my holder side by side with my door lock so that the top of the servo would align with the centre of the door.

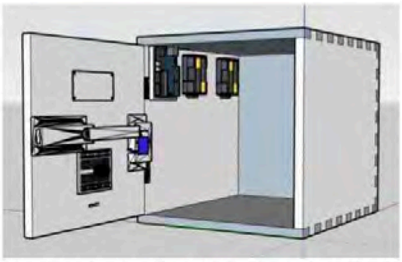


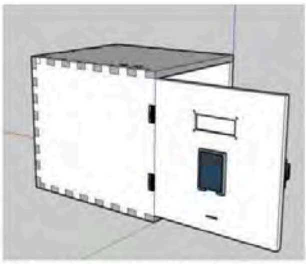
This was done in accordance with my decision to 3D print a servo-door-connector. The new idea arose on the basis of ensuring a secure and stronger connection. The contestable factor was the material and part itself. Though the 3D print material filament is weaker than steel, this decision was influenced by the competing factor of practicality as I believe its size makes it more durable and its design makes a more direct connection than that of a paper clip.





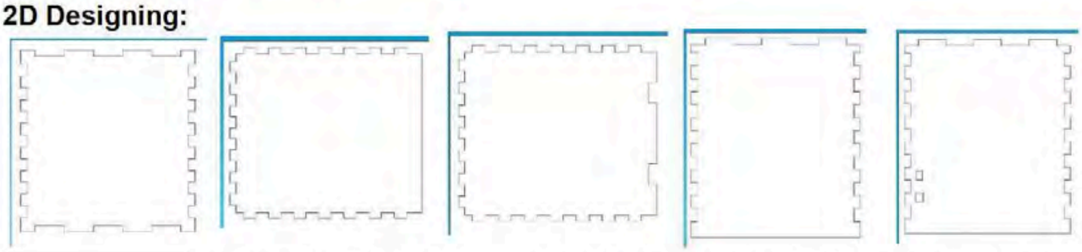
Finally, I designed my RFID receiver and [redacted] holders. These holders were a contestable factor as I could have used nuts and bolts like I did for the LCD module. However, this competed with practicality. Though this would have made my components more secure (nuts and bolts more secure than glue), this would have overcomplicated my design. I only glued components that didn't need to be as secure. For others such as the LCD module (and servo), this needed to be secure as someone could otherwise break in by pushing through and puncturing the gap (glue is weaker). For the [redacted], I found its USB slot to be too close to the edge which would have weaken the structure of the safe if I hadn't used a holder. For the RFID holder, this needed a holder because the receiver's wire pins would have obstructed with the door. Thus, the decision to make them came down to the competing factor of practicality.





After 3D modelling was complete, I imported real-size components to test their layout and compatibility with my safe; a contestable factor. Originally, I had wanted most of my circuit to be situated at the door as this is where user authentication and access will take place, similar to the proof of concept from before. To avoid clutter on the door, I decided that the most effective way to layout my circuit was to have the Arduino and switch next to each other on the left wall and the batteries adjacent to the switch (as switch controls power). I decided on the left wall instead of the right as this is where the distance the door moves is less upon opening. There were many ways I could have placed my components, but this layout was ultimately determined by what I believed to be most feasible.

2D Designing:



Now that 3D modelling was complete, I took the refined design and attempted to create the main parts (walls and door) of my safe in 2D using [redacted] 2D Design, a 2D modelling software. Because most key factors were resolved throughout 3D modelling, this process was quite simple and straightforward.

<u>Prototyping Used:</u>

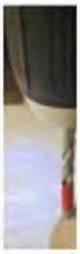
2D Printing:

This phase of modelling is just as difficult as it involves the physical testing and trialling of my design(s) to see if it was feasible after all – assembling my safe to test and trial different factors. Once I had completed functional modelling, I now needed to implement my design in a practical sense. However, before I could use the laser cutter, I needed to address the choice of material, a major contestable factor, which competed with the factor of practicality. Firstly, my decision to 2D print instead of 3D print came down to practicality. I was limited to an area of 20cm x 20cm if I wanted to 3D print, but my dimensions were much larger (smallest being 23.55cm x 22.55cm). I could have made my dimensions smaller, but this would risk less space for components and valuables. Not only would the print itself be time consuming for the machine, but the process of altering my dimensions on SketchUp would add to this. Thus, 3D printing was not an option – laser cutter area 60cm x 42cm. Contestability then arose when I chose to use plywood over acrylic sheets or other types of wood, and this was due to limited resources as there was no acrylic sheet (3mm maximum) or sheets of wood available at my desired thickness.



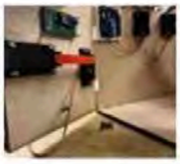
To prepare for laser cutting, I used a power saw to cut 12 4.5mm thick plywood pieces (6 9mm pieces) to ensure the laser cutter would cut through my pieces of wood (9mm still quite thick). My biggest wall was 24.4cm x 28.7cm so my pieces were 30cm x 30cm to allow for space. After laser cutting the 2D design I tested its competing factors of practicality and design by joining the walls together and placing components in their designated areas to see if they would fit, which confirmed the safe's feasibility as everything connected correctly – the test was successful. Now I needed to glue my walls together. Before I did this, I needed to determine which type of glue I would use. I decided to use Polyvinyl Acetate (PVA) because it is considered to be the strongest type of glue for wood as it soaks into the wood and bonds it securely. Had I used super glue or hot glue, this would not have been as strong, as the super glue I had was cheap and hot glue is weak in general. To ensure my walls glued together accurately, I would take one section off the mock build, glue the two walls together, and put it back in place, rotating my design until all layers (except the door) were glued together, letting the structure align the layers for me.





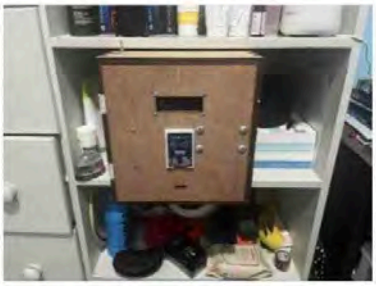

The competing factor of practicality needed to be addressed again as I needed a way to connect my hinge with the door, but the laser cutter cannot cut grooves in the side of wood. I measured the thickness and dimensions of the hinge part that would connect and had two options; glue the door layers and then cut a groove or draw the exact positions of the slots and use a utility knife to scrape off the plywood layers on both door layers, which induced the contestable factor of material. My decision to implement the latter was determined by practicality. Cutting grooves with a plunge router, drill, or Forstner bit and chisel could have worked, however, may have broken the PVA bonds formed prior and made removing any bits of wood lodged on the inside difficult. With a utility knife, I can accurately cut the slots and remove bits of wood prior to glueing the layers together. Practicality also prompted me to drill a slot for the door lock, as it would otherwise be impossible to lock my safe – the laser cutter could not partially cut through (lock would be accessible from the outside and compromise security).

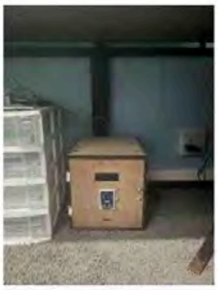
3D Printing:



Now that assembly was complete, I needed to attach the different components and test their feasibility with my build. First, I 3D printed my door lock and tested its functionality – how easily it slides and locks with the handle and its durability which I determined by its thickness. Deeming the test successful led me to making the definitive decision that the door lock design was feasible. The same can be said for the RFID receiver, [redacted] and servo holders which fit their components and designated areas perfectly. For the door hinges, I added super glue to the nails and put my hinge parts together. Note that I wanted the safe to open outwards so that there would be no obstruction with the objects already inside (once safe is functioning fully and in use). Otherwise, this would compete with the factor of practicality. To test its functionality, I rotated the hinge to see if it would turn smoothly, and it did, making the design feasible in a physical sense. For the servo-door connector, using the mark made on [redacted] as a guide, I used a drill press to cut a hole for the servo to slot through. Once my parts were screwed onto the door, I tested the servo-door connectors' functionality and found success by seeing that it fit at the sufficient length.

Once I had connected my parts that required nuts and bolts, I now needed to glue in the rest of my parts which induced the contestable factor of material as I was left deciding between PVA, hot glue, or super glue to do so. I used hot glue to glue in my components to their holders, and the holders to the safe, and super glue for the hinge parts, door-lock handle and servo-door-lock connector. This is because PVA, although stronger, is unnecessary for the components (as I may want to physically remove or move them in future – hot glue weak), and I didn't know how well it would work with the 3D print material. For the hinges, the PVA nozzle was too big, and would have likely made a mess while I was applying glue to the very small area of space. Thus, I compromised and decided to use all three types of glue, but in different moments, as this was most practical.





Physical Environment:
Now that my safe was complete, I needed to address one of the most important parts of prototyping; testing whether my technological outcome fits within its intended environment. Unfortunately, when determining my dimensions, I had not considered the height of my switch which was obstructed by the top part of the cabinet space. I now needed to reconsider the area of situation which is again competing with the factor of size. Considering the safe's fitness for purpose, I decided to change my spot because otherwise my safe would be sticking out, which would make it easy to detect by unwanted others. Going against my original decision and stakeholder feedback, I moved my safe to a spot underneath my desk. This spot is more secure, obscured, and inaccessible by others, however, was less accessible by me. The deterioration of accessibility is but a matter of inconvenience but based off what I have highlighted in this report, though the test was unsuccessful, I believe my safe is still fit for its previously established purpose.

The Outcome:
This report has discussed how technological modelling supported my development of a safe which fulfils my brief and its fitness for purpose in the broadest sense. My brief outlined that my final outcome uses an RFID-based door-lock access control system to keep any valuable items secure in a safe. This criterion was met because of the technological modelling I implemented that allowed me to defend and validate decisions made at certain stages of development which therefore resolved key competing and contestable factors. Note that the competing factor of practicality outcompeted all other factors as it was part of the criteria and therefore could not be ignored. My stakeholders were both satisfied with the outcome which further justifies its fitness. Thus, evidence of the outcome's fitness for purpose against the brief and pleased stakeholders denotes the statement that technological modelling supports technological development and implementation from the processes of functional modelling and prototyping.

Excellence

Subject: Technology

Standard: 91612

Total score: 08

Q	Grade score	Marker commentary
One	E8	The candidate correctly defined technological modelling and competing and contestable factors. The competing and contestable factors were correctly identified and categorised. In-depth explanations were provided about why each identified factor was important in the development of their technological outcome. The candidate provided detailed discussions, using evidence, to justify how competing and contestable factors enabled them to make informed, responsive, and defensible decisions. Modelling stages were correctly categorised between functional modelling and prototyping. Functional modelling and prototyping were equally discussed in-depth and with great detail.