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Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Technology 2024

**91359 Demonstrate understanding of the role of
material evaluation in product development**

EXEMPLAR

Excellence

TOTAL 08

Report for AS91359 Demonstrate the roll of material evaluation in product development

Interior Polyurethane Finish

The following report is on Interior Polyurethane Finish that I have used on my multi-purpose table project for AS91344. The polyurethane finish was applied/used on macrocarpa wood. I have included various tests (both objective and subjective) to fully determine the suitability of both the polyurethane finish conjoined with the macrocarpa as they interrelate.

Section 1: Brief from Multi-purpose table project

This year, the project that we are doing is a multi-purpose table that has special features. This means that we build a table that incorporates a functional feature and a decorative feature, although this may be modified to suit clients interests. What I have decided to do is alter the generic layout and design of the base project slightly, mainly increasing its height and drawer positioning to make it into a gaming and study desk for my little brother to utilise as he grows up.

For the functional aspect of the multi-purpose table, I created a storage drawer built into the table. For the aesthetic aspect of this project, I laser cut a wave motif design onto the table top. The interior walls of the drawer was made with panels, such of which I have briefly touched on during this report.

This table needs to be able to resist damage to impacts and spills and be able to hold a lot of weight acting on it as he will have his gaming equipment on top of it. The tables' dimensions are going to be 900mm high, 1000mm wide and 590mm deep. The table is constructed using PVA glued dowel joints for the legs to rails joints, and glue with biscuit joints to join the top planks. The budget for this project is \$120.



The table project during construction

Performance Specifications for my multi-purpose table

- Impact and scratch resistance
- Structurally durable
- Chemically resistant
- Aesthetically pleasing (blend well within the environment)
- Minimal Maintenance
- Smooth drawer running
- Relatively affordable

Impact and scratch resistance:

This finish must be impact resistant as it will be used for gaming, homework and other miscellaneous activities and therefore needs to be strong enough to withstand any impact or blow that may come to it.

Structurally Durable:

Similarly to impact/scratch resistance, this finish and the table needs to be structurally sound and sturdy enough to prevent damage from ruining the actual wood underneath. As well, the table itself must be rigid enough to bear the weight that is going to be acting upon it, devices, screens, books, etc. Furthermore, the drawer and its runners will need to be strong enough to last many uses of pulling and pushing and must be able to bear the weight of the things within it.

Chemical resistance:

As this table is going to have a multitude of different use cases it must also be able to resist spills. Such as, food, drinks, artistic materials like paints or pens. If something such as this is to happen, the finish must be able to resist the chemicals and spill from seeping into the wood beneath and damaging the table.

Aesthetics:

This table must match the room that it is going to be placed in, while also being neutral enough so that it can be applicable within other rooms that may find itself occupying in the future. This means that the colours as well as the design engraved into the table is sufficiently fitting for the room while not being too specific to only that room.

Minimal maintenance:

This finish needs to have minimal maintenance time and it must be easy to apply, easily and quickly cleanable from any spills or scuffs as the client is a young child. Again, the chemical resistance must be able to prevent a spill from seeping into the finish and damaging the aesthetic appearance of the table .

Smooth drawer operation:

The drawer within the table needs to have a smooth user experience, meaning it must not get stuck or broken while trying to use it. This connects to overall durability as it must be able to withstand all use cases, and many openings and closings.

Affordability:

The sum of the materials for this table must fit within our budget of \$120 while still being able to get the best and most appropriate materials for the use cases of this project. Balancing the pricing and effectiveness of my materials.

Expected performance specifications of project materials**Macrocarpa (Cupressus Macrocarpa or Monterey Cypress):**

I believe macrocarpa wood to be a very appropriate material for the bulk on my project. One of the main uses for macrocarpa wood is to make furniture, this is exactly what I need as one of my performance specifications relates to the structural durability and rigidity of my project. Macrocarpa is an exotic softwood typically grown in plantations or on farms as shelter belts. Resins in the heart wood make it chemically resistant to fungal and insect attack and it can be used for building in above ground situations. This wood is typically easy to work with, machine and glue together, which is exactly what I want for my wood material. Finally, macrocarpa is a great looking wood with a good grain, and can sand down very smooth to provide a great look.

The laminated melamine surface of [REDACTED] makes it a good material to use for my drawer construction. [REDACTED] can come in many different colours and finishes to be able to suit any project's needs. Furthermore, it is very resistant to abrasions, stains and moisture which is ideal in use for a drawer as it is going to house an assortment of items as well as being thoroughly used, therefore it needs to be resistant to constant sliding. While being resistant to stains, [REDACTED] is also easy to clean with its laminated exterior, which is very good in relation to the chemical resistance I require from this project. As for aesthetics, the clean white colour that I've chosen will be good for keeping the project neutral and relatively minimal.

Polyurethane Finish:

[REDACTED] polyurethane finish must be impact and chemical resistant while being easily maintained and aesthetically pleasing. This is to ensure that it can withstand all of the usual wear and tear that will come to it over its lifetime of use as a multipurpose desk. This stain needs to be affordable in comparison to others in the market so that I am able to stay within the project's budget while still being able to get the most value out of it in terms of materials.

Materials chosen in relation to the performance specifications of the project

[REDACTED] is great for use in my project as a drawer material, as it has low maintenance while still upholding a highly durable construction among the fact that melteca can come in a multitude of differing finishes, styles and colours to fit any personal preferences. The durability of this material comes from how it is made; sheets of melamine (a nitrogen rich organic compound) are bonded onto either side of particle board or

medium density fibreboard (MDF). The resin on the overlap cures and thus forms a tough and stain resistant finish. These factors are ideal in relation to the performance specifications of my desk project as the drawer needs to be smooth sliding and withstand a lifetime of opening and closing.

The most important properties of macrocarpa in relation to my project's requirements are its durability, rigidity, ease to work with, and overall aesthetics. Macrocarpa has been rated to be "moderately durable" (most naturally durable exotic softwood grown in New Zealand). With a density of 485 kg/m³, a tangential shrinkage of 3.3% (at 12% moisture content), and a hardness of 3.44kN, I believe this is sufficient for use on my project with these performance specifications. Macrocarpa has an even and fine texture as well as good colour and grain, easily machinable and finished with good overall machining properties that make it very nice to work with. It has excellent dimensional stability, resulting in little change from certain exposures and temperatures and is overall relatively affordable.

polyurethane is stated to be a finish that is durable, tough, and resistant to wear/tear. This finish is also resistant to household chemicals as well as moderate heat; these factors are imperative to the choice of this material as it allows me to meet the performance specifications required for my project as well as living up to the expected performance standards of this material. Although this finish is only suitable for indoor use, this does not bother me as this table will never be located outside or in weather conditions that will taint the quality of this finish.

Section 2: Functional properties of Project Materials

polyurethane finish is suited for indoors only, thus meaning it is suitable for tables, panelling, furniture, doors, and skirtings. Prior to applying this finish I must ensure that my table top is free of dirt and grease, clean and dry. The finish must be stirred and not shaken (shaking will lead to air bubbles in the finish), so that it is blotchy or uneven. It's recommended to apply two to three coats of finish and they should be applied by a long bristled quality brush or spray equipment. Surface should be lightly sanded between coats one and two, leaving at least 8 hours to dry before recoating in normal conditions (20 degrees Celsius, 50% humidity). There is a minimum wait time of three days (in normal conditions) until the finish is dry for general use, this increases to 10 days in winter. One litre can cover up to 16 square metres, depending on application method. The following is the basic data sheet for polyurethane finish:



Macrocarpa can be easily worked with due to its fine texture, it can be cut, sanded and finished easily. I had no problems working with the wood, boring dowel holes, sanding sharp edges, and sanding down the top face all went smoothly. It has good glueing versatility when dry meaning that you are able to use a large range of different glues. Macrocarpa holds nails very well, the heartwood is long lasting and durable (a 50x50 stake put in the ground will last around 10-15 years). Furthermore, it is resistant to insect and borer attacks when in sawn form, it is also said to be naturally termite resistant.

melamine coating is great for its resistance to wear and tear and ease to clean, although it proves to be rather difficult to work with in comparison to traditional wood like macrocarpa. This is because the coating is on the surface of the substrate (MDF or particle board) and when cutting and sizing the cut mustn't remove the coating to reveal the substrate underneath, as it is highly susceptible to water damage. In my case working with the material, side pieces of the drawer were pre-cut to length to fit within the drawer space I have made in my desk (if this pre-cut size was wrong then it would be largely impossible to make adjustments to it because of the materials nature). Although for this project, working with this material was largely straight forwards and I didn't run into any issues. When fixing the melteca sides together, I went in accordance with the spec sheets fastening guide using 8 gauge screws and a 3mm pilot hole.

Fastening Guide:



Consider the functional properties of the project materials in justifying their suitability for the project

Macrocarpa's easy working throughout all of its uses within my project, from the table top to the legs and the rails, all worked smoothly and has produced a great finished product. The glueing and finishing along with its natural resistances and moderate durability to impacts and scratches all lead me to believe that this wood is greatly suitable for use in my multi-purpose table project.

Although is not as nice to work with as macrocarpa is, due to its extremely resistant melamine coating and overall sturdiness solidifies as an excellent material for my desk drawer. This finished draw looks clean and modern thanks to high performance, clean and stylish surface coating.

Finally as for polyurethane varnish finish, the final project will be located inside so the mainly indoor only aspect of the finish does not bother me. I think its use in my project based on its wide range of high resistances makes good sense considering the

final location and the client of the project. When applying with a normal bristled brush I was able to achieve and clean consistent colour and look across the whole surface. The viscosity allowed me to smooth out the brush applied varnish to remove stroke marks without taking off too much of the varnish while still removing the excess. With this particular polyurethane varnish a little went a long way and I was able to cover a large area of the surface using little varnish.

Determine the suitability of each project material through tests

Objective Tests

For me to be able to determine the suitability of [redacted] polyurethane finish as well as the macrocarpa, I performed a range of tests.

My initial test was to compare and investigate the impact resistance of polyurethane with that of [redacted], this test was done as it connects to my projects' performance specifications and I believe it is important to create a product that will last the test of time especially as the client (my brother) is young and he could potentially drop or hit things on the table.

Secondly, I wanted to compare the heat resistance of both polyurethane and [redacted] as finishes for my project. This is a test I was especially interested in as I really want a project that can withstand many different variables and situations.

The last of my objective tests was to test the chemical resistance of a differing amount of coats of polyurethane to conclude how many coats of which I should apply onto my project. Along with impact and heat resistance I was very interested in the chemical resistance that polyurethane possesses as again I want the product to be reliable and versatile in relation to my performance specifications.

Test One: (Impact Resistance)

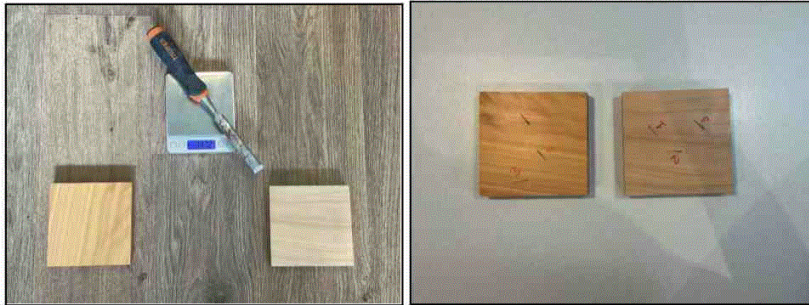
For my first test I machined two equal sized macrocarpa sample blocks, one finished with 2 coats of the [redacted] polyurethane and the other with 2 coats of [redacted]. I then dropped a chisel from a controlled height of 100cm on each block 3 times to be able to generate an average depth, this was done to simulate any object that may scratch or impact the surface of the finished product.

Drop Height: 100cm

Weight of Object (Chisel): 197.2g

	Polyurethane Sample (2 coats)	[redacted] Sample (2 coats)
Drop 1	3mm	2.5mm

Drop 2	3.5mm	5mm
Drop 3	2mm	3mm
Avg Depth	2.83mm	3.5mm



(Left is Polyurethane, Right is Briwax) This applies to both images)

As we can see from the data on the table, the macrocarpa block that was finished with 2 coats of polyurethane performed a lot better than the block that was finished with the 2 coats of Briwax. With the average impact depth for the polyurethane block only being 2.83mm, this is quite a bit less than the Briwax average depth at 3.5mm. I can safely conclude from this test that polyurethane performs very well and does hold up to its claims on impact resistance.

Test Two: (Heat Resistance)

For my second test, the purpose was to test the heat resistance of polyurethane comparatively to Briwax. Similarly to my first test I finished one sample macrocarpa block with 2 coats of polyurethane and the other with 2 coats of Briwax. To simulate a realistic heat resistance test, I placed two equal mugs filled with 250ml of freshly boiled water and left them both to sit for a total of 20 mins. I believe 20 minutes was a good time to leave the mugs as this gave them enough time for the water to cool down to room temperature. After the 20 mins I took both mugs off and recorded the results.

Test time: 20 mins

Water Amount per Mug: 250ml

Before:



After 20 Mins:

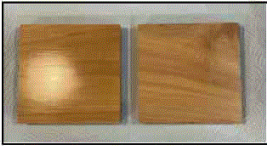
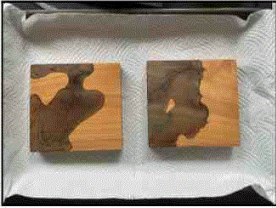



(For both images, left is polyurethane, right is Briwax)

As you can see from the above photos, after 20 mins the [redacted] sample has a noticeable ring of discoloration whereas the polyurethane is completely unchanged. Furthermore, even after the test the polyurethane sample felt identical to what it did before; no perceivable change or misshaping to the finish or to the wood itself. The result of this test pleasantly surprised me as I believed that putting a generous amount of boiling water within a mug onto the polyurethane sample would at least leave a visible mark/ring, although in this test that was not the case.

Test Three: (Chemical Resistance)

For my last objective test I wanted to compare the chemical resistance of both 2 coats and 3 coats of [redacted] polyurethane finish to see what mount would be appropriate for use on my project. In order to simulate an accurate chemical resistance test, I decided to drop 2 ml of alcohol ink to both samples coating around half of each surface. I let the spill sit for 3 hours, then proceeded to clean with a small amount of isopropyl alcohol.

Coats:	Before:	After 3 Hours:	After Cleaning:
Left sample piece has 3 coats of Polyurethane, the Right sample piece has 2 coats of Polyurethane.			

Spill Amount: 2ml

As we can observe from the pictures, there is visible staining on both the 3 coat and 2 coat samples even after cleaning. Although the amount of staining that we see on both samples seems pretty similar side by side, it is pretty unrealistic that there will be a stain left unnoticed for a long period of time and if there were to be a stain of this degree it would be likely that it would be cleaned up immediately and there would be significantly less staining left by the spill. Having said that, I believe that it is necessary to have three coats of polyurethane on my project as the result from this test lead me to believe that the chemical resistance is largely the same between the samples 2 coats and 3 coats.

Subjective Tests

For my first subjective test I wanted to get the opinion of my stakeholders for the use of the [redacted] polyurethane on the project, this was in terms of look and feel in relation to the room it was going to be in. I wanted to get their opinion as it is their house that the table will be in. This is what my mother had to say about the test samples...

“The waxed test sample appeared almost unfinished when compared to the polyurethane sample and didn’t provide as much protection against impacts and heat. I

think two coats of polyurethane would be best, I like how it allows the wood's natural grain to shine through whilst still providing good protection against spills etc”.

As for my father, who has around 30 years of experience in carpentry and building. “Macrocarpa is a great timber that resists denting and staining, perfect for furniture making”.

Secondly, I wanted to perform a survey for everyone in my house, excluding myself in order to get a group opinion of either the use of 2 coats or 3 coats of polyurethane for the project. I simply handed everyone 2 test blocks, one with 2 coats of polyurethane and one with 3 coats. I got them to feel them and then asked them which one they’d prefer, and these were the results.



As we can see from the results, it was even at 3 votes of preference for both the 2 coat sample and the three coat sample. With this in mind it seems that I could choose either option as there is no particular bias to any one opinion.

Section 3 Composition

Polyurethanes are a result of a chemical reaction between polyol resin and a poly-isocyanate curing agent, this created polyurethane has a highly cross-linked chemical structure and has large molecular weight. In paints and coatings, this allows the polyurethane to offer a tough and durable finish that has high resistance to many variables. Such as, weather (sun, wind, and rain), abrasions and impacts, chemical resistance, among others.

Manipulation

Once we have properly prepared and cleaned the surface(s) of what we are coating, we must stir the stain, this is to allow the components of the stain that may be unevenly spread throughout the tin to become more evenly distributed. Polyurethane is recommended to be applied by brush, roller or spray, although with brush and roller application there are limited risks of hazards. The few of these being splashing of the coating directly onto areas of the body that are unprotected as well as inhalation of the solvents vapours. We can easily work around this by wearing the appropriate PPE as well as safe practices such as working in a well ventilated area. For me personally, the best way to apply the polyurethane finish was to apply a generous amount of varnish

with a normal brush and apply it as evenly as possible across the whole surface. Finally allowing it to fully dry (recommended around 8 hours for recoat and 3 days for fully cured) before handling or applying a further coat.

Why it was important for the development of my multipurpose table to perform certain tests at different stages of production

The objective as well as subjective testing that I performed at different stages of development were vitally important in determining the overall suitability of the different materials within my project. Not only structurally/functionally but also aesthetically and affordably as well as suitable to meet my project's performance specifications. In comparing the impact and heat resistances of polyurethane with that of [REDACTED] both coated on macrocarpa, it further helped me justify the suitability of both polyurethane as well as macrocarpa. Furthermore, in my comparison of chemical resistance between 2 coats and 3 coats of polyurethane finish I was able to ascertain the level of finish I would need to apply onto my final project to achieve the best level of resistance without compromising on cost, look, feel, or time. Testing different joins to connect the differing pieces of the table together allowed me to experiment and find the ones that would be the most structurally effective while still looking sleek and aesthetically pleasing. As well, testing different application methods of my finish. Through all of these different tests and manipulation of my projects materials, it allowed me to create the finish that my client and stakeholders wanted.

Section 4: How the evaluation of project materials supported my decision making

Through the evaluation of my projects materials I was able to come to a confident solution about the suitability of each project material. With my first test on impact resistance, it allowed me to gauge the resistances of not only the Polyurethane comparatively to the [REDACTED] but also that of the macrocarpa that is being used for the project. My second test showed me that the polyurethane was capable of withstanding intense temperatures without posing any visual or physical changes to the surface of the wood, this was good news as the [REDACTED] sample incurred quite a noticeable discolouration on the surface. These first two tests lead me to pick polyurethane for use in the project as I determined it suitable based on these initial tests, then with this in mind I was able to do my third test which compared 2 coats and 3 coats of polyurethane. For this third test on chemical resistance I was able to see that there wasn't too much difference in the actual performance when ink was spilled onto the two sample blocks, this result was ideal as I was able to use only 2 coats on the final project while knowing that it would perform just as well as if I had finished the project with 3 coats of polyurethane instead.

How my evaluation of project materials impacted environmental, social or cultural factors of society

The [redacted] polyurethane that I have used for my project is oil-based rather than water based which is inherently less environmentally friendly. There are many negatives to using oil based polyurethane, such as the fumes that come off the polyurethane (as it is a petrochemical resin) can be toxic and may cause breathing or eye irritation. Furthermore, if any of the polyurethane was spilled it is told that the user must not let it enter drains or watercourses due to its toxicity. We can expect this to have an harmful effect on the environment if it is accidentally let into any drainage systems. Oil based polyurethane also takes longer to dry than a water based polyurethane would. Although there are some benefits to using an oil based polyurethane finish compared to a water based one, this includes the finish having a faster build up which results in needing less coats, more consistent colour, also it provides a more durable and resilient finish which is what I'm after. This is why I have chosen to use an oil based polyurethane over a water based one instead.

As for the macrocarpa used on my project, the store that we got it from does not have any statements on their website to the sustainability of the macrocarpa that they produce. Although through some research we can come to the conclusion, due to the fact that macrocarpa is grown and harvested here in New Zealand meaning it does not need to be imported as well as sustainable farming practices that are associated with the production of this wood. We can safely say that the macrocarpa is an environmentally friendly option for use on this project.

Disposal and Maintenance

Disposal of oil-based polyurethanes can be complicated due to its inherently toxic composition. If you only have a minimal amount of finish left over it is claimed that you could mix it with an absorbent substance such as sawdust in order to alter the finish into a solid which you can then dispose of in the regular rubbish collection. If you find yourself with a large quantity of left over then it is highly recommended that you take that to a hazardous waste facility where they can use their specialised equipment to safely and effectively dispose of the waste.

For maintenance regular cleaning using a damp cloth with soap and water is recommended on a polyurethane finished table top, the use of soap and water is recommended as many standard cleaning products contain an ammonia or alcohol base, this can possibly over time lead to it eating through the tables' finish. If you do need to recoat for any reason you should lightly sand with 180 grit sandpaper then just re apply a layer of finish.

Availability of [redacted] Interior Polyurethane Finish

[redacted] products are available mainly at [redacted] and other smaller retailers, which allows you to compare differing prices across stores to get the cheapest. Macrocarpa is available at a wide range of stores across New Zealand, although we sourced ours from our local [redacted] Tuaranga.

Final Feedback from Client/Stakeholders

The final feedback that I received from my clients and stakeholders was the following,
Mum - "It's so unique! I love the idea of the engraved wave on the top and that it is made from macrocarpa rather than pine".

[REDACTED] (Client) - "I really like the drawer, it can hold my mouse and keyboard that I use for gaming".

Through all the comments that I have received over all the stages of product development, I am confident in the fact that I have chosen the right materials to achieve the project that my client/stakeholders want.

Bibliography

- Macrocarpa specifications:

<https://www.nzffa.org.nz/farm-forestry-model/species-selection-tool/species/cypress/macrocarpa/#:~:text=Macrocarpa>

- [REDACTED] functional properties:

https://www.autospec.co.za/productmedia/wattyl_australia/new-images/espato/polyurethane-gloss-satin-matt.pdf

- Macrocarpa functional properties:

<https://www.woodsolutions.com.au/wood-species/softwood/macrocarpa>

- [REDACTED] fastening guide and data sheet:

<https://static1.squarespace.com/static/5b04e4457c9327ead0e35668/t/5b7ce6fa6d2a73947ed36f5f/>

- Polyurethane Composition and manipulation:

https://www.duluxprotectivecoatings.com.au/media/1556/311_polyurethanes.pdf

- Macrocarpa Sustainability:

<https://cutek.co.nz/timber/macrocarpa/#:~:text=Despite%20being%20a%20softwood%20C%20Macrocarpa's>

- Disposal of Polyurethane Finishes

<https://pinecarve.com/how-to-dispose-of-polyurethane/>

Excellence

Subject: Technology

Standard: 91359

Total score: 08

Q	Grade score	Marker commentary
One	E8	<p>The candidate lists the performance specifications for the product and provides details of these. These specifications include material properties / characteristics.</p> <p>The candidate identifies the expected properties of several potential materials for the product and explains how these properties suit the product.</p> <p>Throughout this report there is discussion occurring around the relationship between the product design and the material evaluation. It addresses the maintenance / disposal criteria through looking at the differences between water based and oil based finishes.</p>