Assignment Brief and Front Sheet PGT

This front sheet for assignments is designed to contain the brief, the submission instructions, and the actual student submission for any WMG assignment. As a result the sheet is completed by several people over time, and is therefore split up into sections explaining who completes what information and when. Yellow highlighted text indicates examples or further explanation of what is requested, and the highlight and instructions should be removed as you populate 'your' section.

This sheet is only to be used for components of assessment worth more than 3 CATS (e.g. for a 15 credit module, weighted more than 20%; or for a 10 credit module, weighted more than 30%).

To be completed by the student(s) prior to final submission:
Your actual submission should be written at the end of this cover sheet file, or attached with the cover sheet at the front if drafted in a separate file, program or application.

Student ID or IDs for group work	**5569029**

To be completed (highlighted parts only) by the programme administration after approval and prior to issuing of the assessment; to be consulted by the student(s) so that you know how and when to submit:

Date set	3/3/25
Submission date (excluding extensions)	**21/3/25 by 1 pm UK time**
Submission guidance	Tabula link
Marks return date (excluding extensions)	22/4/25
Late submission policy	If work is submitted late, penalties will be applied at the rate of **5 marks per University working day** after the due date, up to a **maximum of 10 working days** late. After this period the mark for the work will be reduced to 0 (which is the maximum penalty). "Late" means **after the submission deadline time as well as the date** – work submitted after the given time even on the same day is counted as 1 day late. For **Postgraduate** students only, who started their **current course before 1 August 2019**, the daily penalty is **3 marks** rather than 5.
Resit policy	If you fail this module and/or component, the University allows students to remedy failure (within certain limits). Decisions to authorise resits are made by Exam Boards. These will be issued at specific times of the year, depending on your programme of study. More information can be found from your programme office if you are concerned. If this is **already a resit** attempt, this means you will not be eligible for an additional attempt. The University allows as standard a maximum of two attempts on any assessment (i.e. only one resit). Students can only have a

	third attempt under exceptional circumstances via a Mitigating Circumstances Panel decision.

To be <u>completed</u> by the <u>module leader/tutor</u> prior to approval and issuing of the assessment; to be <u>consulted</u> by the <u>student(s)</u> so that you understand the assignment brief, its context within the module, and any specific criteria and advice from the tutor:

Module title & code	WM9F7-15 Managing Design and Manufacturing Technology
Module leader	Helen Ascroft
Module tutor	See above
Assessment type	**Module Assignment 3 (IMA3) – Materials and Manufacturing Selection**
Weighting of mark	20 %

Assignment brief

Material and manufacturing selection task based on IMA1 case study.
Provide a written account of the approach and outcome of investigations into possible material and manufacturing solutions related to your case study.

For **ONE** component of your case study product:

1. Determine the functional requirements.
2. Narrow down a small list of candidate materials which help to meet these functional requirements.
3. Use a selection method (such as Pugh Analysis) to logically show why your final material choice is most suitable.
4. Select and justify suitable primary manufacturing process(es) i.e. the main process to achieve the final part form.
5. Determine the manufacturing route of your component from raw material stage to fully finished form in line with your primary process.
6. Identify what steps along the manufacturing route you would automate.
7. Propose and justify the type of automation facility or machinery (e.g. robot/type of robot, conveyors…etc.) you would you employ.

Criteria for Assessment PMA (20% of final mark)

This table details the weightings of the criteria by which your work will be assessed.

Weighted criteria	Allocated Marks
1. List of functional requirements:	**25%**
2. Selection method and justification for: Material selection and Primary manufacturing process selection	**50%**
3. Process flow diagram	**15%**
4. Chosen Automation	**10%**
5. Overall structure of the report: • **Logical structure / sequence** • **Clarity / written style/grammar/ spelling/referencing** • **Proper business report style (page numbers, table of contents; sub-headings etc.)** • **Appropriately presented charts / diagrams/figures and other illustrations**	**10%**
Total	**100%**

Word count	The word count is 800 (+/- 10%). **Deductions for excess length:** More than 10% and less than 30% - 10 percentage points from original total mark. More than 30% - Mark is capped at the pass mark. Note: marks less than the pass mark are returned as normal. The word limit includes quotations and citations but excludes figures, tables, references list and appendices.
Module learning outcomes (numbered)	1. Demonstrate an advanced understanding of the fundamentals of product design and development processes, including: methods; technologies; latest trends; tools and techniques; outcome and functional/resource interdependence, interpreting their relationships from concept to customer. 2. Critically evaluate and make recommendations on approaches to the management of product design and development processes. 3. Critically evaluate and contrast: materials; manufacturing processes; manufacturing tools and technologies that are most used in the manufacturing industry. 4. Critically evaluate manufacture-design, demonstrating detailed knowledge of fundamental aspects of manufacturing and materials processes and technologies in the context of a circular /sustainable economy.
Learning outcomes assessed in this assessment (numbered)	3
Marking guidelines	See next page

Learning Outcome Assessed	Comments	80 Outstanding	70-79 Distinction	60-69 Merit	50-59 Pass	40-49 Marginal Fail	<40 Fail
3. Critically evaluate and contrast: materials; manufacturing processes; manufacturing tools and technologies that are most used in the manufacturing industry.	**University standard PGT marking descriptors for reference.**	An exemplary answer, showing complete mastery of the learning outcome, with an exceptionally developed and mature ability to analyse, synthesise and apply concepts, models, and techniques. All requirements of the learning outcome are exceeded, and the answer is free from errors. The answer demonstrates originality of thought, with strong critical reflection and the ability to tackle issues not previously encountered. Ideas are explained with great lucidity and in an extremely structured manner.	An excellent answer, showing mastery of the learning outcome, with a highly developed and mature ability to analyse, synthesise and apply concepts, models, and techniques. All requirements of the learning outcome are covered, and work is free from all but very minor errors. There is good critical reflection and the ability to tackle issues not previously encountered. Ideas are explained very clearly and in a highly structured manner.	A strong answer, showing a sound grasp of the learning outcome and a skillful attempt at analysis, synthesis and application of concepts, models, and techniques. All requirements of the learning outcome are covered, but there may be some minor errors. There is some critical reflection, and a reasonable attempt is made to tackle issues not previously encountered. Ideas are explained clearly and in a well organised manner, with some minor exceptions.	A satisfactory answer, showing a grasp of the learning outcome but analysis, synthesis and application of concepts, models and techniques is mechanical, with a heavy reliance on course materials. The requirements of the learning outcome are covered but with little or no critical reflection and limited ability to tackle issues not previously encountered. Ideas are explained adequately but with some confusion and lack of organisation.	An unsatisfactory answer. The learning outcome is not met, but it would not take too much to meet it. There is a weak attempt at analysis, synthesis and application of concepts, models, and techniques. Only some of the requirements of the learning outcome are covered. Inability to reflect critically and difficulty in beginning to address issues not previously encountered. Ideas are poorly explained and organised.	An inadequate answer and there are extremely serious gaps in knowledge and many areas of confusion. Few or none of the requirements of the learning outcome are covered. There is a lack of serious engagement with the learning outcome and there is no evidence that issues not previously encountered can be addressed. The levels of expression and organisation in the work are very inadequate.

Evaluation Criteria	90-100	80-89	70-79	60-69	50-59	40-49	30-39	0-29
	Outstanding		Distinction	Merit	Pass	Marginal fail	Fail	
1. Up to 25% for List of functional requirements:	Unequivocal functional requirements cover four main areas: Service Economic Environment Manufacturing Completed with rigour and appropriately evidenced and referenced. Obviously linking to specific materials properties or processing requirements. Well linked to the case study PDS.	Sophisticated functional requirements cover four main areas: Service Economic Environment Manufacturing Completed with rigour and appropriately evidenced and referenced. Obviously linking to specific materials properties or processing requirements. Well linked to the case study PDS.	Challenging and relevant functional requirements cover four main areas: Service Economic Environment Manufacturing Completed with rigour and appropriately evidenced and referenced. Obviously linking to specific materials properties or processing requirements. Well linked to the case study PDS.	Functional requirements cover four main areas: Service Economic Environment Manufacturing Completed to a high standard and appropriately evidenced and referenced. Obviously linking to specific materials properties or processing requirements. Well linked to the case study PDS. Minor errors-imbalance.	Functional requirements cover four main areas: Service Economic Environment Manufacturing Completed to a good standard and appropriately evidenced and referenced. Some attempt at linking to specific materials properties or processing requirements. May be generic and not well linked to the case study. May be errors/imbalance	Functional requirements cover four main areas: Service Economic Environment Manufacturing Completed to a routine standard Some missing evidence/ references and errors. Rigour may be in doubt. Generic and not linked to the case study.	Incomplete list of functional requirements. Completed to a routine standard Missing evidence/ references and errors. Rigour may be in doubt.	No functional requirements. If any output, completed to a routine standard No evidence/ references and errors.
2. Up to 50%. Selection method and justification for: Material selection and Primary manufacturing process selection.	Identified and used an appropriate decision support tool or tools and used them comprehensively to support recommendations for the material choice and compatible process. Criteria will be unequivocally suitable and linked to the case study component. All output /cases study tasks completed with rigour.	Identified and used an appropriate decision support tool or tools and used them comprehensively to support recommendations for the material choice and compatible process. Criteria will be sophisticated and linked to the case study component. All output /cases study tasks completed with rigour.	Identified and used an appropriate decision support tool or tools and used them comprehensively to support recommendations for the material choice and compatible process. Criteria will be relevant, challenging and linked to the case study component. All output /cases study tasks completed with rigour.	Identified and used an appropriate decision support tool or tools and used them comprehensively to support recommendations for their material and compatible process. The recommendations will be broadly suitable for the case study component but there may be minor errors. Approaching excellence in some areas with a well-developed and relevant argument, good degree of accuracy and technical competence.	Identified and used an appropriate decision support tool but its application may be trivial. There may be some mismatch between the criteria and the component functional requirements. The material and process will be compatible but may not be the most suitable. Broadly satisfactory with a degree of competency but incomplete or narrow argument, or some imbalance. Contains some inaccuracies.	Presents argument for material and process selection decisions but does not demonstrate use of decision support tools, little evidence of independent thought. Generic argument and not always linked to the case study and the final design idea. Recommendations routine. May choose a process that is not compatible with the chosen material or cannot achieve component requirements. Rigour may be in doubt.	Fundamental misunderstanding of materials and processes. No evidence of technical knowledge. Does not use a decision support tool. Obvious errors. Generic and not always linked to the case study and the final design idea.	Incomplete. Obvious errors. Generic. Output poor or routine.

Evaluation Criteria	90-100	80-89	70-79	60-69	50-59	40-49	30-39	0-29
	Outstanding		Distinction	Merit	Pass	Marginal fail	Fail	
3. Up to 15% Process flow diagram	Complete diagram. Unequivocally linked to the case study primary process. All output /cases study tasks completed with rigour and appropriately evidenced and referenced.	Complete diagram. Mainly linked to the case primary process. All output /cases study tasks completed with rigour and appropriately evidenced and referenced.	Complete diagram. Related to the primary process. All output /cases study tasks completed with rigour and appropriately evidenced and referenced.	Process flow diagram. May be minor errors. May not start at raw material. Incorrect boundary. Likely case study part from parts factory to assembly or dispatch. Completed to a high standard and appropriately evidenced and referenced.	Process flow diagram presented. May be errors or lack detail at some stages. Mainly linked to the case study. Incorrect boundary. Completed to a good standard and appropriately evidenced and referenced. Imbalance.	Incomplete or superficial diagram. Likely errors. Generic and not always linked to the case study and the final design idea. Only part of the manufacturing route presented. Completed to a routine standard Some missing evidence/ references and errors. Rigour may be in doubt. Imbalance.	Incomplete. Diagram but no discussion or narrative only. Obvious errors. Disorganised and difficult to navigate. Generic. Completed to a routine standard Missing evidence/ references and errors. Rigour may be in doubt. Imbalance.	Superficial or not presented. Disorganised and difficult to navigate. Generic. Output poor or routine No evidence/ references.
4. Up to 10 % Automation	Unequivocally linked to the case. All output /cases study tasks completed with rigour and appropriately evidenced and referenced.	Mainly linked to the case study. All output /cases study tasks completed with rigour and appropriately evidenced and referenced.	Related to the case study. All output /cases study tasks completed with rigour and appropriately evidenced and referenced.	Related to the case study. May be minor errors. Completed to a high standard and appropriately evidenced and referenced.	Mainly related to the case study. May be errors or lack detail at some stages. Generic discussion on automation. Completed to a good standard and appropriately evidenced and referenced. Imbalance.	Generic automation discussion and not always linked to the case study. Completed to a routine standard Some missing evidence/ references and errors. Rigour may be in doubt. Imbalance.	Incomplete. No discussion or narrative only. Obvious errors. Generic. Completed to a routine standard Missing evidence/ references and errors. Rigour may be in doubt. Imbalance.	Superficial or not presented. Generic. Output poor or routine No evidence/ references.
5. Up to 10 % for Overall structure of the report	Full range of sources used selectively to support argument. The ability to analyse primary sources critically. Coherent and compelling argument well presented. Professional standards of writing and presentation. Error free.	Full range of sources used selectively to support argument. The ability to analyse primary sources critically. Coherent and compelling argument well presented. Error free.	Good range of sources used selectively to support argument. Coherent and compelling argument well presented.	Complex work and concepts presented. Key texts used effectively. Argument concise and explicit.	Sound knowledge base of primary and secondary sources. The argument is developed but lacks fluency.	Limited sources used. Argument not fully developed and lacks structure.	Overreliance on course notes. Missing references. Limited argument. No logical structure.	Missing or no references. Not in the style of a business report. Incomplete. Trivial.

Academic guidance resources	Lecture slides and recommended reading list

Where to get help:

1. Talk to your module tutor if you don't understand the question or are unsure as to exactly what is required.
2. There are also numerous online courses provided by the University library to help in academic referencing, writing, avoiding plagiarism and a number of other useful resources. https://warwick.ac.uk/services/library/students/your-library-online/
3. If you have a problem with your wellbeing, it is important that you contact your personal tutor or wellbeing support services https://warwick.ac.uk/services/wss

Contents

Introduction 9
Functional Requirements 9
Economic Requirements 10
Manufacturing Requirements 10
Environmental Requirements 10
Material Shortlisting 10
Material Selection Process through Pugh Matrix 13
Primary Manufacturing Processes 14
Automation in Manufacturing Processes 14
Conclusion 15
References 16

List of Figures

Material Property Density 10
Material Properties Youngs Modulus Yield Strength, Tensile Strength, Hardness 11
Material Impact and Fracture Properties (Toughness) 11
Shortlisted Materials 12
Robotic Sanding Arm 14

List of Tables

Pugh Matrix for material selection 13
Automation Process 14

Introduction

The Levi Stool is designed to offer both comfort and durability while maintaining aesthetic appeal. A key aspect of the is selecting the right material for its seat and finding the most efficient manufacturing process. The aim of this analysis is to choose a material that meets functional requirements such as stability, strength, and user comfort, while also considering manufacturing feasibility. This document explores the material selection process, the reasoning behind the choice, and the manufacturing steps needed to produce a high-quality stool seat.

Functional Requirements

The Levi Stool seat must meet several functional requirements to guarantee stability, durability, and ergonomics. First, the material must be lightweight for easy portability. It should also maintain high strength, stiffness, and toughness to withstand daily use.

Strength and Durability – The material must have a tensile strength of at least 60 Mpa to handle daily use and impacts without breaking. It should also have a Vickers hardness of 15 or higher to resist scratches and surface damage over time (EXOTIQUE).

Lightweight Design – The stool should be easy to move while still being strong enough to support weight. Its density should be under 1.3 g/cm^3, ensuring portability without compromising strength (EXOTIQUE).

Resistance to Environmental Damage – The material must be moisture-resistant to prevent warping and degradation. It should withstand humidity and temperature changes to ensure long-term durability in different environments

Economic Requirements

Material and Manufacturing cost – The cost of the material should not be too high, so $ 4.39/kg per cubic meter is the limit. It makes sure that it is economically viable for the production (UK).

Manufacturing Requirements

The wood for a wooden stool should be easy to machine for smooth CNC milling, with a fine, consistent grain to prevent rough edges. It should also have good finishing qualities to achieve a polished surface when sealants are applied, and be stable in size to avoid shrinking or swelling (Smardzewski 2015).

Environmental Requirements

The material should be sustainably sourced to maintain the environmental balance and should be FSC – Certified (Matias, Cagnacci et al. 2024).

Material Shortlisting

In stage 1, we added Density, and based on that we got 754 results

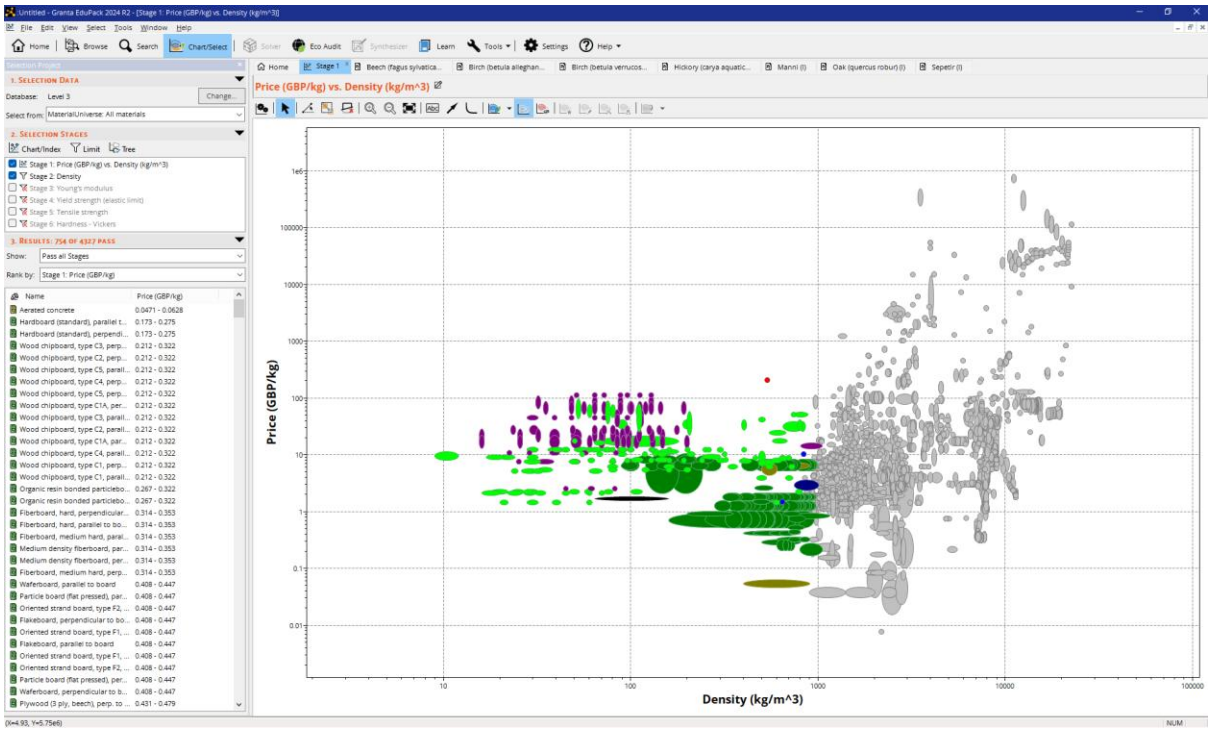

Fig.1 Material Property Density

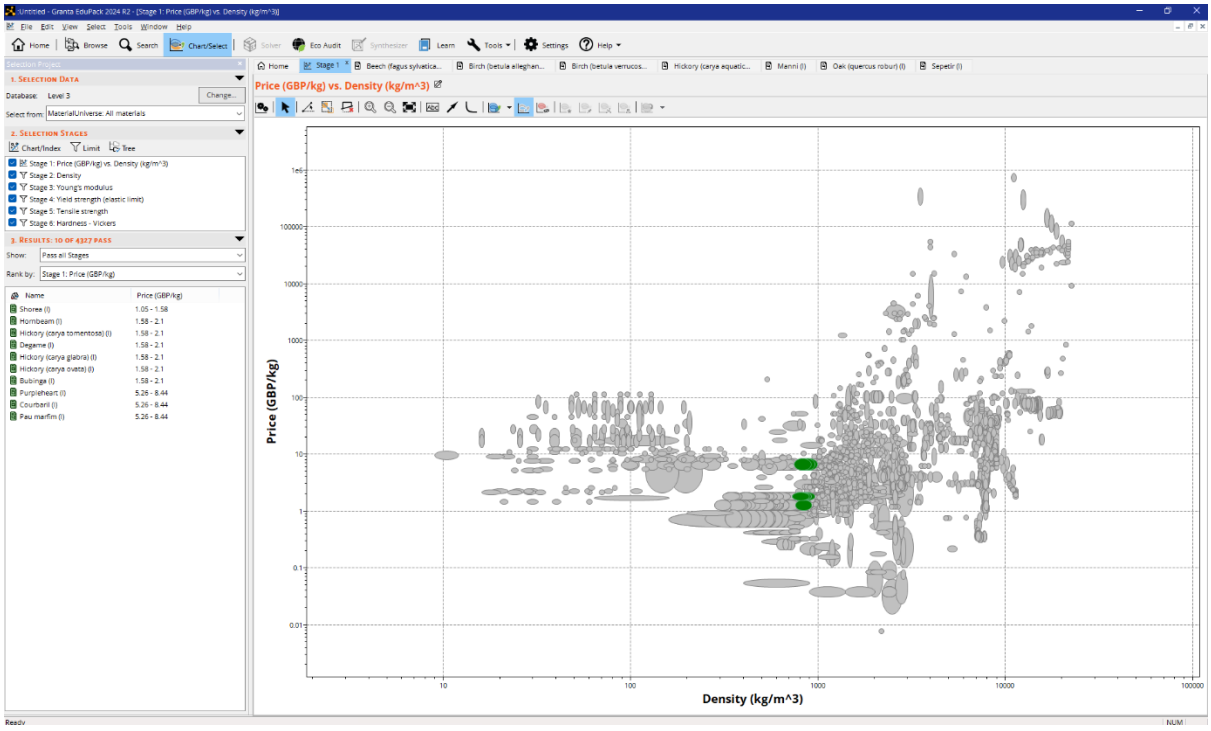

Fig. 2 Material Properties Youngs Modulus Yield Strength, Tensile Strength, Hardness

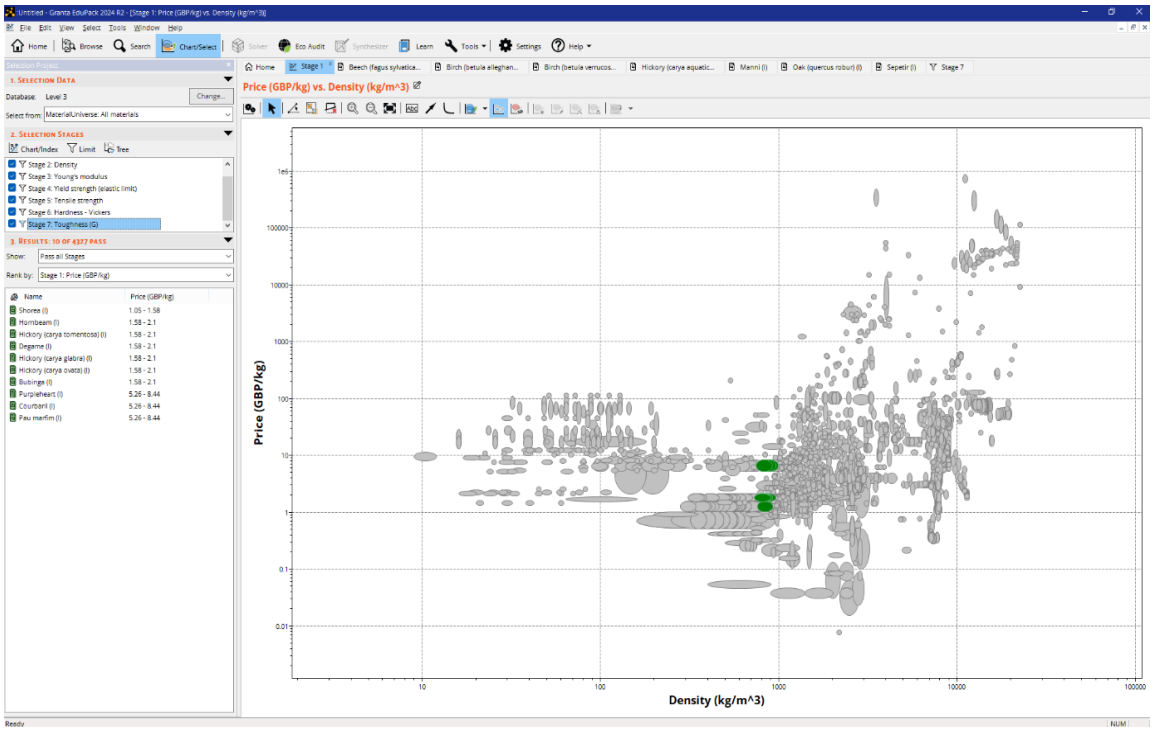

Fig 3 Material Impact and Fracture Properties (Toughness)

Name	Price (GBP/kg)
Shorea (l)	1.05 - 1.58
Hornbeam (l)	1.58 - 2.1
Hickory (carya tomentosa) (l)	1.58 - 2.1
Degame (l)	1.58 - 2.1
Hickory (carya glabra) (l)	1.58 - 2.1
Hickory (carya ovata) (l)	1.58 - 2.1
Bubinga (l)	1.58 - 2.1
Purpleheart (l)	5.26 - 8.44
Courbaril (l)	5.26 - 8.44
Pau marfim (l)	5.26 - 8.44

Fig 4 Shortlisted Materials

For selecting the material for the Levi stool, we used Granta Edu Pack to evaluate materials based on their physical, mechanical and fracture properties. We chose beech wood as the base material due to its light weight.

In the first stage, we selected materials with a density equal to or less than beech wood. From 4327 materials, 754 were chosen based on this density limit.

In the second stage, we compared mechanical properties like Young's modulus, yield strength, and hardness, using beech wood as the baseline. This narrowed down the options to 10 materials.

In the final stage, we considered toughness for fracture properties, and all 10 materials passed. These were the best materials for the stool.

Material Selection Process through Pugh Matrix

Using Granta Edu Pack, ten materials were initially chosen for the Safety stool, but three were excluded due to high costs, leaving seven for further evaluation. A Pugh Matrix was used to compare these materials against key criteria, with Bubinga as the reference material (scored 0). Materials better than Bubinga scored +1, and worse materials scored -1. Addressing gaps in traditional stool designs (Lønmo and Muller 2014). The results are shown in the table below.

Criteria		Weightage	Hickory (carya glabra)	Shorea	Hornbeam	Hickory (carya tomentosa)	Degame	Bubinga	Hickory (carya ovata)
Physical Properties	Density	3	1	-1	-1	1	-1	0	0
Mechnical Properties	Youngs Modulus	4	1	-1	-1	0	-1	0	-1
Mechnical Properties	Yield Strength	5	1	0	0	0	0	0	0
Mechnical Properties	Tensile Strength	5	1	1	-1	1	0	0	0
Mechnical Properties	Hardness (Vickers)	2	1	-1	-1	0	-1	0	0
Impact & Fracture Properties	Toughness	4	1	-1	1	1	0	0	1
		23	23	-8	-14	12	-9	0	0

Table 1. Pugh Matrix for material selection

The above Pugh Matrix results show that Hickory (Carya glabra) is the best material for the Safety Stool, with a score of 23. It performed well in areas like density, Young's Modulus, tensile strength, hardness, and toughness compared to the reference material, Bubinga (scored 0). Hickory (Carya tomentosa) scored 12, doing well in some areas but not as consistently. Shorea (-8), Hornbeam (-14), and Degame (-9) scored negatively, meaning they didn't perform as well. Hickory (Carya ovata) scored 0, like Bubinga, so it didn't offer any improvement. Therefore, Hickory (Carya glabra) is the best choice for the stool's needs.

Primary Manufacturing Processes

- **Wood Cutting**: A panel saw cuts the 8×8 hardwood sheets into frame pieces with precise measurements, ensuring all parts are the same size for a stable assembly (Smardzewski 2015).
- **Thickness**: A planer thicknesser makes sure the stool's parts have an even thickness, improving strength and balance when used (Li, Zhao et al. 2023).
- **Shape and Profile**: A scroll saw is used to cut curved shapes for the legs and side arms, creating ergonomic designs that make the stool comfortable for users (Smardzewski 2015).
- **Slots**: A CNC (Computer Numerical Control) milling machine cuts slots into the side arm mechanism, ensuring they fit securely and work correctly for safety (Smardzewski 2015).
- **Sanding**: A sanding machine smooths out the surfaces, giving the stool a polished finish and preventing splinters to ensure user safe (Li, Zhao et al. 2023).
- **Coating**: Manual application of a protective sealant makes the stool more durable and resistant to moisture, helping it last longer in different environments (Smardzewski 2015).

Automation in Manufacturing Processes

Automation of Machinery	Manufacturing Processes	Machinery Replaced
Laser Cutting Machine	Cutting sheet, profiling and slots	Panel Saw Cutting Machine, Scroll Saw, CNC milling machine
Robotic sanding arm (MWES)	For thickness Polishing and deburring	Sander Machine Planer thicknesser

Table 2 Automation Process

Fig. 5 Robotic Sanding Arm (MWES)

The manufacturing process can be automated by using a conveyor belt to feed wooden sheets into a laser cutting machine, which precisely cuts them into the required shapes. This eliminates the need for a panel saw, scroll saw, and CNC milling machine (MWES). After cutting, a robotic sanding arm smooths the surfaces and adjusts thickness, replacing the planer thicknesser. Finally, the parts are coated and assembled.

Conclusion

In conclusion, Hickory (Carya glabra) was finalised as the final material for our Levi stool on the basis of density, durability along with the machinability. Afterwards, the automation in manufacturing was figured out where robotic arm can be installed for various processes including sanding.

References

EXOTIQUE, B. "Pignut Hickory (Carya glabra)." Retrieved 23/03/2025, 2025, from https://www.bois-exotique.com/product/pignut-hickory/#:~:text=Color%2Fappearance%20%3A%20Heartwood%20tends%20to,is%20a%20paler%20yellowish%20brown.&text=Common%20Uses%3A%20Tool%20handles%2C%20ladder,rungs%2C%20wheel%20spokes%2C%20flooring.

Li, R., et al. (2023). "Research on the application status of machine vision technology in furniture manufacturing process." Applied Sciences **13**(4): 2434.

Lønmo, L. and G. Muller (2014). 7.1. 2 Concept Selection-Applying Pugh Matrices in the Subsea Processing Domain. INCOSE International Symposium, Wiley Online Library.

Matias, G., et al. (2024). "FSC forest certification effects on biodiversity: A global review and meta-analysis." Science of the Total Environment **908**: 168296.

MWES. "Robotic Sanding." Robotic Sanding. Retrieved 23/03/2025, 2025, from https://www.mwes.com/capabilities/material-removal/sanding/.

Smardzewski, J. (2015). Furniture design, Springer.

UK, E. H. "EXOTIC HARDWOODS UK

The number one shop for Exotic Hardwoods and Timbers from across the World.". Retrieved 23/03/2025, 2025, from https://exotichardwoodsukltd.com/?gad_source=1&gclid=Cj0KCQjw4v6-BhDuARIsALprm33LSF4Dem8f7_2M5_tiRpacLLBCDVmVJlzxqU_R50_F3DqHnFyzsZIaAlsKEALw_wcB.