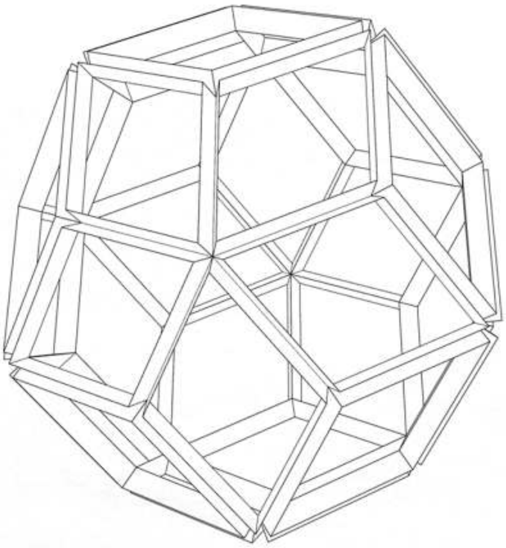
BEST VIEWED FULL SCREEN



MA ARCHITECTURAL DESIGN
COMPLEX MATERIAL ASSEMBLY PROJECT (CMA)

ARC6854
ENVIRONMENT AND TECHNOLOGY IN DESIGN
Module leader: Aidan Hoggard
CMA Project supervisor: Danni Kerr

University of Sheffield | School of Architecture

THE STRUCTURE OF PROJECT

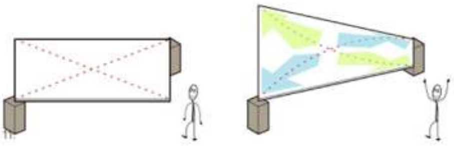
In Stage 2 we carefully selected technologies and materials from Stage one as a larger team with considerations on how component technology could be tranferred to a different project with new systems.

For the final Complex Design/Material Assembly project we decided to create an Interactive Pavilion. The collaborative studio, working as the design, production and management team, developed and an interactive surface, which would respond to human motion by producing corresponding movements based on selected projects from Stage 1. We aimed to 'execute this to the best extent and quality within time and budget to produce a manifest outcome suitable for public exhibition'.

'The project is both a research and design project. Through the development of prototypes students were engaging in a robust form of research to inform and test global research objectives through which the studio team was engaged in interpretation and intervention in the city.'
Danni Kerr

RESEARCH QUESTIONS

- HOW CAN MATERIALS AND TECHNOLOGIES BEHAVE DIFFERENTLY, ACTING ASCOMPONENTS OF DIFFERENT SYSTEMS?
- WHAT POTENTIALS RESIDE IN 'ASSEMBLING' AS A CONTRIBUTION TO DESIGN RESEARCH?



11.

INTRODUCTORY WALK

We visited and walked around a few material shops to get inspired by materials available and get familiar with the range of tools available for the Complex Material/Design Assembly project

09. Photo: Daria Belova.
10. Introductory walk.Photo: Daria Belova.
11. Sketch and concept: Danni Kerr

09.

10.

TEAM STRUCTURE

PROJECT MANAGEMENT TEAM

- Set up a shared information centre. Provide areas with shared folders for: Project and Cost Management; Design Development and a Reporting Area
- Create a project plan showing key target dates, resources and immediate actions
- Show on a big diagram and/or project software

DESIGN CO-ORDINATION TEAM

- Put together a design brief with sketches for a moving surface which considers:
- What will it be for; will it have an environmental function?
- What technologies and materials will it use?
- How will it fit together and how will it work?
- How will it provide and demonstrate your learning?
- Show sketches on a big diagrams and/or rapid 3D models

COST MANAGEMENT TEAM

- Set up a list of materials and services which can show: type, price, quantity, source, time etc.
- Set up the list so alternative cost scenarios can be created
- Talk to the teams and find out what they may need
- Start to find out easily accessible cost effective materials, components and services
- Be creative and find things that can be adapted.
- Work out procedures for purchasing.
- Show on a big diagram and/or spreadsheet

DIGITAL DESIGN TEAM

- Research alternative digital systems to control the moving surface. Investigate:
- What control systems (such as arduino), what sensors (or other input) and what outputs puts you can offer to control the surface?
- How can a control system connect to powered actuators?
- Can the system support the design brief?
- Draw a big System Diagram and/or demonstrate with technology.

ELECTROMECHANICAL DESIGN TEAM

- Research alternative electromechanical control systems to actuate the moving surface.
- What will be the best type of power unit, how will these be digitally controlled, how will these actuate a mechanical system?
- How we can adapt existing and easily accessible components.
- Create a big technical drawing and/or rapid 3D model and/or physical model

MATERIAL DESIGN TEAM

- Research and demonstrate materials to fabricate the moving surface.
- What are the best types of material, should they be light, strong, easily obtained and transported?
- Should they be flexible or rigid?
- How can they be shaped and fixed to each other and to the actuation system?
- How we can adapt existing and easily accessible materials to suit?
- Create a big technical drawing and/or rapid 3D model and/or physical model

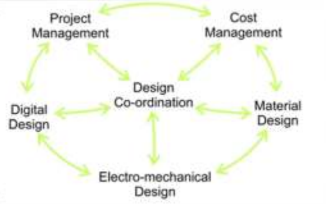
REPORTING TEAM

- Set up the project recording and communication channels.
- Clearly set out the topics you need to cover to:
- Sell the project to ourselves, the school of architecture, meet the academic requirements and look great in the portfolio.
- Remember to cover the work done so far. Interview the teams and use the material that they and you generate to record and communicate the project.How will the project and individual posters be exhibited?
- Create a record of the day ready for communication.

Brief: Danni Kerr.

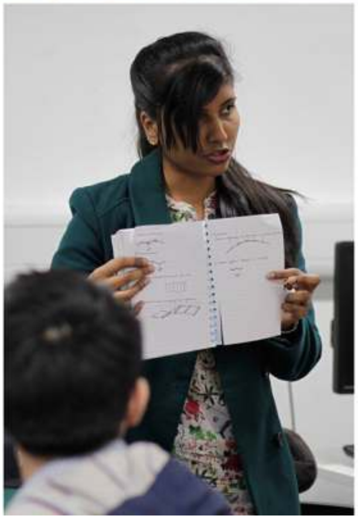
12.

14.



13.

12. Initial concept. Model: Kasturi Priya. Photo: Daria Belova.
13. Group structure. Diagram: Danni Kerr.
14. Brainstorming session. Photo: Daria Belova.



15.

TUTORIAL 1. DESIGN OPTIONS. DESIGN BRIEF.

DESIGN BRIEF

The project aims to create an interactive pavilion and provide us with skills that can be applied in complex material assembly through the process of design to fabrication.

We came up with the basic ideas for an ' open rhombic tricontahedron' from the origami fireball (fig.1) which would respond to physical movements using sensory components. By exploring the principles and rules from creating the origami fireball, we explored it's potential to be translated into a human size pavilion with a move-able surface. The pavilion should possess the capacity to transform creating different delineations of space, like a spherical dome or semi-enclosed space.

DESIGN PROCESS

1. The source of the idea: Origami Fireball. A rhombic tricontahedron created using folded pieces of paper attached in joints of 5's and 3's.
2. Exploration of basic elements of the finished product
- Principles and rules for the digital and physical components: The digital and physical design groups were responsible for exploring the principles and rules for the succesdul completion of the project through digital prototyping and physical prototyping respectively.
- Actuators & power source: The Electromechanical design team was responsible for exploring the actuators and power source that would control the basic components.
3. Form finding
- What forms can be easily controlled or actuated? (e.g. dome)
- Which form has the potential to accomodate more functions? What are these functions?
- Size and scale of the pavilion
- Anchor points of the pavilion
4. Experimenting the feasibility of the project
- Small-scale pavilion
- Full-scale basic components - how should parts fit together?
5. Assembling

METHODOLOGY AND METHODS

Assembling, Experimenting, Simulation

OPEN RHOMBIC TRIACONTRAHEDRON
(Lattice with 30 diamond shaped faces)
- It is made of 30 faces and 60 Edges and 120 pieces in total
- Each edge will be made of a V shaped section
- From the image (left) 0.5m long edges will make a sphere of about 1.5m in height and a cylinder 2.5m in height

NOTES:

a)
- Verticies are made of 3 or 5 converging Vs
- For our project Vs are facing outwards not inwards as shown on these images
- For our project we need to make 12 of these 5 pointed stars.

b)
- 120 pieces 500mm x 80mm
- Scale 1:10
- about 9 sheets 1220mm x 607mm 3.6mm plywood
- Cost £12.94 per sheet from B&Q, Total £130

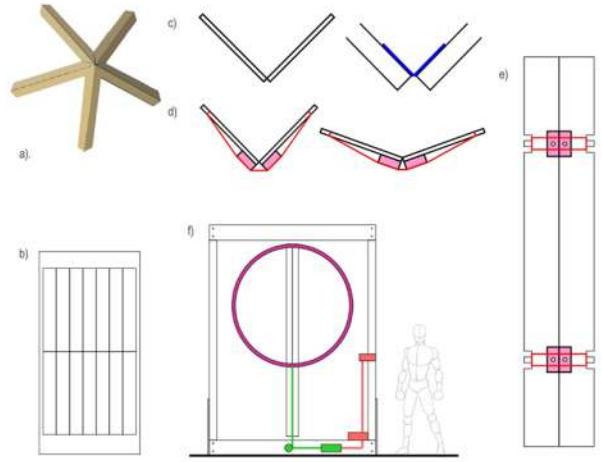
c)
- V Edge can be made of: 3.6mm ply (or other), 500m long by 80mm (or other)
- A hinge needs to be formed Use a high spec tape (or other)

d)
- The hinge needs to be sprung
- Use: elastic bands OR foam blocks OR small screws or tape
- Notch the pieces toreceive the elastic band

e)
We need to make 60 of these:
-2 of
500mm x 80mm
3.6mm ply
(120 in total)
-2 of
50mm elastic bands
(120 in total)
-4 of
25mm x25mm x60mm
foam block
(240 in total)

We need to make a frame
2 of 100mm x 100mm x 3m post
4 of 200mm x 2200mm 9mm ply plan
2 of 600mm x 1200 18mm ply legs
12 of 120mm M10 nuts and bolts
Fishing Line and or String

f)
We need to install the power;
1 electric motor which can reel control line
1 controllable power supply



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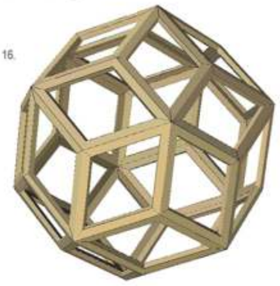
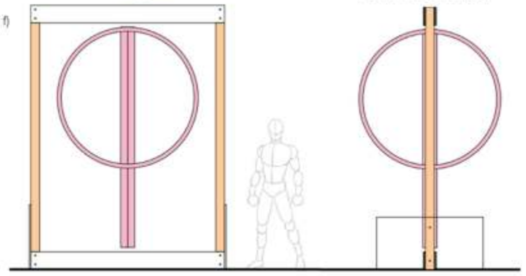


f)



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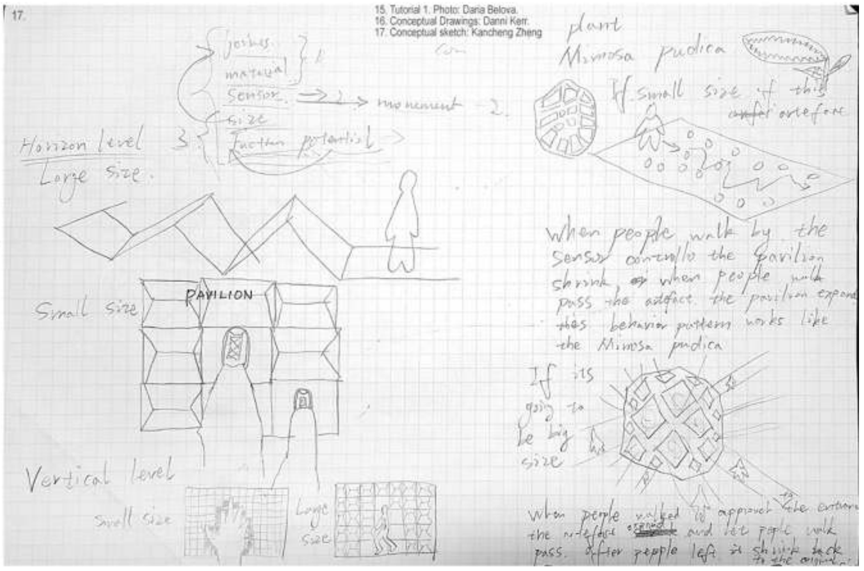


15. Tutorial 1. Photo: Daria Belova.
16. Conceptual Drawings: Danni Kerr.
17. Conceptual sketch: Kancheng Zheng

DIGITAL DESIGN PROCESS

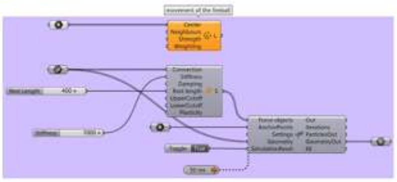
1. In accordance with the 'origami fireball' concept of the design, a digital 3D model was created using Rhino+ Kangaroo (a plugin of Grasshopper). The digital model shows the basic configuration of the jint parts of the 'sphere', as well as the model in motion.

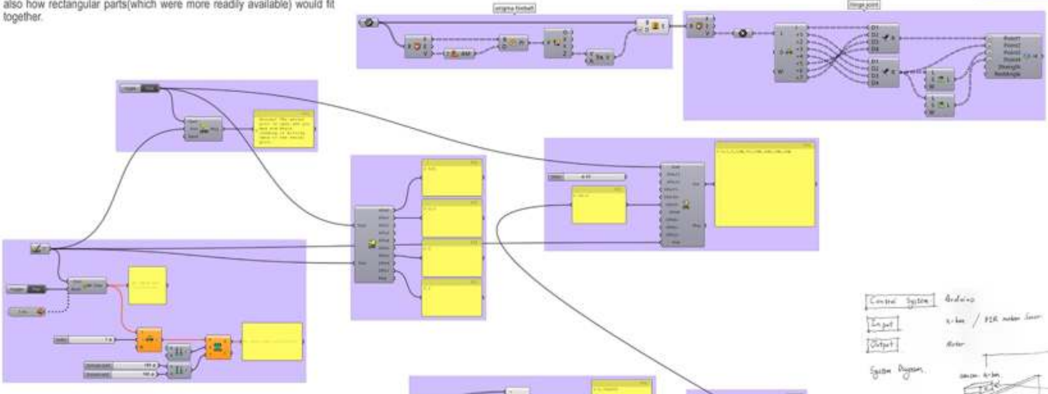
2. We used Xbox 360 Kinect as sensor to capture people's gestures which would serve as actuators for the movement of the completed model(Reference to how PIR sensor work available at: https://www.youtube.com/watch?v=6Fdrr_1guok)

3. The digital model also served to inform our speculations as to the amount of materials needed to complete all the faces of a sphere, and also how rectangular parts(which were more readily available) would fit together.

19. Algorythm in Rhyni+Grasshoper
20. 3D Model: Ming Zhong
21. Working principle. Sketch: Yingran Sun.
22. Xbox 360 Kinect sensor
23. Working principle. Sketch: Yingran Sun.

19.





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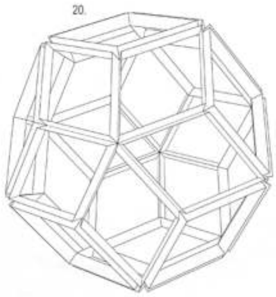

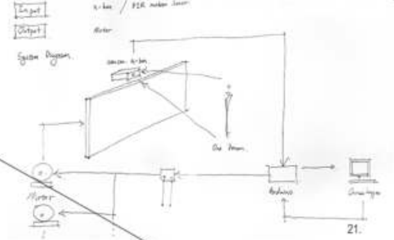

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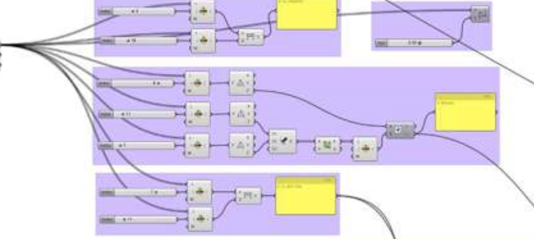

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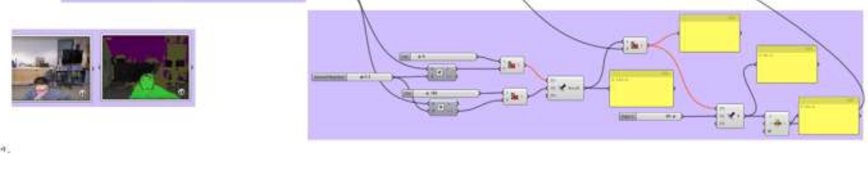

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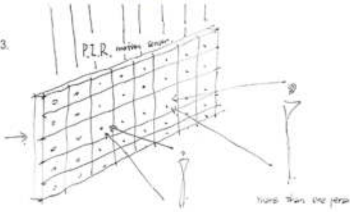
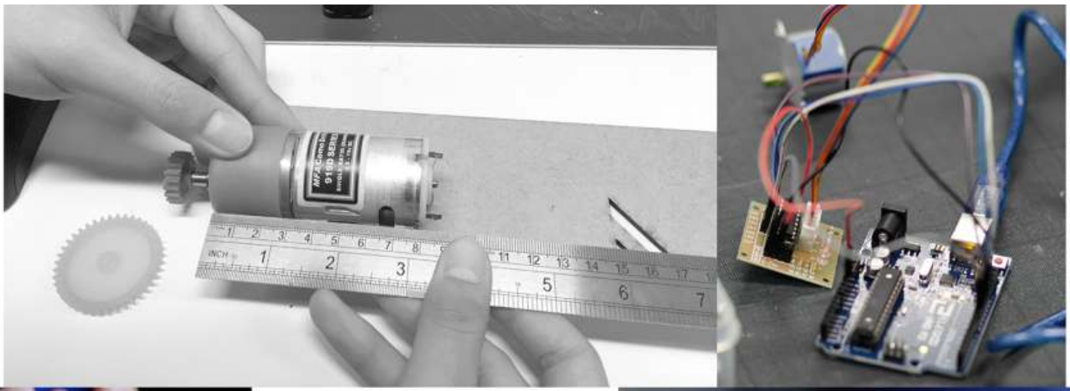




ELECTROMECHANICAL DESIGN PROCESS

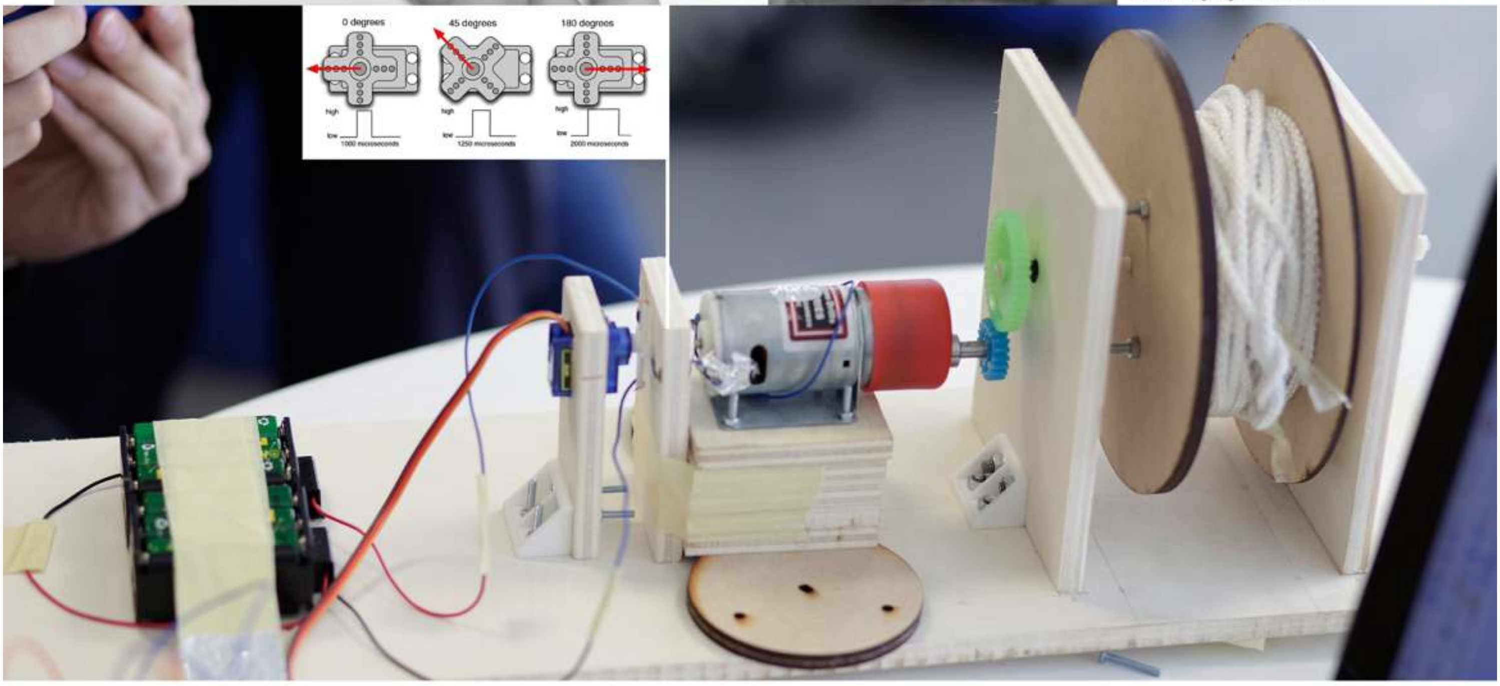
We used 12 AA batteries as a power source for the whole system. A servo-motor was used to operate as a switch. As the servo motor is able to rotate from 0 degree to 180 degree, it is effective to aid the change in direction needed for the project. This implies that this powerful motor can rotate clockwise and anti-clockwise. The servo motor is then controlled by an Arduino kit in addition to a motion sensor - the X-box Kinect.

X-box Kinect is capable of capturing motions of at least two people. As an interface between the sensor and computer commands, grasshopper and it's plug-in called Firefly, were used to simulate the joints in the human body. Data from these points were then programmed to suit to three situations. When there is nobody present within range of the sensor, or if the person in the area does not lift their hands, the servo motor rotates at 90 degree, which means the switch is off. When the person lifts their hands with their palms touching, the servo motor rotates at 0 degree, which means the switch is on and the powerful motor keeps rotating clockwise. If the person opens up their hands, the powerful motor will rotate anti-clockwise.

The motor was designed to power the wheel of a cable which was supposed to connect to the "fireball", such that the shape of the "fireball" can be changed by the motions of a person.

Video demos available at: https://maadfireballproject.wordpress.com/digital-design/

18. Operating system. Electromechanical design: Li Wu, Shaoshuai Zheng, Yufu Liu, Yincheng Wang. Photo: Daria Belova.

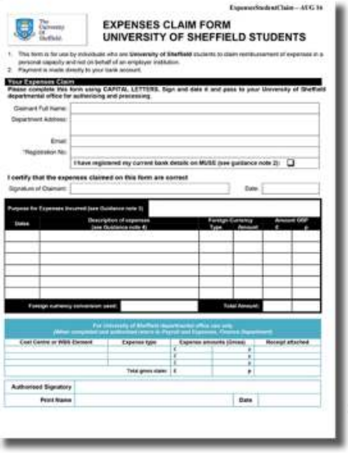


PROJECT MANAGEMENT. BUDGET. MATERIALS

ARCHITECTURE WORKSHOP	ROOM NUMBER	DATE & TIME	COST	PAID BY	RECEIPT OR NOT
GEORGE PORTER BUILDING	A03	03/05/17 08.28	£4.70	YOTI	YES
GEORGE PORTER BUILDING	A03	03/05/17 15.30	£3.50	JING	YES
GEORGE PORTER BUILDING	A03	05/05/17 11.50	£3.50	DU	YES
GEORGE PORTER BUILDING	A03	05/05/17 15.27	10.2	MING	YES
GEORGE PORTER BUILDING	A03	05/05/17 15.30	3.5	JING	YES
			£25.40		

MARTIERIAL DESCRIPTION	SIZE	PRICE	QUANTITY	TOTAL COST	SUPPLIER	DATE & TIME	PAID BY	RECEIPT OR NOT
Plastic (foam)		£1.50	1	£1.50	Materials Workshop	03/05/17 11.07	YOTI	YES
WBP EXT PLY	F	£14.73	7	£103.11	B&Q	02/05/17 20.47	DANNI	YES
BUTT HINGE	25MM STEEL Qty 2	£1.40	1	£1.40	B&Q	02/05/17 20.47	DANNI	YES
RIGID JOINT	34 × 20 MM White Qty	£3.02	1	£3.02	B&Q	02/05/17 20.47	DANNI	YES
7/0.2 Wire 10M Blu		£2.79	1	£2.79	maplin	03/05/17 16.37	YUFU	YES
6A Figure 8 (1m)		£1.69	3	£5.07	maplin	04/04/17 13.14	YUFU	YES
Gears Cams & Pulleys		£6.99	1	£6.99	maplin	04/04/17 13.15	YUFU	YES
148:1 Lge Gear Box		£24.99	1	£24.99	maplin	04/04/17 13.16	YUFU	YES
NickelZinc AACharger		£12.99	1	£12.99	maplin	04/04/17 13.17	YUFU	YES
PanelSpeed Regultr		£14.99	1	£14.99	maplin	04/04/17 13.18	YUFU	YES
NickelZinc AA 4Pk		£12.99	3	£38.97	maplin	04/04/17 13.19	YUFU	YES
6AA Battery Box		£1.79	2	£3.58	maplin	04/04/17 13.20	YUFU	YES
Sub-Min Toggle B		£2.79	1	£2.79	maplin	04/04/17 13.21	YUFU	YES
Rigid PP3 Clip		£1.49	2	£2.98	maplin	04/04/17 13.22	YUFU	YES
PP3 Clip		£1.79	1	£1.79	maplin	04/04/17 13.23	YUFU	YES
Elegoo UNO R3 Project		£48.98	1	£48.98	amazon	03/05/17	Yingran Sun	email receipt
stationery		1.99	2	3.98	carson stationery	03/05	V	yes
stationery		1.99	2	3.98	carson stationery	05/05	V	yes
WBP EXT PLV; CLS TIMBER; GORILLA TAPE;				127.79	B&Q	04/04/17 19.28	DANNI	YES
CABLE TIES; FELT PADS; HEX BOLT; RIGID JOINT; VEST CARRIER; STARTER CORD								
Metal (61); Misc;				6.2	Materials Workshop	10/05	MING	YES
Metal;				1	Materials Workshop	10/05	YUFU	

26.



ExpensesStudentClaim – AUG 16

EXPENSES CLAIM FORM
UNIVERSITY OF SHEFFIELD STUDENTS

1. This form is for use by individuals who are University of Sheffield students to claim reimbursement of expenses in a personal capacity and not on behalf of an employer institution.
2. Payment is made directly to your bank account.

Your Expenses Claim

Please complete this form using CAPITAL LETTERS. Sign and date it and pass to your University of Sheffield departmental office for authorising and processing.

Claimant Full Name:
Department Address:
Email:
*Registration No:
I have registered my current bank details on MUSE (see guidance note 2): ☐

I certify that the expenses claimed on this form are correct

Signature of Claimant: Date:

Purpose for Expenses Incurred (see Guidance note 3)

Dates	Description of expenses (see Guidance note 4)	Foreign Currency Type	Foreign Currency Amount	Amount GBP £	Amount GBP p
Foreign currency conversion used:		Total Amount:			

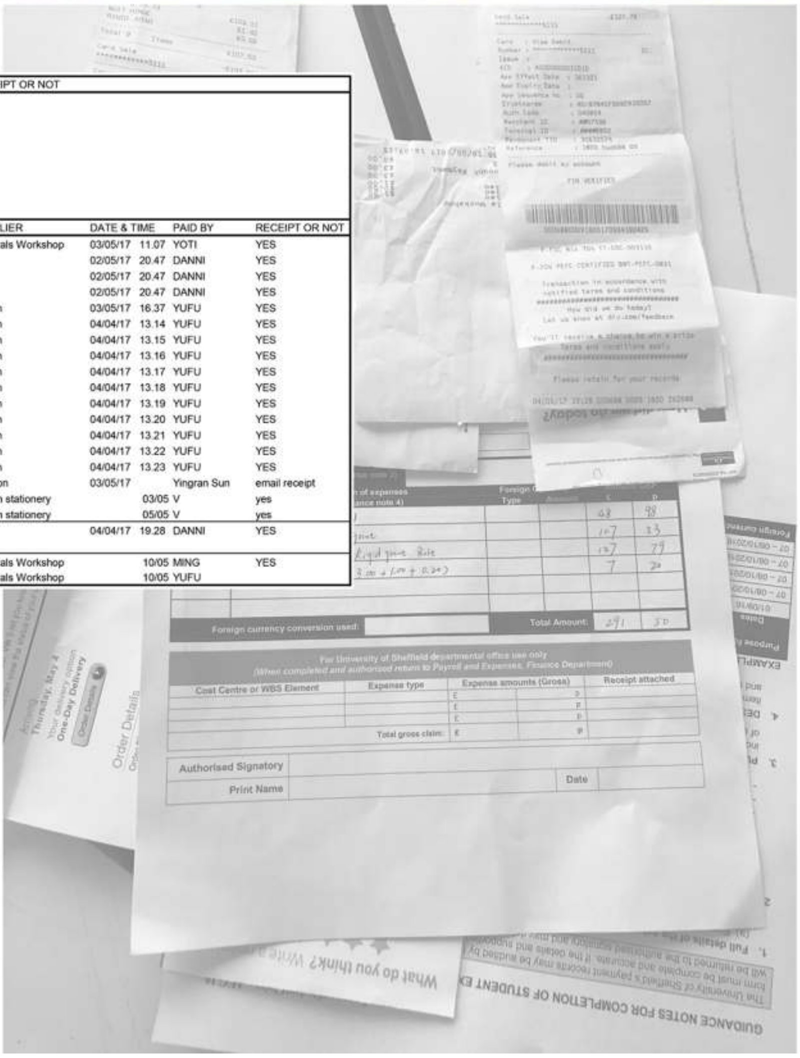
For University of Sheffield departmental office use only
(When completed and authorised return to Payroll and Expenses, Finance Department)

Cost Centre or WBS Element	Expense type	Expense amounts (Gross) £	Expense amounts (Gross) p	Receipt attached
		£	p	
		£	p	
		£	p	
	Total gross claim:	£	p	

Authorised Signatory
Print Name Date

24.

24. Expences Claim form
25. Collection of receits. Weilin Wang.
26. Table of materials. Xuejing Sun



25.

PROJECT MANAGEMENT

The project management team presented a project plan for review by the entire group at the start of preparations for building the large scale model. The purpose of this review was to apply for approval of the budget which would enable us complete the project, as well as an explanation of the time-specific requirements for performance from each member of the different teams. This was done to ensure the project would be completed in time and in good quality. The plan upon further scrutiny exposed areas where some tasks were not clearly defined or explained.

The project plan demonstrated in the form of a worksheet set out the following:

- Research, Design and Prototyping Activities.
- Integrated and Detailed Design Strategies
- Material, Technology, and Fabrication Requirements.
- Studio Team Organisation
- Costs
- Meaningful Application to Design Contexts.
- Research Objectives.
- Sustainable Credentials

DAILY SCHEDULE
Week of: **24 April**
PROTOTYPING 1

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY
week 1			Day Workshop				
			26/4	27/4	28/4	29/4	30/4
week 2			Finalise Design Purchasing Making Components		Puchasing Making Components Testing Assembly		
	1/5	2/5	3/5	4/5	5/5	6/5	7/5
week 3			ake Final Components Assembly Test System		AM inal Assembly PM REVIEW		
	8/5	9/5	10/5	11/5	12/5	13/5	14/5
week 4	poster submission						
	15/5						

over view

26th April	start
26th April ~ 3rd May	design
3rd May	review
3rd May ~ 5th May	modify
5th May	confirm design
5th May ~ 10th May	buying and assembling
10th May	finish artefact
10th May ~ 12th May	preparing for final review
12th May	final review

DAILY SCHEDULE
Week of: **1 May**
PROTOTYPING 2

Groups	1/5 MONDAY	2/5 TUESDAY	3/5 WEDNESDAY	4/5 THURSDAY	5/5 FRIDAY	6/5 SATURDAY	7/5 SUNDAY
material design	urchase Test Materials 3mm ply 6mm ply 30mm sheet foam 50mm elastic bands		Laser Cut Some Components and make test hinges.	# Buying Materials # Fixing Components	Making Components; Laser Cutting; Assembling System; Settle down the # material # cost availability # size of the installation		
digital design	Research: how to control a power motor; what equipment is required; where can this be acquired		Absolutely decide on equipment and where to get it				
electromechanical design	Research: what motor and power supply can reel in and plot a line; what safe power supply can it use; where can this be aquired						
cost management	Find out how to release funds, List all requirements Prepare to buy materials, Record all purchases.		Complete main shopping list by the end of the day				
design coordination	Make a laser cutting file of main component. Evaluate proposed fire ball system, Identify issues and possible solutions.		Components and make test hinges. Liase with Control and Power Teams to develop				
project management	BOOK LASER CUTTER FOR WED BOOK 4 HOURS LASER CUTTING FOR FRIDAY		Update this plan as agreed by end of Wed; Consult about CMC machine.				
reporting	Put together a template of for the 20 page report. Make a 3D model of system (work with reporting team)		Update team on progress. Start Blogging				

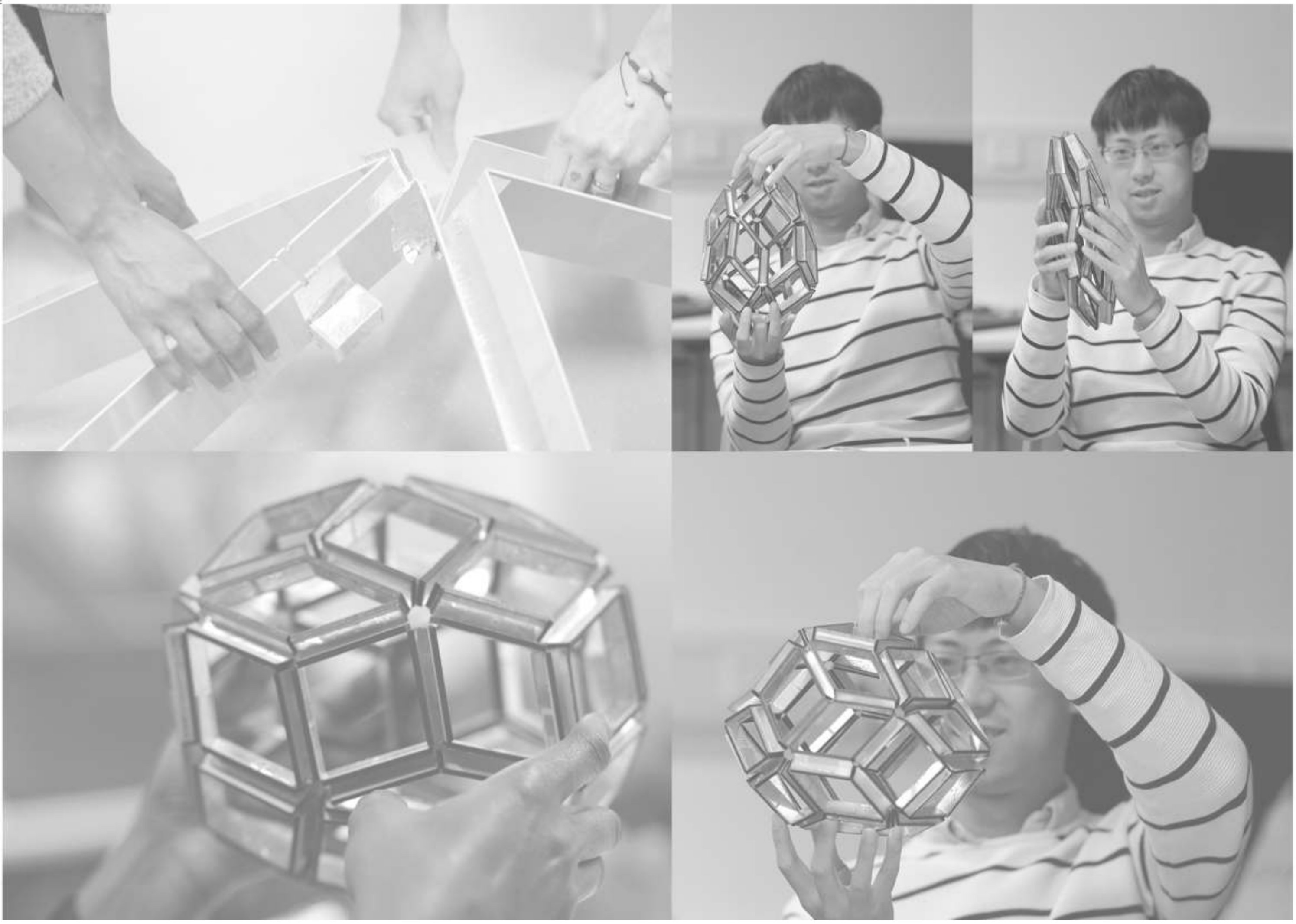
APRIL

M	T	W	T	F	S	S
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30

MAY

M	T	W	T	F	S	S
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				

27. Schedule by Jing Yan.



TUTORIAL 2. EXPERIMENTING WITH ASSEMBLY

> 'THE MICROSPHERES OF FOAM ARE WORLDS OR PLACES THAT ARE ISOLATED AND FRAGILE. EACH BUBBLE CAN ONLY IGNORE ITS NEIGHBOURS TO A CERTAIN EXTENT, AS THEY ARE DEPENDENT ON THE SPHERES AROUND THEM AND EACH ONLY HAS A LIMITED PERSPECTIVE.'
>
> Peter Sloterdijk, "Foam city."

We started out by experimenting on materials we could use to produce our desired object. This helped us in understanding what kind of joints we needed to make, how parts could be attached to each other, or which parts would remain fixed while the others moved.
As a task we were sorted out into different teams to create some type of movable surface using cardboard, rubber bands, cutting knives, and some joints from a children's game.
We each developed several types of nodes, each with their own advantages and disadvantages. The combination of features of nodes compensated for disadvantages of each type of joint.

In addition, we assembled a small-scale model of the fireball using plywood(our proposed material for the larger component) to test its physical properties. This exposed the most fragile joints as the corners of the 5-point and 3-point stars. This led to our decision to reinforce them in the larger scale model using stronger tape, and providing extra support to parts most susceptible to gravity.

In conclusion, it can be said that this tutorial helped us to work out the physical properties of materials and nodes, which would have not been possible by working merely with hand drawn or computer models.

Videos showing our individual experiments with moving parts are available at: https://maadfireballproject.wordpress.com/2017/05/01/testing-our-ideas/

19. The scaled model of fireball. Photo: Daria Belova.
20. Working on variations of components. Photo: Daria Belova.

28.

29.

30.

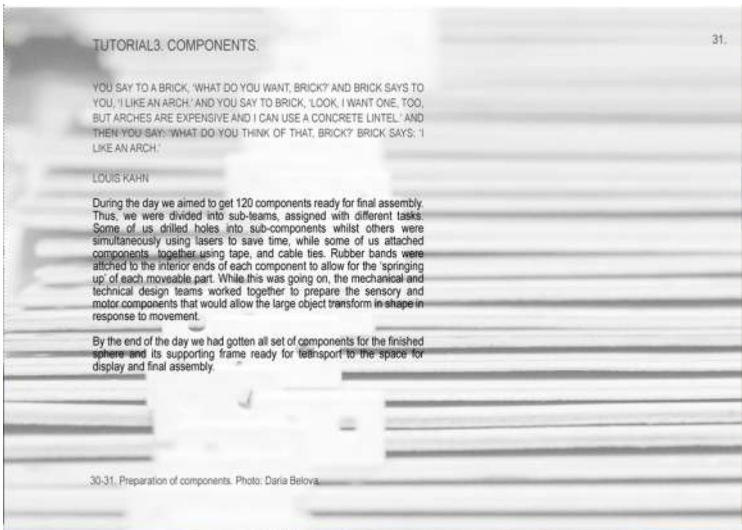
TUTORIAL3. COMPONENTS.

YOU SAY TO A BRICK, 'WHAT DO YOU WANT, BRICK?' AND BRICK SAYS TO YOU, 'I LIKE AN ARCH.' AND YOU SAY TO BRICK, 'LOOK, I WANT ONE, TOO, BUT ARCHES ARE EXPENSIVE AND I CAN USE A CONCRETE LINTEL.' AND THEN YOU SAY: 'WHAT DO YOU THINK OF THAT, BRICK?' BRICK SAYS: 'I LIKE AN ARCH.'

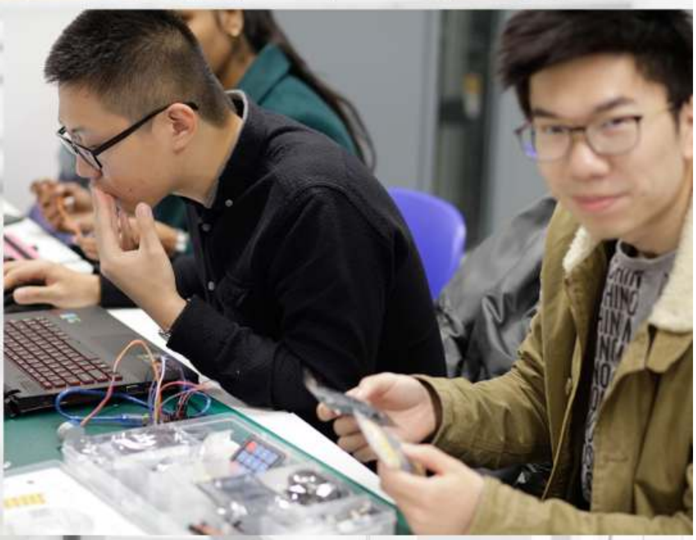
LOUIS KAHN

During the day we aimed to get 120 components ready for final assembly. Thus, we were divided into sub-teams, assigned with different tasks. Some of us drilled holes into sub-components whilst others were simultaneously using lasers to save time, while some of us attached components together using tape, and cable ties. Rubber bands were attched to the interior ends of each component to allow for the 'springing up' of each moveable part. While this was going on, the mechanical and technical design teams worked together to prepare the sensory and motor components that would allow the large object transform in shape in response to movement.

By the end of the day we had gotten all set of components for the finished sphere and its supporting frame ready for teansport to the space for display and final assembly.



30-31. Preparation of components. Photo: Daria Belova.



TUTORIAL 4. FINAL ASSEMBLY

REFLECTIONS/CONCLUSIONS/AREAS FOR FURTHER RESEARCH

At the beginning we panicked at the thought of designing, organizing and building the entire structure within a 10-day time period. Though daunting at first, as the work started to progress, we became more positive about the outcome of the project. A strong sense of ownership within all the members was spectacular as people started to take on tasks outside of their job description to ensure the successful completion of the project. In addition, the original concept was created using folded paper, so an initial concern was how to translate this foldability to plywood.

As an end result of **Tutorial 2**, we were able to understand what kind of joints were too strong or too weak, what kind of arrangements would enable the co-ordinated movement of jointed parts by the movement of a singular component. what sizes are suitable for notches to allow for nuts and bolts, elastic components etc.
Some components failed at the initial experiments, and understanding exactly why they failed was crucial to the successful assembly of the larger model.

It also became evident that some types of tape or adhesive were too weak and pulled apart when parts of the component moved, and also that nuts and bolts would not allow for an effective 'closing' of the components. In the end, 'Gorilla' tape proved the most efficient adhesive for holding the pieces of plywood together. The rubber bands which were attached to enable springing also needed a specific arrangement to ensure sturdiness and achieve the required elasticity.
The final design solution was a combination of ideas derived from this exercise. Thus, in addition to assembling our large scale model technically, we also assembled ideas to the one compromising solution.

The completed model was suspended from a wooden frame using a chain of rubber bands, and parts of the diamond shaped nodes at the top of the square that began to sag under the force of gravity were re-inforced using extra pieces of plywood.

In programming the sensory components, some setbacks became apparent. For example,in creating the sensor controls, at the initial stage, it was a difficult task to define the exact human movements that would 'start' and end' the actuation of the motor designed to move the entire model. There were difficulties in defining what exact type of data would start and stop the motor in motion without the entire model collapsing under the speed of the movements.
In the end, only one motor was successfully actuated. In the long run, it might be possible to control several motors using the arduino+grasshopper+xbox Kinect sensor. Due to the immense weight of the sphere, unfortunately , we were unable to actuate it using the motor we had succesfully actuated.

An alternative to this project would be to actuate a moving surface that rests only in a horizontal x- axis. This would reduces the effects of gravity of the model, as well as requiring fewer components which would inversely result in a lighter form that could be powered by the motor we had succesfully actuated. Alternatively, more components could be made and added to result in a completely different component.

Given more time, it would be interesting to explore more sophisticated joints and fasteners for the moving parts, and perhaps large scale materials that lend themselves more easily to folding other than plywood. In this project, we were unable to actually actuate the completed structure to move, it might be worth testing this out in further research projects.

In general, the experimentation, time planning, budgeting, interaction and teamwork skills gained from this project will prove useful to each member of the group team in their individual careers or for future projects.

32-33.Artefact. Photo: Daria Belova.
34. Artefact.- Human Scale
35. Basic Joint showing cable ties and Gorilla Tape

More details about the project not included in this report can be found at
www.maadfireballproject.wordpress.com

34.

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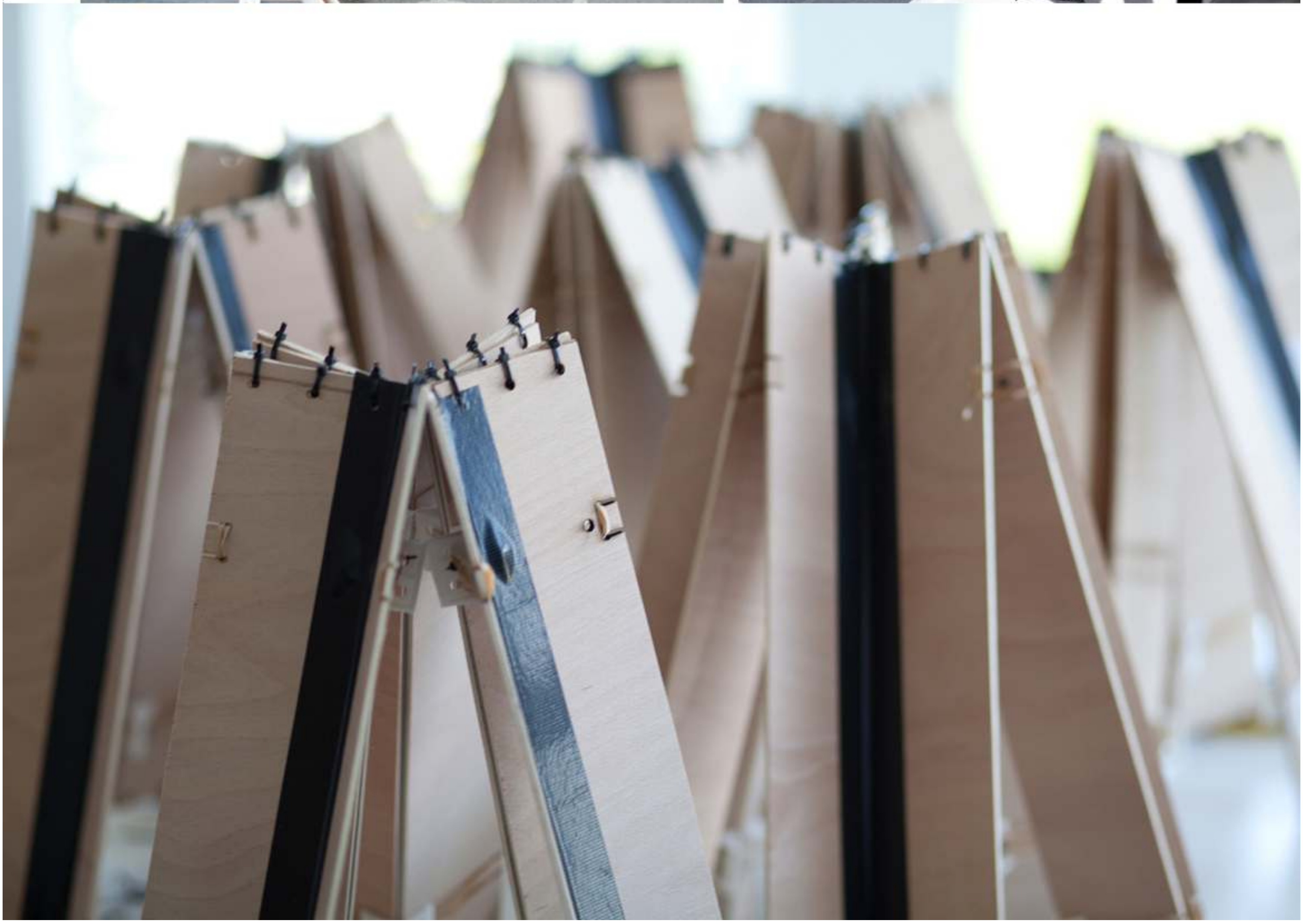

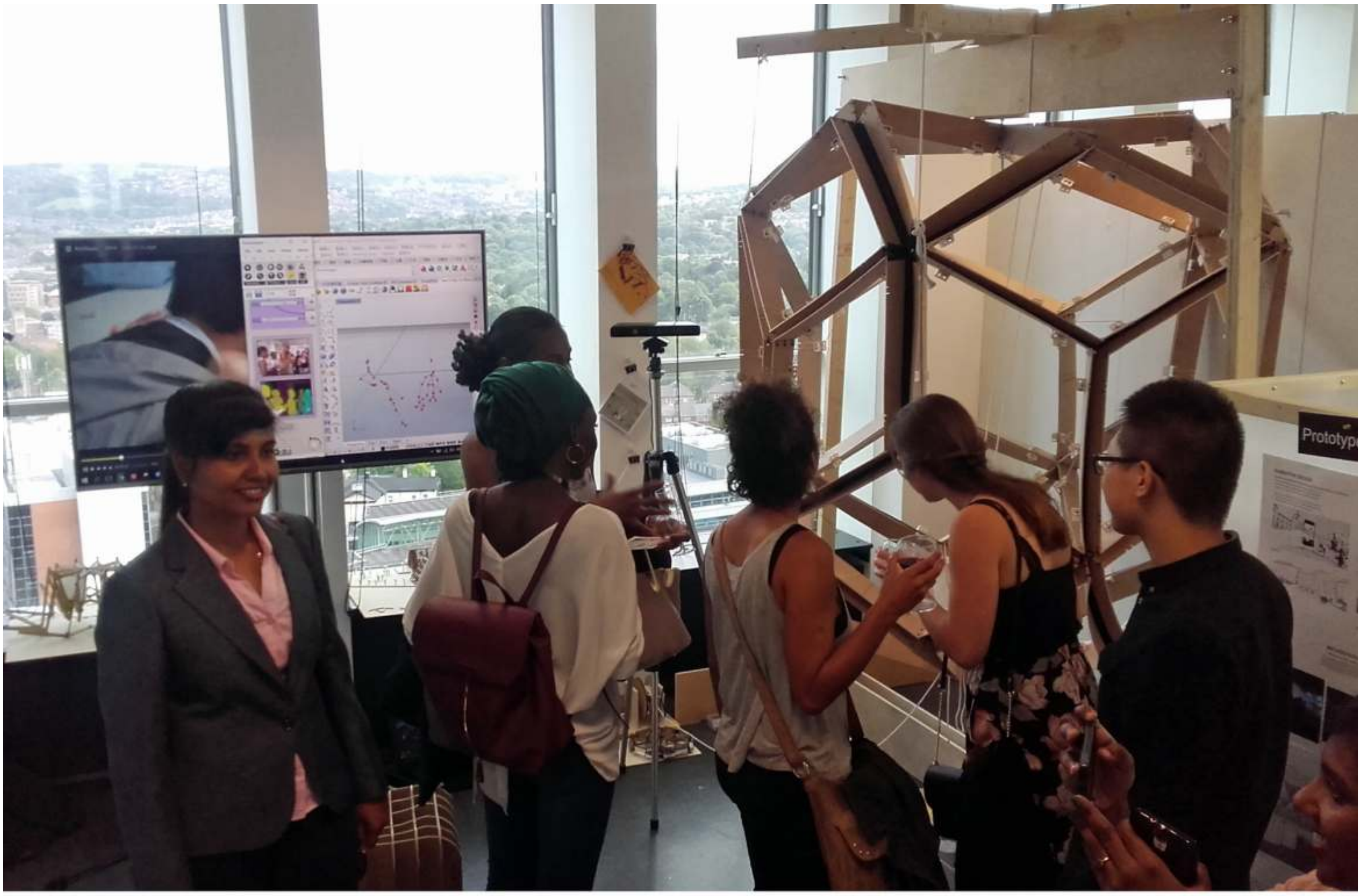
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