A Structured Approach to the Creative Design Process for Civil Engineering Students

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University of Liverpool

ANNEX B: DESIGN IN DEGREE PROGRAMMES

… projects are characterised by: extremely complex briefs which are full of diverse and often contradictory aspirations; numerous and often obscure constraints; unexplored opportunities relating to the site and the socio-economic context; typically incomplete information; and only approximate data.

ANNEX C: SUSTAINABILITY IN DEGREE PROGRAMMES

Aims

Students will become attuned to the need to design and engineer projects which manage our impact on the environment, and which enhance humankind's endeavours in a sustainable manner.

ANNEX F – PROFESSIONALISM AND ETHICS IN DEGREE PROGRAMMES

Knowledge and understanding

Students will be able to:

- Understand the nature of professional responsibility.
- Identify the ethical elements in decision-making.
- Understand the interaction between engineering, the environment and society.
- Understand how to overcome the practical difficulties in bringing about change.

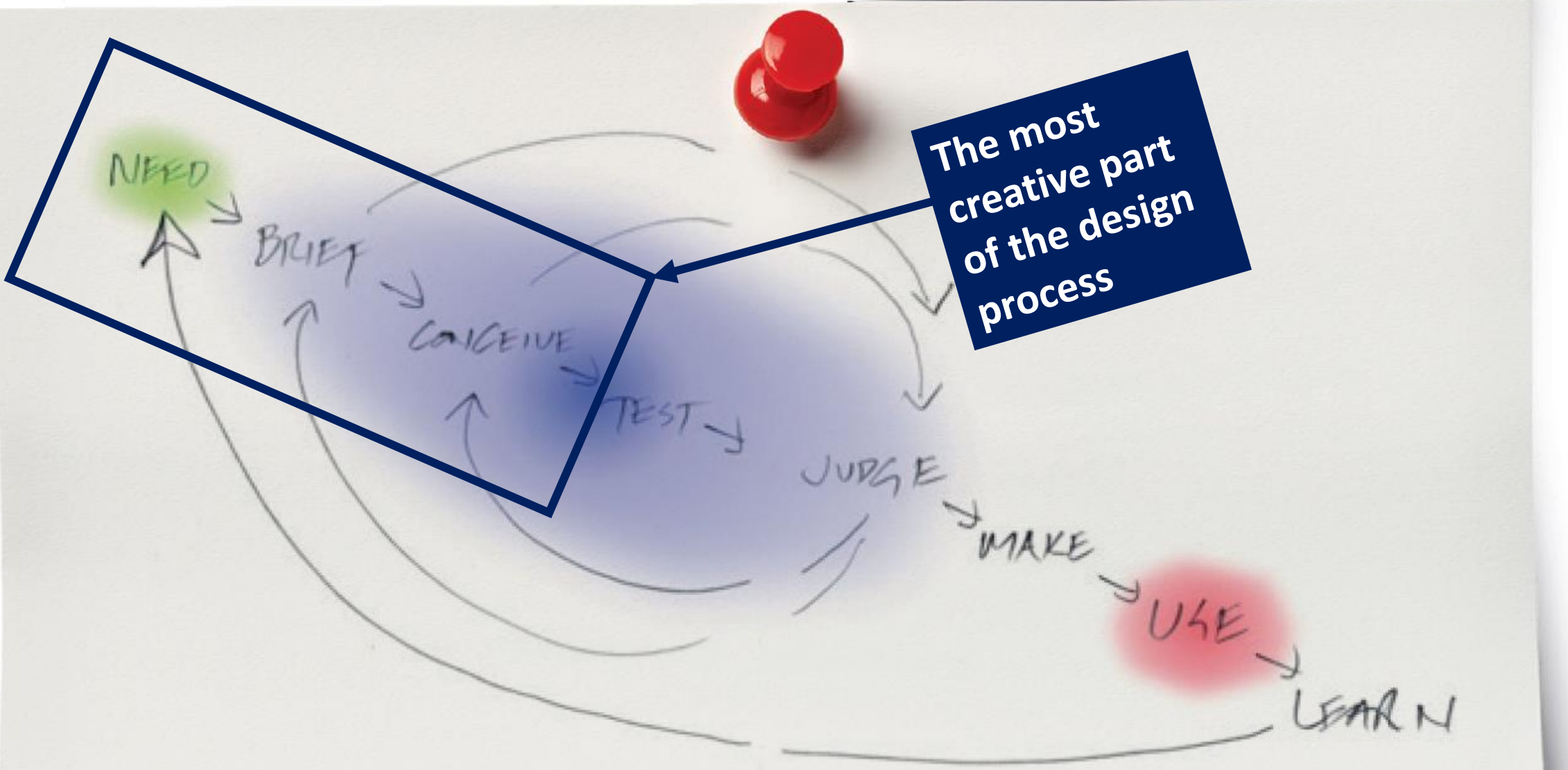

Figure 2.3: The anchor diagram for the overall design process

RIBA

The RIBA Plan of Work 2013 organises the process of briefing, designing, constructing, maintaining, operating and using building projects into a number of key stages. The content of stages may vary or overlap to suit specific project requirements. The RIBA Plan of Work 2013 should be used solely as guidance for the preparation of detailed professional services contracts and building contracts.

www.ribaplanofwork.com

RIBA Plan of Work 2013

Tasks ▼ / Stages ▼	0 Strategic Definition	1 Preparation and Brief	2 Concept Design	3 Developed Design	4 Technical Design	5 Construction	6 Handover and Close Out	7 In Use
Core Objectives	Identify client's **Business Case** and **Strategic Brief** and other core project requirements.	Develop **Project Objectives**, including **Quality Objectives** and **Project Outcomes**, **Sustainability Aspirations**, **Project Budget**, other parameters or constraints and develop **Initial Project Brief**. Undertake **Feasibility Studies** and review of **Site Information**.	Prepare **Concept Design**, including outline proposals for structural design, building services systems, outline specifications and preliminary **Cost Information** along with relevant **Project Strategies** in accordance with **Design Programme**. Agree alterations to brief and issue **Final Project Brief**.	Prepare **Developed Design**, including coordinated and updated proposals for structural design, building services systems, outline specifications, **Cost Information** and **Project Strategies** in accordance with **Design Programme**.	Prepare **Technical Design** in accordance with **Design Responsibility Matrix** and **Project Strategies** to include all architectural, structural and building services information, specialist subcontractor design and specifications in accordance with **Design Programme**.	and	Handover of building and conclusion of **Building Contract**.	Undertake **In Use** services in accordance with **Schedule of Services**.
Procurement *Variable task bar	Initial considerations for assembling the project team.	Prepare **Project Roles Table** and **Contractual Tree** and continue assembling the project team.	The procurement strategy does not fundamentally alter the progression of the design or the level of detail prepared at a given stage. However, **Information Exchanges** will vary depending on the selected procurement route and **Building Contract**. A bespoke **RIBA Plan of Work 2013** will set out the specific tendering and procurement activities that will occur at each stage in relation to the chosen procurement route.				ration of ct.	
Programme *Variable task bar	Establish **Project Programme**.	Review **Project Programme**.	Review **Project Programme**.	The procurement route may dictate the **Project Programme** and may result in stages overlapping or being undertaken concurrently. A bespoke **RIBA Plan of Work 2013** will clarify the stage overlaps. The **Project Programme** will set out the specific stage dates and detailed programme durations.				
(Town) Planning *Variable task bar	Pre-application discussions.	Pre-application discussions.	Planning applications are typically made using the Stage 3 output. A bespoke **RIBA Plan of Work 2013** will identify when the planning application is to be made.					
Suggested Key Support Tasks	Review **Feedback** from previous projects.	Prepare **Handover Strategy** and **Risk Assessments**. Agree **Schedule of Services**, **Design Responsibility Matrix** and **Information Exchanges** and prepare **Project Execution Plan** including **Technology** and **Communication Strategies** and consideration of **Common Standards** to be used.	Prepare **Sustainability Strategy**, **Maintenance and Operational Strategy** and review **Handover Strategy** and **Risk Assessments**. Undertake third party consultations as required and any **Research and Development** aspects. Review and update **Project Execution Plan**. Consider **Construction Strategy**, including offsite fabrication, and develop **Health and Safety Strategy**.	Review and update **Sustainability**, **Maintenance and Operational** and **Handover Strategies** and **Risk Assessments**. Undertake third party consultations as required and conclude **Research and Development** aspects. Review and update **Project Execution Plan**, including **Change Control Procedures**. Review and update **Construction** and **Health and Safety Strategies**.	Review and update **Sustainability**, **Maintenance and Operational** and **Handover Strategies** and **Risk Assessments**. Prepare and submit Building Regulations submission and any other third party submissions requiring consent. Review and update **Project Execution Plan**. Review **Construction Strategy**, including sequencing, and update **Health and Safety Strategy**.	Review and update **Sustainability Strategy** and implement **Handover Strategy**, including agreement of information required for commissioning, training, handover, asset management, future monitoring and maintenance and ongoing compilation of **'As-constructed' Information**. Update **Construction** and **Health and Safety Strategies**.	Carry out activities listed in **Handover Strategy** including **Feedback** for use during the future life of the building or on future projects. Updating of **Project Information** as required.	Conclude activities listed in **Handover Strategy** including **Post-occupancy Evaluation**, review of **Project Performance**, **Project Outcomes** and **Research and Development** aspects. Updating of **Project Information**, as required, in response to ongoing client **Feedback** until the end of the building's life.
Sustainability Checkpoints	**Sustainability Checkpoint — 0**	**Sustainability Checkpoint — 1**	**Sustainability Checkpoint — 2**	**Sustainability Checkpoint — 3**	**Sustainability Checkpoint — 4**	**Sustainability Checkpoint — 5**	**Sustainability Checkpoint — 6**	**Sustainability Checkpoint — 7**
Information Exchanges (at stage completion)	**Strategic Brief**.	**Initial Project Brief**.	**Concept Design** including outline structural and building services design, associated **Project Strategies**, preliminary **Cost Information** and **Final Project Brief**.	**Developed Design**, including the coordinated architectural, structural and building services design and updated **Cost Information**.	Completed **Technical Design** of the project.	**'As-constructed' Information**.	Updated **'As-constructed' Information**.	**'As-constructed' Information** updated in response to ongoing client **Feedback** and maintenance or operational developments.
UK Government Information Exchanges	Not required.	Required.	Required.	Required.	Not required.	Not required.	Required.	As required.

The most creative part of the design process

*Variable task bar – in creati ber of options.

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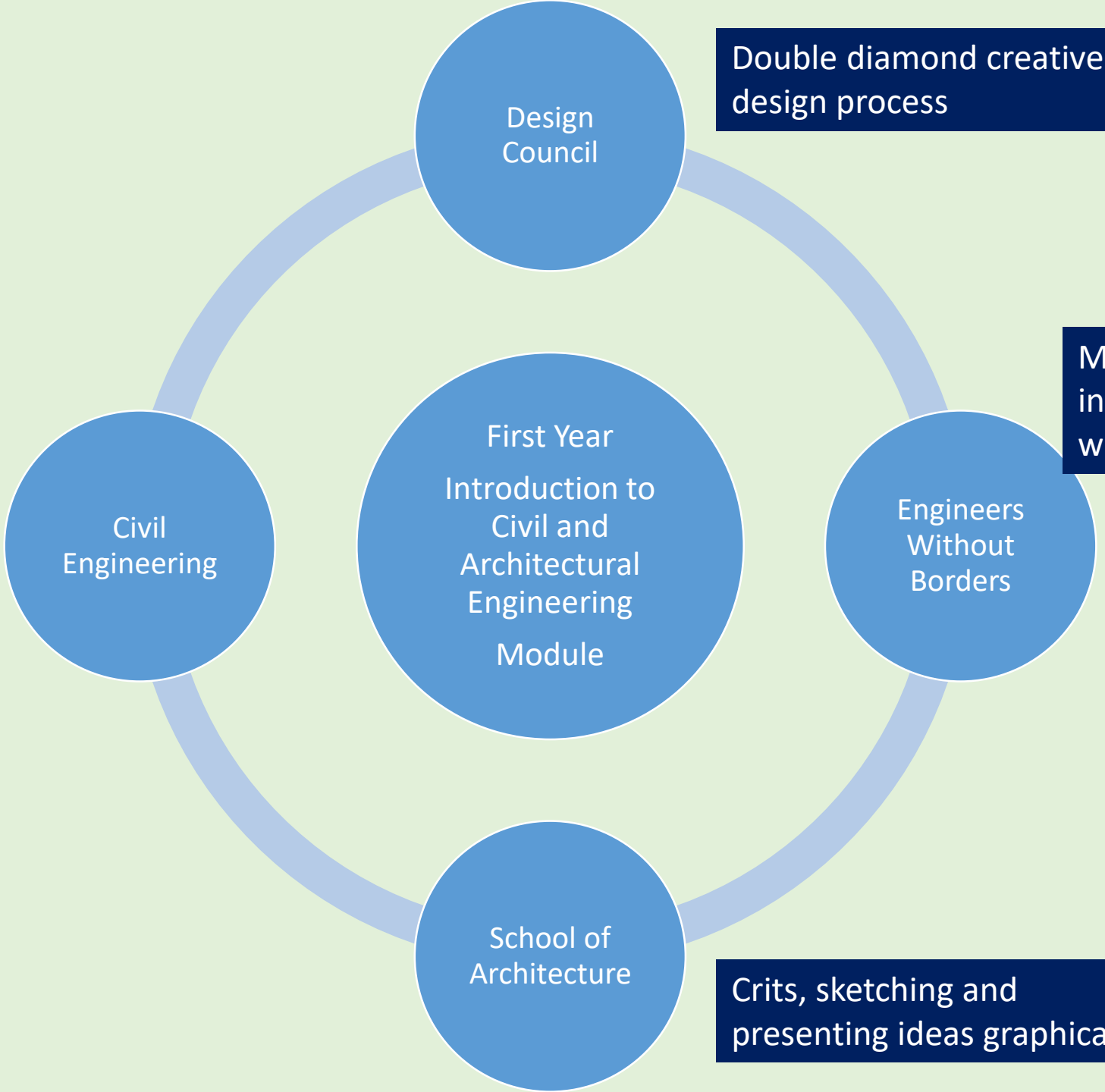


Double diamond creative design process

Global and local civil engineering challenges

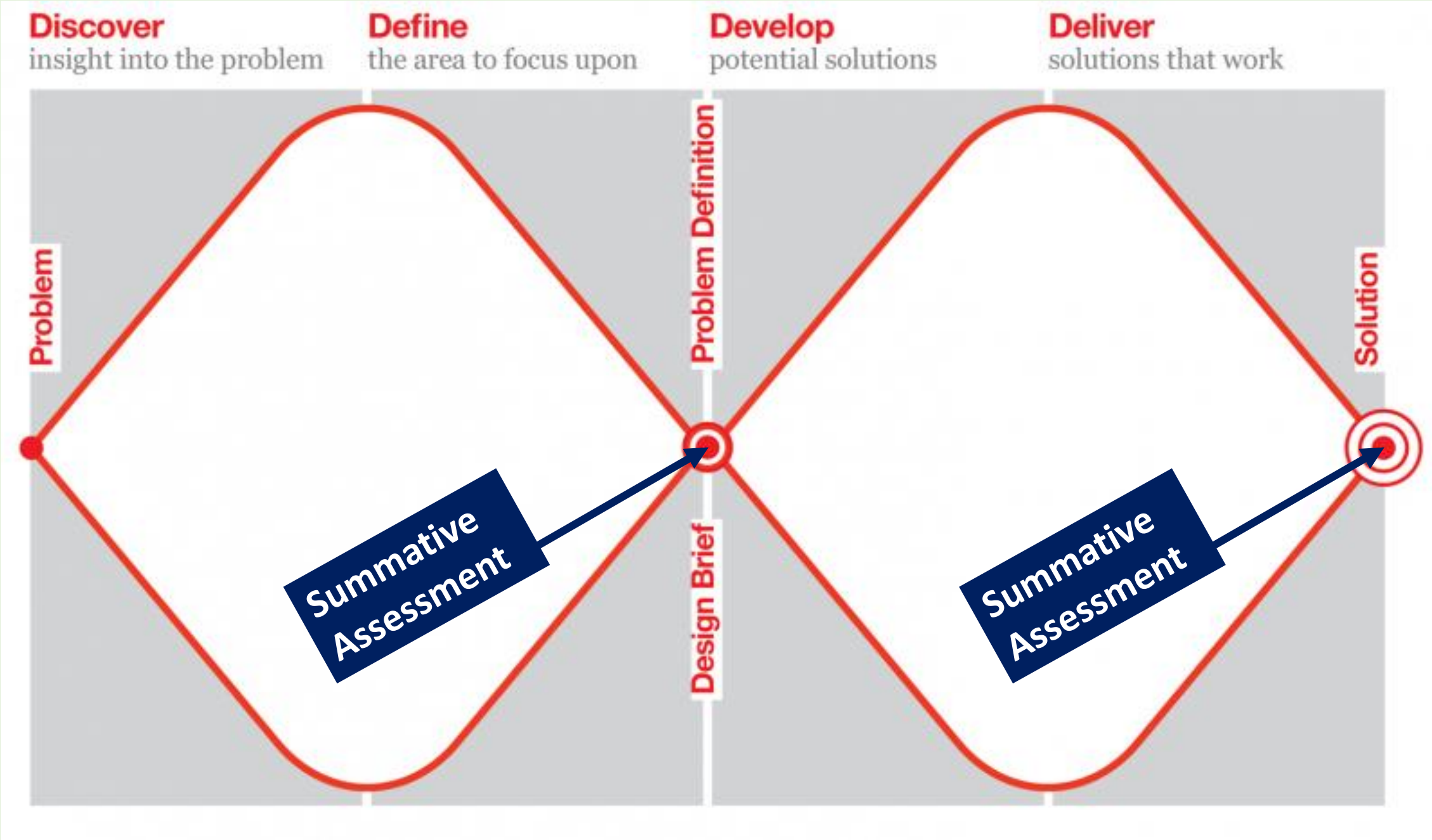
Multi-disciplinary international context with resources

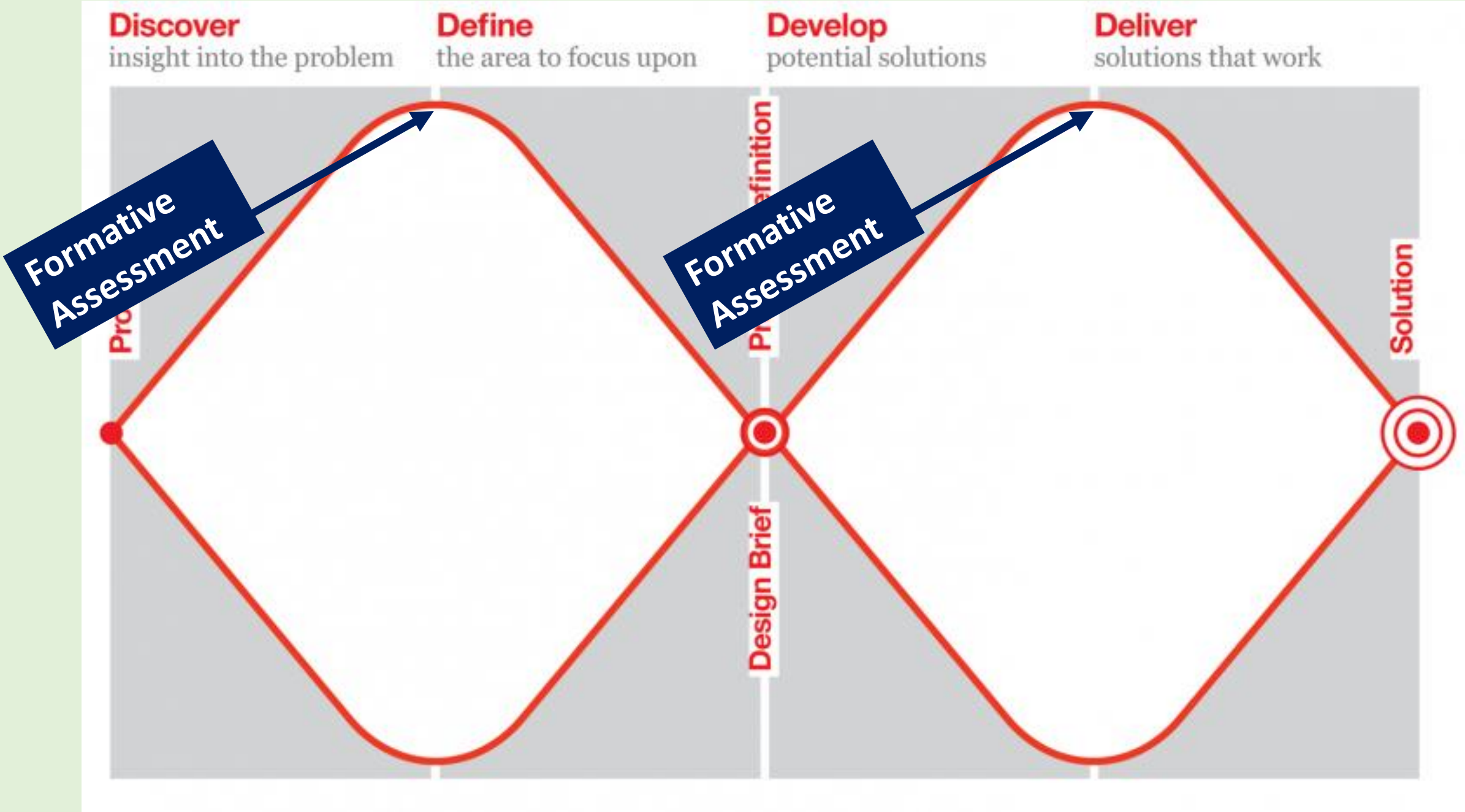
Crits, sketching and presenting ideas graphically

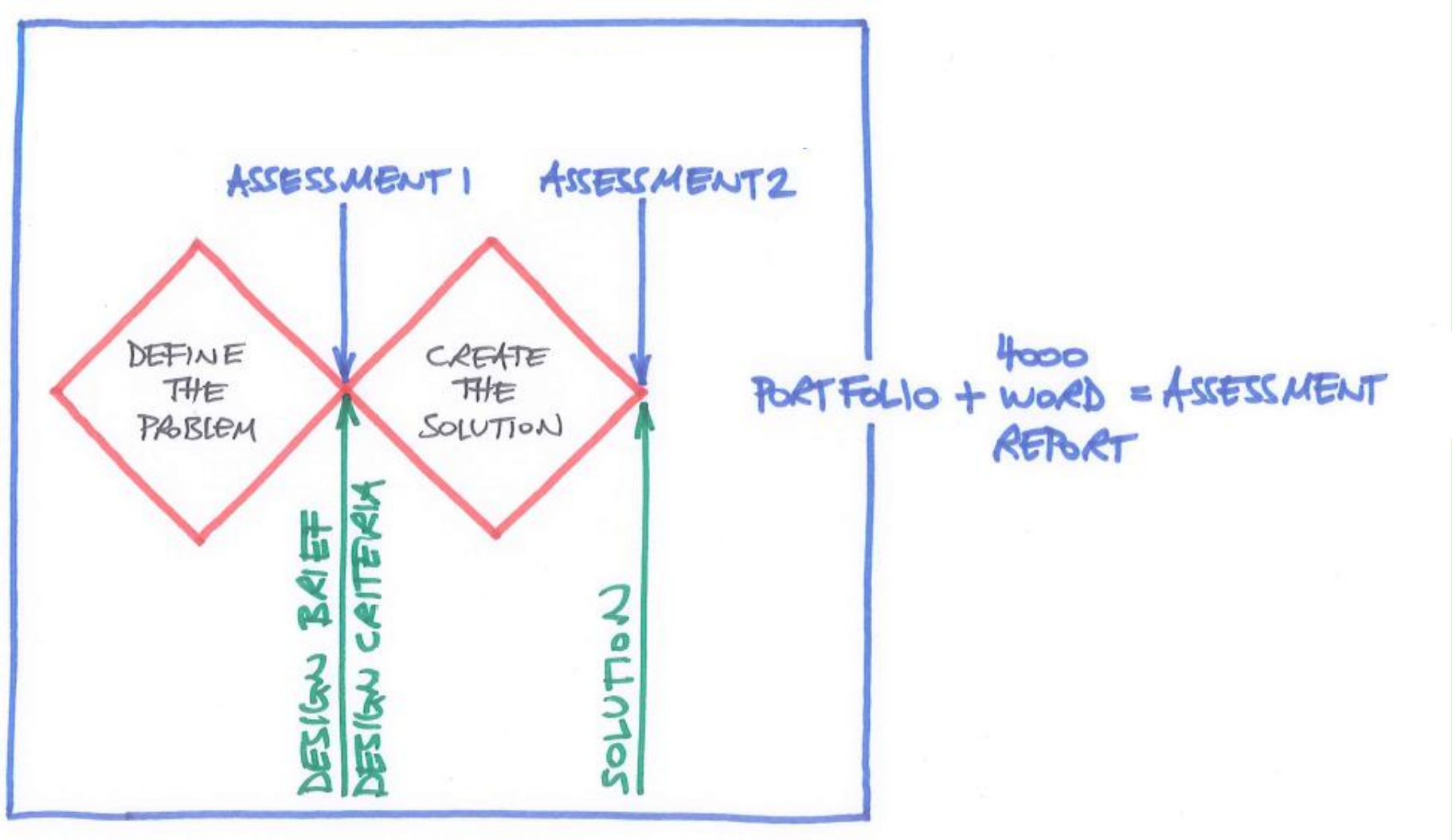
BORROWED FROM THE DESIGN COUNCIL

Double diamond design process

Tools and methods to carry out each of the stages


Discover
insight into the problem
Define
the area to focus upon
Develop
potential solutions
Deliver
solutions that work
Problem
Problem Definition
Design Brief
Solution
Summative Assessment
Summative Assessment


Discover
insight into the problem
Define
the area to focus upon
Develop
potential solutions
Deliver
solutions that work
Formative Assessment
Formative Assessment
Design Brief
Solution


ASSESSMENT 1
ASSESSMENT 2
DEFINE THE PROBLEM
CREATE THE SOLUTION
DESIGN BRIEF
DESIGN CRITERIA
SOLUTION 2
PORTFOLIO + 4000 WORD REPORT = ASSESSMENT

BOUGHT FROM ENGINEERS WITHOUT BORDERS

Multi-disciplinary context and resources

Entry into a national competition

Focus on people and the design process

Some (far from sufficient) information to get the students started

CHALLENGE HOME 2018-19 CHALLENGE FORUM GUIDANCE

allenge

E AT THE HEART OF ADDRESSING THE GLOBAL CHALLENGES OF THE 21S

ering for People Design Challenge prepares students, the engineers of the future, t

te engineering courses, the Engineering for People Design Challenge gives underg

UK ENGINEERS WITHOUT BORDERS

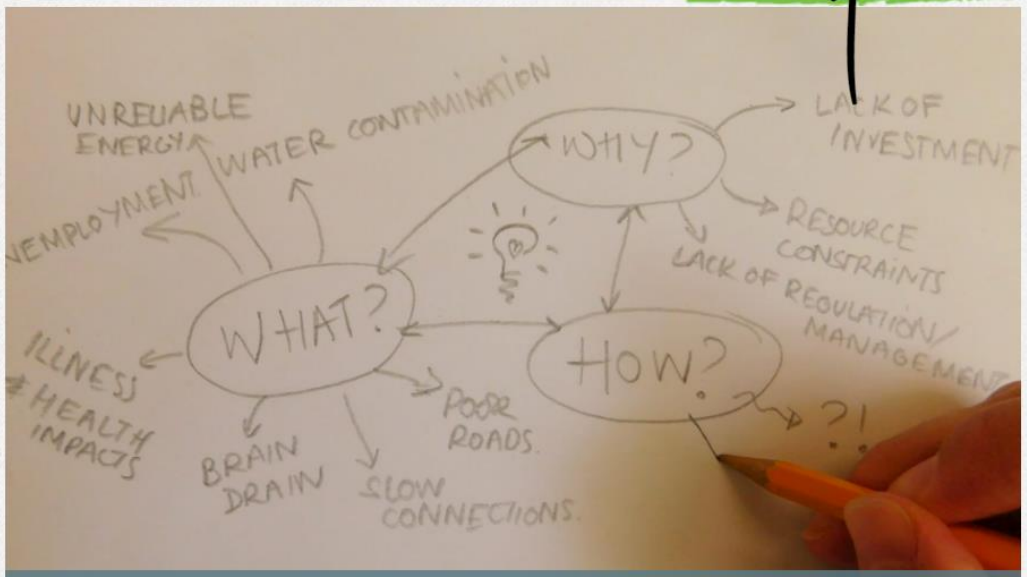
CHALLENGE HOME 2018-19 CHALLENGE FORUM GUIDANCE YOU ARE LOGGED IN

Home - Engineering for People Design Challenge - 2018-19 Challenge - Resources

DOWNLOAD

CLICK ON THE LINK ABOVE TO DOWNLOAD A FOLDER OF ADDITIONAL RESOURCES THAT WILL HELP YOU IN YOUR PROJECT. THIS INCLUDES FURTHER READING SUCH AS ARTICLES FROM ACADEMIC JOURNALS, LOCAL AND NATIONAL

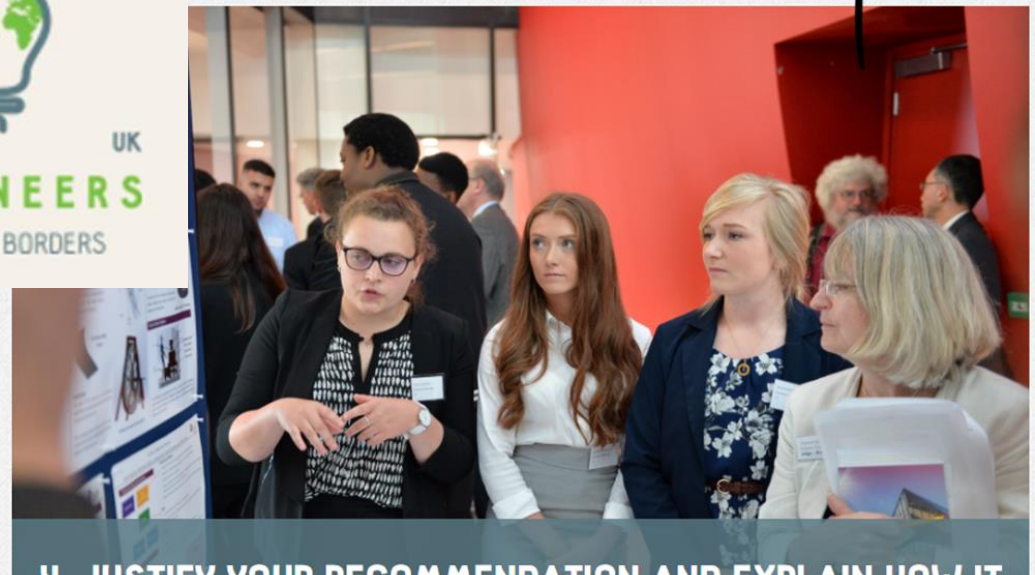
1. ANALYSING THE CONTEXT



2. DEFINING THE PROBLEM AND THE DESIGN CRITERIA

UK ENGINEERS WITHOUT BORDERS

3. EXPLORING LOTS OF OPTIONS



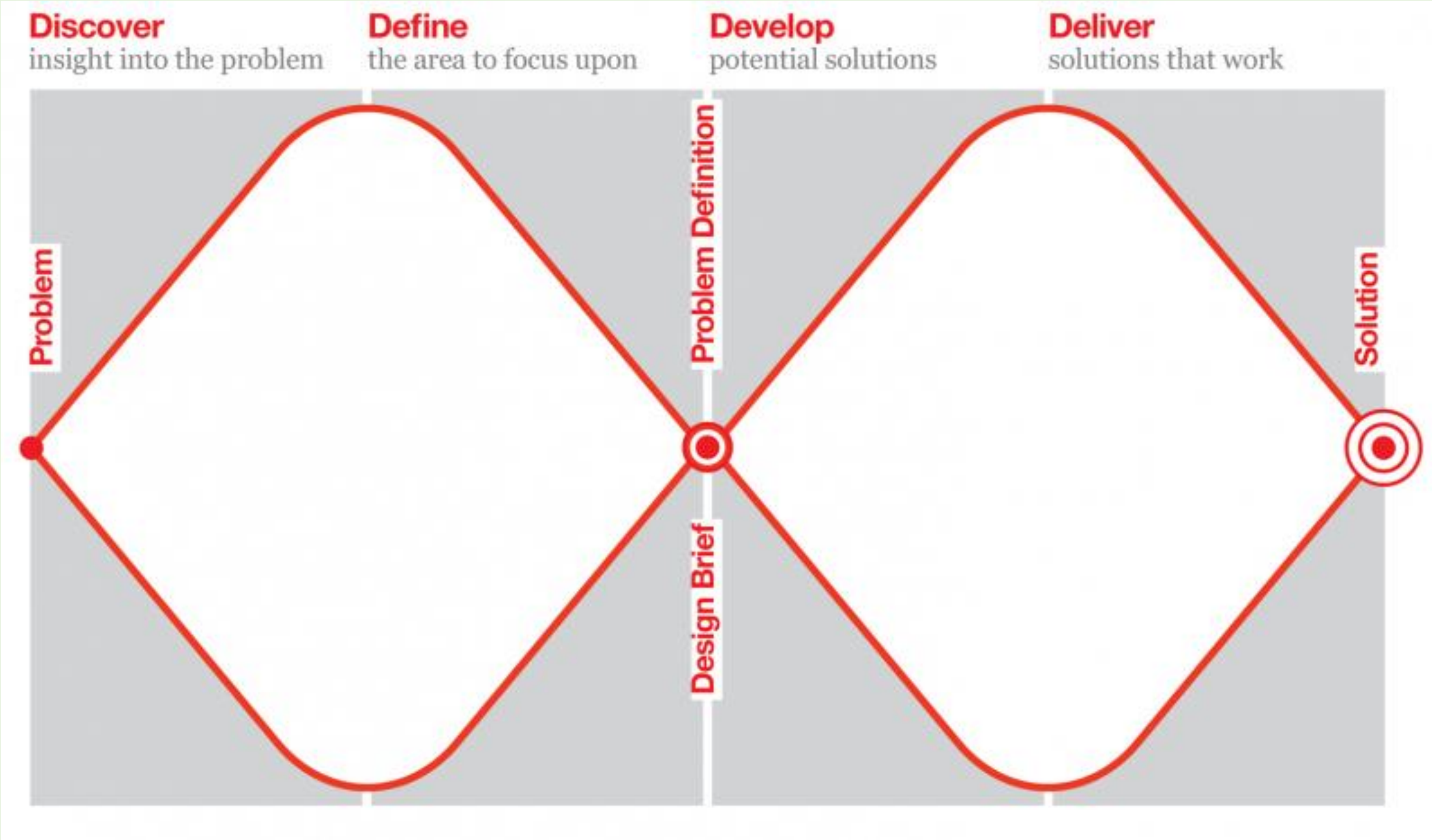
4. JUSTIFY YOUR RECOMMENDATION AND EXPLAIN HOW IT WORKS

Approaches for DISCOVER or ANALYSING THE CONTEXT

1. Ask questions (demographics, age, gender, who, what, where, etc.)
2. UN Sustainable Development Goals
3. Precedent studies (good and bad)
4. Resources (materials, skills, infrastructure)
5. Budget, barriers, challenges, constraints
5. PESTLE, scale and time – see the EWB website

Approaches for DEFINE

1. Create a **design brief** that directly relates to the stakeholders – stand in their shoes or better, get their feedback
2. Use techniques such as rose, bud and thorn, personal profiling, and aggregating themes and evaluate against criteria
4. Create **design criteria** (e.g. economic, social, environmental, etc.) that can be used to judge proposed solutions


Discover
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potential solutions
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solutions that work
Problem
Problem Definition
Design Brief
Solution

Approaches for DEVELOP

1. Turn off the internal policeman and generate lots of ideas (use the ‘kalideascope’ to connect disparate ideas and knowledge)
2. Talk, sketch, act out the problem(s)
3. As a group, fill a large sheet of paper with ideas
4. Change the way the problem is framed (remove barriers such as cost, change the timeframe, resources or priorities)
5. Use de Bono’s 6 hats

Thanks to Oliver Broadbent and Thinkup!

Approaches for DELIVER

1. Systematically evaluate the solutions developed against the design criteria
2. Really focus on local resources – buildings, skills, people, views, beliefs
3. Model solutions using maths, economics, systems diagrams, construction sequences and even using physical models or prototypes
4. Act as stakeholders reviewing feasibility presentations
5. Iteratively improve your chosen solution(s)

INPPUT FROM THE SCHOOL OF ARCHITECTURE

1. Crits, which are an opportunity to present work and to receive feedback immediately

2. A system for giving instant feedback using iPads – giving grades of A, B, C, D, E (not marks) against assessment criteria, a few carefully chosen comments and photos of the occasion

3. Architects leading small student groups (around 20 students) on sketching journeys around the streets of Liverpool

4. Free sketch books and bottomless refills for all students

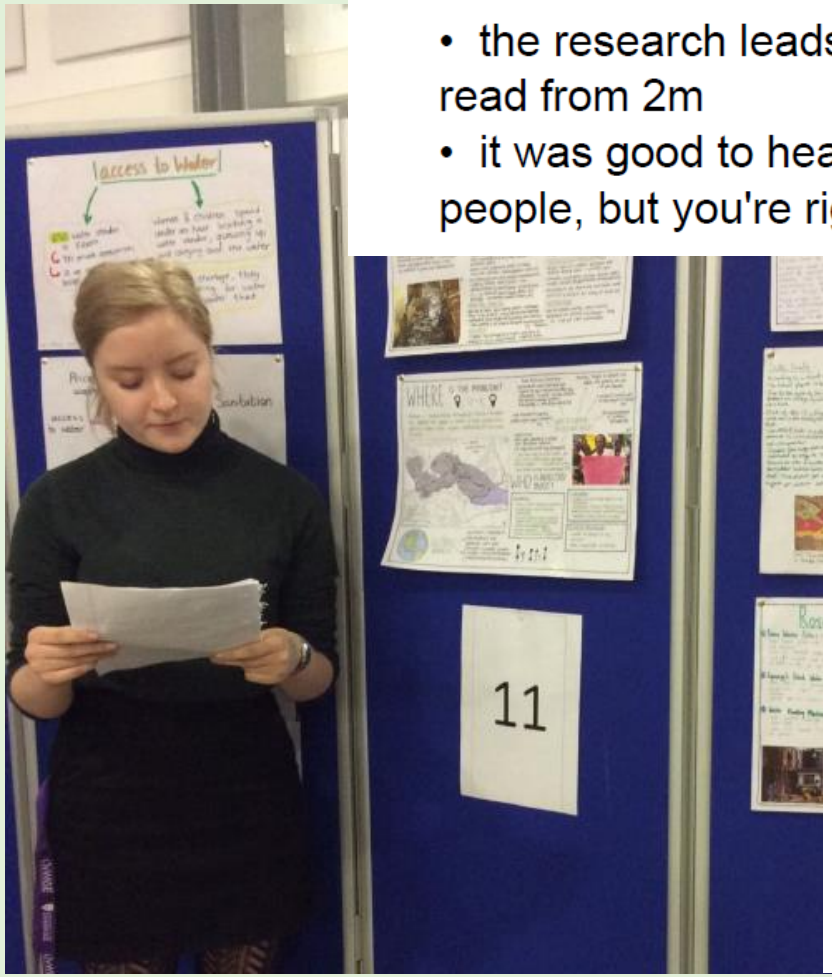
5. The banishment of computer drawing and design programmes from the module

6. Focus on communication and replacing words with graphics

CIVE113 : Review

03 Nov 2017

- well done for trying to look up from your comprehensive notes
- some excellent research
- the research leads to a very text heavy wall. Try and distil it down into a presentation that might be read from 2m
- it was good to hear about the personal position in regard to privacy - it can sometimes embarass people, but you're right to explore the challenges as they are truly essential



Definition of the problem:
is this methodically chosen, and short and precise?

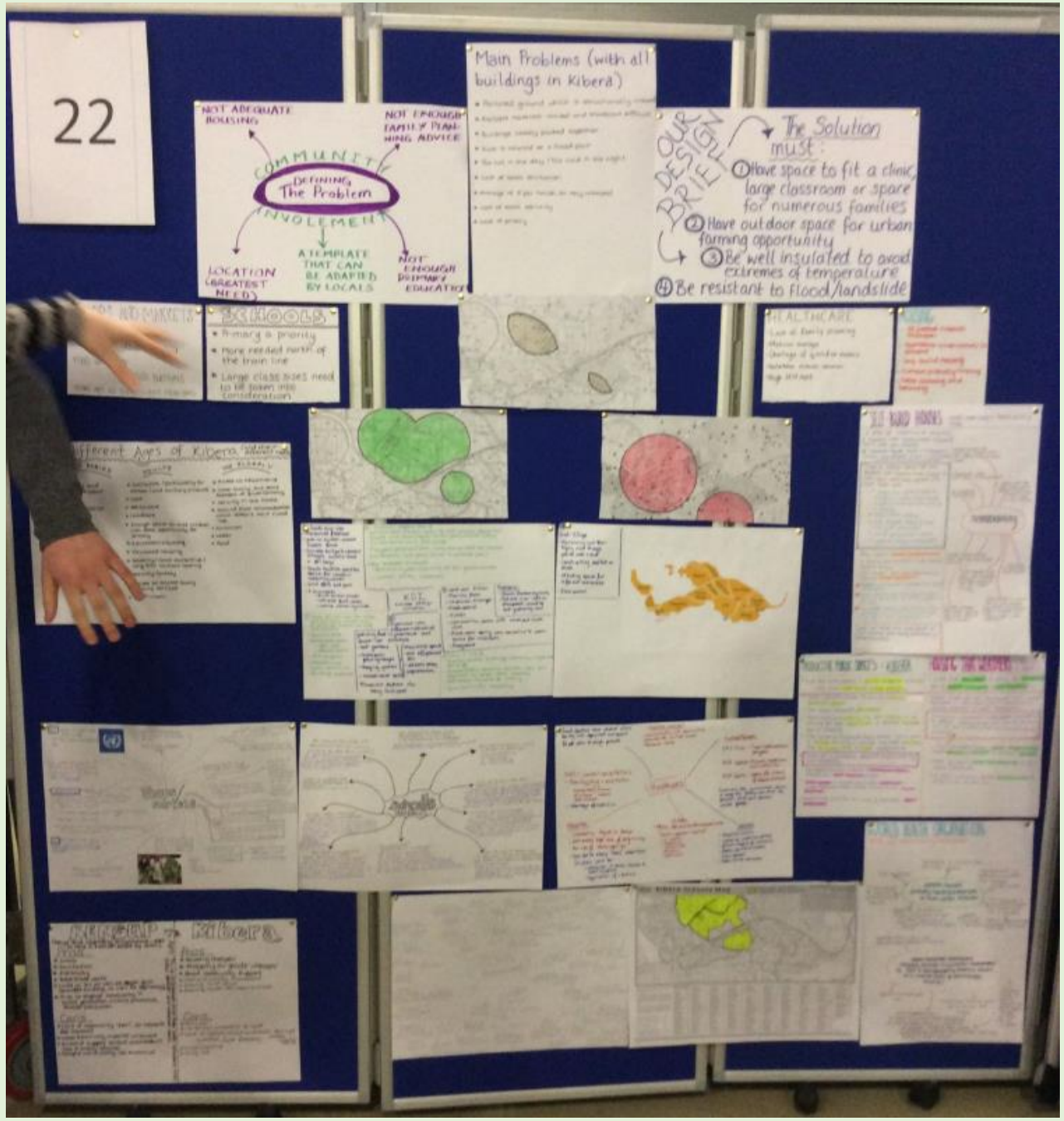
● A ○ B ○ C ○ D ○ E

Design brief and design criteria:
is the brief clear enough to enable the next stages of design to progress and are useful criteria provided for assessing the success of possible solutions?

○ A ○ B ○ C ● D ○ E

Sketches and hand drawn presentation material:
how well is information conveyed and the design process shown?

○ A ○ B ● C ○ D ○ E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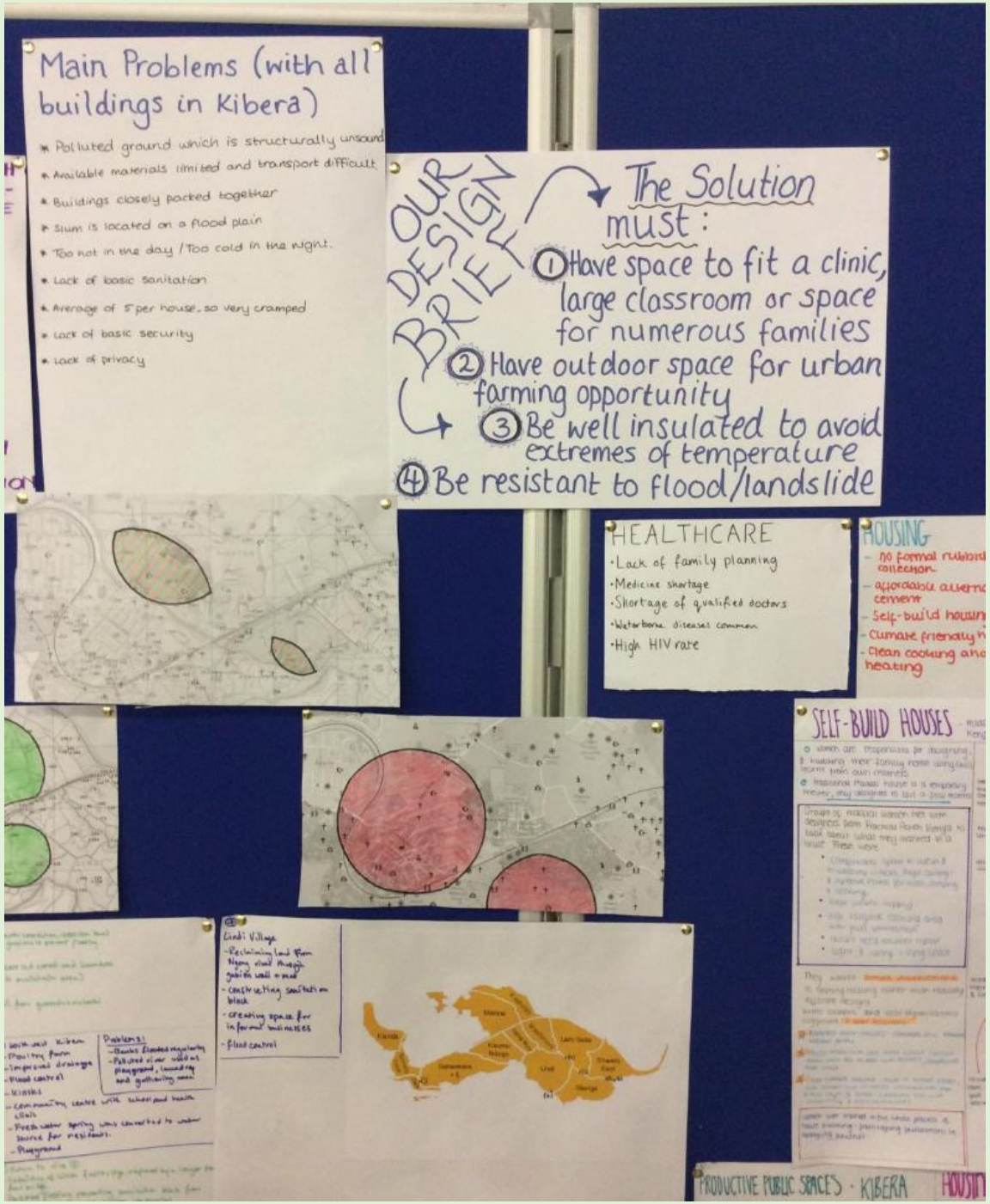
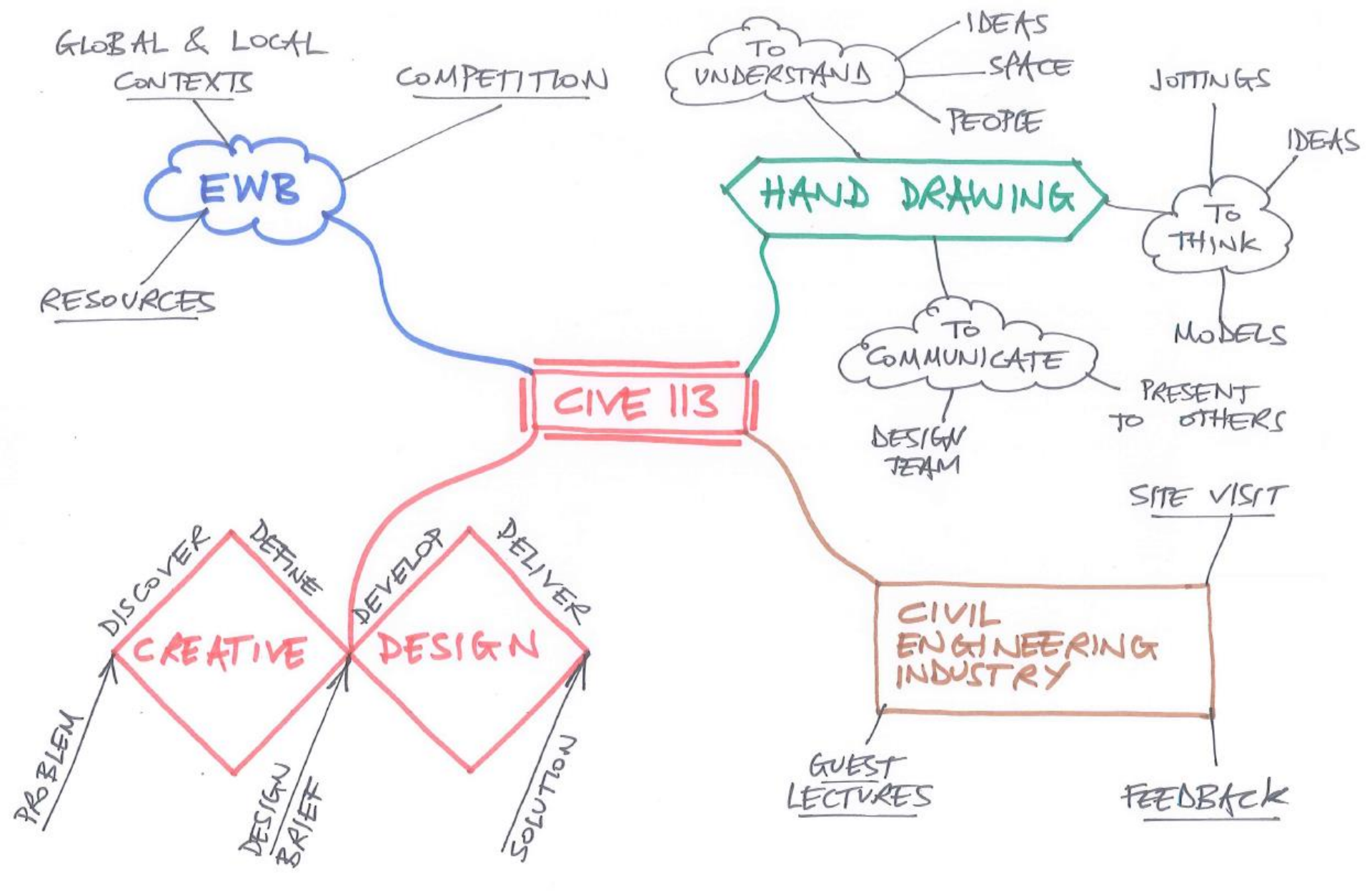
Main Problems (with all buildings in Kibera)
NOT ADEQUATE HOUSING
NOT ENOUGH FAMILY PLANNING ADVICE
COMMUNITY
DEFINING The Problem
INVOLEMENT
LOCATION (GREATEST NEED)
A TEMPLATE THAT CAN BE ADAPTED BY LOCALS
NOT ENOUGH PRIMARY EDUCATION
OUR DESIGN BRIEF
The Solution must:
1 Have space to fit a clinic, large classroom or space for numerous families
2 Have outdoor space for urban farming opportunity
3 Be well insulated to avoid extremes of temperature
4 Be resistant to flood/landslide
SCHOOLS
Primary is priority
More needed north of the train line
Large class sizes need to be taken into consideration
HEALTHCARE
Different Ages of Kibera


Main Problems (with all buildings in Kibera)
Polluted ground which is structurally unsound
Available materials limited and transport difficult
Buildings closely packed together
Slum is located on a flood plain
Too hot in the day / Too cold in the night.
Lack of basic sanitation
Average of 5 per house, so very cramped
Lack of basic security
Lack of privacy
OUR DESIGN BRIEF
The Solution must:
1 Have space to fit a clinic, large classroom or space for numerous families
2 Have outdoor space for urban farming opportunity
3 Be well insulated to avoid extremes of temperature
4 Be resistant to flood/landslide
HEALTHCARE
Lack of family planning
Medicine shortage
Shortage of qualified doctors
Waterborne diseases common
High HIV rate
HOUSING
No formal rubbish collection
Affordable alternative cement
Self-build housing
Climate friendly
Clean cooking and heating
SELF-BUILD HOUSES
Lindi Village
Reclaiming land from Nairobi river through gabion wall + mud
constructing sanitation block
creating space for informal businesses
flood control
PRODUCTIVE PUBLIC SPACES · KIBERA


GLOBAL & LOCAL CONTEXTS
COMPETITION
EWB
RESOURCES
TO UNDERSTAND
IDEAS
SPACE
PEOPLE
JOTTINGS
IDEAS
HAND DRAWING
TO THINK
MODELS
TO COMMUNICATE
PRESENT TO OTHERS
DESIGN TEAM
CIVE 113
SITE VISIT
DISCOVER
DEFINE
DEVELOP
DELIVER
CREATIVE
DESIGN
PROBLEM
DESIGN BRIEF
SOLUTION
CIVIL ENGINEERING INDUSTRY
GUEST LECTURES
FEEDBACK

2.00 – 5.00pm each week

Week	Work shop	EWB	Set 1 Groups 1 - 10	Set 2 Groups 11 - 21
2	1	DISCOVER	Hand sketching	Group meeting
3	2		Group meeting	Hand sketching
4	3	DEFINE	Hand sketching	Group meeting after formative presentations
5	4		Group meeting after formative presentations	Hand sketching
6			Presentations and assessments	
7	5	DEVELOP	Hand sketching	Group meeting
8	6		Group meeting	Hand sketching
9	7	DELIVER	Hand sketching	Group meeting after formative presentations
10	8		Group meeting after formative presentations	Hand sketching
11			Group preparation for next week	
12			Presentations and assessments	

Design Brief

Improve current building methods to tackle extremes in temperature and security/privacy

DESIGN CRITERIA

* Temperatures should stay between 10°C (at night) and 30°C (in the daytime).
* Use locally sourced and sustainable materials.
* Any points of ventilation must not affect security of building.

INITIAL SOLUTIONS

MONORAIL

(-) EXPENSIVE
(+) DOESN'T ADD TO AIR POLLUTION
(+) TAKES UP LITTLE GROUND SPACE
(-) DIFFICULT TO INSTALL

SKYBRIDGE

(+)
T
f
(+)
(-

CABI

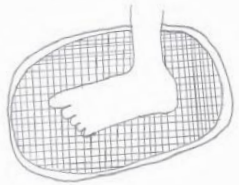
(+) DOESN

M.,

Adam

Initial Solutions

Mud Shoes

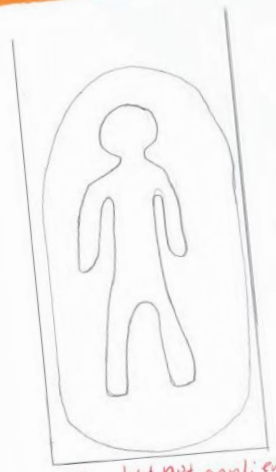


+ Cheap
+ Locally responsible
+ Could be crafted locally, providing jobs
+ Uses simple resources
- Not possible to tell how many events needed
- Doesn't really deal with the root issue

Wooden Platforms

+ Cheap
+ local materials
+ Rainwashes mud off
- Difficult to maintain
- Splinters
- Slipps when wet
- not useable by vehicles

Futurama-style Tube Transport



- Technology exist, but not applied to humans
- Exorbitantly expensive
- large amounts of Rand required
+ Fast

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Initial Solutions

Jetpack

Ruohao Zhang

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SOLUTION	SUSTAINABLE?	LONG-TERM?	COST?	VULNERABLE?	REALISTIC?	TOTAL
MONORAIL	~~4~~ 3	5	1	3	3	15
SKY BRIDGE	~~4~~ 3	5	1	~~3~~ 4	2	15
CABLE CARS	4	5	2	2	3	16
MUD SHOES	5	4	5	4	4	22
WOODEN PLATFORM	5	3	~~5~~ 4	3	5	20
TUBE-TRANSPORT (FUTURAMA)	2	4	1	1	1	9
METRO	2	5	1	2	2	12
HOVERCARS	1	5	1	1	1	9
JET-PACKS	1	2	1	1	1	6
BIKE RENTAL SCHEMES	5	4	~~4~~ 5	1	4	19
DOUBLE-DECKER BUSES	3	4	3	5	3	18
LAZER POWER ROCKET	1	4	1	3 Adam	1 Liam	10 Ruohao Zhang

Discover
insight into the problem
Define
the area to focus upon
Develop
Flow
28
29

CIVE161 STUDENT TIMETABLE FOR SEMESTERS 1 AND 2 - 2018-19 v5

ARCHITECTS — Architect led sessions
INDUSTRY — Industry and professionalism
EWB — Engineers Without Borders Design Challenge

SEMESTER 1

	WEEK 1	WEEK2	WEEK3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12
	PROFESSIONAL DEVELOPMENT						EWB PROJECT AND THE CREATIVE DESIGN PROCESS					
1 - 2.00PM	INTRO TO MODULE	WHAT IS SKETCHING?	INTRO TO GROUP WORK	INTRO TO GAUNTLET	PROFESS-IONAL DEVELOP-MENT	GAUNTLET + PROF. INDUSTRY	INTRO TO EWB CHALLENGE	DOUBLE DIAMOND + DISCOVER	PRESENT COMPLEX IDEAS	DEFINE	DRAWING AS PROBLEM SOLVING	INTERIM EWB PRESENT-ATIONS
2 - 5.00PM SET2	INTRO TO MODULE CONTD. PLUS INTRO TO BRIDGE CHALLENGE	SKETCHING WITH ARCHITECTS	BRIDGE CHALLENGE	BRIDGE TESTING PLUS INTRO TO GAUNTLET	SKETCHING WITH ARCHITECTS	GAUNTLET CHALLENGE	INTRO TO EWB CHALLENGE PLUS RESEARCH SKILLS	SKETCHING WITH ARCHITECTS	EWB GROUP WORK DISCOVER	DIAGRAMS WITH ARCHITECTS	EWB GROUP WORK DEFINE	
2 - 5.00PM SET 1		BRIDGE CHALLENGE	SKETCHING WITH ARCHITECTS		GAUNTLET CHALLENGE	SKETCHING WITH ARCHITECTS		EWB GROUP WORK DISCOVER	SKETCHING WITH ARCHITECTS	EWB GROUP WORK DEFINE	DIAGRAMS WITH ARCHITECTS	
				ASSESSMENT Bridge Challenge	ASSESSMENT Gauntlet Challenge (Set 1)	ASSESSMENT Gauntlet Challenge (Set 2)						ASSESSMENT EWB Interim Presentation and Report

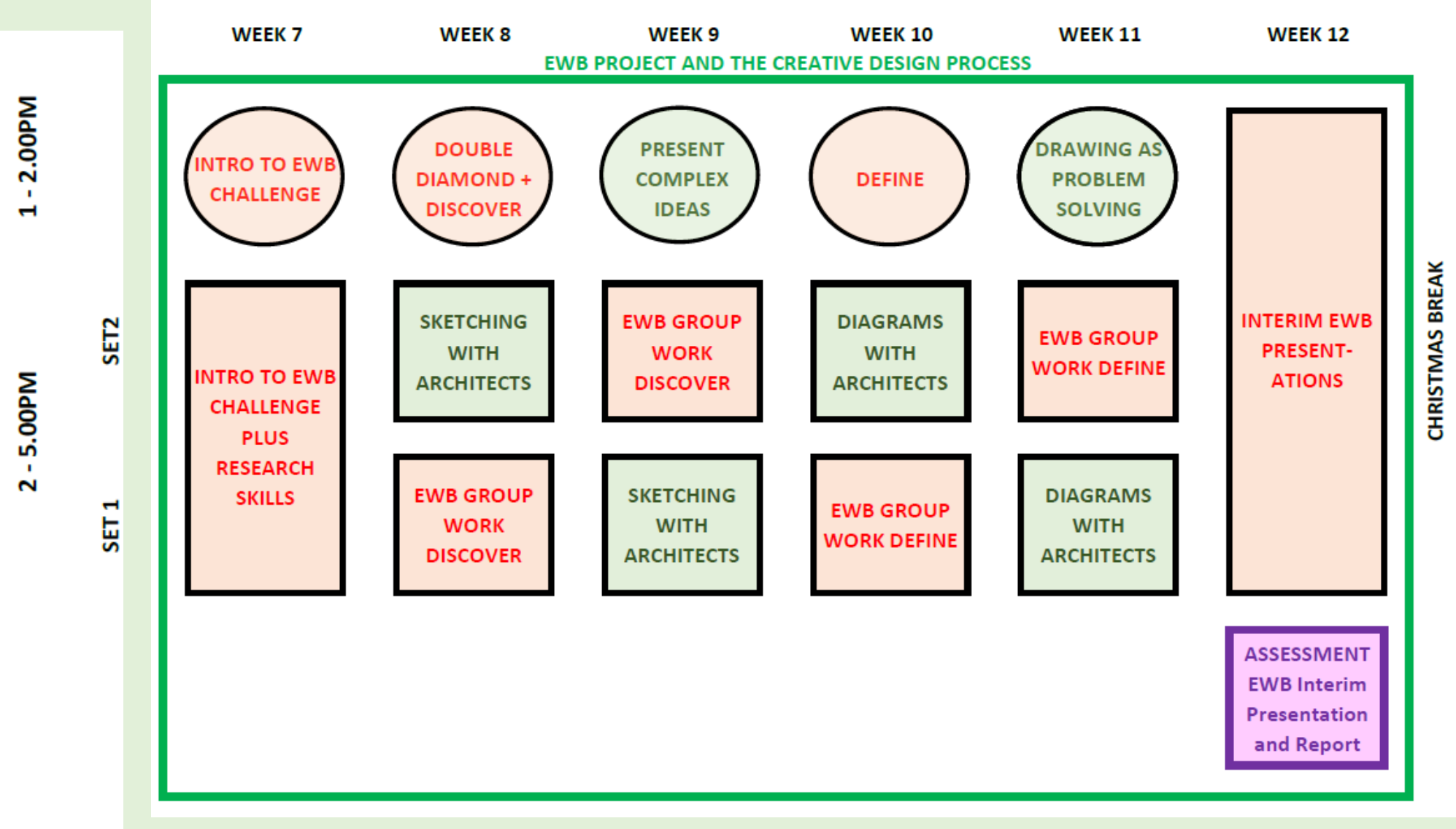
CHRISTMAS BREAK

SEMESTER 2

	WEEK 1	WEEK2	WEEK3	WEEK 4	WEEK 5	WEEK 6	WEEK 7	WEEK 8	WEEK 9	WEEK 10	WEEK 11	WEEK 12
	EWB PROJECT AND THE CREATIVE DESIGN PROCESS						PROFESSIONAL DEVELOPMENT					
1 - 2.00PM	INTRO TO SEM 2 + FEEDBACK	REPORT WRITING MASTER CLASS	DEVELOP	SAM'S EWB TALK	DELIVER	INTRO TO PROJECT LIFE CYCLE	DESIGN TEAM ROLES	CHARRETTE FOR ENGINEERS	FEEDBACK + SITE TEAM ROLES		PROFESS-IONAL DEVELOP-MENT	PRIZE GIVING AND REVIEW
2 - 5.00PM SET2	EWB DESIGN CRITERIA SURGERIES	REPORT AND CV WRITING 1 AND PROFESSION-AL DEVELOP-MENT	DIAGRAMS WITH ARCHITECTS	EWB GROUP WORK DEVELOP	SKETCHING WITH ARCHITECTS	EWB GROUP WORK DELIVER	SITE VISITS	CHARRETTE FOR ENGINEERS [CONSTRUCTIONARIUM FOR CIVILS LECTURERS]	EWB PREP	FINAL EWB PRESENT-ATIONS	CV WRITING 2 AND PROFESSION-AL DEVELOP-MENT	SURGERIES AND FEEDBACK FOR CV WRITING
2 - 5.00PM SET 1	EWB DESIGN CRITERIA SURGERIES		EWB GROUP WORK DEVELOP	DIAGRAMS WITH ARCHITECTS	EWB GROUP WORK DELIVER	SKETCHING WITH ARCHITECTS	EWB PREP		SITE VISITS			
					ASSESSMENT Sketches and sketch books (Set 2)	ASSESSMENT Sketches and sketch books (Set 1)		COMPETITION		ASSESSMENT EWB Final Presentation, Report, Poster and Portfolio		ASSESSMENT CV and Personal Statement

EASTER BREAK

Semester 1


WEEK 7
WEEK 8
WEEK 9
WEEK 10
WEEK 11
WEEK 12
EWB PROJECT AND THE CREATIVE DESIGN PROCESS
1 - 2.00PM
2 - 5.00PM
SET2
SET 1
INTRO TO EWB CHALLENGE
DOUBLE DIAMOND + DISCOVER
PRESENT COMPLEX IDEAS
DEFINE
DRAWING AS PROBLEM SOLVING
INTRO TO EWB CHALLENGE PLUS RESEARCH SKILLS
SKETCHING WITH ARCHITECTS
EWB GROUP WORK DISCOVER
DIAGRAMS WITH ARCHITECTS
EWB GROUP WORK DEFINE
INTERIM EWB PRESENT-ATIONS
EWB GROUP WORK DISCOVER
SKETCHING WITH ARCHITECTS
EWB GROUP WORK DEFINE
DIAGRAMS WITH ARCHITECTS
ASSESSMENT EWB Interim Presentation and Report
CHRISTMAS BREAK

Assessment 1

Format

5 minute group presentation (including all group members) using A3 sketches. The presentation is to lecturers, fellow students and industry judges, followed by a brief (approximately 5 minutes) question and answer session.

Assessment 2

Format

5 minute group presentation (including all group members) using an A1 poster accompanied by A3 sketches and drawings. The presentation is to lecturers, fellow students and industry judges, followed by a brief question and answer session.

Assessment 3

Format

(i) Group 4000 word report. This must be submitted through VITAL for assessment by Turnitin.

(ii) Group A1 poster that may be produced from the scanned A3 and A4 sketches and drawings used in Assessments 2 and 3. The A1 poster may be the same as the one used in Assessment 3. An electronic version (e.g. a PowerPoint slide) of the A1 poster is sufficient for this part of the submission.

(iii) Individual A5 sketch books