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SHIFT College

Shift College - Shifting the perspective of Mathematics, Science and Technology Education in South Africa

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Submitted in partial fulfillment of the requirements
for the degree of Masters in Interior Architecture (Professional)

by Liné Visser

Department of Architecture
Faculty of Engineering, Built Environment
and Information Technology

University of Pretoria
2016

Course Coordinator: Barbara Jekot
Study Leader: Catherine Karusseit

In accordance with Regulation 4(e) of the general Regulations (G.57) for dissertations and theses, I declare that this thesis, which I hereby submit for the degree Masters of Interior Architecture (Professional) at the University of Pretoria , is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution. I further state that no part of my thesis has already been, or is currently being, submitted for any such degree, diploma or other qualification.

I further declare that this thesis is substantially my own work. Where reference is made to the work of others, the extent to which that work has been used is indicated and fully acknowledged in the text and list of references.

Liné Visser

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SHIFT College

Shift College- Shifting the perspective of Mathematics, Science and Technology Education in South Africa

Project Summary

Project description:	This thesis is concerned with the spatial articulation of experience-based learning and the potential this type of learning has to integrate with the existing teacher-fronted spaces of traditional formal-based learning.
Programme:	High school design.
Site Description:	Adaptive Reuse of a 1955 building.
Site location:	ERF 3134, Pretoria, Tshwane.
Address:	193 Jeff Masemola St, Pretoria, Gauteng
Research Field:	Housing and Urban Environments (HUE)

Ekserp

Die tradisionele opvoedkundige leermodel van herhaling en gewoonteleer is nie meer voldoende nie. Studente moet geleer word om self-leerders te word wat deelneem in opvoedkundige aktiwiteite en hulle moet kritiese denkers word wat kan leer deur hul ervaringe.

Studente moet geïnspireer word om die wêreld om hulle te verken, om ‘n begeerte te ontwikkel om te verstaan hoe dinge werk. Deur die kombinasie van geleerde kennis en konkrete ervaringsleer sal die studente bemagtig word om innoveerders te word.

Skole is die opleidingsfasiliteite van die samelewing. Die sosiale interaksies en blootstelling aan ander mense in ‘n persoon se skooljare beïnvloed hoe hulle die wêreld sien en ‘n ryk skoolervaring kan lei tot ‘n nouer verbinde samelewing waar individue met mekaar kan assosieer.

Tradisioneel en selfs vandag nog maak baie skole in Suid-Afrika hoofsaaklik gebruik van ‘n opvoedkundige model waar die onderwyser die leerproses lei. Hierdie tradisionele model het spesifieke ruimtelike eienskappe – skole is rigiede omgewings met min ruimte vir buigsaamheid en verskeidenheid.

Dit is bewerkstellig dat daar meer onderwysers van studente is as bloot net volwassenes. Die student se portuurgroep, die student self en die omgewing kan ook onderwysers wees. Hierdie drie onderwysers leer studente die beste deur werklike lewenservarings.

Die interieure ingryping is gemoeid daarmee om ‘n ryk skoolomgewing te skep waar ervaringsleer deel van die bestaande skoolmodel kan word.

Wiskunde, Wetenskap en Tegnologie (WWT) opvoeding word gebruik as ‘n katalisator vir ervaringsleer. Die fisiese omgewing word ‘n informele onderwyser van WWT.

Onafhanklike skole maak gebruik van verlate geboue in Pretoria se sentrale sakegebied en deur aanpasbare hergebruik word hierdie ruimtes in geïmproviseerde skole omskep. Die ingryping handel oor so ‘n skool.

Abstract

The traditional educational model of passive rote learning is no longer adequate. Students should be taught to become self-learners who partake in educational activities and they should become critical thinkers who can learn through their experiences.

Students should be inspired to explore the world around them, to develop a desire to understand how things work. Through the combination of taught knowledge and concrete experiential knowledge students will be empowered to become innovators.

Schools are the training facilities of society. The social interactions and exposure to others in a person's school years influence how they perceive the world and a rich school experience can lead to a connected society where individuals are able to associate with others.

Traditionally and today still, many schools in South Africa make use predominantly of the teacher-fronted educational model. This traditional model has specific spatial characteristics - schools are rigid environments with little room for flexibility and variety.

It has been established that there are more teachers of students than just adults. Peers, the student and the environment can also be teachers and it is these three teachers which teach best through real life experiences.

The interior intervention is concerned with creating a rich school environment where experiential learning can become part of the existing school model.

Mathematics, Science and Technology (MST) education were used as a catalyst for experiential learning. The physical environment therefore becomes an informal teacher of MST.

Independent schools make use of abandoned building stock in Pretoria's Central Business District and through adaptive reuse turn these spaces into makeshift schools. The intervention deals with one such school.

Table of Contents

List of Figures
Preamble

1. Introduction

1.1 Background 6
1.2 Real World Problem 8
1.3 Problem Statement 10
1.4 Hypothesis 10
1.5 Research Questions 10
1.6 Contribution of this Study 10
1.7 Aims 10
1.8 Limitations 10
1.9 Delimitations 10
1.10 Assumptions 10
1.12 Methodology 11
1.13 Conclusion 12

2. Theory

2.1 Introduction 14
2.2. Educational Theories
2.2.1 The Traditional Model 14
2.2.2 The New Education Movement 16
2.2.3 Informal Education and Museum Education 18
2.2.4 Technology and Education 19
2.2.5 Timeline of Educational Theories 20
2.3. Spatial theories
2.3.1 The School as a Micro-city 22
2.3.2 The Environment as Third Teacher 24
2.4 Conclusion 26

3. Context

3.1 Introduction 28
3.2 Statement of Significance 28
3.3 Site Selection 29
3.4 Macro Context 29
3.5 Block Study 30
3.6 History 32
3.8 Spatial Qualities 34
3.8.1 Ground Floor
3.8.2 First Floor
3.8.3 Second Floor
3.8.4 Third and Fourth Floors
3.8.5 The Corridors
3.9 Classrooms 36
3.10 Interior Climate 38
3.10.1 Lighting
3.10.2 Interior Acoustics
3.10.3 Ventilation
3.11 Conclusion 40

4. Case studies & Precedent Studies

4.1 Introduction 44
4.2 Case studies
4.2.1 Streetlight Schools 44
4.2.2 Bambisanani - Community Learning Program 46
4.2.3 Sci Enza - Hands on Science 48
4.3 Precedent studies
4.3.1 Montessori College Oost, Amsterdam 50
4.3.2 MIT Beaver Works 51
4.3.3 The Exploratorium - The Museum as a laboratory 52
4.3.4 High Tech High 53
4.4 Conclusion 54

5. Design Development

5.1 Introduction 56
5.2 Adaptive Re-use 56
5.3 The MST Plug-in as a Catalyst 56
5.4 Two Poles
5.4.1 School as a Micro-City 58
5.4.2 Building Blocks 58
5.5 Programmatically Breaking the Existing
5.5.1 Cutting Away 62
5.5.2 Programme 62
5.6 Users 67
5.7 Client 67
5.9 Conclusion 68

6. Conceptual Development

6.1 Introduction 70
6.2 The Environment as an Informal MST Teacher 71
6.3 Conclusion 76

7. Design Discourse

7.1 Introduction 78
7.2 Plan Development
7.2.1 Ground Floor Plan 80
7.2.2 First Floor Plan 80
7.2.3 Second Floor Plan 82
7.2.4 Third Floor Plan 84
7.2.5 Fourth Floor Plan 86
7.2.6 The Roof Plan 86
7.2.7 North-Western Corner 87
7.2.8 Elevations 88
7.2.9 Sections 92
7.2.10 Circulation Spaces 94
7.2.11 Makerspace 97
7.2.12 Science labs 98
7.3 Conclusion 100

8. Technical Investigation

8.1 Introduction 102
8.2 Design Innovations 102
8.2.1 Passive Solar Design 102
8.2.2 Natural Daylight 102
8.2.3 Ventilation 102
8.2.4 Site 102
8.2.5 Rain Water Collection 102
8.3 Acoustics 105
8.4 Artificial Lighting 106
8.5 Detail Call-outs 109
8.6 Sample Board 114
8.7 Sustainable Building Assessment 115
8.8 Conclusion 116

9. Conclusion

10. References

10.1 List of Sources 120

List of Figures

All figures by author unless indicated otherwise.

Chapter 1
Figure 1.1 Grade 6, Technology Centre: Plan diagram drawn from memory 2
Figure 1.2 Thinkers and doers make innovations 6
Figure 1.3 Jim Stoten Illustration - Traditional physical environment with technology. http://www.jimtheillustrator.co.uk/ (Accessed: 16 August 2016) 9

Chapter 2
Figure 2.1 Classrooms as building blocks 15
Figure 2.2 Peer assistance and student centered learning 17
Figure 2.3 Sci-bono Science Centre hands on exhibit 18
Figure 2.4 How Khan Academie is changing the rules of education (Pugliese, 2011) 19
Figure 2.5 Pupils from Phomolong secondary school in Tembisa, using tablets in the classroom (Mkhize, 2015) 19
Figure 2.6 Diagram of behaviorism classroom (Guneya & Selda Al, 2012) 20
Figure 2.7 Before Dewey (Unknown) This photo is estimated to be taken be taken between 1900 and 1910 in an American School. http://milwaukeeidscohort.wikispaces.com/John+Dewey+Page (Accessed: 03 May 2016) 20
Figure 2.8 1960 Delf Montessori (Hertzberger, 2008) 20
Figure 2.9 John Dewey's progressive/experiential classroom. https://onlinelearninginsights.wordpress.com/category/instructional-design/page/2/ (Accessed: 03 May 2016) 20
Figure 2.10 John Dewey's progressive/experiential classroom. http://milwaukeeidscohort.wikispaces.com/John+Dewey+Page (Accessed: 03 May 2016) 20
Figure 2.12 Vittra School Södermalm (Wendt, 2012) 21
Figure 2.13 Vittra School Södermalm (Wendt, 2012) 21
Figure 2.14 Vittra School Södermalm (Wendt, 2012) 21
Figure 2.16 Perspective from classroom: Classroom extended into corridor with visual links 22
Figure 2.17 Perspective from corridor: Educational Shopping street 22
Figure 2.18 Experiencial learning in a school (Hertzberger, 2008) 22
Figure 2.19 From adult fronted to social learning (Hertzberger, 2008) 22
Figure 2.20 Plan Diagram of Transformation of long corridor in to educational and social learning street 23
Figure 2.21 Perspective of classrooms claiming space from corridor 23
Figure 2.22 Sectional diagram of corridor spaces connection vertically 23
Figure 2.23 Traditional Classroom 23
Figure 2.24 Articulated Classroom 23
Figure 2.25 Science lab, International School of India by Cannon Design. http://thethirdteacherplus.com/international-school-of-indiana/ (Accessed: 10 July 2016) 25
Figure 2.26 Scocial Learning Spaces, International School of India by Cannon Design. http://thethirdteacherplus.com/international-school-of-indiana/ (Accessed: 10 July 2016) 25
Figure 2.27 Open Theatre, North Shore Country Day School by Cannon Design. http://thethirdteacherplus.com/nscd/ (Accessed: 10 July 2016) 25
Figure 2.28 Social Learning Space, North Shore Country Day School by Cannon Design. http://thethirdteacherplus.com/nscd/ (Accessed: 10 July 2016) 25
Figure 2.29 Learning Landscape, Hamilton Southeastern School District Senior Academies by Cannon Design. http://thethirdteacherplus.com/hamilton-southeastern-school-district/ (Accessed: 10 July 2016) 25
Figure 2.30 Group work spaces, International School of India by Cannon Design. http://thethirdteacherplus.com/international-school-of-indiana/ (Accessed: 10 July 2016) 25

Chapter 3
Figure 3.1 Location of Gauteng in South Africa 28
Figure 3.2 Location of Tshwane in the Gauteng Province 28
Figure 3.3 Location of site in Tshwane 28
Figure 3.4 Illustration of prominent features in the north western corner of the site 28
Figure 3.5 Locality plan of site in Tshwane CBD 29
Figure 3.6 Short distance bus routes around site 29
Figure 3.7 Mapping of day tome pedestrain movemnet 29
Figure 3.8 Map of learning 29
Figure 3.9 Building's location in relation with land marks & traffic flow 30
Figure 3.10 Illustration of prominent features on the north eastern corner of the site 30
Figure 3.11 Map of Typologies 30
Figure 3.12 Stations Place consist out of 3 properties 30
Figure 3.13 City Sections 31

Figure 3.25 Illustration of acoustic qualities 39
Figure 3.26 Interior sun study 40

Chapter 4

Figure 4.1 Plan of interior layout (Fieldworks,2016). 45
Figure 4.2 Photo of classroom wall detail 45
Figure 4.3 Photo of aquaponics (Fieldworks, 2016). 45
Figure 4.4 Photo of open theatre space (Fieldworks, 2016). 45
Figure 4.5 photo of play wall (Fieldworks, 2016). 45
Figure 4.6 Photo of play wall with ambiguously programmed space (Fieldworks, 2016). 45
Figure 4.7 Photo of classroom walls with poly-carbonate sheet for windows (Fieldworks, 2016). 45
Figure 4.8 Photo looking north-west of science building (TJA, 2012). 46
Figure 4.9 Photo from science building looking out on courtyard (TJA, 2012) 46
Figure 4.10 Photo of auditorium seating (TJA, 2012) 47
Figure 4.11 Photo of laboratories in science building (TJA, 2012) 47
Figure 4.12 Photo of classroom in mathematics building (TJA, 2012) 47
Figure 4.14 Diagrammatic illustration of Sci- Enza plan 48
Figure 4.13 Photo of auditorium seating 48
Figure 4.15 Photo of auditorium "Science Stage" 48
Figure 4.16 Photo of audience participation in science show 48
Figure 4.17 Photo of workshop space 49
Figure 4.18(a) Diagrammatic illustration of user interaction in auditorium 49
Figure 4.18(b) Diagrammatic illustration of user interaction in workshop 49
Figure 4.19 Photo of storage in workshop space 49
Figure 4.20 Photo of experience base learning in workshop space 49
Figure 4.21 Plan of school (Hertzberger:2008) 50
Figure 4.22 Section of school indicating half storeys and circulation (Hertzberger:2008) 50
Figure 4.23 Section through working balcony and half storey (Hertzberger:2008) 50
Figure 4.24 Section with visual links created by half storeys (Hertzberger:2008) 50
Figure 4.25 Photo of school building exterior.
http://www.detail-online.com/inspiration/montessori-college-oost-in-amsterdam-103696.html (Accessd: 25 June 2016) 50
Figure 4.26 Photo of school building interior circulation.
http://www.detail-online.com/inspiration/montessori-college-oost-in-amsterdam-103696.html (Accessd: 25 June 2016) 50
Figure 4.27 Frames from Music Video shot in the school (Bluf Producties, 2011) 50
Figure 4.28 Plans illustrating various interior layouts (Merge Architects, 2013) 51
Figure 4.29 Photo of Cafe space (Horner, 2014) 51
Figure 4.30 Photo of classroom particioned of (Horner, 2014) 51
Figure 4.31 Photo of classroom (Horner, 2014) 51
Figure 4.32 Photo of prototyping/laboratory space (Horner, 2014) 51
Figure 4.33 Photo of prototyping shop soldering station & storage units (Horner, 2014) 51
Figure 4.34 Photo of prototyping shop workstation 51
Figure 4.35 Machine with Concrete. https://www.exploratorium.edu/
(Accessed: 15 March 2016) 52
Figure 4.36 Wind Arrows. https://www.exploratorium.edu/ (Accessed: 15 March 2016) 52
Figure 4.37 Shadow House. https://www.exploratorium.edu/ (Accessed: 15 March 2016) 52
Figure 4.38 Exploratorium on Pier 15. https://www.exploratorium.edu/ (Accessed: 15 March 2016) 52
Figure 4.39 Exploratorium entrance. https://www.exploratorium.edu/ (Accessed: 15 March 2016) 52
Figure 4.40 Exploratorium interior. https://www.exploratorium.edu/ (Accessed: 15 March 2016) 52
Figure 4.41 Photo of classroom (A4LE, 2009) 53
Figure 4.42 Photo of student presenting to peers (A4LE, 2009) 53
Figure 4.43 Photo of CEO demonstrating his passion for tools and making (A4LE, 2009) 53
Figure 4.44 Photo of school interior (A4LE, 2009) 53
Figure 4.45 Photo of student work exhibited (A4LE, 2009) 53
Figure 4.46 Photo of student project (A4LE, 2009) 53
Figure 4.47 Photo of project base learning (A4LE, 2009) 53

Chapter 5

Figure 5.1 Conical Intersect 2. From "Conical Intersect" París, France (Matta-Clark, 1975) 56
Figure 5.2 Circus 2. From "Circus-Caribbean Orange", Chicago (Matta-Clark, 1978) 56
Figure 5.3 Skin 57
Figure 5.4 Mass 57
Figure 5.5 Structure 57
Figure 5.6 Plug-in 57
Figure 5.7 Plug-in between parking & school 57
Figure 5.8 Plug-in acting as catalyst 57
Figure 5.13 Science store becomes display 57
Figure 5.10 Diagram of MST facility plugging into traditional school enviroment 57
Figure 5.11 Diagram of MST informal learning intersecting with formal learning 57
Figure 5.12 Diagram of catalysing experiential learning 57
Figure 5.14 School as micro city moodboard 58
Figure 5.16 Conceptual models 60
Figure 5.17 Desks as creative spacial organisers 61
Figure 5.18 Naef Cubicus 61
Figure 5.19 Exchange by Smart Desks 61
Figure 5.20 Exchange by Smart Desks 61
Figure 5.21 Exchange by Smart Desks 61
Figure 5.22 Models investigating connection between levels 63
Figure 5.23 Minimum Norms and Standards (DBE; 2013) 62
Figure 5.24 Models investigating connection between levels 64
Figure 5.26 Models investigating connection between levels 65
Figure 5.27 Models investigating connection between levels 66
Figure 5.28 Everyday users 67
Figure 5.29 New proposed name and logo for the school 67

Chapter 6

Figure 6.1 Node light by Odd Matter Studio, resembles circuit diagrams. http://www.dezeen.com
(Accessed: 29 April 2016) 71
Figure 6.2 Windswept, Charles Sowers . http://www.dezeen.com/ (Accessed: 30 April 2016) 71
Figure 6.3 Electricity Paper vinyl, installation view 5, Daniel Buren, 3013. http://www.petzel.com/
(Accessed: 05 August 2016) 71
Figure 6.4 Proposed screens for social learning areas 71
Figure 6.5 African Fractals. https://www.ted.com/talks/ 72
Figure 6.6 Museum wall 72
Figure 6.7 Storage wall 73
Figure 6.8 Conceptual Models 74
Figure 6.9 Conceptual Models developed from Sine and Cosine trigonometric graphs 74
Figure 6.10 Compilation of frames from short film, Beauty of Mathematics (Parachutes, 2013) 75

Chapter 7

Figure 7.1Triangles and curves co-exists in nature 78
Figure 7.2 Original Ground Floor Plan, 1955 80
Figure 7.3 City Property Ground Floor Plan, 2009 80
Figure 7.4 Conceptual Ground Floor Plan, June 2016 80
Figure 7.5 Ground Floor Design Plan 81
Figure 7.6 Original First Floor Plan, 1955 82
Figure 7.7 City Property First Floor Plan, 2009 82
Figure 7.8 Conceptual First Floor Plan, June 2016 82
Figure 7.9 First Floor Spatial Planning 83
Figure 7.10 Original Second Floor Plan, 1955 84
Figure 7.11 City Property Second Floor Plan, 2009 84
Figure 7.12 Conceptual Second Floor Plan, June 2016 84
Figure 7.13 Conceptual Second Floor Plan, August 2016 84
Figure 7.14 Second Floor Space Planning Plan 85
Figure 7.15 Original Third Floor Plan, 1955 86
Figure 7.16 City Property Third Floor Plan, 2009 86
Figure 7.17 Conceptual Third Floor Plan, June 2016 86
Figure 7.18 Conceptual Third Floor Plan, June 2016 86
Figure 7.19 Conceptual Third Floor Plan, August 2016 86
Figure 7.20 Conceptual Third Floor Plan, August 2016 86
Figure 7.21 Third Floor Design Plan 87
Figure 7.22 Original Fourth Floor Plan, 1955 88
Figure 7.23 City Property Fourth Floor Plan, 2009 88
Figure 7.24 Conceptual Fourth Floor Plan, August 2016 88
Figure 7.25 Original Roof Plan, 1955 88
Figure 7.26 Conceptual plan, May 2016 88
Figure 7.27 Conceptual Roof Plan, June 2016 88
Figure 7.28 Conceptual Roof Plan, August 2016 88
Figure 7.29 Existing Exterior 89
Figure 7.30 Conceptual Exterior Intervention, June 2016 89
Figure 7.31 Conceptual Exterior Intervention, August 2016 89
Figure 7.32 Conceptual Exterior Intervention, September 2016 89
Figure 7.33 Northern Elevation 90
Figure 7.34 Western Elevation 91
Figure 7.35 Section A-A 92
Figure 7.36 Section B-B 93
Figure 7.37 Conceptual Circulation Narrative, June 2016 94
Figure 7.38 Atrium as social learning space, October 2016 94
Figure 7.39 Atrium as a circulation node, October 2016 94
Figure 7.40 Atrium as social learning space, November 2016 95
Figure 7.41 Atrium as a circulation node, November 2016 95
Figure 7.42 Theatre of science, November 2016 95
Figure 7.43 Conceptual Circulation Narrative, September 2016 96
Figure 7.44 Curved wall becoming spatial gradient between lab and passage, October 2016 96
Figure 7.45 Curved wall with framed views into laboratories, November 2016 96
Figure 7.46 The makerspace, November 2016 97
Figure 7.47 View of the makerspace from computer lab, November 2016 97
Figure 7.48 Conceptual Science classrooms, June 2016 98
Figure 7.49 Conceptual Science classrooms, June 2016 98
Figure 7.50 Student's view of Science store when in laboratory, October 2016 98
Figure 7.51 Student's view of teaching wall, October 2016 98
Figure 7.52 Section C-C 99
Figure 7.53 Student's view of Science store when in laboratory, November 2016 99
Figure 7.54 Student's view of teaching wall, November 2016 99
Figure 7.55 Science store, November 2016 99
Figure 7.56 Science store, November 2016 99

Chapter 8

Figure 8.1 Design innovation - Solar chimney 103
Figure 8.2 Design innovation - Sun Shade 104
Figure 8.3: Sound insulation wall (Lafarge:7)- sound insulation reduction index of 53dB.
http://www.lafarge.co.za/LAF_514917_Partition_Brochure_F.pdf (Accessed: 15 September 2016) 105
Figure 8.4: 63mm Glasswool cavitybatt by Isover.- Aids reduction of sound transmittance. http://www.isover.co.za/glasswool
(Accessed: 10 October 2016) 105
Figure 8.5: Acoustic absorbent wall panels edge track FS110 by Fabricmate.
http://www.aluglass.co.za/wp-content/uploads/2015/02/Fabricmate-brochure.pdf (Accessed: 10 October 2016) 105
Figure 8.6: 600X600mm Drop in ceiling panels, Cosmos 68/N (Needled) with 49 dB sound reduction index by OWA.
http://www.owa.co.za/products/OWAcoustic_cosmos_intro.html (Accessed: 10 October 2016) 105
Figure 8.7 Marmoleum Decibel, Dove Grey and Dove Blue with impact sound reduction of 17dB.
http://www.forbo.com/flooring/en-gl/products/linoleum/acoustic-linoleum/marmoleum-decibel/bnruhx (Accessed: 20 Jine 2016) 105
Figure 8.8 Carpet tile by Van Dyck. http://vandyckcarpets.com/browse/flooring-for-the-office/ (Accessed 10 October 2016) 105
Figure 8.9 Lighting Calculations 106
Figure 8.10 Lamp Quantities 107

Figure 8.11 Ceiling Plan 108
Figure 8.12 Atrium - Concrete edge detail section 109
Figure 8.13 Atrium - Raked seating detail section 109
Figure 8.14 Atrium - Balustrade Detail 110
Figure 8.15 Exploded axonometric - Golden Ratio table fixed height 111
Figure 8.16 Exploded axonometric - Golden Ratio table with crank mechanism 111
Figure 8.17 Exploded axonometric - Science store 113
Figure 8.18 Sample board 114
Figure 8.19 Sbat report 115

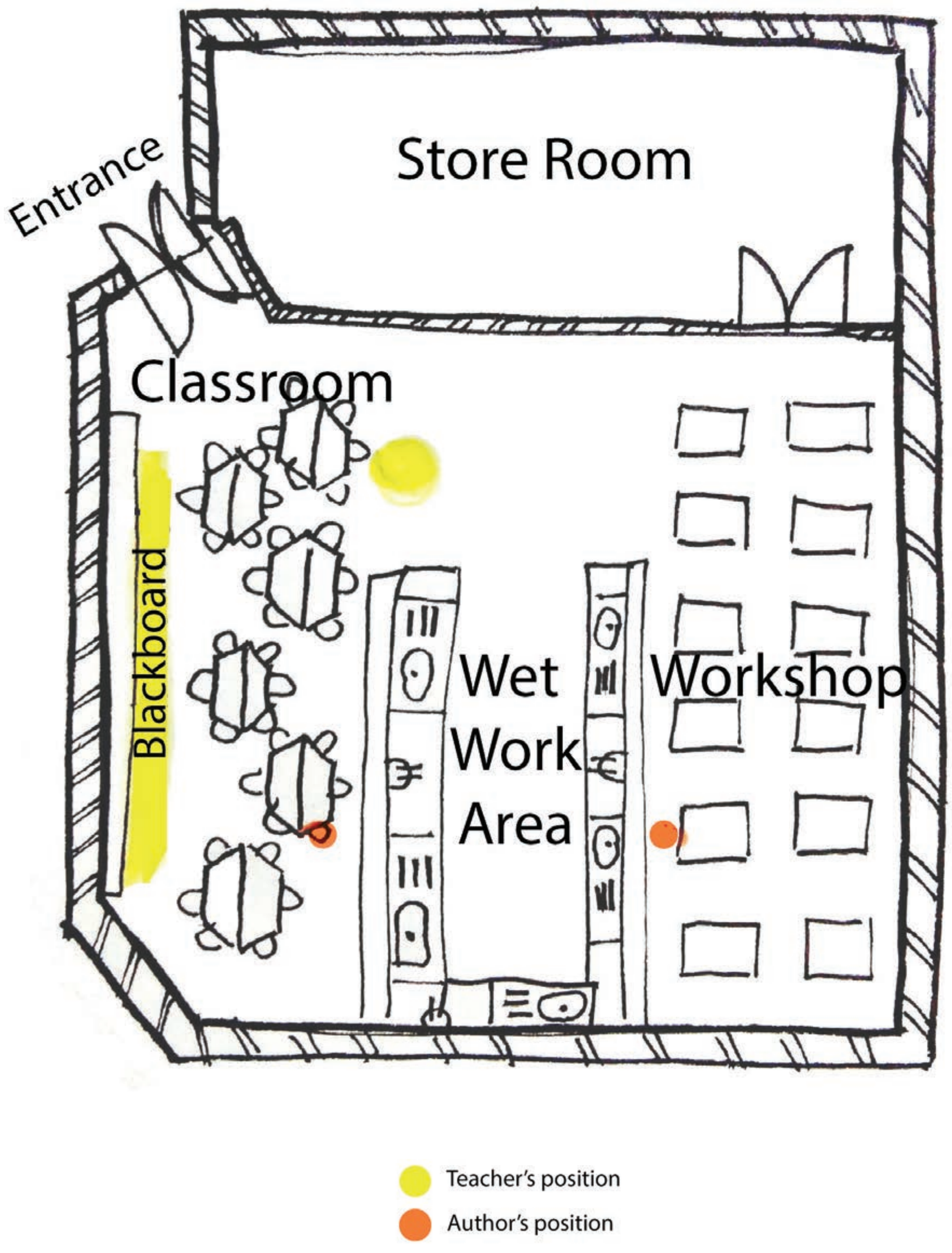

Figure 1.1 Grade 6, Technology Centre:
Plan diagram drawn from memory

Preamble

Memories of school

"Of all the schools you visit during your life, it's always the first one you attended that leaves the biggest impression on you, and for an architect it must have a considerable bearing on their practice later on." (Hertzberger, 2008: 27)

As a designer my approach is to respond intuitively to the identified problem, followed by research to support, enrich and iterate the design response. Working from out of this intuitive position the problem identified for this thesis is the design of Mathematics, Science and Technology facilities for an independent secondary school, Ed-U-College in Jacob Mare Building located at 193 Jeff Masemola Street, Pretoria CBD. The focus for this thesis followed from my own experience as a scholar:

When I was in grade six, my school opened a new Technology Centre (Figure 1.1).This had a major impact on my schooling experience. For the first time I was not confined to the traditional, teacher-centred, rectangular, unarticulated classroom. The space was divided by low walls into three areas. The first area was where information was transferred and tasks explained. The desks were hexagonal, thus the teacher was not the dominant focus point of the class. The second space was an intermediate space with kitchen counters and sinks where we could make a mess. The third, my favourite space, was the workshop area. Timber tables and workbenches filled the space. Two to three students could stand and work around one table. All the tools and materials needed to complete tasks were provided.

High school was different. All the classrooms were of the rectangular type, with a blackboard in front and the teacher being the most important person in the room. In grade 10, we had to choose our subjects without ever seeing what the older students did in those subjects. Those spaces were off-limits to juniors. I did not take Woodwork, Technical Drawing or Computer Studies because I was limited to 7 subjects. I still regret that I could not experiment with these subjects at a younger age. I took Art and this classroom was just as off-limits to other students as I was cut off from Woodwork.

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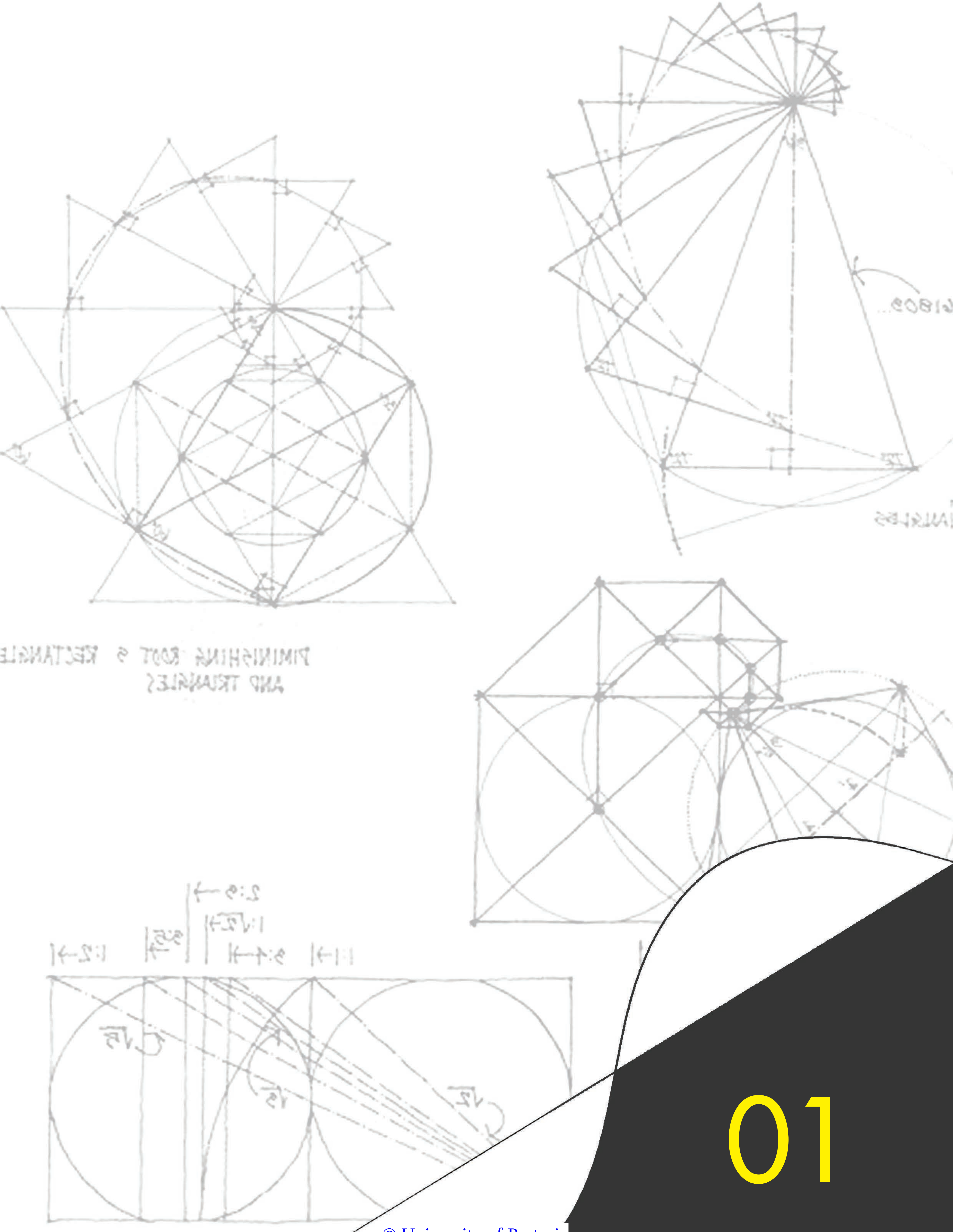

01

1. Introduction

"It is not the answer that enlightens but the question"
Eugene Ionesco (Delacôte, 1998: 2054)

1.1 Background

"Education... is about exploring the world. It is not just obtaining insight that is important but, increasingly, accumulating interest and love for the riches our world has to offer. This happens in interactive situations that could be stimulated more by the physical environment than designers are prepared to concede."(Hertzberger, 2008: 46)

Schools are one of the few building types that have truly evolved poorly. Variations only started appearing at the end of the 20th century (Hertzberger, 2008: 11). School environments play a major role in education and learning. Many schools in South Africa lack basic teaching facilities, and skilled teachers, let alone have the spatial requirement for new learning methods.

The internet and new technology enables many students to access online courses to broaden their knowledge on a variety of topics. There are numerous online exercises focusing on improving high school Mathematics and Science, and should be considered as a contributing aspect to learning.

In South Africa, the Department of Basic Education focuses on improving Mathematics, Science and Technology education (DBE, 2015). However, the enrolments for Further Education and Training (FET) Mathematics has decreased from 263 000 students in 2010 to 143 0000 students in 2013 (Nkosi, 2014). Through the Mathematics, Science and Technology (MST) Sector Plan, the Department of Basic Education and the National Development Plan strives to increase students' eligibility for bachelors programmes within Science and Mathematics to 450 000 by 2030 (DBE, 2015).

Mathematics and Science enrolments in schools are dropping and the pass rate is weak. In 2013's matric examination, more than 280 000 pupils wrote Mathematics Literacy with a pass rate of 87%. In contrast, only 143 000 wrote maths with a pass rate of 60% (Nkosi, 2014). As a result the Department of Education is invested in improving MST at schools (DBE, 2015).

Speaking on the issue of traditional teaching versus experience based learning, Sir Ken Robinson described traditional formal education as being a mechanistic, industrialised system focusing on standardisation and conformity. This system operates through teaching and testing rather than what he argues should be teaching and learning (TEDtalk, 2013).

Claim on space is becoming greater, school equipment is becoming more expensive and the number of scholars to teachers is increasing, the result is a worldwide scarcity of qualified skilled teachers (Hertzberger, 2008:8). Problems such as these could be alleviated by embracing new methods of teaching and learning, such as the American online high school classes known as the Khan Academy and other forms of online education.

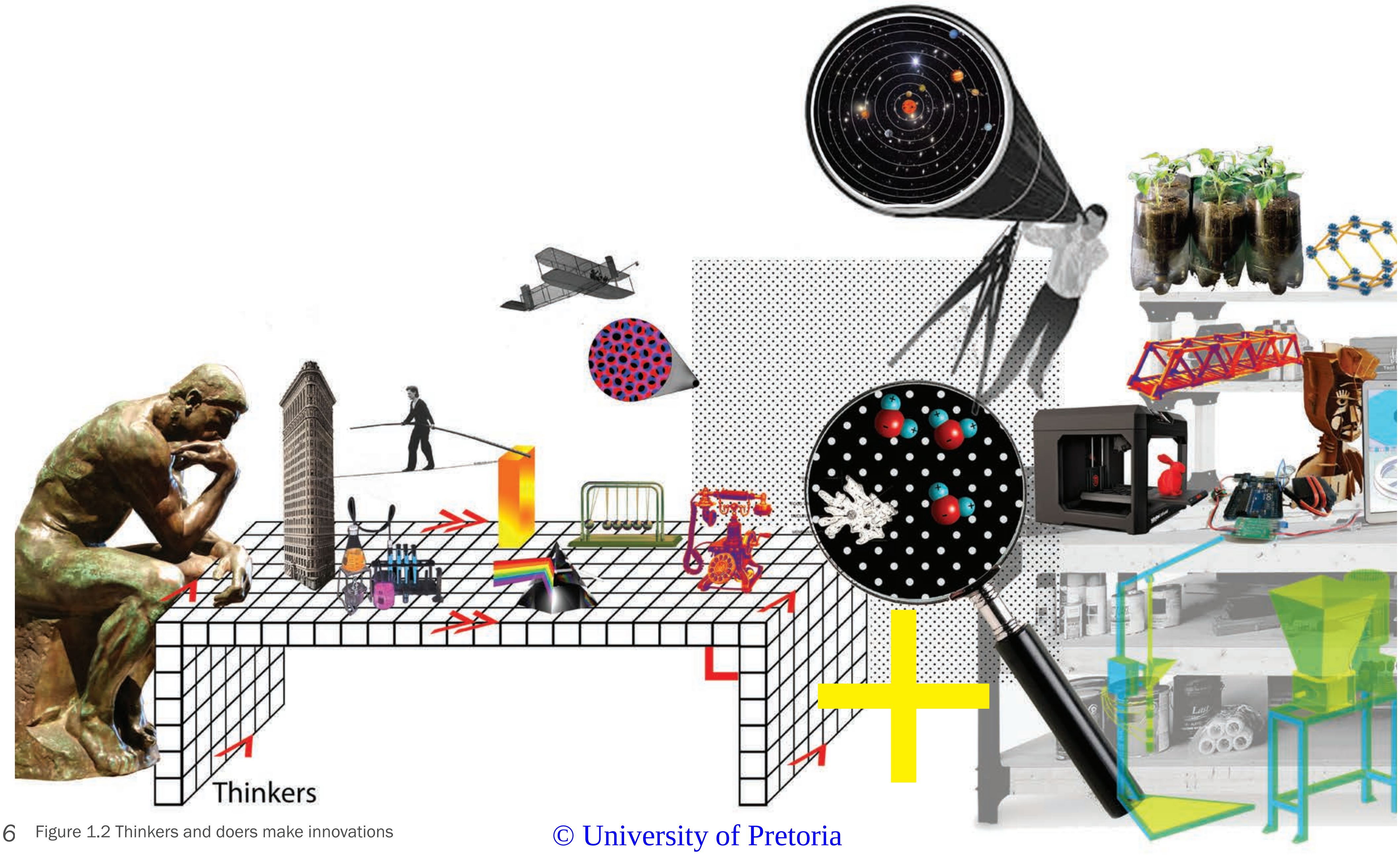

Figure 1.2 Thinkers and doers make innovations

Such new approaches lead to new spatial requirements and qualities that should be able to function alongside the traditional teacher-fronted lessons. The focus on individual-based education is growing and with it the spatial complexity of school buildings will increase (Hertzberger, 2008:8).

This thesis is concerned with the spatial articulation of experience-based learning and the potential this type of learning has to integrate with the existing teacher-fronted spaces of traditional formal-based learning. The school will be rebranded as Shift College, an educational environment that is shifting the way schools teach and how learners learn.

Museums and more specifically science centres have adopted experience-based learning as a focus for their exhibitions and workshops. Science centres can be strategic allies in the Science education reform movement, as they help to integrate formal and informal ways of learning (Delacôte, 1998: 2054). Schools can combine formal learning with informal learning, by providing a rich environment that emulates the museums of today, where pupils can interact with the displays.

To ensure a valuable experience for the learner it is important that there is a seamless connection between informal learning and structured traditional learning. A cross-fertilization between learning opportunities available in museums and learning methods available in schools needs to be explored. An interdisciplinary and multifunctional approach should be adopted, in order to create intriguing environments that appeal to the senses (Delacôte, 1998: 2055).

Learning should be about more than just absorbing knowledge (Hertzberger, 2008: 8).

A school should be an ever-changing, stimulation environment. The school space should encourage more than just reading, writing and arithmetic (Hertzberger, 2008: 9).

A school can be seen as a kind of microcosm: an idealised representation of the world where we send our young citizens (Jacob, 2015: 45). Hertzberger (2008: 117-18) argues that a school should represent as far as possible the most complete world for the untrained citizen. He compares corridors to educational streets and states that there should be spaces like city plazas and squares where social interaction can take place.

The physical environmental qualities of schools have a considerable influence on children (Figure 1.2). They develop the first conscious impressions of their environment that will influence their whole life. A sense of quality of environment and what they can expect and demand of life is generated. Thus, the learning environment should be varied and rich, leaving the student with the best of memories and associations (Hertzberger, 2008: 9).

1.2 Real-world problem

A substantial amount of youth have to travel a great distance daily from home to reach the schools they deem fit. A study done by Sekete, Shilubane and Badiri of 120 urban schools in South Africa showed that 49% of the students are from other residential neighbourhoods than where the school is located (Fataar, 2007: 1). It is evident from this study that certain areas in South Africa do not have adequate educational resources.

Du Plessis (2010:6) investigated inner city schools, the study revealed that even where these schools are safe or functional, the majority are not adequate educational environments. They do not meet the prescribed norms and standards as per the Department of Education's regulations as stated in the *National Minimum Norms and Standards for School Infrastructure* published on 21 November 2008.

In 4 August 2014 it was reported that 353 schools in South Africa do not offer Mathematics at FET level. The main reasons were that they do not have the necessary and qualified teachers. Schools drop Mathematics for Mathematics Literacy to achieve a better matric pass rate (Nkosi, 2014). Without Mathematics students cannot take Science, limiting their subject choices.

The "post-provisioning model" determines the number of teachers according to the number of pupils in the school; this does not take into account the number of grades or subjects the school offers (Nkosi, 2014). It is clear that many schools have restricted choices of subjects, resources and qualified staff. If students do not continue with Mathematics and Physical Science into grade 10 their choices for university courses become restricted and they cannot enter scarce skill professions (Nkosi, 2014).

This foundation of inequality has led to a situation where certain young adults are less prepared for the work environment and tertiary education than others.

Students should be able to develop, explore and discover their own interests and strengths in their school years. There is a need to emphasise the interconnected role Science and Mathematics play in everyday life.

The school environment, in particular the interior spatial environment, plays a major part in facilitating learning. However, it is evident from the site analysis (see chapter 3.9) and theoretical investigations (see chapter 2.2.1) that the typical South African school is currently suited for teacher-fronted learning.

"We reach out to that world to preserve or to change it and so to make visible our desire." – Kevin Lynch (1972:1).

Buildings outlive civilisations. Through adaptive reuse they evolve and change and thus endure the test of time (Brooker and Stone, 2004:9). A number of buildings in Pretoria CBD are abandoned (Du Toit, 2009:3) and according to the Tshwane Inner City Development and Regeneration Strategy, the City of Tshwane is currently not functioning as it should (2005:2). Building stock is not utilised properly even though the city is well connected to its surroundings through multiple public transportation infrastructures. Through adaptive reuse these buildings can provide urgently needed school facilities. Many inner-city independent and public schools, such as Pretoria Secondary School, located in an old clinic, and DANSA International College are already utilising this leftover building stock in Pretoria's CBD through adaptive reuse.

Thus the site selected for this design investigation, Jacob Maree Building, 193 Jeff Masemola Street, Pretoria CBD was originally used as storage facilities for military arsenal and clothing. In 2009 an Independent secondary school moved in.

In the Pretoria CBD the newly established independent schools have employed adaptive reuse to transform disused apartments, offices and warehouse stock into schools and educational facilities (Du Plessis, 2010: 3).

The current recommendations for school design is to design classrooms that are large enough to accommodate movement, flexible and mobile layouts which caters for multiple learning and teaching styles (Brittin, et al, 2015: 13).

Information and Communications Technology (ICT) has a growing importance in learning but too often it is considered as an afterthought. Many schools are moving towardz handheld devices and this brings new spatial requirements (Wright, 2015: 25).

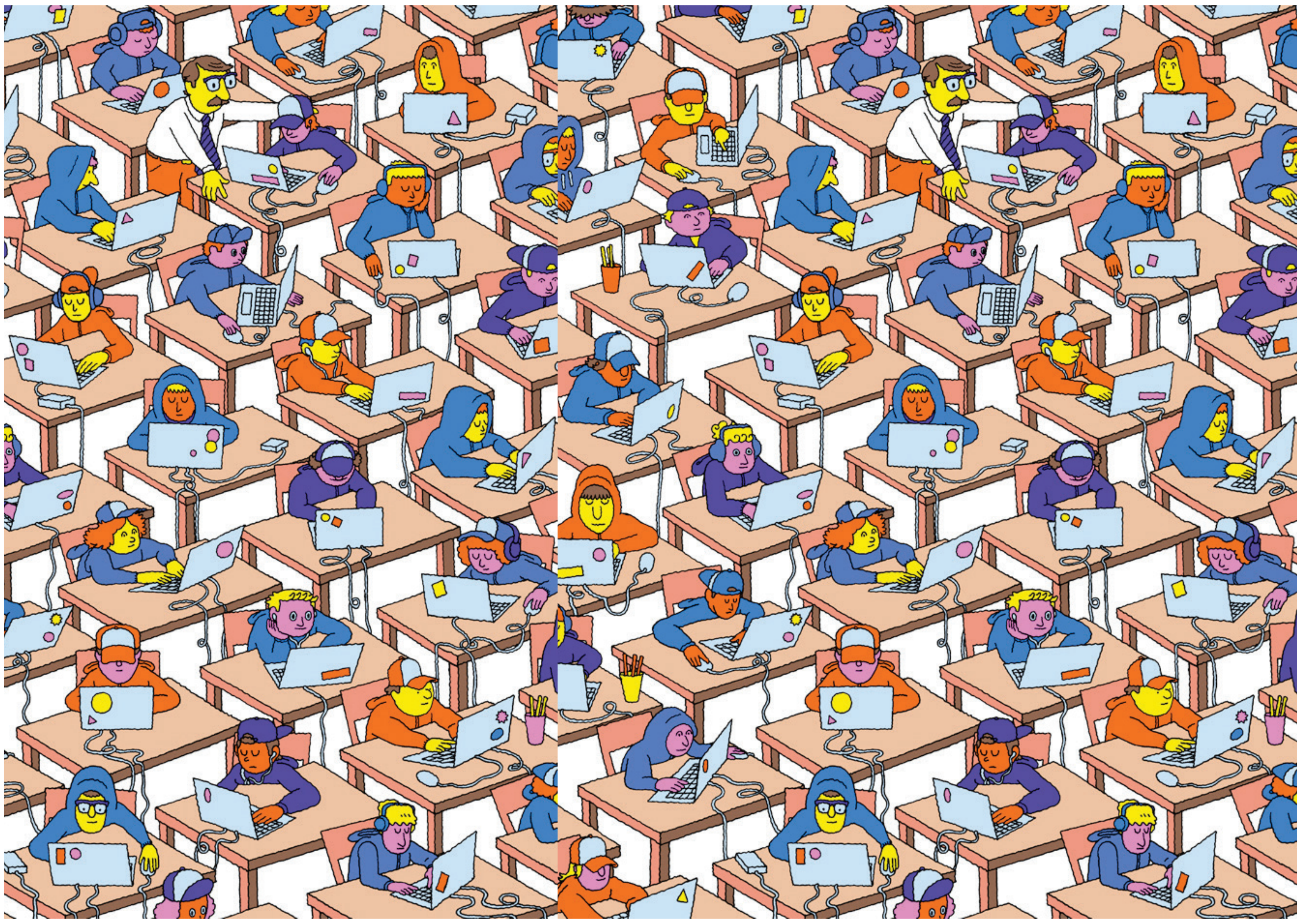

Figure 1.3 Jim Stoten Illustration - Traditional physical environment with technology.

1.3 Problem Statement

There is an urgent need to shift the perspective of MST education in schools. Traditional education in traditional built education facilities is no longer adequate. Educational methods are changing and with it the environmental requirements where learning takes place. There are scholars in South Africa that do not have access to the necessary Mathematics, Science and Technology resources that they need in order to reach their full potential. Schools should have spaces which facilitate varied and layered teaching and learning methods.

1.4 Hypothesis

The design of interior spaces to facilitate experience-based learning will stimulate curiosity, learning and application of Mathematics, Science and Technology amongst scholars.

1.5 Research Questions

· Who and what can teach students?

· How do students learn?

· How can the interior environment enable varied learning methods?

· How can the physical school environment resemble real life?

· How can space teach MST?

1.6 Contribution of this Study

This study will prove that interior design can contribute to the facilitation of MST learning. The study will determine the interior qualities that encourage active and collaborative engagement with tasks needed for experience-based learning. The physical environment will be used to reveal how stuff works, to provoke curiosity towards MST. This study will determine the most recent teaching and learning methods and how interior design can facilitate these methods.

1.7 Aims

The investigation aims to create an environment that will encourage exploration and learning, specifically in the fields of Mathematics, Science and Technology. The objective is to create an environment that can facilitate different learning methods and show how interior design can incubate a passion and holistic understanding of MST's role in the world around us.

"Create a climate of possibility"-
Sir Ken Robinson (TEDtalk, 2013)

1.8 Limitations

Due to ethical constraints interviews have not been conducted. Published interviews with policy holders, educators and scholars have been used instead.

1.9 Delimitations

The target group is secondary education with a focus on MST promotion. MST will be used to investigate the role of interior design on education even though all subjects are valued as equally important to a scholar's academic development. The study acknowledges that the lack of qualified skilled MST teachers is a problem; however, this study is limited to the physical spatial aspect of the MST problem.

1.10 Assumptions

The assumption will be made that the project is sponsored by a private business or NGO.

This study further acknowledges that while currently the majority of schools have not adapted new learning methods, but as is evident from the literature, this change is inevitable. In chapter 2.2.2 it is inferred that schools will adapt teaching methods to experience-based learning.

Through consultations with an engineer and by conducting a site analysis it has been determined that portions of the host building's floor slabs can be demolished without diminishing the building's structural integrity.

1.12 Methodology

The author will use a number of research techniques to form an appropriate conceptual approach and design that fulfils the aims of this project.

Intuitive Design is a method where the designer uses observation and analysis of unconscious behaviours of people as guidelines to generate functional targets and also to determine the functional effects of a product (Yang, 2015:513) or environment. The first step in intuitive design is user analysis. The designer should study the targeted users entirely and deeply in order to understand their common preferences, characteristics, acceptance, wishes and needs (Yang, 2015:513).

"By including unstructured participant observations, the information gained from participants can be validated as authentic and unbiased (and vice versa). It is posited that if an account of observation is thorough, clear, precise and written as honestly as possible, it is unlikely that it can be disbelieved" (Brinkmann, 2012:74).

Case Studies are conducted in order to understand complex social phenomena. Using a case study as a research method allows the investigators to collect holistic and meaningful characteristics of real world events (Yin, 2003:2). Case studies try to illuminate why a decision was made, how it was implemented and with what results (Yin, 2003:12).
"A case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident." Robert K Yin (2003, 23)

Qualitative Research is a method that studies elements in a natural setting, in order to make sense and interpret phenomena in terms of the meanings people bring to them. This is done by observing routine and problematic moments and meanings in individuals' lives in order to form a complex, holistic picture (Creswell, 1997:15).

The following methods will be utilised to determine the spatial qualities needed to facilitate MST learning

Case studies: The author will conduct multiple case studies where she will analyse the building, but also silently observe the users, keeping track of how they use space and the roles they play. Through case studies a list of strengths and weaknesses will be written.

Precedent studies: The author will conduct precedent studies to investigate good practice examples for typology, concept, spatial qualities and programme.

The literature review: A literature review will be used to reduce a large body of knowledge to key references that have a direct bearing on the research question. In this way the literature review will be used to ensure that the research questions are not too narrow or too broad (Groat and Wang, 2013:145).

Historical educational literature review: The author will first determine how modern educational theories changed over time and how they influenced the spaces where education happened.

1.13 Conclusion

This study investigates the role that the interior environment plays in educational facilities. MST education will be used as the starting point of the investigation in order to show how the interior can be used to facilitate specific learning methods.

The real world problem identified that not enough students continue with Mathematics and Science at FET level, thus it is essential to incubate curiosity towards these subjects with students.

In the problem statement it is clear that traditional educational methods are no longer adequate and that new spatial requirements need to be identified to facilitate new learning methods.

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02

2. Theory

"...the school shall serve as a laboratory. A place where a child can become an experimentalist," (Palm, 1940: 447).

2.1 Introduction

This chapter includes a review of relevant literature on traditional and non-traditional education methods. By investigating the history of educational theories the designer will be able to better understand how previous theories influenced educational environments and, by understanding current educational theories guidelines for 21st century, appropriate MST educational spaces can be developed. This chapter is concerned with how space can act as an informal teacher and why a school should resemble a real life environment.

"The world is changing at a fast rate with every day and every class period the gap grows wider between what students actually need to learn and what they are being taught." Khan (2012:2)

"In today's world we need a workforce of curious, creative and self-directed lifelong learners. They should be capable of conceiving and implementing innovative ideas." (Khan, 2012:80)

2.2. Educational Theories

2.2.1. The Traditional Model

Both historically and today still, children are still taught in classrooms. These **classrooms have been used as the building blocks of schools (Figure 2.1) .** Traditionally, the teacher belonged in front of the blackboard where he or she passed knowledge onto the students. This traditional hierarchy of the teacher-fronted way of teaching led to the following spatial conditions. The classroom environment had to ensure that children are distracted as little as possible and the teacher should have the best view over the class. The classroom became and stayed the territory of the teacher where children have little to no control over it. **The dominant spatial character of the typical school's physical make-up is a series of autonomous, compartmentalised spaces.** The doors to these spaces are arranged in repetition along long corridors. Windows are usually set high so that seated pupils can not look out, thereby limiting any potential external distraction (Hertzberger, 2008:28).

In this model the teacher is the most important and dominant person in the room, the pupils visit the classroom for a predetermined length of time within a predetermined schedule. In most instances **there is little flexibility for a student to adapt the environment to his own needs.** they are only passing through being instructed by the teacher at the same standardised speed as everyone else.
Salman Khan, founder of the online secondary school, Khan Academy, questions the traditional classroom model where information is transferred from the teacher to pupils in school time and homework done solitarily. He questions whether this model still makes sense in a digital age (2012: 5). **He posits that the needs of education are changing and that the traditional classroom model can no longer satisfy these needs.** The traditional model revolves largely around passive learning. In the traditional model students are grouped in age groups and are pushed through at an one-speed-fits-all pace (Khan, 2012:1).

There is a limited amount of time to grasp a given concept despite a variety in comprehension time amongst pupils (Khan, 2012:39). **Schools have prescribed times and methods in which learning must take place. This pace might not be optimal for each student** (McCombs and Whistler, 1997:42). Once a topic has been covered the class moves on, those that do not comprehend are left behind.

The conventional approach to learning is to take pieces of subjects and separate them. A group will spend an allocated time on a piece of information, get tested and move on (Khan, 2012:48-51). Sometimes the teaching process consists only out of rote memorisation with plug-in formulas. In the current model Physics is taught in a separate class from Algebra and Calculus despite it being a direct application of the latter two. Chemistry is partitioned from Physics even though they study many of the same phenomena. **All of these divisions limit understanding and suggest a false picture of how the universe actually works** (Khan, 2015:49).

In the 1990s, McCombs and Whisler (1997:38) asked students and teachers in America why they feel that school is not working for them. **The pupils stated that it feels like the school curriculum is not relevant to the real world.** They feel detached from teachers and peers, they do not receive the support they need, they feel like they do not belong and they feel misunderstood (1997:38). The educators on the other hand said the model is flawed because of a high dropout rate, low achievement by students, low motivation etc.
The educators' focus lay with behaviour and performance, while the students focussed on feelings and needs (McCombs and Whisler, 1997: 37-38).

Figure 2.1 Classrooms as building blocks (Author 2016)

2.2.2. The New Education Movement

The new educational movement started about a hundred years ago. Many current alternative education systems are based on these new theories.

In the early 1900s, **John Dewey** initiated a modern movement in education. According to Reuben Parker, Dewey's progressive education led to the notion that "the school shall serve as a laboratory. A place where a child can become an experimentalist" (Palm, 1940:447). **Dewey's work influenced educational theories of the twentieth century and is used as guiding principles for experiential learning.** In 1938, he wrote *Experience and Education* in which he tried to clarify the growing conflict between traditional education and his progressive approach (Kolb, 2014)

The term progressive was used by Dewey in his theory where **he stated that education is a constant reconstruction of experiences** [John Dewey (Palm, 1940:449)]. To him school activities should be current and representative of life (Palm, 1940:448). **Schools are places** where pupils receive life apprenticeships and **where meaning, knowledge and skills are embedded in reality.**

Jean Piaget followed in Dewey's footsteps and believed that **pupils naturally build and alter comprehensions through everyday interactions with their surroundings**. To Piaget, the aim of education was to provide a stimulating environment which supports pupils' natural epistemic curiosity (Hannafin and Land, 1997:169).

Piaget believed that the principal goal of education should be to create pupils who are capable of doing new things, pupils who do not simply repeat what other generations have already done. **Pupils should be creative, inventive and discoverers** (O'Donnell et al, 2010).

In 1922 **Carleton W. Washburne,** who at that time was the president of the Progressive Education Association, developed the concept of Mastery Learning. **Mastery learning** was built firstly on the **belief that any student can learn if the conditions provided matched their needs. Secondly, the curriculum was not structured around** predetermined time per concept but rather around achieving **a certain level of comprehension on a concept.** Thus, exercises could be done at a self-determined pace so that all pupils reached the same level of mastery (Khan, 2012:38-39).

In the 1960s the second wave of progressive education came about by Benjamin Bloom and James Block. With refined testing methods and feedback, **teachers were seen as mentors** instead of lecturers. **Peer assistance and mastery learning was encouraged** (Khan,2012:40). **Student centred experiential learning** (EL) can be defined as a form of **learning from life experience;** often contrasting it with classroom and lecture based learning (Kolb, 1014) Kolb quotes Keeton and Tate, defining EL as:

"Learning in which the learner is directly in touch with the realities being studied. It is contrasted with the learner who only reads about, hears about, talks about, or writes about these realities but never comes into contact with them as part of the learning process." (Kolb, 1014)

Learner-centred is an empirically informed philosophical perspective where one focuses on and understands each learner (McCombs and Whistler, 1997:xii). **Schools** are living systems. Firstly, they **serve students to learn** and secondly, other people who support learning (McCombs and Whisler, 1997:1).

Learner-centred educational systems and **classrooms can better meet the needs of more students,** ensure that students stay in school, and that they learn skills to be productive and satisfied citizens. In addition, these systems can create the desire for lifelong learning (McCombs and Whisler, 1997:36).

In The Foundations of Contemporary Approaches to Experiential Learning, Kolb (2014) argues that **the learning process should be rich with human experiences, shared and interpreted through discussions with one another.**
The world is changing fast, we are more globally connected and access to knowledge has seen an exponential growth. These aspects all add to the need to develop people that can adapt to changing needs, and keep their skills up-to-date (Kolb, 2014)

We need a society of life-long learning. Some believe that **we are heading towards an education revolution fuelled by economic, social and technological changes.** Front-loaded educational practices are becoming obsolete (Kolb, 2014)

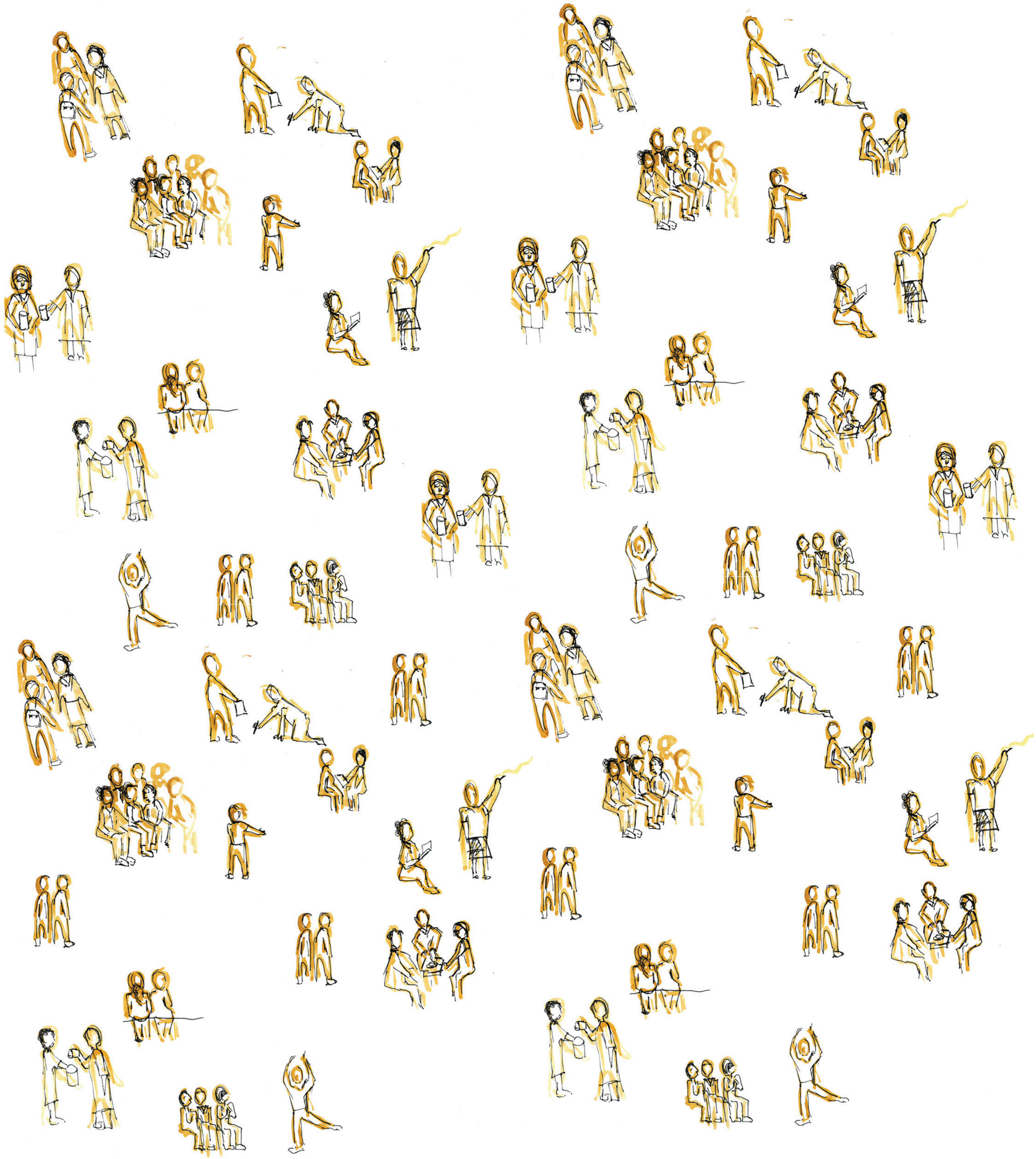


Figure 2.2 Peer assistance and student centered learning (Author 2016)

2.2.3. Informal Education and Museum Education

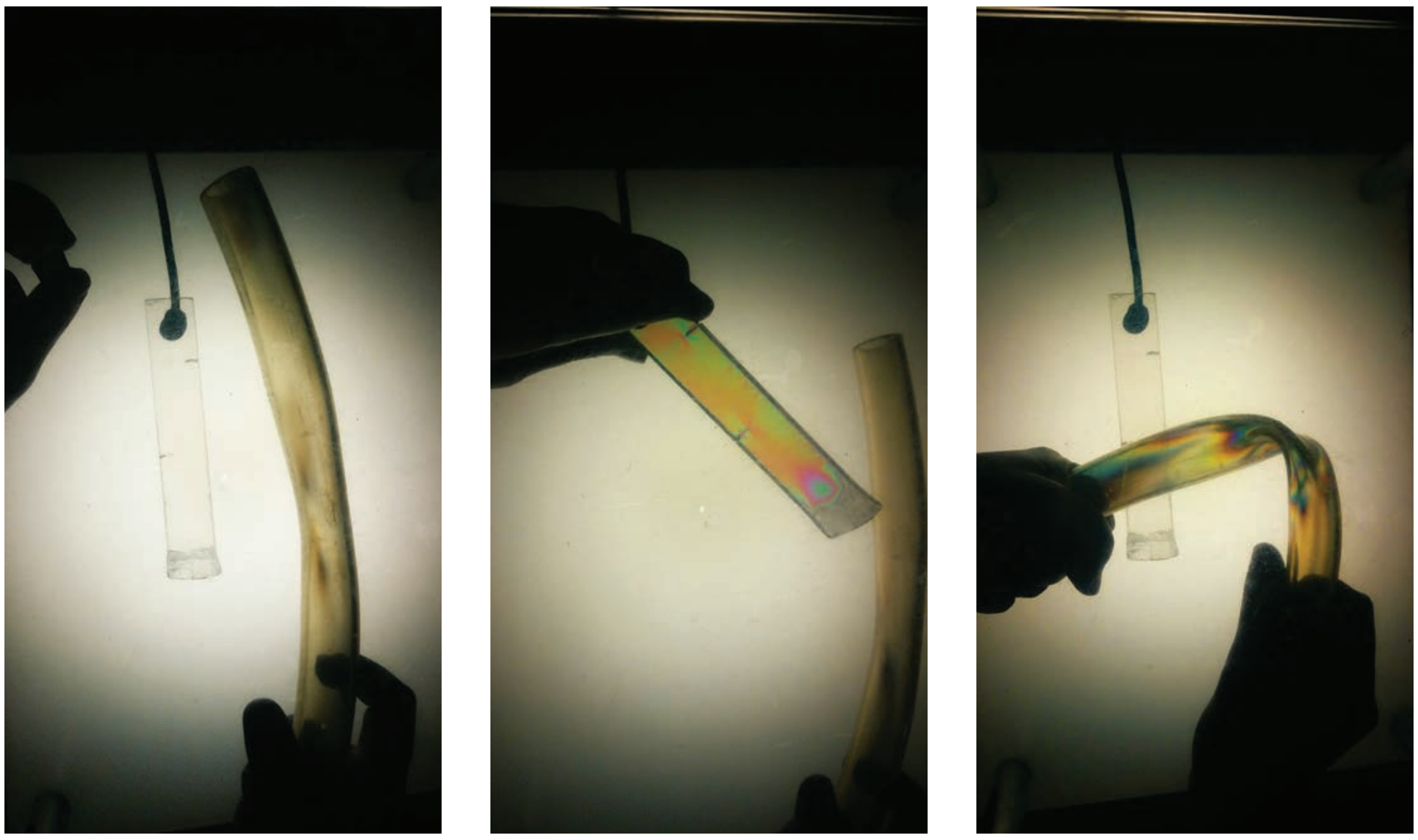


Figure 2.3 Sci-bono Science Centre hands on exhibit (Author 2016).

"The whole point of the Exploratorium is to make it possible for people to believe they can understand the world around them. I think a lot of people have given up trying to comprehend things, and when they give up with the physical world, they give up with the social and the political world as well." – Oppenheimer (Hein, 1990 :xv).

Informal education happens through everyday interactions and through life experiences.
The informal science movement gave people of any age and status access to lifelong learning, debate and entertainment through the exploration of the technological and physical world (Delacôte, 1998:2054). Informal science resources include natural history museums, zoos, science centres and planetariums.
The informal science movement became a success because of its learner-centric approach (Delacôte, 1998:2054).

Museum education and progressive education developed around the same time. Their ideals and practices are similar (Hein, 2006:161). Museum education emphasised the progressive agenda: to learn from an object (Hein, 2006:163). **The keynote of youthfulness** and childhood **is action.** The objectives of a museum should be to understand the interests of the youth. A museum should offer help and opportunities towards learning that schools and homes cannot give (Hein, 2006:167). One such museum was the Exploratorium in San Francisco. **The Exploratorium is a museum of science, art, and perception** (Hein, 1990:vii). A unity of Art and Science is achieved in the museum exhibits. The onlooker is an essential participant in the work (Hein, 1990:viii). This will be discussed in chapter 4.3.3.

In the 1960s, **many museums** and Science centres like the Exploratorium **developed exhibitions modelled on progressive educational theories.** A significant focus shift was for museums to re-establish education as a central idea of museums. There was a universal realisation that **visitors need active engagement in order to ensure understanding** and this led to interactive parts being added into exhibitions (Figure 2.3). This active engagement was evident in Science centres as well as Art and History museums. Thus activity centres, resource rooms and virtual extensions became standard in exhibits (Hein, 2006:171).

The Oppenheimer brothers presented San Francisco's community with a proposal for a museum where people could directly experience and manipulate things, instead of just being told about them. **They wanted to create a place where the public could interact with objects in the way that experimental scientists would do both in the natural world as well as in a laboratory.**

"The museum's mission was to teach that the subject matter of Science is all around us, comprehensible and accessible to all." (Hein, 1990: xv). The aim was to convince people that practising Science can be interesting and fun (Hein, 1990:xv).

2.2.4. Technology and Education

Figure 2.4 How Khan Academy is changing the rules of education (Pugliese, 2011)

Figure 2.5 Pupils from Phomolong Secondary School in Tembisa using tablets in the classroom (Mkhize, 2015).

"Don't limit a child to your own learning, for he was born in another time." - Rabindranath Tagore (Khan, 2012: vii).

With the birth of the Information Revolution, the pace of change has become swift thus creativity and analytical thinking are no longer optional, they are survival skills (Khan, 2012: 7).

The Khan Academy was started by Salman Khan who began by tutoring his cousin Mathematics via the telephone and internet. Today the Khan Academy has grown to become one of the most used online resources to learn Mathematics and Science.

The aim of the Khan Academy was to teach students not only the logic but the beauty of Mathematics and Science. The videos had to be helpful to pupils studying a subject for the first time, for adults who want to refresh their knowledge and for students needing extra help with homework (Khan, 2015:7).

Distributing knowledge through computer-based instruction:
The Khan Academy believes that through lessons and exercises that have been pre-recorded and can be accessed on a computer, valuable class time can be freed up. Traditionally these lessons were and still are used to "broadcast" knowledge to students. Pupils listen passively and there is not an effective way that the teacher can know who comprehends and who does not. Khan argues that if the students have done the lessons beforehand they can discuss it in class with greater opportunity for exchange. A teacher's role is also changing from rote lecturing to inspiring, mentoring and providing perspective. **Computer-based lessons can help teachers to do more teaching by freeing up time for the classroom to become a workshop (Figure 2.4) with interaction and mutual learning instead of the traditional passive sitting** (Khan, 2012:35-36).

The South African Department of Education is moving towards paperless schools by supplying goverment schools with tablets starting in grade 8 and 9 as the first phase. The department have developed a digital learning system (Matshediso, 2014).

Tablets are interactive, light weight devices. They enable students to carry all their learning materials at once. Learners have access to all the apps, e-books and software they need (Pilane, 2015).

By providing students with tablets and giving them access to digital learning students are enabled to take learning into their own hands and to research topics that interest them (Figure 2.5).

2.2.5. Timeline of Educational Theories

Figure 2.9 John Dewey's progressive/experiential classroom

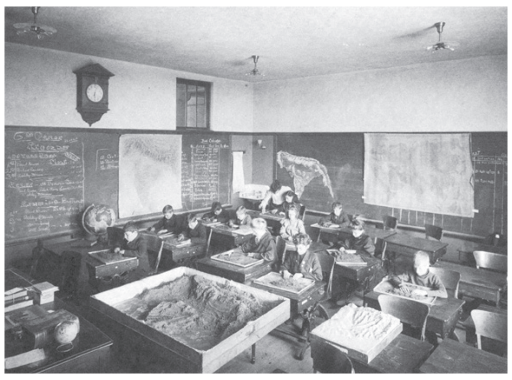


Figure 2.10 John Dewey's progressive/experiential classroom

Figure 2.7 Before Dewey (Unknown)
This photo is estimated to have been taken between 1900 and 1910 in an American School

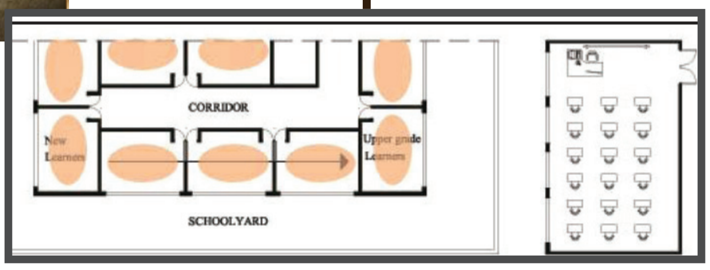


Figure 2.6 Diagram of behaviourism classroom (Guneya & Selda Al, 2012)

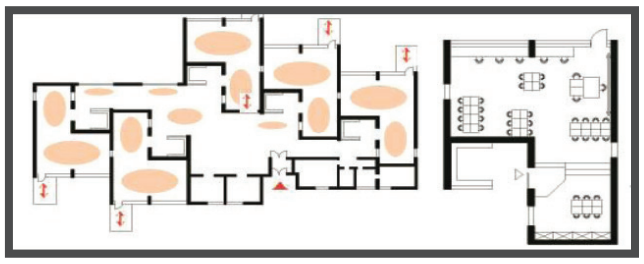


Figure 2.8 1960 Delf Montessori (Hertzberger, 2008)

1922
John Dewey
Progressive Education

1840
Horace Mann

1906
Maria Montessori
Casa dei Bambini

1952
Jean Piaget

1919
Rudolf Waldorf

1790-1810	1870	1913	1950	1960

Prussian model

Free compulsory education

The birth of a public education systems

An industrial-age factory model of education. Around the world public education systems started with the purpose to meet the needs of Industrialism. Subjects were placed in a hierarchy of the most useful subjects firstly for work and secondly for academic ability. The whole education system around the world is a protracted process of university entrance. Universities designed the system in their image (TED Talk, 2013).

Behaviorism
(Edward Thorndike & John Broadus Watson)

In the behaviourism movemnet learning was based on stimulus-response-reinforcement associations, Students learned trough drill and practice (Hannafin and Land, 1997: 172).

Cognitivism
(Ulric Dick Neisser)

Cognitivism was concerned with the processes of learning. Students learned by arranging a slection of stimuli into meaningful units. They were thought to retrieve and use skills and knowledge, connecting new with existing knowledge. (Hooper & Hannafin, 1991).
This information-processing theory led to a shift from the external, behavioural conditions of learning to a system that became more aware of the underlying processes involved in selecting, encoding, and retrieving (Hannafin and Land, 1997: 172-3).

Figure 2.12 Vittra School, Södermalm (Wendt, 2012)

Figure 2.13 Vittra School, Södermalm (Wendt, 2012)

Figure 2.14 Vittra School, Södermalm (Wendt, 2012)

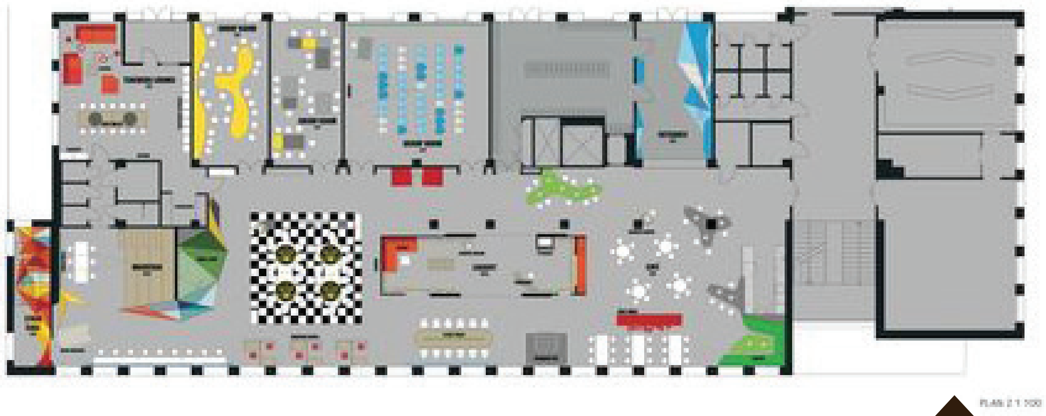


Figure 2.15 Vittra School, Södermalm (Rosan Bosch Studio, 2012)

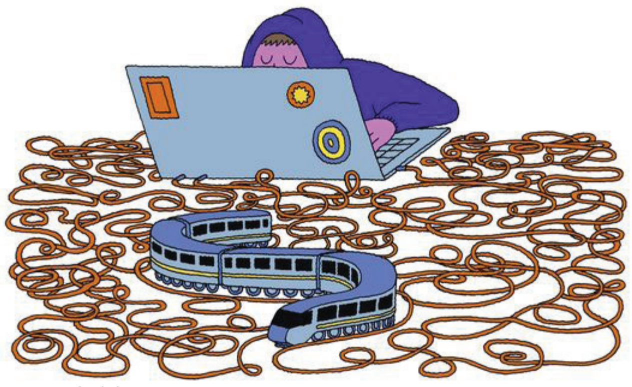
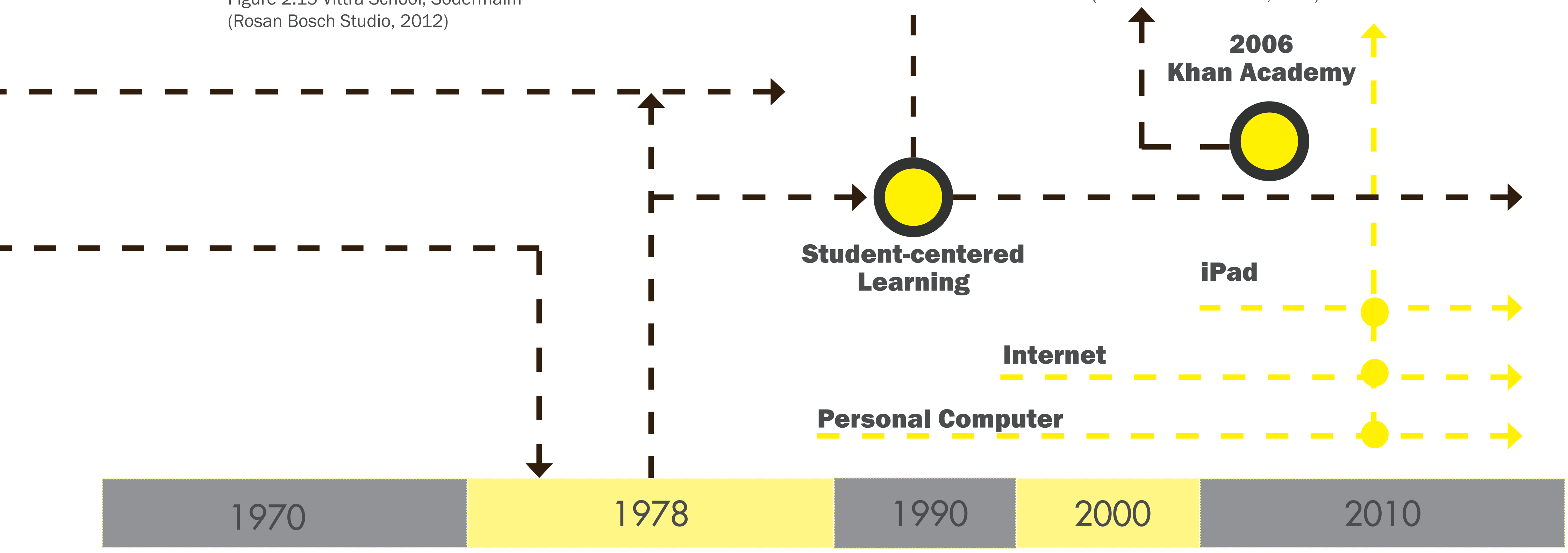


Figure 2.11 The capsulising digital world (Jim Stoten Illustration,2013)



Social Cognitivism
(Albert Bandura)

Social cognitivism theories focused on the relationship between context and knowledge. The socially-mediated dimension of learning and how social context influenced understanding became the focus (Young & McNeese in Hannafin and Land, 1997: 172-3). It was belived that the context in which a student formed meaning of knowledge played an integral part in the understanding. Thus knowledge isolated from contexts has little productive value. It became important for learning to happen in a contextually-rich enviroment with authentic experiences (Hannafin and Land, 1997: 172-3).

Constructivism
(Vygotsky, Piaget)

Contemporary constructivism evolved from the theories of Piaget (1952) and Vygotsky (1978). Constructivists believed that knowledge is not fixed or external. They say that it is individually constructed.

Students form an understanding through experiences. Student-centered learning environments emphasise real experiences that enable students to construct individual meaning. Today many contemporary learning systems are based on constuctivism (Hannafin and Land, 1997: 172-3).

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2.3. Spatial Theories

2.3.1. The School as a Micro-City

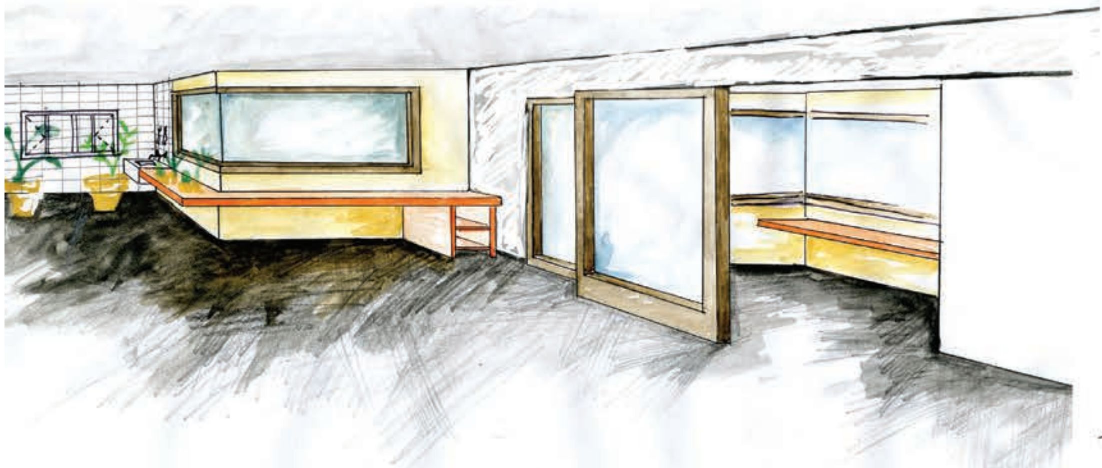


Figure 2.16 Perspective from classroom: Classroom extended into corridor with visual links (Author, 2016).

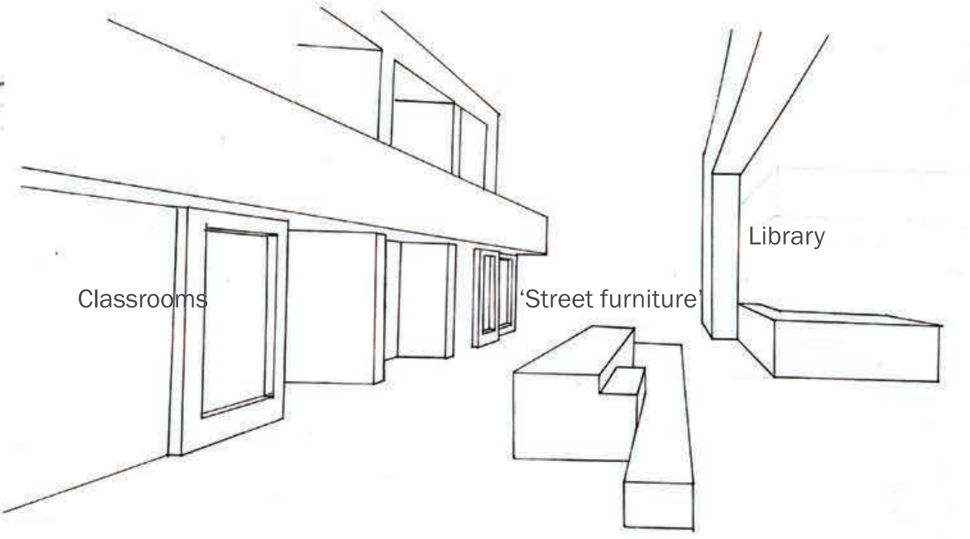


Figure 2.17 Perspective from corridor: Educational shopping street (Author, 2016)

"We must make buildings in such a way that they are an incentive for people to undertake activities." Herman Hertzberger (2008)

For many pupils, school is their second home and for some even their first (Hertzberger, 2008:69). **The progressive educationalist believed that it is the school's job to achieve learning in its widest sense.** Unfortunately schools with their minimal spatial programs are not designed to achieve the progressive ideals. Ambitious pedagogic ideals are often not realised due to the penny-pinching reality. Tight budgets result in schools that consist of **classrooms of minimal size with no flexibility** to practice something outside of the traditional study program. Hertzberger (2008: 68) argues that it is these spatial limitations that **prevent a broader learning program.**

Times are changing and so is the spatial requirements of schools. **Computers are changing education and the spaces in which education happens.** The amount of stimuli in the modern world causes distraction, loss of concentration and motivation. **Schools are now competing against the internet and television.**

Complicated situations at home are changing the needs of pupils at school. School, to some, has become their safe space. These elements call for new spatial conditions (Hertzberger, 2008: 69).

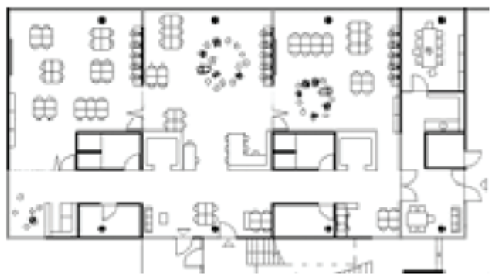
The educational facilities of the middle ages were collections of teachers and students that were attracted to these facilities because of what they had to offer. **Universities were market places of ideas, people shopped around town for ideas and learning that was applicable to them** (Alexander et Al, 1977:232).

Schools should be more adaptable and have more open forms. Architects should search for a new form of learning space that **enables a wider range of experiences like that found in a city and on the internet** (Hertzberger, 2008:69).

To achieve an **educational shopping experience** (Figure 2.17) the physical and social environment of a school should encourage freedom of thought and individuality. The school environment should allow the student to find out for himself or herself what ideas make sense to them. The school setting should expose the student to a variety of ideas enabling the opportunity for the student to make up his or her own mind (Alexander et al, 1977:232).

There is a shift to a more personal initiative in learning, thus there is a need for an environment that is more house-like, closer and less detached. **Pupils personalise schools with an array of drawings and models.** Thus a school's aesthetic is seldom what the architect had envisioned. Architects should design schools that allow for deviation, change and the unexpected, in order for a school to become like a city (Hertzberger, 2008:72). Alexander et al (1977:232) recall the image of a traditional market place where the stall owners have developed a speciality and students were attracted to them because of their genuine quality.

The site for this design investigation, Shift College, is an inner city school, the pupils either live in the city or commute from nearby townships. It is argued that by designing a school that resembles their everyday surroundings of a city or a



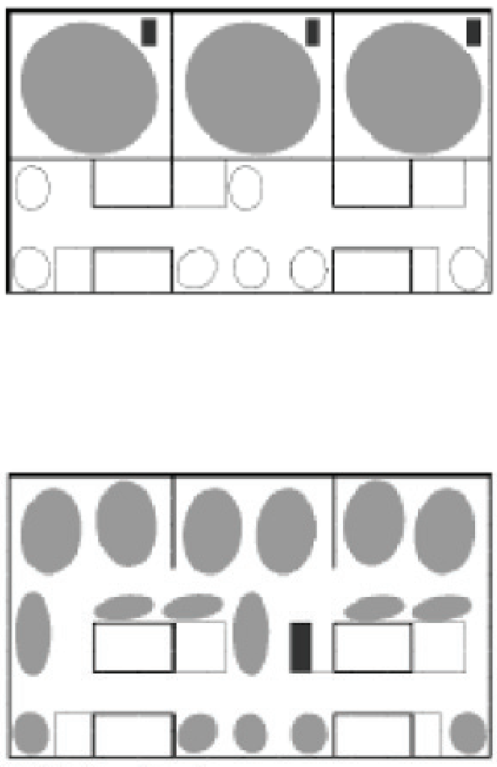


Figure 2.19 From adult-fronted to social learning (Hertzberger, 2008)

Figure 2.18 Experiential learning in a school (Hertzberger, 2008)

marketplace, the students should be able to relate better to their school environment.

The presence of others are what gives school spaces the most meaning (Hertzberger, 2008:69).

In South Africa people have diverse backgrounds and cultures, schools should have spaces where these pupils can interact with other students. Thus preparing them to interact with people from all walks of life when they leave school.

Architects need to counterbalance the individual attention of the computer and cell phone screen. Circulation spaces can be used to reconnect the student submerged in the virtual world. These spaces should become more relevant as social space in order to create the reality of community (Hertzberger, 2008:69). **The school environment should provoke exchange and confrontation,** intellectually, culturally and politically, in order to give a more expansive view of the world. **Learning should not be restricted to the classroom walls but should claim the whole building** (Figure 2.20). Space can be used to show pupils and teachers possibilities, to inspire them and open them up for change. A school building should be able to change its contents, thus enabling it to function in changing situations (Hertzberger, 2008:69-70).

Schools should provide spaces that act as 'nests', **places that resemble shelters, the right size for individuals, as well as groups,** to imbed themselves in work. Students can still access the virtual world in books and on the internet but from the safety of these "nest" spaces. The space surrounding the 'nest' should arouse students' curiosity and encourage confrontation (Hertzberger, 2008:35).

Outside the classroom pupils come into contact with others busy with school activities which they are perhaps not ready for. These activities can have a magical galvanising effect on pupils (Hertzberger, 2008:46). **Access to ideas are facilitated by allowing the student to view into the window when he or she cannot access the door** (Alexander et al, 1977:101) (Figure 1.17). The students acquire insight into what there is on offer. This way pupils get a taste of what they are going to be confronted with later in their school careers (Hertzberger, 2008:46).

Hertzberger (2008:123) warns against a network of excessively long dark corridors where pupils walk past each other with no architectural language that encourages contact. Such spaces only manage to encourage pupils to become anonymous to each other. Nair and Gehling, in Harrison and Hutton (2014:85) insist that **long corridors do not function as good public space in schools**.

To Hertzberger (2008:123) architects designing schools should firstly strengthen spatial unity, and ensure clarity of organisation after which the smaller units that a school is made out of should be tied together as a coherent whole. These units can be compared to urban quarters and neighbourhoods which are tied together by their main roads and smaller network of streets, thus becoming an entity that is accessible to all (Hertzberger, 2008:123). **Successful public spaces have three important characteristics: the marketplace, thoroughfares and meeting places** (Gehl in Harrison and Hutton 2014:90). The marketplace in the school is where ideas can be exchanged. Thoroughfares encourage people to move, thus needing a destination on each end as well en route. Meeting places allow people to pause and chat (Harrison and Hutton, 2014:90).

Educational buildings that are structured as streets and squares in order to form a small city ensures that there is a great deal of social contact, confrontations, adventures, meetings and discoveries. **Pupils come into contact with a wider world, not just with those their own age** (Hertzberger, 2008: 123).

Interactive and collaborative leaning can happen in circulation spaces. Niches in corridors create cave-like spaces that aid in individual study and reflection (Harrison and Hutton, 2014: 85)

In order to encourage interaction in school buildings, storeys should be tied up through visual links (Figure 2.16), to prevent floors from becoming detached, isolated departments. A split-level can connect floors and voids. This makes a building legible and suggests continuity of space and thought. By increasing the height of ceilings over **circulation spaces,** their importance is emphasised and **when filled with natural light they resemble outside streetscapes.** By projecting vertically through the building, the building organisation becomes clear and the circulation becomes the main artery of the building. The internal traffic becomes visible to all (Hertzberger, 2008:124).

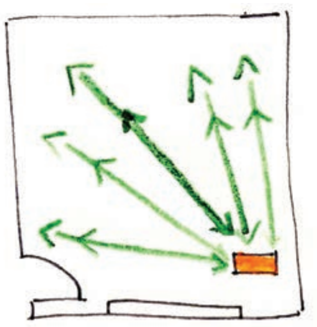


Figure 2.23 Traditional classroom

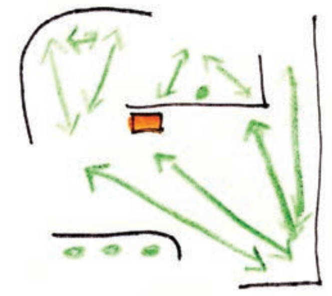


Figure 2.24 Articulated classroom

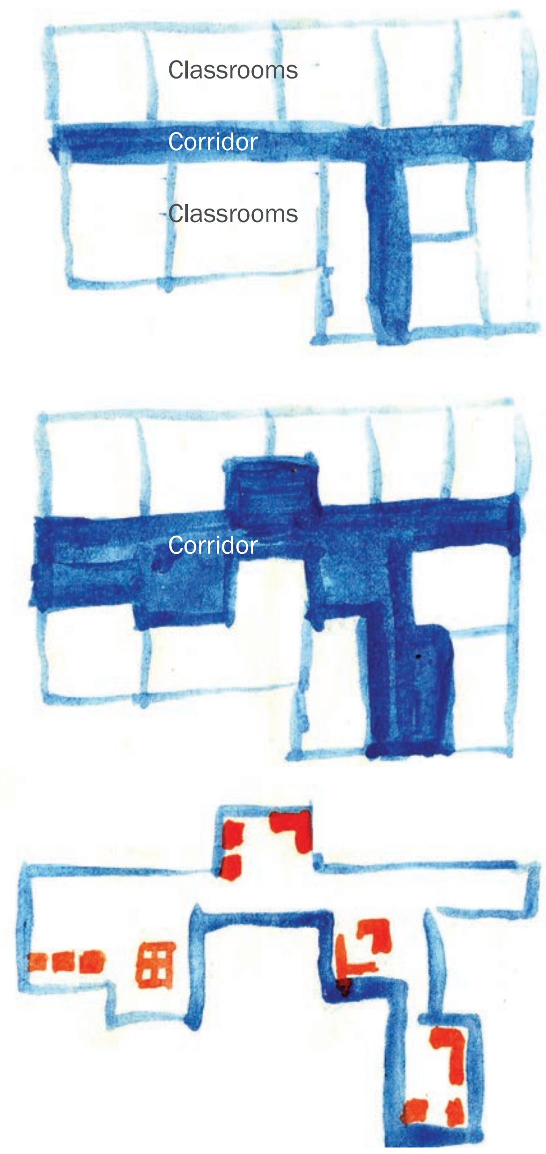


Figure 2.20 Plan diagram of transformation of long corridor into educational and social learning street

Figure 2.21 Perspective of classrooms claiming space from corridor

Figure 2.22 Sectional diagram of corridor spaces connection vertically

2.3.2. The Environment as Third Teacher

“There are three teachers of children: adults, other children, and their physical environment.”- Loris Malaguzzi (in O'Donnell Cannon Design, Wicklund Pigozzi, Peterson, Architects Inc, VS Furniture., & Bruce Mau Design, 2010).

O'Donnell et al (2010) view space as the third teacher and compiled 79 design principles to guide the design of interior space so as to enhance learning. In the following section, selected principles are investigated and aligned with the educational theories previously discussed.

- **The environment can enhance learning by providing the necessary basic spatial requirements needed for different ways of learning to take place.**

Spaces should be designed for speech and hearing. Classrooms must have acoustic qualities that enhance the audibility of words, achieved by a quiet background and by controlling reverberation. Young pupils have smaller vocabularies compared to adults. This makes it difficult for them to fill in words and syllables that are not heard clearly (O'Donnell et al, 2010: no. 8). Increased daylight in interior spaces helps to cut down on absenteeism and to improve test scores (O'Donnell et al, 2010: no. 9).

- **Locations of learning activities can change**

This enables students to explore concepts in different environments (O'Donnell et al, 2010: no. 10). These environments can be formal learning spaces, or an open auditorium-type space, or even a cul-de-sac could be utilised for this. Open auditorium-type spaces become demonstration spaces visible from the main circulation route encouraging passersby to stop and engage (Figure 2.27). Cul-de-sac spaces are also visible from circulation routes taking up the space of a classroom, they serve as hubs for informal learning activities (Figure 2.30). These spaces contain flexible furnishings and collaborative technology. They catch and accommodate the spillover pre-class and post-class as well as class activities (Harrison and Hutton, 2014: 143). Teachers should be freed from the desk at the front of the classroom and new settings for teaching and learning should be encouraged (O'Donnell et al, 2010: no. 12).

- **Pupils in the act of learning should be displayed**

This enables them to track progress (O'Donnell et al, 2010:15). Open auditorium-type spaces can be used to display student data and presentations (Harrison and Hutton, 2014: 143). By displaying student work, pupils from lower grades know what is to come and what is expected from them in the future. Displays encourage peer review and assistance.

- **Schools should emulate museums**

When an environment, classroom or museum, is rich in evocative objects it stimulates active learning by allowing pupils to pick what they want to engage with (O'Donnell et al, 2010: no16). Students can design in-school museums, this enhances their creativity and broadens their own as well as their peers' knowledge. Pupils can learn through project-base learning by designing exhibitions for a wide range of topics. Exhibition-based projects can work in any school, scholars can share important topics to their peers and community. School museums combine creative and academic learning and they connect students with their community (D'Acquisto, 2013). **By creating schools that emulate museums and Science centres, the planes and elements that the space is made out of can have an informal learning quality as well as a space defining function.**

- **Informal learning achieved through revealing how stuff works.**

A school's infrastructure can become exposed, to display all the usually hidden flows of water and waste and so pupils are taught the workings of the real world (O'Donnell et al, 2010: no42).

- **Cross-pollination of Art and Science**

The 79 design principles of Cannon Design, VS Furniture and Bruce Mau Design (2010) reiterate the theories of Frank Oppenheimer (Hein,1990): **Art and Science need each other. Thus it is essential that students have a place for cross-disciplinary work** for their minds to flourish (O'Donnell et al, 2010: no18). Connections should be drawn between traditionally separated subjects to honestly represent them as they exist in the real world.

- **The outside should be brought inside**

The community, the landscape, and faraway places should be represented in the classroom through visuals and objects that call them to mind (O'Donnell et al, 2010: no19). By curating, displaying and demonstrating on everyday objects concepts can be related back to the outside world.

- **Studios, workshops and laboratories**

Students of all ages need a place where they can be hands-on. These spaces enable them to learn through touch, manipulating and making things with their hands (O'Donnell et al, 2010: no54). Cognitive development can be enhanced by providing places where pupils can test new skills (O'Donnell et al, 2010: no13) (Figure 2.25). By allowing students time and space where they can choose what they want to learn can illuminate their individual intelligences (O'Donnell et al, 2010: no14)(Figure 2.26). **Studios, workshops, and laboratories should be provided where pupils can translate theory and test them on practical applications** (O'Donnell et al, 2010: no72). Maker-spaces can help to achieve this. **A makerspace is a Science lab, Computer Study lab, Woodwork room and an Art room all at once.** It should accommodate a wide range of activities, tools and materials enabling cross-pollination of activities that are necessary for the design, making and exploration process (Cooper, 2013).

- **Furniture can enhance learning**

Furniture and classrooms should absorb growing bodies, and allow for fidgeting, twisting and movement (O'Donnell et al, 2010: nos. 20 ,21 ,22). **Classrooms should be agile and able to be reconfigured easily for different kinds of learning** (O'Donnell et al, 2010: no. 23).

- **Technology enhances the learning capabilities in a space and can enhance how space can act as a teacher.**

Expand learning beyond the classroom's four walls. Classrooms should have the capacity to link into virtual learning opportunities. Install technology that simulates the real world. The environment should allow teachers to adapt their methods as technology changes. **Students should have laptops and places where they can be unplugged and still connected** (O'Donnell et al, 2010: no73-75 & 77).


Figure 2.25 Science lab, International School of India by Cannon Design


Figure 2.26 Scocial Learning Spaces, International School of India by Cannon Design


Figure 2.30 Group work spaces, International School of India by Cannon Design


Figure 2.27 Open Theatre, North Shore Country Day School by Cannon Design


Figure 2.28 Social Learning Space, North Shore Country Day School by Cannon Design


Figure 2.29 Learning Landscape, Hamilton South Eastern School District Senior Academies by Cannon Design

2.4 Conclusion

The time has come to transform educational buildings, the form of which was derived to facilitate traditional teaching. The physical environment can enhance learning by encouraging different ways of learning. Space can act as a teacher through informal learning.

Classrooms should be designed to encourage adaptation for different tasks. Students do not have uniform needs and do not flourish in the same type of spaces. This can be overcome by designing spaces that cater to both individual needs as well as that of the group's needs. The physical environment should encourage active learning. Interior spaces should have a student-centred approach. Users should be able to manipulate space for their needs.

By arranging classrooms and facilities in such a way that they better relate to and connect with each other students can be stimulated to draw connections between subjects. To form a more holistic view of the physical world, the compartmentalised perspective of subjects and themes can be broken down through spaces that blur the boundaries.

Schools should provide the basic facilities needed to enable learning but they should also be able to adapt to changing needs. Schools therefore need a new set of facilities, add-ons, where students can take their traditionally taught material and explore, interact and adapt these into innovative ideas and understanding. Thus grounding concepts in self-experienced, real life situations that clarify the relevance of what they have learned.

Students are training to become citizens in towns and cities. By designing schools to resemble a city students become more prepared for the situations that they will encounter after schooling.

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3. Context

Figure 3.1 Location of Gauteng in South Africa

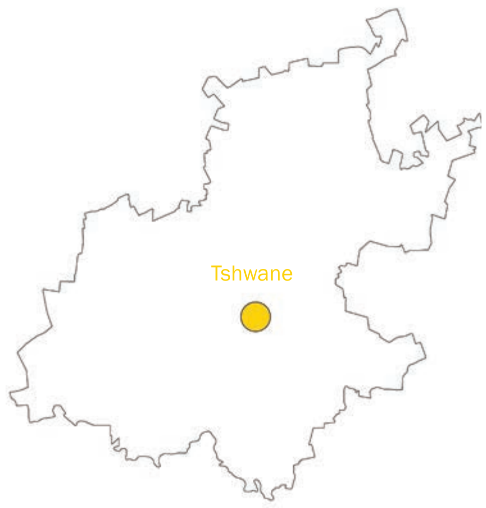


Figure 3.2 Location of Tshwane in the Gauteng Province

Figure 3.3 Location of site in Tshwane

3.1 Introduction

The selected site is located on the southern side of Jeff Masemola Street and the eastern side of Christina Avenue in Pretoria Central Business District (CBD). Originally the building was designed for Angel Investment (Pty) Ltd by Oscar Hurwitz and Murray Architects. The plans were signed off in 1955 and thus it can be concluded that the building is about 60 years old. In 2009 an independent secondary school moved into the top three storeys of the building. Both the ground and first floors were converted into parking lots.

3.2 Statement of Significance

The building recently became protected by the National Heritage Resources Act (No 25, 1999) Section 34, no. 1, which states that no building 60 years or older can be altered or demolished without a permit.

However, this building is not well-documented. The building is no longer fulfilling its original function and in order to avoid redundancy it urgently needs to be adapted to meet the current and future needs of the city.

The main features of the building are its strong horizontal lines on the northern and western facades. The northern stairwell with its glass facade is the most prominent feature of the building. The stairwell was designed in such a way that the interior movement on the stairs was meant to be visible from the street. Currently a steel mesh obscures this feature. The north-western exterior corner of the building is another prominent feature. Located on the corner of two one-way streets, it is the first feature that vehicular traffic would notice. This corner currently has a brick wall stretching from the bottom to top with a pattern of bricks sticking out, making the most of the western sun. As the sun falls on the wall, the wall gets cast in an ever-changing pattern of shadows.

The building's structure consists of concrete slabs and concrete columns with drop panels. The walls are brick infill. On the street-facing northern and western facades the brickwork disguises the structure. On the southern and eastern facades the building has an honest and unrefined character. Here columns and slabs are easily distinguishable from the brick infill and fenestrations.

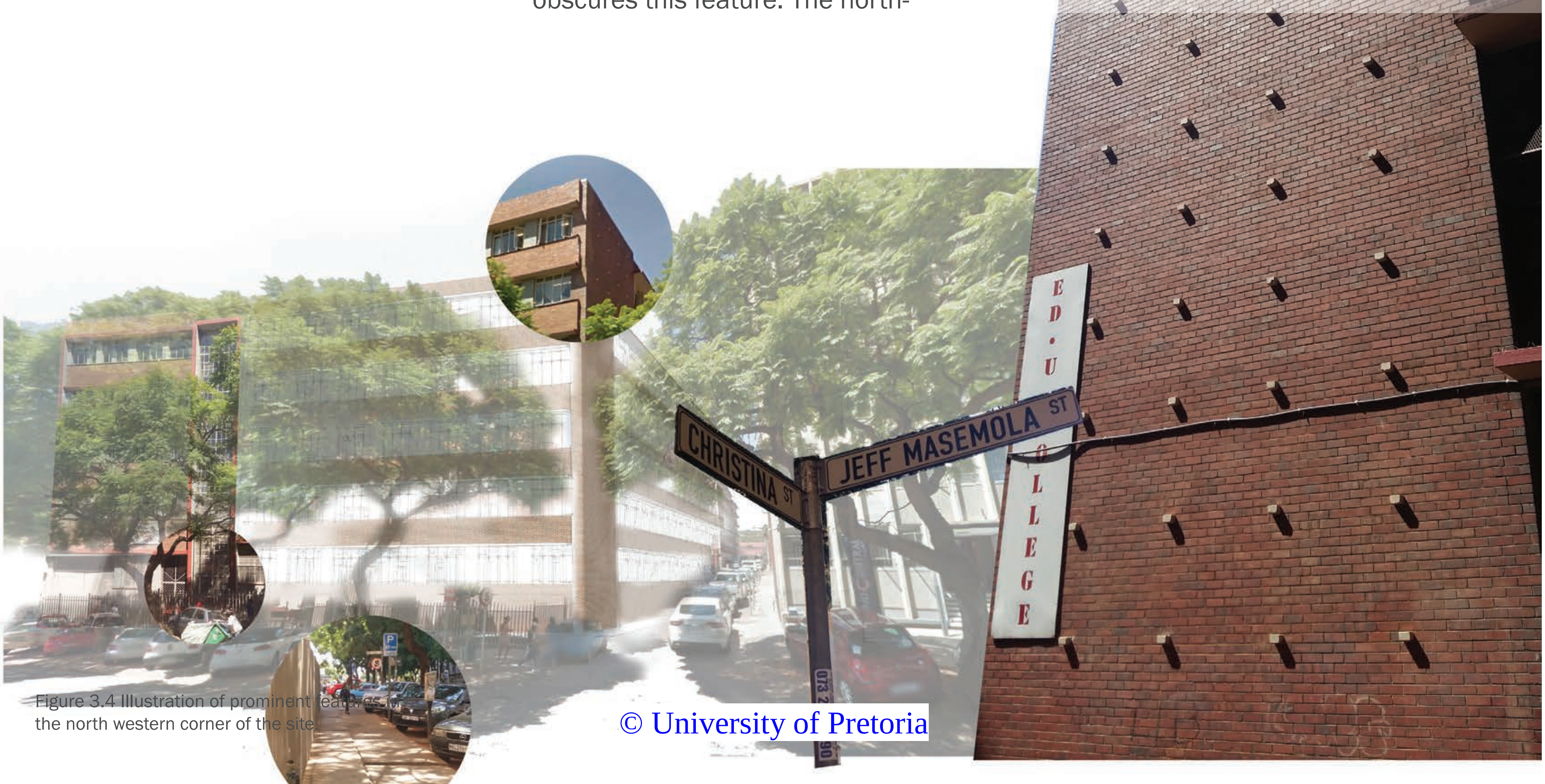


Figure 3.4 Illustration of prominent features of the north western corner of the site

Figure 3.5 Locality plan of site in Tshwane CBD

Figure 3.6 Short distance bus routes around site

Figure 3.7 Mapping of day tome pedestrain movement

3.3. Site Selection

The site was selected according to the following criteria:

The author visited a number of existing educational facilities in Pretoria and the Eastern Cape. Schools with limited facilities were identified.

The existing schools should have access to a host building where alternative educational facilities can be investigated as an interior intervention.

The host building should be located so that it is easily accessible to middle and lower income communities. This ensures that the proposed new resources are distributed to communities that require these facilities and currently do not have access to such facilities.

Figure 3.8 Map of learning

Tertiary Education
Informal Science Institutions
Secondary Schools
Informal Learning Institutions

3.4. Macro Context

At the UDISA, Re-Imagine Urbanism, conference in June 2016 Shaakira Karolia from the City of Tshwane presented the Sustainable and Inclusive Growth strategy for the city. She stated that the City of Tshwane will focus on education, agribusiness and tourism for the Tshwane 2055 vision. The city aims to drive access to education and to gain recognition as a global education, as well as a research and development hub. They want to expand the capacity in key skill gaps courses (Karolia, 2016). By increasing the capacity of these courses at tertiary institutions the City of Tshwane will have to have strong candidates graduating from high school to achieve these goals. Thus the proposal to upgrade an inner city secondary school that aims to shift the perspective of MST education aligns it self with the Tshwane 2055 vision and growth strategy.

The school is walking distance from informal science institutions like the Ditsong Natural History Museum, Burgers Park's greenhouse and is travel distance by bus from the Pretoria Zoo.

The South African Agency for Science and Technology Advancement (SAASTA) is also walking distance from the site. SAASTA is responsible for managing all 35 educational Science centres in South Africa and also a few across the continent.

The site is well connected with public transport and located near middle to lower income communities. Thus students that do not have the necessary resources, space and exposure at home can enrol in the school.

3.5. Block Study

Figure 3.12 Station's Place consist out of 3 properties

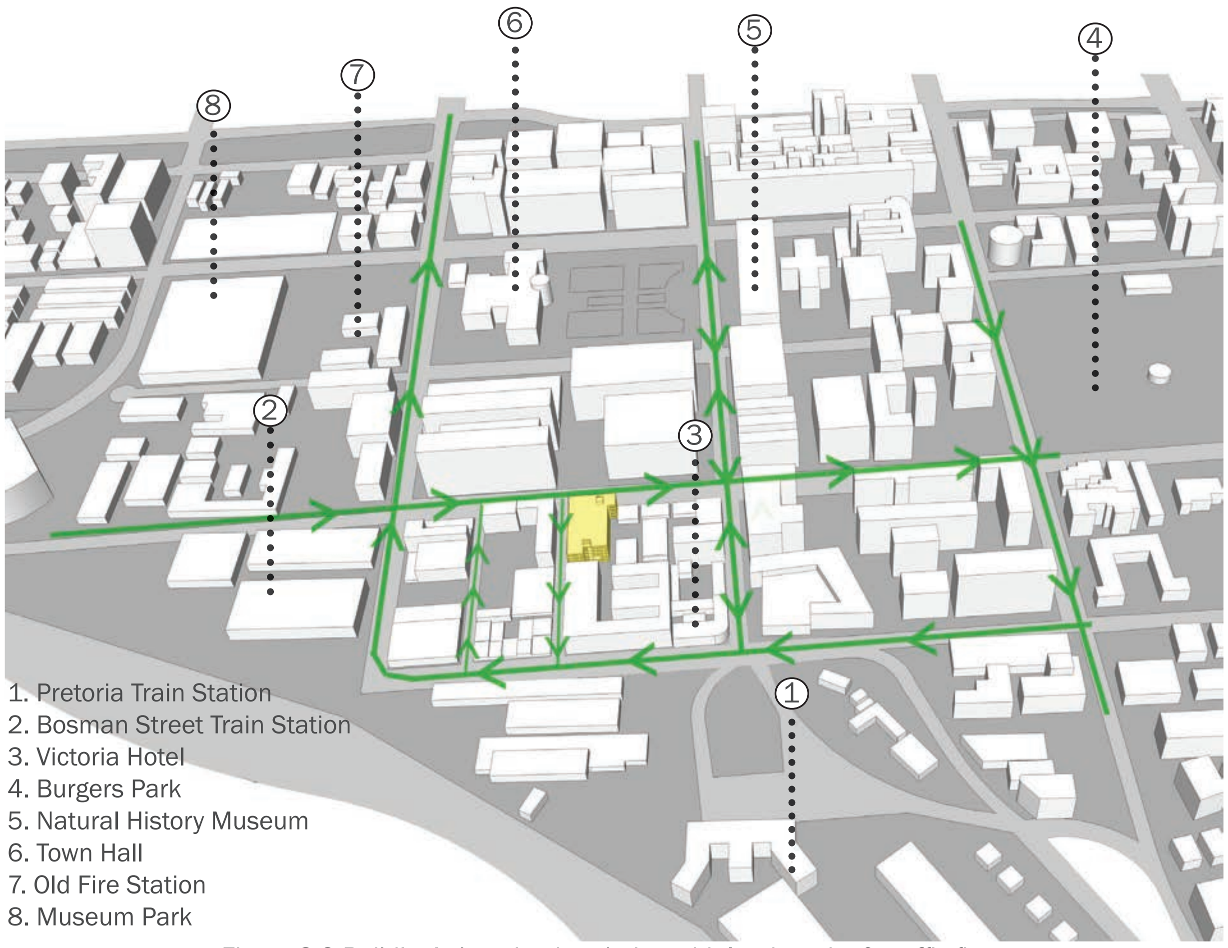


Figure 3.9 Building's location in relation with land marks & traffic flow

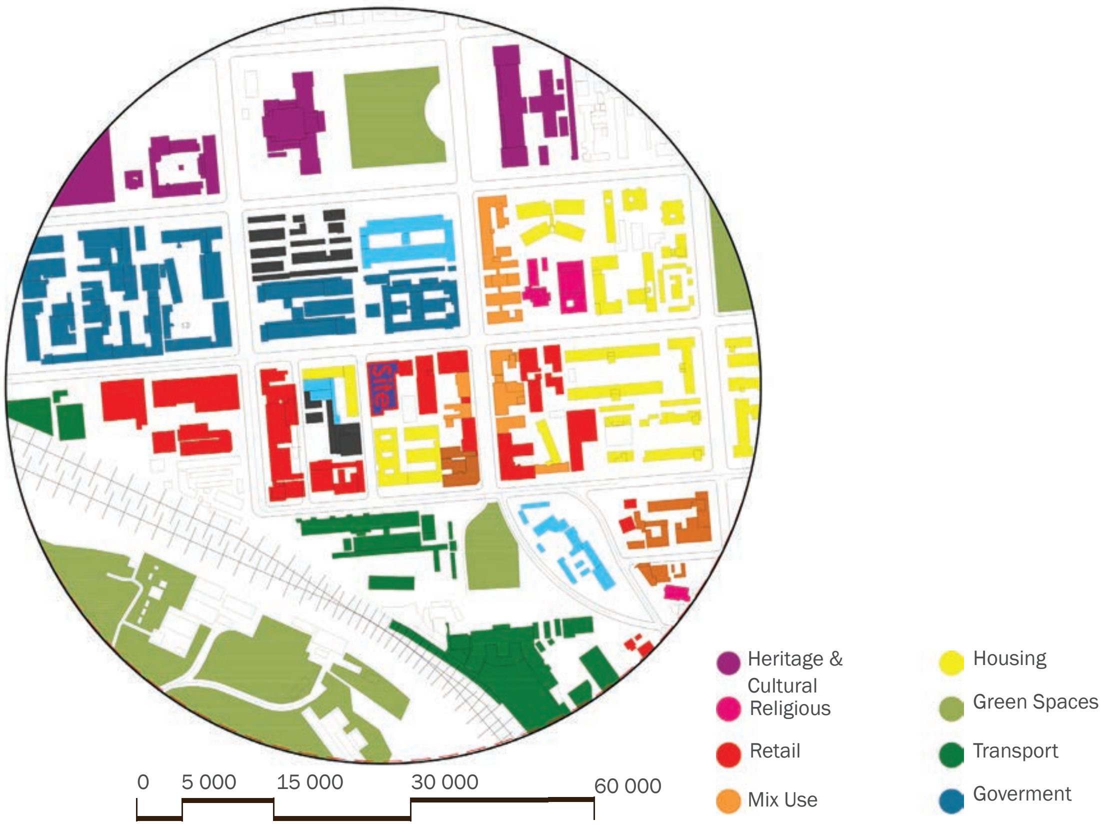


Figure 3.11 Map of Typologies

Currently the Jacob Mare Building belongs to City Property, it forms part of their block development known as Station's Place. They adapted the surrounding buildings' top floors into apartments and the ground floors into parking lots. Jacob Mare Building has two street-facing facades.

Christina Avenue is a narrow one-way street. No buildings face this street and its only used as side entrances to buildings or to reach bigger streets by car. Walls, fences, road signs and gates to side entrances are the characteristics of Christina Avenue and Hope Street (Le Roux and Botes, 1993: 43). Due to the narrow nature of this street the western windows of the school building has views into the apartments on the eastern edge of the street. It is not ideal that the semi-public classrooms look into their neighbours' private spaces.

Figure 3.10 Illustration of prominent features on the north eastern corner of the site.

Figure 3.14 Sun Study of block

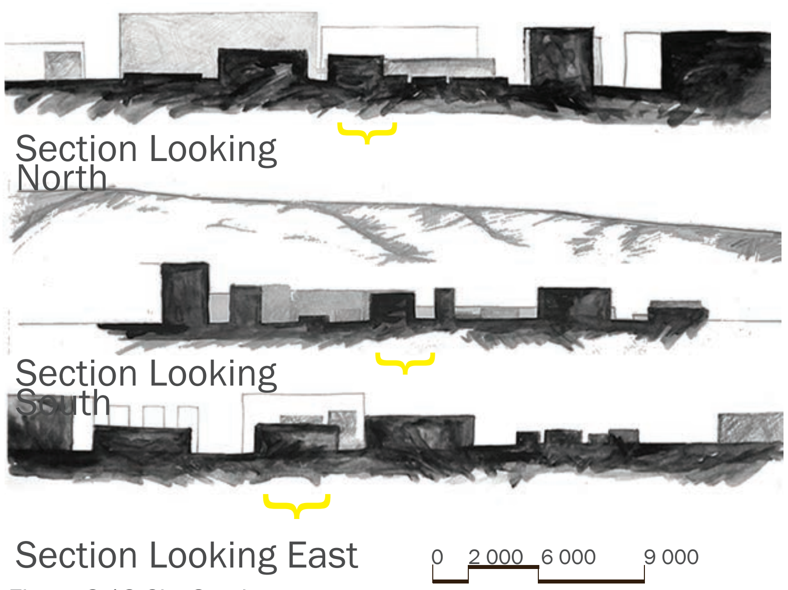


Figure 3.13 City Sections

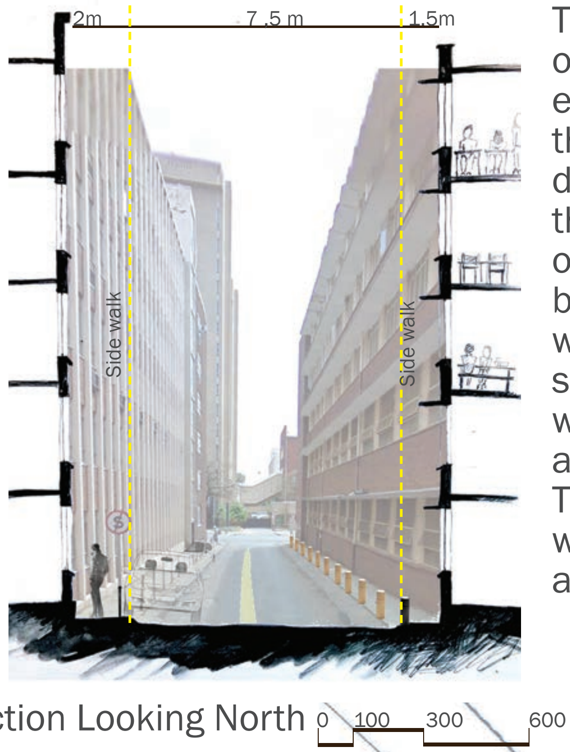
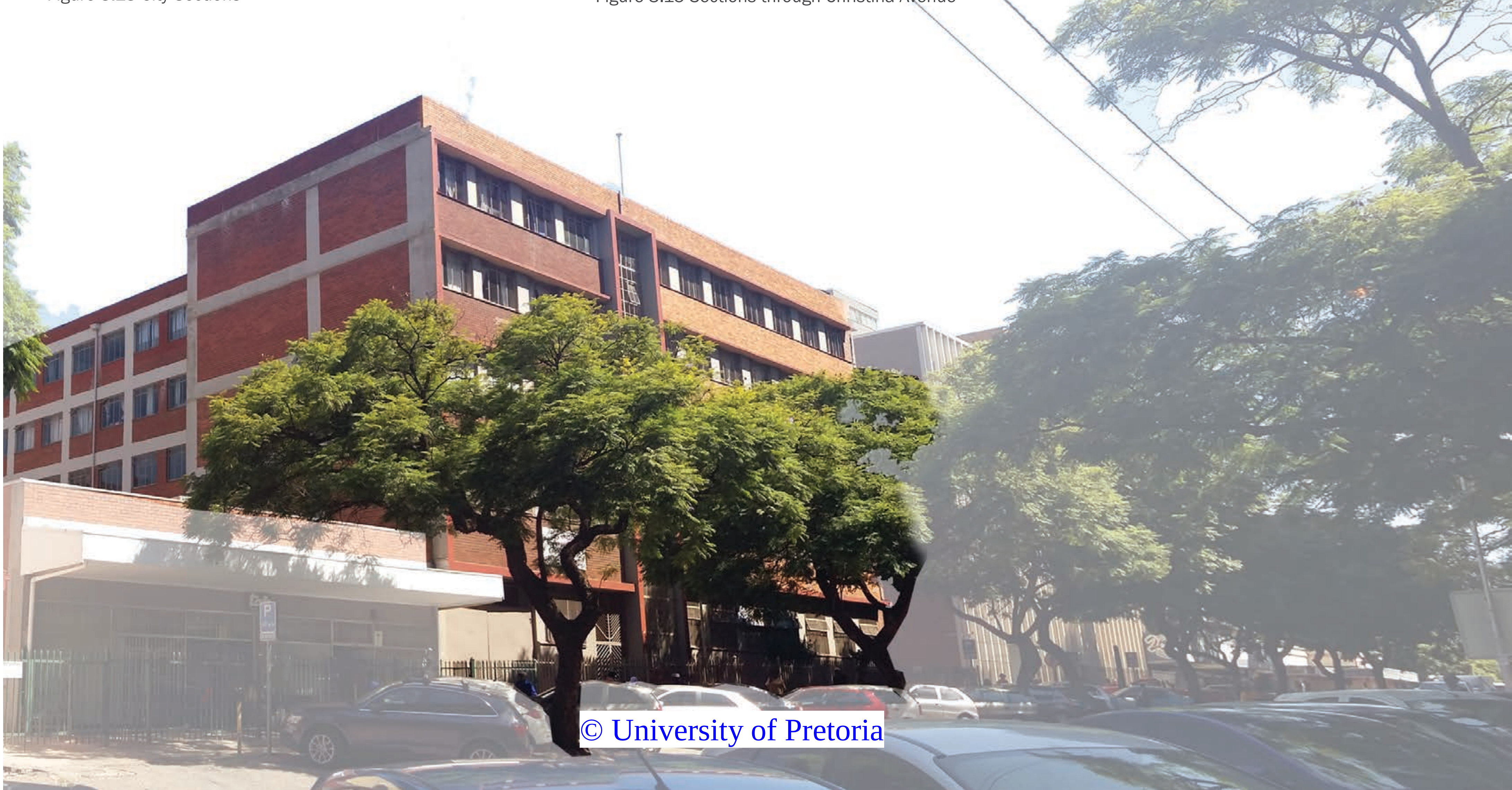


Figure 3.15 Sections through Christina Avenue

The western and north-western sides of the neighbouring buildings are either the same height or higher than the site. This influences the amount of direct sunlight the building receives in the late afternoon. The lower storeys on the western facade gets shaded by its neighbouring building which will help with solar glare and direct sunlight in the winter months, but it will also lessen the possibility for heat absorption through thermal massing. This side of the building will struggle with heat gain in summer and heat absorption in winter.



3.6. History

The building plans were approved in 1955. Designed by by Oscar Hurwitz and Murray Architects who, together with Pokroy, designed the second Poynton Building on 138 WF Nkomo Street in Pretoria CBD.

The building was originally designed to accommodate offices and storage facilities. In 2009 alterations were made to subdivide the storage rooms into classrooms. The original interior layout governed most of the new layout decisions. Most of the then existing walls were kept, even though they were never meant to house a school. The different original functions existed detached from each other and this detachment between storeys and spaces is still evident in the current interior.

The largest part of the ground floor housed storage and packing facilities. The first floor had offices and saddlers on the northern side and armoury store rooms were located on the rest of the floor. The second floor on the north-eastern side was allocated to tailors and the rest of the floor consisted of clothing store rooms. The third and fourth floors were mostly offices with administrative functions. These floors had ablutions and kitchens.

The floor finishes were mostly a granolithic finish in the store rooms, a linoleum finish in the corridors and a parquet finish in the offices and administrative spaces. These are still the predominant floor finishes in the building.

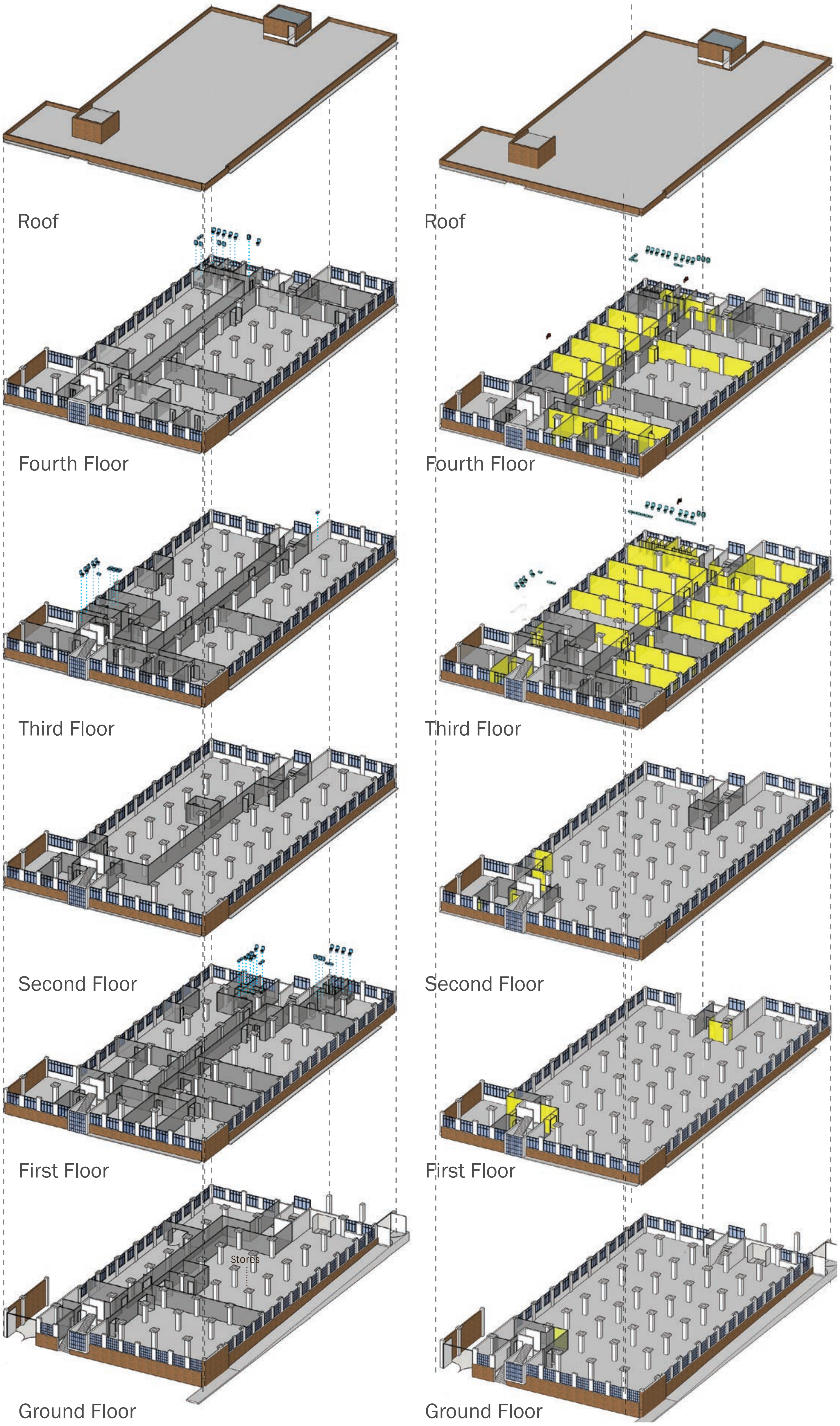
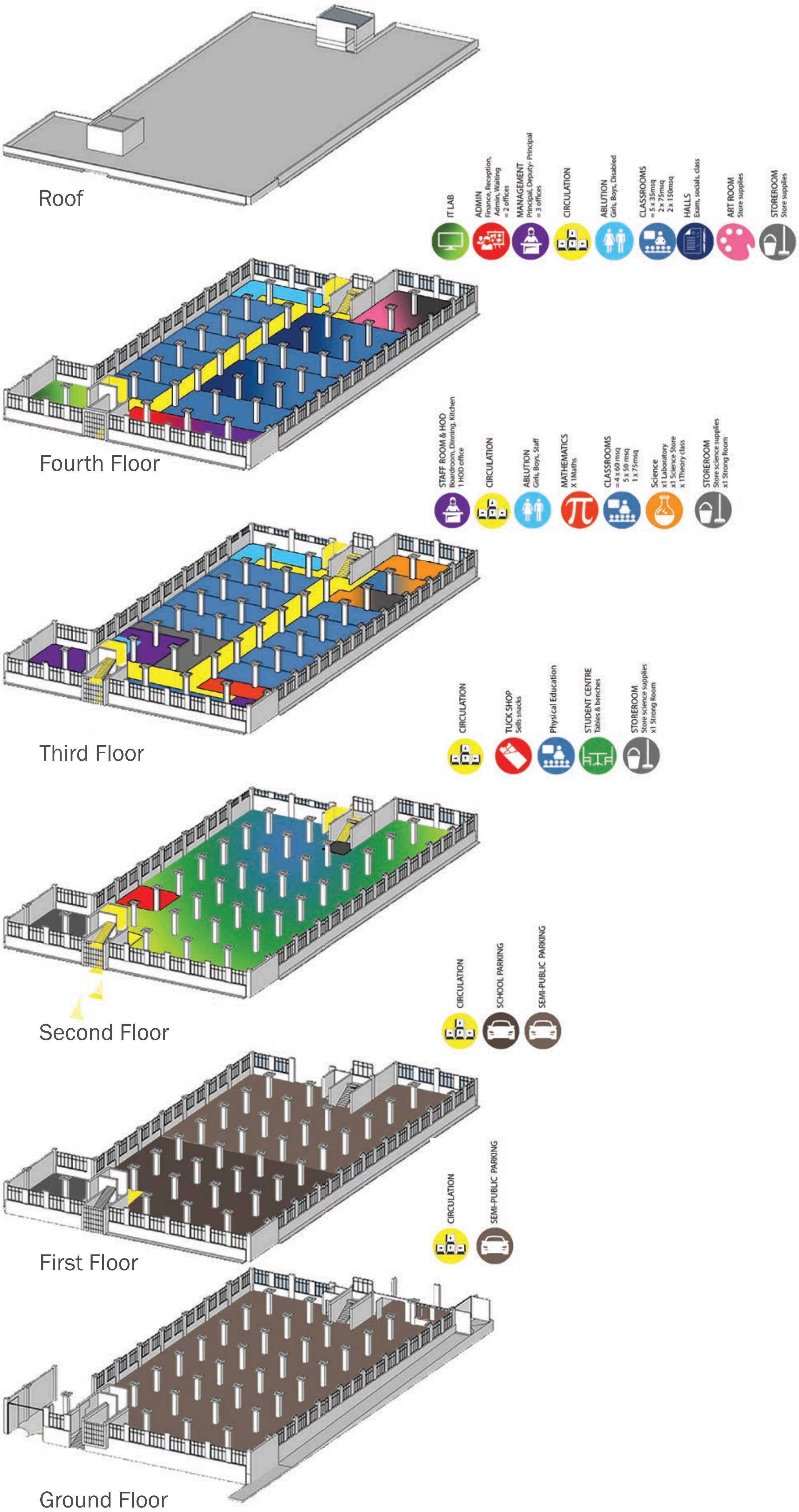


Figure 3.16 Axo of building appropriation over time

1955 Original Building

2009 Alterations in to School

3.7 Alterations



2016 Current Use

In 2009 City Property made alterations to the building to adapt it into a secondary school. From 2009 until now the interior had minimal alterations.

On the ground floor most of the interior walls were demolished. The two stairwells and lifts were maintained. Currently, the northern side of the ground floor houses a small foyer through which pedestrians may access the school. The rest of the floor is a parking lot rented out by City Property.

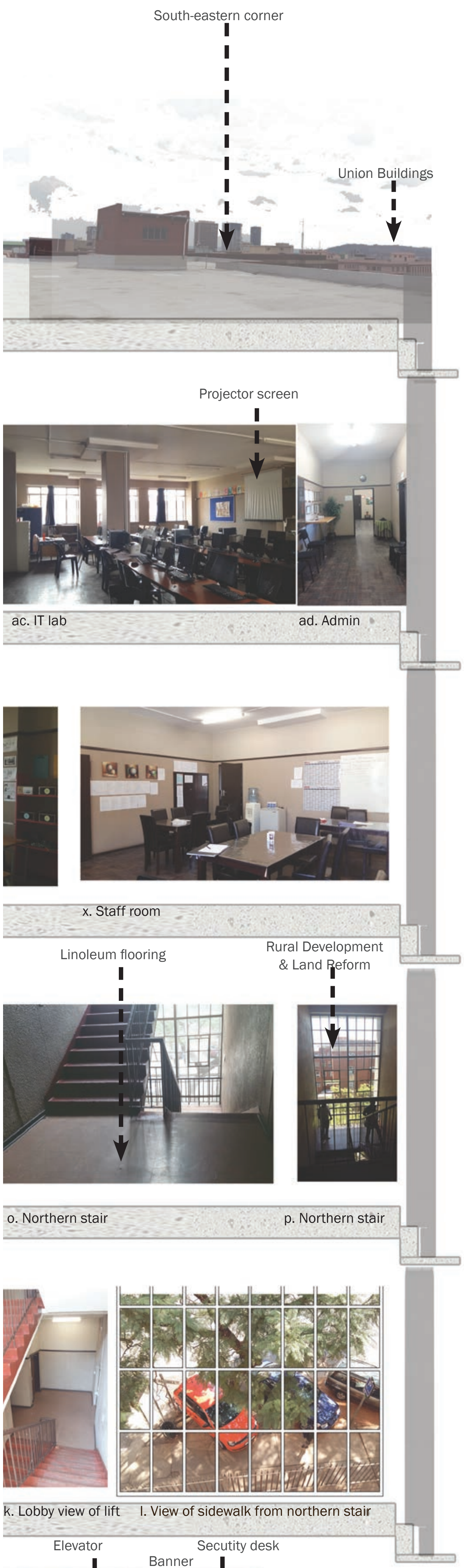
The first floor can be accessed by the northern stairwell or by a car ramp on the southern side. Most of this floor's interior walls were demolished to re-adapt it into a parking lot. The car ramp was added on the southern side.

On the second floor most of the original interior walls were also demolished with the intention that the floor may be rented out. Currently, the school uses this empty floor as their student centre and for physical education. After the 2009 alterations a tuck shop was added.

On the third and fourth floor most of the original interior was kept. The spaces were subdivided to form classrooms. The parquet finish was also kept.

3.8 Spatial qualities

Figure 3.17 Illustration of spacial qualities



3.8.1 Ground Floor

The school has no connection with the street and sidewalk. There is a sign on the northern facade with the school's name and this is the only indication that there is in fact a school inside the building. There is no place for pupils to wait in the mornings before school or for their transport after school. As a result, the building's appearance from the street is uninviting. The exterior of the building shows nothing of the school's identity.

The northern side of the ground floor is accessible from Jeff Masemola Street. Pupils and visitors enter the grounds from a bustling sidewalk through a palisade security gate. Behind the palisade fence there is a small garden with a planter and nine steps leading up to the foyer. These steps immediately exclude any children and teaching staff who may be in a wheelchair and makes it difficult and hazardous for users who have difficulties climbing stairs. The foyer leads to a security desk and from there the user has the option of using the stairs or the elevator to move up in the building to the school.

The elevator is out of date, with a large heavy wooden swing door that the user has to pull on to open. This limits the use of wheelchair bound users and/ or those who experience difficulties traversing stairs.

Behind the security desk is a banner with the school's slogan and logo. The foyer is a dark space with hard finishes. The security guard informs visitors where to go and he usually escorts them, leaving no-one to man the security gate. The rest of the floor is a parking lot. On the southern side the elevator is completely closed off and the stairwell only acts as a fire escape for the floors above.

3.8.2 First Floor

The first floor is used as a parking lot and a lobby to the northern stairwell and elevator. The parking lot is accessible through a vehicle ramp on the southern side of the building. The teachers park on this level. Again a palisade security gate divides the teachers' parking from other parking which is rented out to the public.

3.8.3 Second Floor

The student centre and break-out space is located on the second floor. The interior is almost completely bare. The concrete floor slab, soffit and columns overpower the spatial qualities of the space. The finishes are harsh and they reflect sounds, making the space extremely noisy during break times. There are timber benches scattered throughout the interior. A4 Papers with printed basketball hoops are stuck on the columns and there are a few broken table tennis tables in the corner. The windows wrap around the space letting in a lot of natural light. However, the floor plate is deep and as a result the sunlight does not penetrate so deep. The effect is that most of the space is in relative darkness, while the exterior edge is lit by a bright strip of sunlight, which causes uncomfortable glare. The space is lit by fluorescent tube lights.

3.8.4 Third and Fourth Floors

The original layout still has a strong presence in the layout of these two floors. The corridors were kept intact, resulting in long, narrow and dark circulation spaces. There are windows high against the soffit between the corridor and classrooms. Each classroom has a door leading into the space. Thus, when the doors are closed there is no connection (physical and/ or visual) between the different spaces, classes, age groups or subjects.

The larger classrooms are also used as exam halls and for social events but when teaching happens the columns restrict the use of the class a great deal, as the desks are arranged for a clear view of the teacher and board. The rest of the class becomes wasted space. The finishes in the classrooms are hard surfaces, thus sound is reflected and the rooms have an echo-quality that interferes with audibility. Audibility is one of the basic needs as identified in The Third Teacher (O'Donnell et al, 2010:8) .

3.8.5 The Corridors

The classrooms are reached by long dark corridors with no articulation or places of pause. Aside from the staircase and elevator, there is no visual connection between levels, which leaves the individual storeys disconnected as well as visually and socially unstimulating. The same happens in the classroom spaces, they become disconnected from the corridors and adjacent classrooms, compartmentalising learning and restricting educational exchange.

3.9 Classrooms

The author spent a day in the school as an observer. The layout of the Science laboratory and the Science and Mathematics classrooms were sketched out. Furniture, chairs and equipment together with the students' and teachers' movements and interactions were mapped over layout sketches.

The first lesson was a science theory class. The teacher's desk was located at the back of the room and the white board at the front. The teacher stood in front of the class and used the white board to explain theory, concepts and the application thereof. He adapted two normal school desks as a desk in front of which he can stand. Students choose their own seats and some students moved desks during the theory class. Some students preferred to sit alone and others were more interactive with each other.

There was a lot of clutter at the back of the class. The shapes of the desks are not ideal as they do not allow the desks to be placed side by side. This leads to the space feeling disorganised and it also limited the possible interior layouts of the classroom.

The second lesson attended was a Science practical. The students were excited when they were told that they should go to the lab. In the lab there were a few Science objects displayed on a table. The lab desks are long timber tables that are 730mm high. These tables were fixed to the floor and the way that they were arranged made working in groups less effective. Also, their height meant that it would not be comfortable to stand while busy with a practical investigation.

The lab was located at the far end of the school, completely off-limits for pupils who did not take Science.

If pupils in younger grades were allowed to glimpse into their future, this could potentially trigger curiosity and interest.

The Science store was the most exciting and interesting space in the whole school, yet this space was locked and hidden away for exclusive use by the Science teacher. While the equipment and chemicals stored here spark a sense of endless possibilities and discoveries to be made.

The Mathematics classroom had a rigid layout. The desks were placed in neat rows and the students filed into the spaces from the front. The natural light was blocked out by a curtain and the teacher used a projector and screen to explain mathematical problems. Some pupils sat quietly, but one student became fidgety in this environment even though he was enthusiastic about participating.

Figure 3.18 Mathematics class

Figure 3.19 Science store

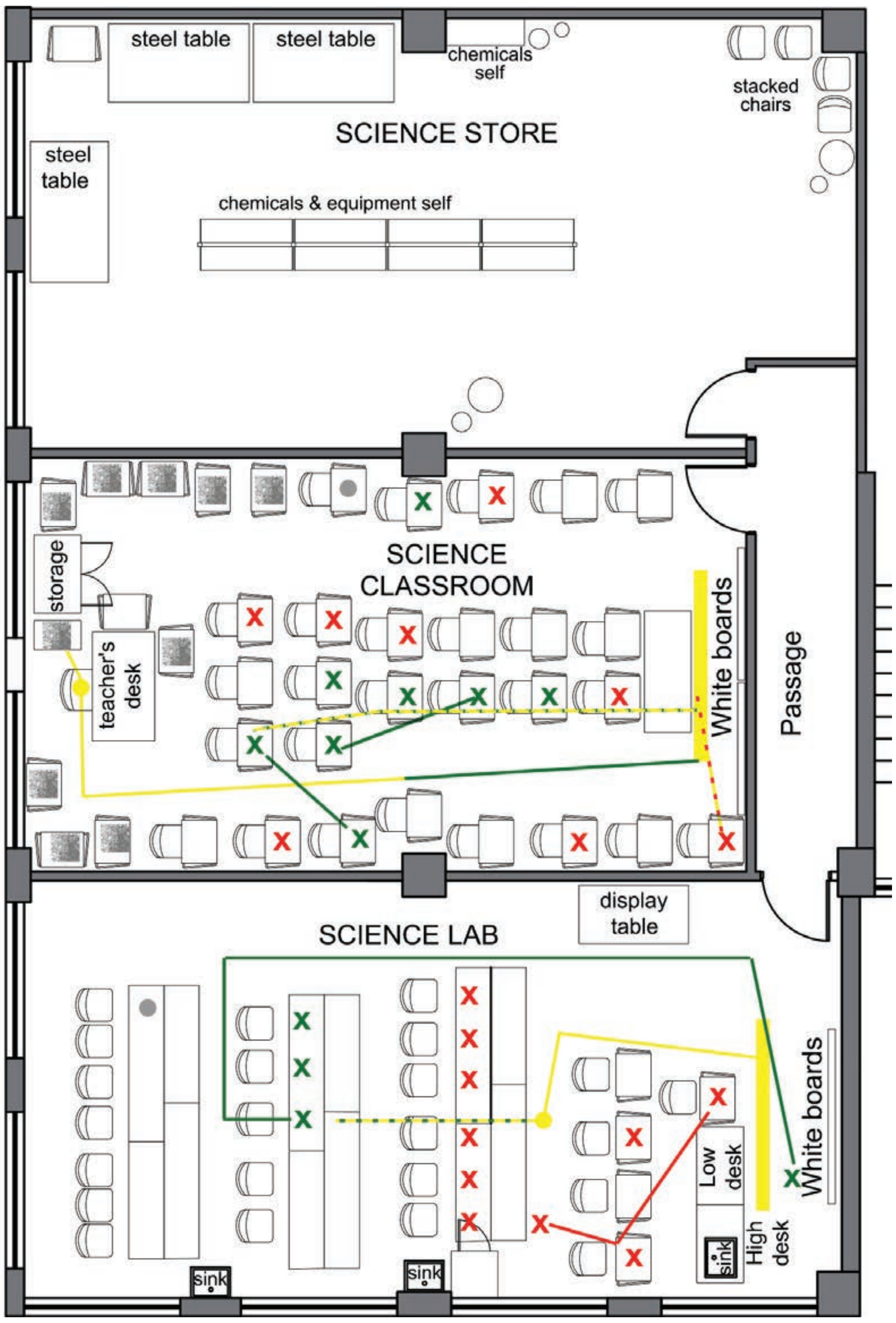
Figure 3.20 Science laboratory

Figure 3.21 Science theory class

Figure 3.22 Science theory class

Science Theory
Gr12 at 10:00 -11:00
15/04/2016
14 pupils

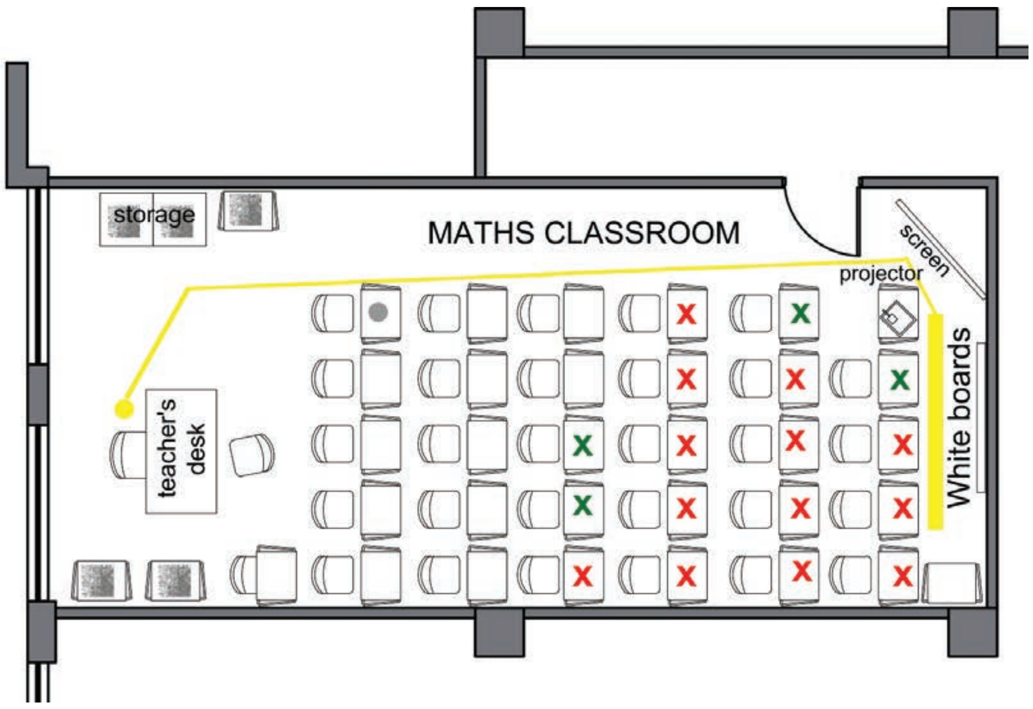
Science Practical
Gr10 at 12:00 -13:00
15/04/2016
11 pupils



Science Class

Figure 3.23 Plan diagram of user interaction

Maths
Gr10 at 13:00 -14:00
15/04/2016
17 pupils



Mathematics Class

Figure 3.24 Plan diagram of user interaction

3.10 Interior Climate

3.10.1 Lighting

Most of the daylight in the interior penetrates from the eastern and western facades. The school day currently runs from 07:50 until 14:00, thus the classrooms on the eastern side of the building receive direct sunlight for most of the school day. The occupants block out the direct sunlight through additions like curtains and blinds. In the process most of the daylight is blocked out and the occupants depend on artificial fluorescent tube lights to provide them with the appropriate lux levels. A solution is needed where the direct sunlight is prevented, to be able to penetrate into the interior spaces and still allow the occupants to make the most of the natural, free and healthy sunlight available to them.

The building has a deep footprint, thus it becomes essential that the fenestration design and material specifications allow the daylight to be reflected into interior spaces as deep as possible. Currently the ceilings are painted white which aids with the reflection but the floor finishes in the classrooms are dark with a low light reflection factor. There are no light shelves, thus the floor becomes an important element which should reflect the daylight.

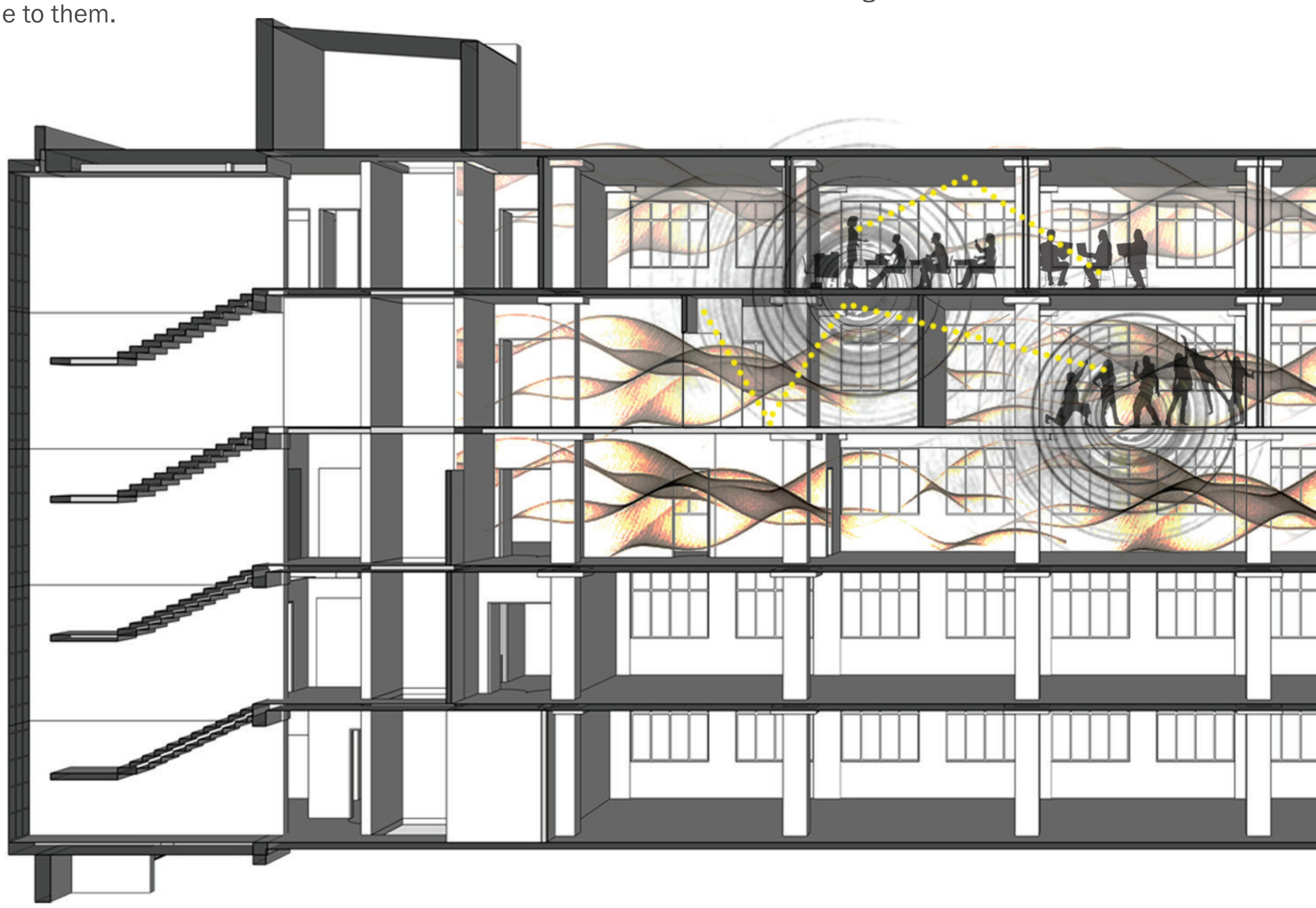
The classroom wall also does not allow sunlight into the corridors, thus the corridor spaces are lit artificially.

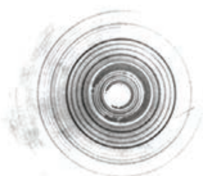
3.10.2 Interior Acoustics

The building interior consists of many hard, sound-reflecting surfaces. The classroom acoustics are not appropriate for teacher-fronted lessons even though that is the main method of instruction.

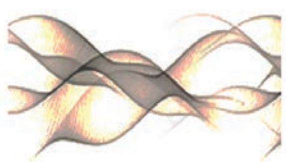
Also, the hard surfaces lead to the generation of impact sounds. These sounds travel through the concrete slabs affecting the classrooms underneath and around. Thus, each person in the building generates unnecessary sounds when they walk or pull out a chair.

Many of the acoustic problems in the school can be solved by providing appropriate surface finishes to the building.





Impact noises travelling through slab

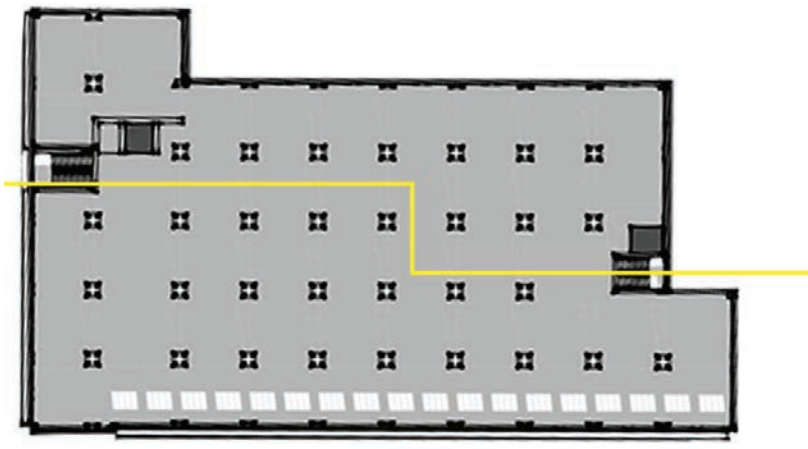


Parallel surfaces causing a lack of sound dissipation

Representaion of sound reflection off hard surfaces

3.10.3 Ventilation

The school currently makes use of passive cross-ventilation. The building has a deep footprint which is not ideal for passive cross-ventilation. The classroom walls adjacent to the corridor contains high set louvre windows which should allow the air to ventilate into the corridors. Unfortunately the corridors are not ventilated, thus the air movement between the classrooms and corridors are too slow to properly remove stale air from the building. Also, due to acoustic reasons some teachers prefer to close the louvres to the corridor preventing cross-ventilation.



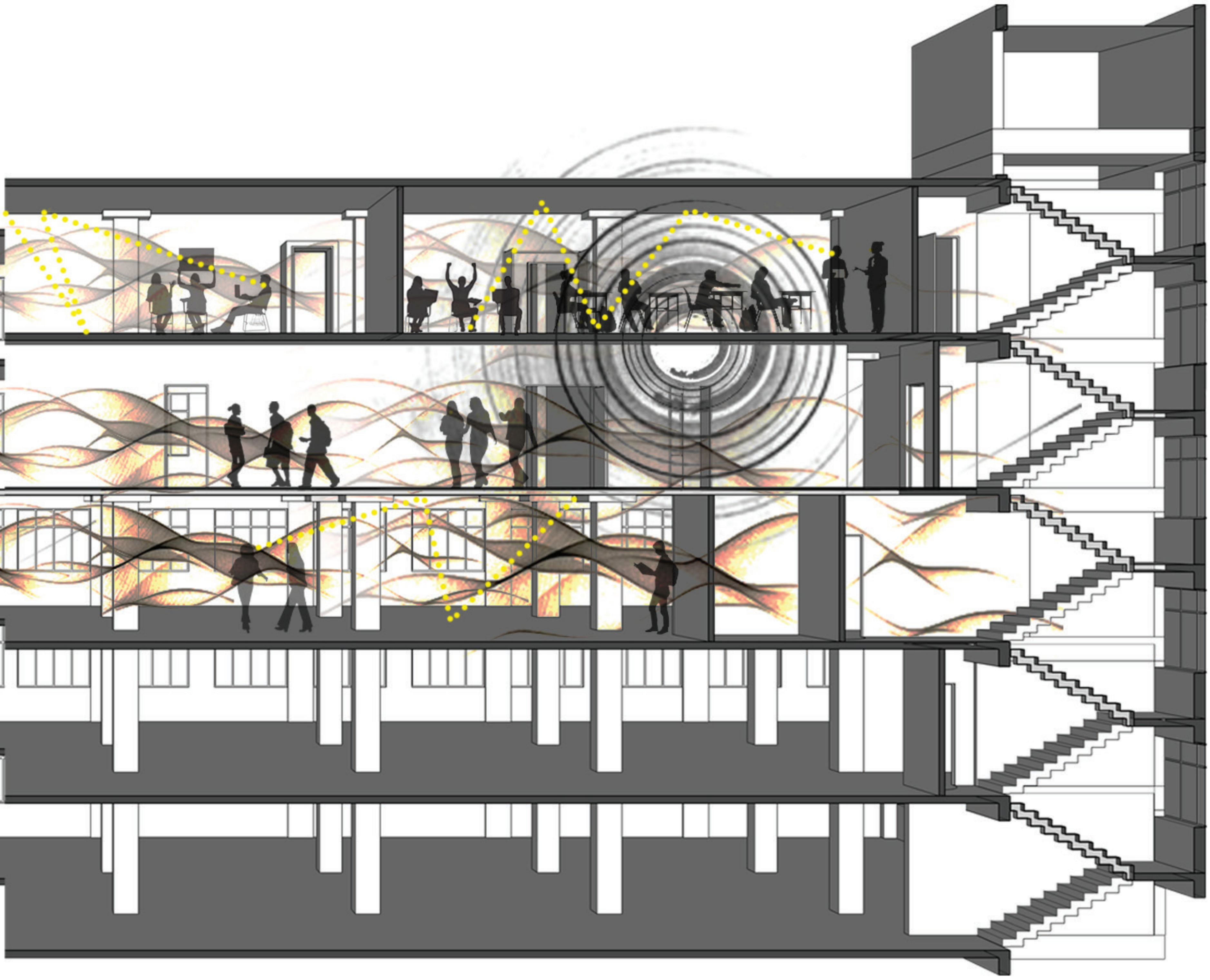


Figure 3.25 Illustration of acoustic qualities

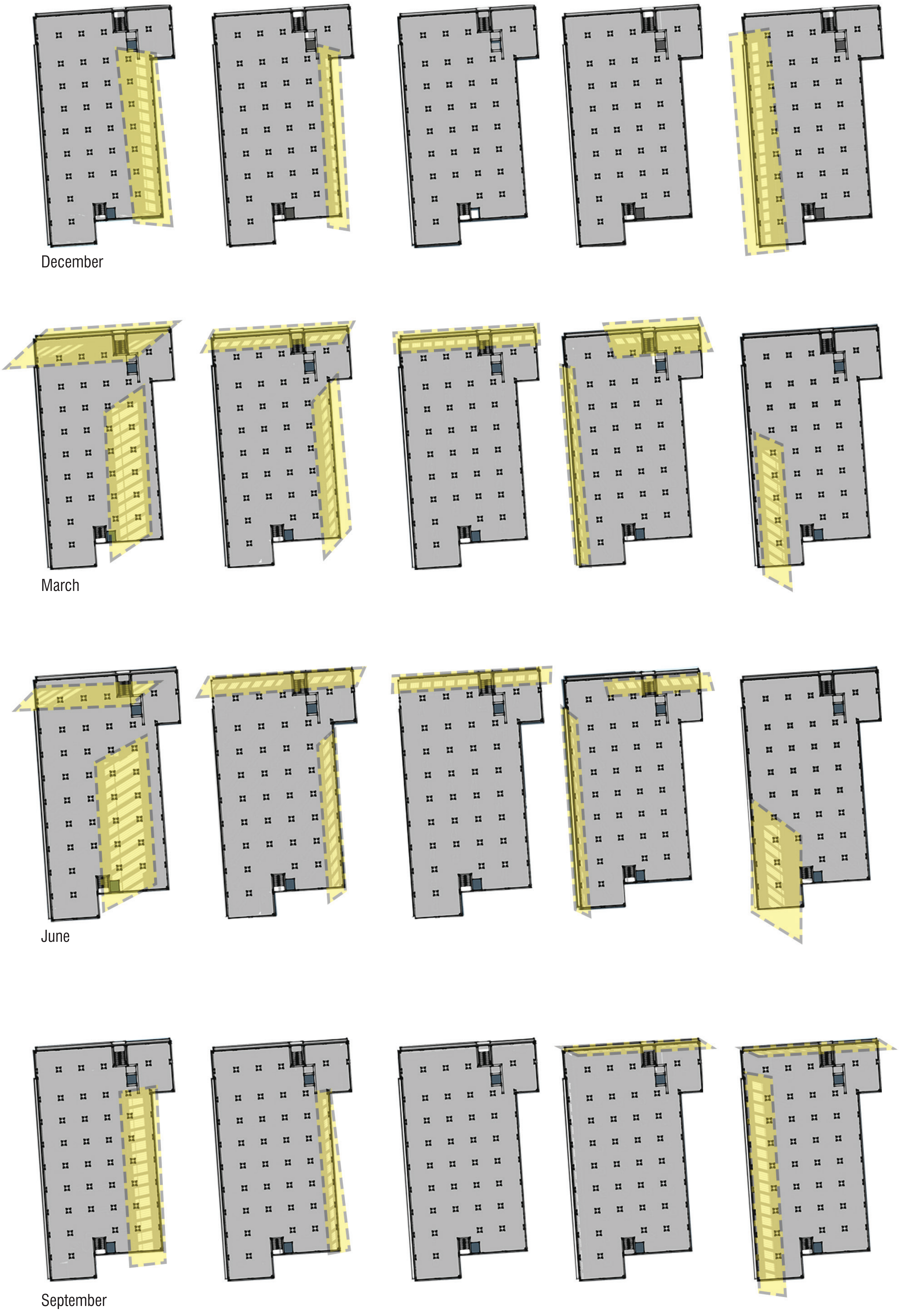


Figure 3.26 Interior sun study

3.11 Conclusion

The school's current layout is the result of the adaptive reuse of a building originally intended for industrial use and storage. The current interior does nothing special to enhance learning except to provide a number of autonomous classrooms arranged along a long, dark, narrow corridor.

There are potential educational and stimulating elements, but these have been locked away in the storerooms. There is potential for the building itself to activate interest and excitement about learning, but this has been left untapped, locked away in the building's structure and facade.

The different levels of the school, the classrooms on those levels, as well as the school against the backdrop of a city, exist disconnected from each other.

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04

4. Case Studies & Precedent Studies

4.1 Introduction

The following chapter will investigate case studies of local schools and a Science centre. These case studies were conducted to determine appropriate local approaches to MST education promotion. Investigating how resources can be shared between communities, how an interest in Science can be stimulated and determining how adaptive reuse of building stock can provide good practice educational environments in our city centres.

Precedent studies will be conducted to determine how the built environment can promote community, collaboration and how a school can resemble real life. Museum education will also be investigated to determine how informal MST education can happen through Art and the natural environment.

4.2 Case Studies

4.2.1. Streetlight Schools

Typology: Primary school
Location: Jeppestown, Johannesburg
Architects: Fieldworks
Completion: 2016-ongoing
Green Star Rating: 4-Star SA Interiors rating

Background: Streetlight School is located in Jeppestown, Johannesburg. It is an inner-city school housed in an office building which was adapted into a school. The school is a work in progress and will expand as the oldest grade moves to the next grade. Currently, the school has only grade R and grade 1 pupils.

Streetlight Schools are low-cost, innovative primary schools based on a model that focuses on inquiry, exploration, collaboration, relevance, and the use of technology to teach and learn. This approach empowers pupils to master core skills while developing curiosity through project-based learning (SolidGreen, 2016).

In 2016 the Streetlight Schools opened the first school in a mixed-use building located opposite Jeppe Park and walking distance from Jeppe Station. The school initially started as an after-school programme and after two years evolved into a school for 45 pupils. The school plans to expand to 200 pupils in the near future (SolidGreen, 2016).

The architects aimed to establish an interactive learning environment by creating spaces that would strengthen the Streetlight Schools' curriculum. Through adaptive reuse they created a low-cost interior which merges with a high-technology learning model. The school is a multi-functional learning centre which uses green construction principles as far as possible (SolidGreen, 2016).

In February 2016, the total cost spent on the 1,200 sq m project stood at R1,5 million (SolidGreen, 2016). Through the clever use of material, the reuse of existing inner city building stock and systematic expansion the interior of the school presents an affordable solution for the provision of educational facilities in the city of Johannesburg.

As far as possible the design was material-efficient. Dry-wall offcuts,

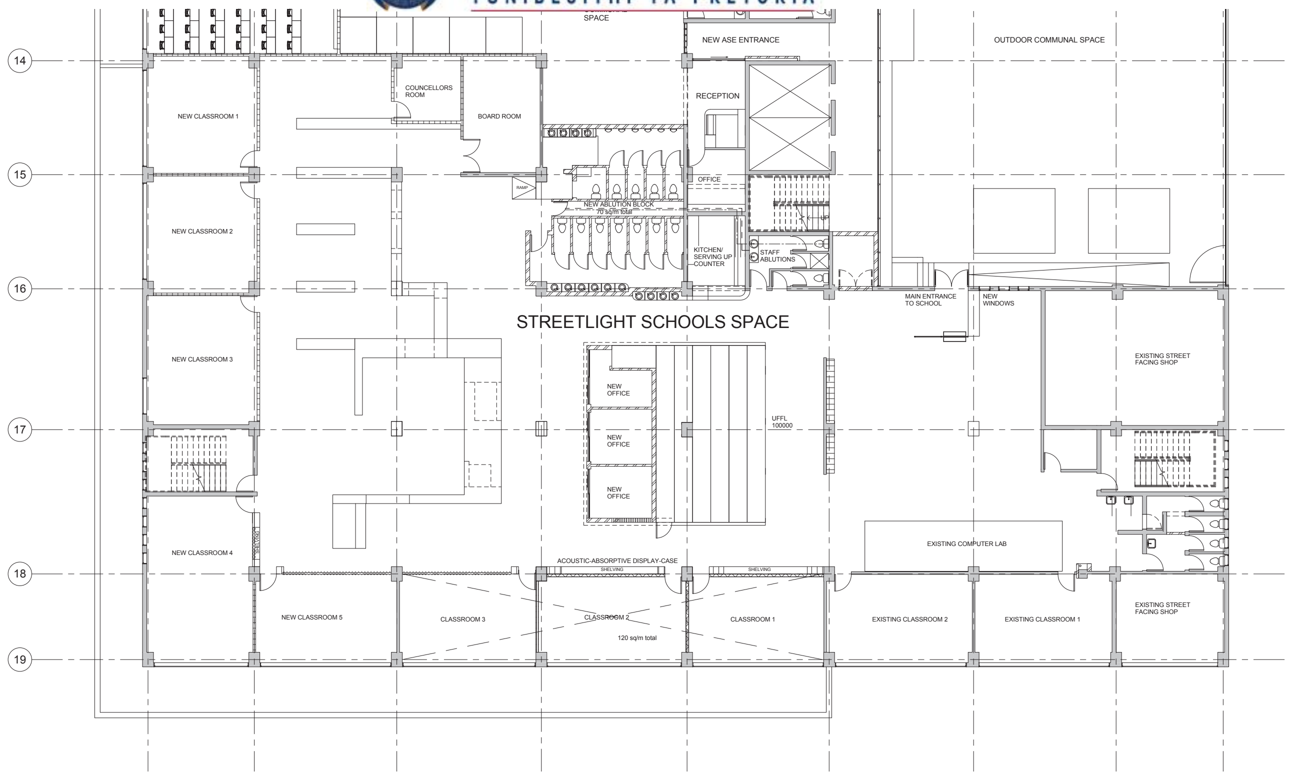


Figure 4.1 Plan of interior layout (Fieldworks,2016)

recycled wooden pallets and reclaimed wooden flooring were used in the project. The bricks and rubble from onsite demolition work was reused (SolidGreen, 2016).

Situated in an area of Johannesburg where the recycling and reclaiming of scrap metal and materials plays a major part for some of the businesses, the school's interior brings reclaimed elements into the school, connecting the city character with the interior. The interior is built out of affordable and easily accessible materials which are used in innovative ways.

The building: Classrooms are placed on the periphery and alternative educational spaces are placed at the core of the school. These spaces have an ambiguous quality enabling them to be used in multiple ways.

One striking feature of the design is the playwall that acts as a divide between different programs without detaching the spaces from each other. The playwall contains niches and spaces that can be used in different ways.

The walls of the classroom are constructed out of a dry wall system that was detailed to form deep window sills. The interior side of the classroom has a gypsum board layer and the exterior wall is clad in a black mesh with timber slats. The interior of the wall contains sound absorbing insulation. Polycarbonate sheeting installed on both sides of the dry walling studs function as large windows on the interior classroom wall. The polycarbonate allows views in from the darker passages beyond, while at the same time obscuring the view out from the lighter classrooms. The polycarbonate sheets also ensure that natural light reaches into the deep interior space.

Lessons learned:

- Alternative educational spaces can be created by using cost effective materials.
- By providing ambiguously programmed spaces students and teachers can use the space alternatively.
- Through cleverly designed details it is possible to create visual links to classrooms and in-between spaces without disrupting the education process.

Figure 4.2 Photo of classroom wall detail (Author:2016)

Figure 4.3 Photo of aquaponics (Fieldworks, 2016)

Figure 4.4 Photo of open theatre space (Fieldworks, 2016)

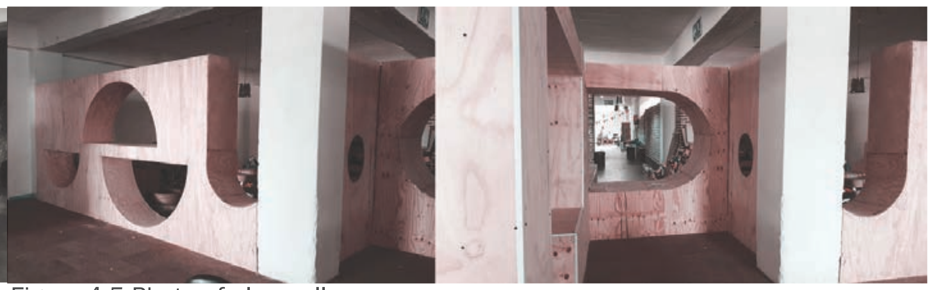


Figure 4.5 Photo of play wall (Fieldworks, 2016)

Figure 4.6 Photo of play wall with ambiguously programmed space (Fieldworks, 2016)

Figure 4.7 Photo of classroom walls with polycarbonate sheet for windows (Fieldworks, 2016)

4.2.2 Bambisanani Community Learning Program

Typology: Science and mathematics facilities
Location: Grantleigh Schools, Mposa, Kwa Zulu Natal
Sponsors: Richards Bay Minerals (Building & transport)
Rotary International (IT)
Architects: TJA - Richards Bay
Completion: June 2012

Students talking about their experience of the project in an online video interview with Bambisanani:

"Now I find life so exciting, so exuberant so much more extra super-sonic."

"I'm doing grade 12, it made me realise that Science is part of how we live everyday. I just got motivated to do my work, to love Science and Maths. Everything is so perfect. The teachers are patient, they make you understand so easily. Everything is perfect. Thank you."

"It's like a dream come true, I've always dreamed of improving my marks in Physics and Maths and they have been improving since I started the Bambisanani project. I'm so grateful, it shows that my future are becoming brighter."

"Especially attending here we help other learners in our school because we take the information that we get here and use it in our school. It helps us, we help one another." (Bambisanani Learning Community Project, 2013)

Background: The Bambisanani project is an example of a multi-disciplinary collaboration where Grantleigh School, an independent school in Richards Bay, together with Richards Bay Minerals (RBM) owned by Rio Tinto, TJ-Architects and the Department of Education partnered to create a Science and Mathematics facility which is intended both for the students of Grantleigh as well as for students from fourteen local rural schools who demonstrate remarkable potential (Bambisanani Learning Community Project, 2013).

360 promising students from Grade 10 to 12 from surrounding schools visit the educational premises for 35 sessions during the course of a year. The learners attend lessons in STEM related subjects, including Mathematics, Science and English. Through this project these learners get access to highly skilled teachers and they are exposed to state of the art Science and Mathematics resources (Bambisanani Community Learning Program, 2013).
They are also exposed to high-tech environments and smart-classrooms. A problem in rural schools is that due to lack of facilities and skilled teachers, students are never able to do experiments. Bambisanani offers them an opportunity for hands-on experience with the many experiments which form part of the Curriculum Assessment Policy Statements (CAPS).

Grantleigh Schools also conduct several teacher training seminars each year. The Science and Mathematics teachers from surrounding schools are invited. Here they have access to lecturers from various South African universities. Workshops are provided by Grantleigh School's staff to cover difficult sections of work (Bambisanani Learning Community Project, 2013).
Shaun McMurtry, headmaster of Grantleigh Schools, in an online interview (2016) stated that the independent sector of schooling recognises the responsibility it carries in terms of its privileged position with regard to access to resources, expertise and facilities. Thus, to extend these resources to the youth from the local rural communities, Bambisanani, which means we stand together in isiZulu, was formed. By recognising that through a collaboration of industry, private schooling and state education we could arrive at a situation which benefits students from local schools which form part of the partnership agreement (Bambisanani Learning Community Project, 2013).
The main purpose of the Mathematics and Science partnership is to ensure that students with potential will be able to apply at universities of their choice for STEM related careers like engineering, metallurgy and geology, which will allow increased opportunity to work in the mining industry.

The building: The roof of the building is reminiscent of the ribcage of a mammal. The bent steel roof of the building reaches down, almost touching the ground at the entrance to the auditorium. The roof exposes how the structure works. The ventilation ducts are exposed and painted in bright colours.

The facilities consist of a double storey Science centre. The building can be divided in two halves. The theory classrooms are located on the western side and double up as the practical laboratories. The eastern side is an auditorium space.

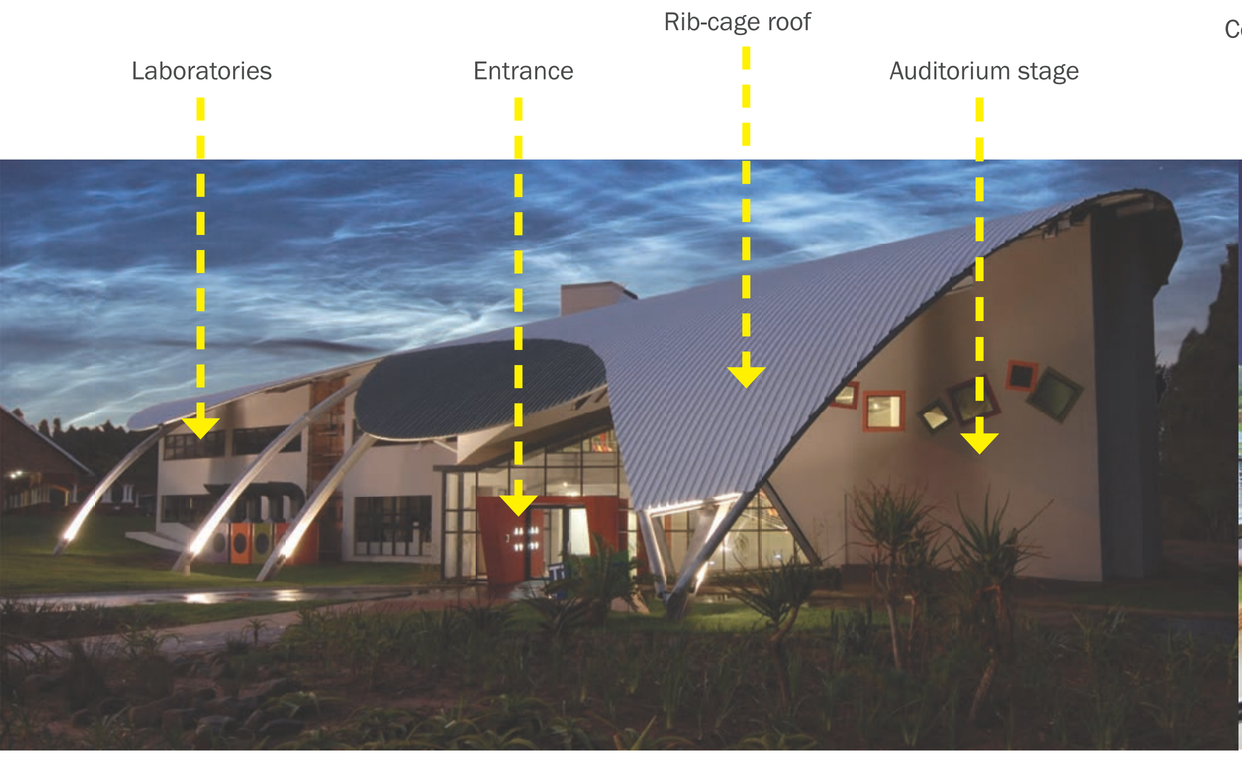


Figure 4.8 Photo looking north-west of Science building (TJA)

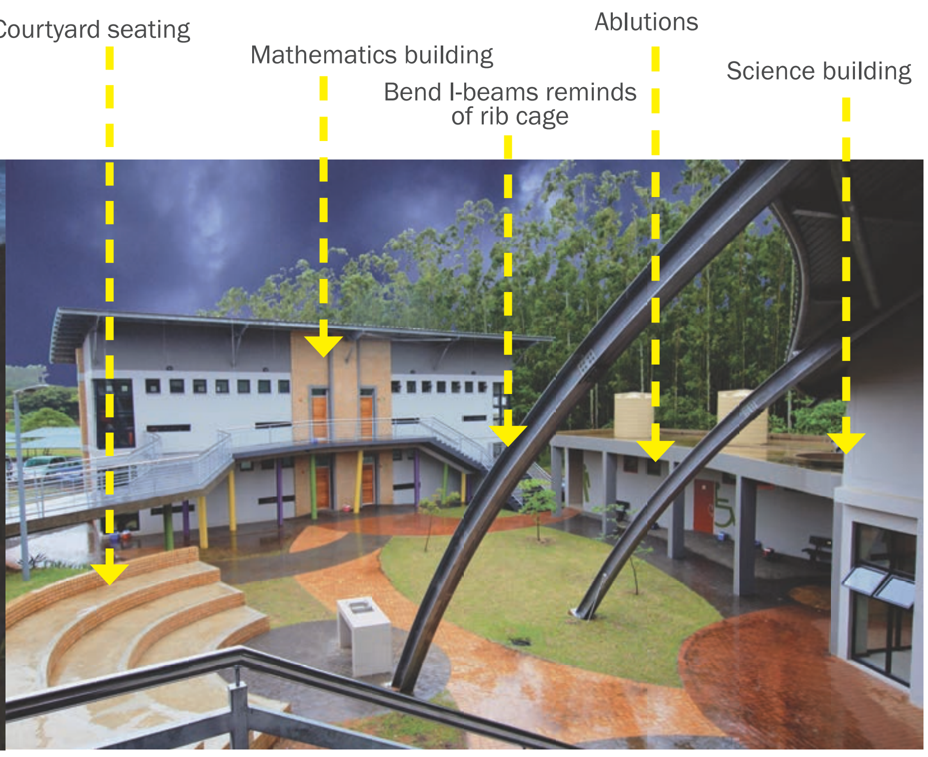


Figure 4.9 Photo from Science building looking out on courtyard (TJA)

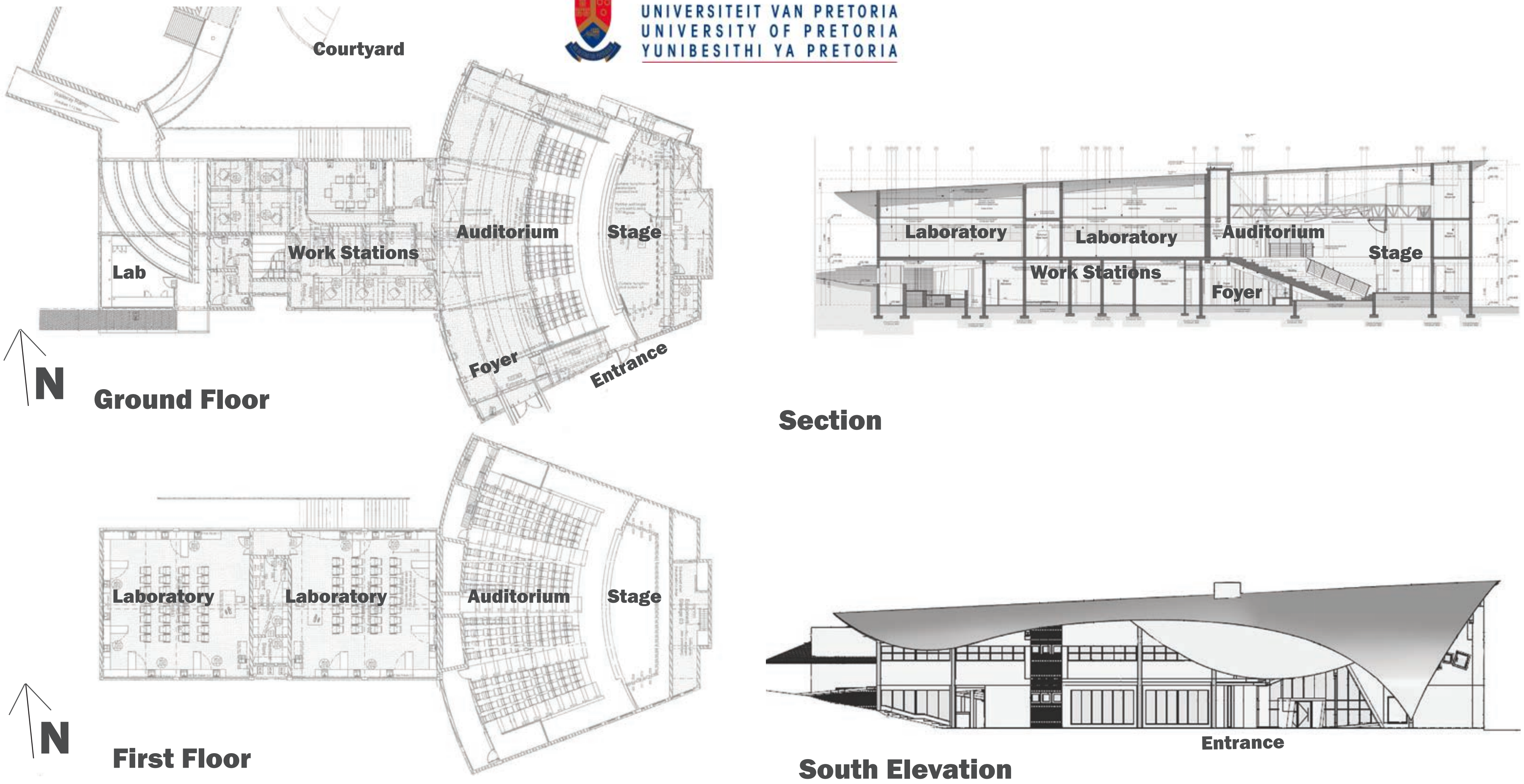


Fig. 4.3 Architectural drawings of the science building (TJA, 2011)

The Auditorium: The stage in the auditorium functions as a laboratory where Science shows can take place. Here Science experiments can be demonstrated on stage in front of a larger audience. The demonstrations are also projected on a screen at the back of the stage. The stage is raised with four steps which improves the view for the audience but divides the audience from the demonstrators creating a theatre-like experience.

The Science show is ideal to get pupils excited about Science and to demonstrate concepts through real life experiences.

The science classrooms and laboratories: The desks are regular seating height with regular height chairs. There is a clear view to the front of the classrooms where the smart board is installed. The tables are rectangular and can easily be rearranged into different configurations. Sinks and fold-out laboratory tables are fixed around the edge of the classroom, allowing for flexible use of space. These laboratory tables are at a comfortable standing height. Some of the plumbing for the basins and the ventilation system are exposed adding an informal educational layer to the space.

The floor also indicates to the user how the furniture should be arranged for the space to function optimally. Computer stations are situated in the back corners of the classroom.

The Mathematics classroom has smaller desks and soft seating. Here the floor finish does not inform layout and the desks cannot be placed side by side due to the desks' legs. The room seems disorganised due to the desks.

Lessons learned:

- Science should be exhibited in a way so that interest and excitement is sparked in pupils, as done by a Science show on the stage in the auditorium.
- The building in itself houses opportunity for informal learning. Here the architects exposed the services.
- The furniture should be designed in such a way that it can be rearranged easily without becoming disorganised.
- Science experiment tables should be at an ergonomic height comfortable for standing and working.
- The interior elements can educate the user how the space can be used, as in the case of the Science laboratory where the floor finish becomes an educational tool.

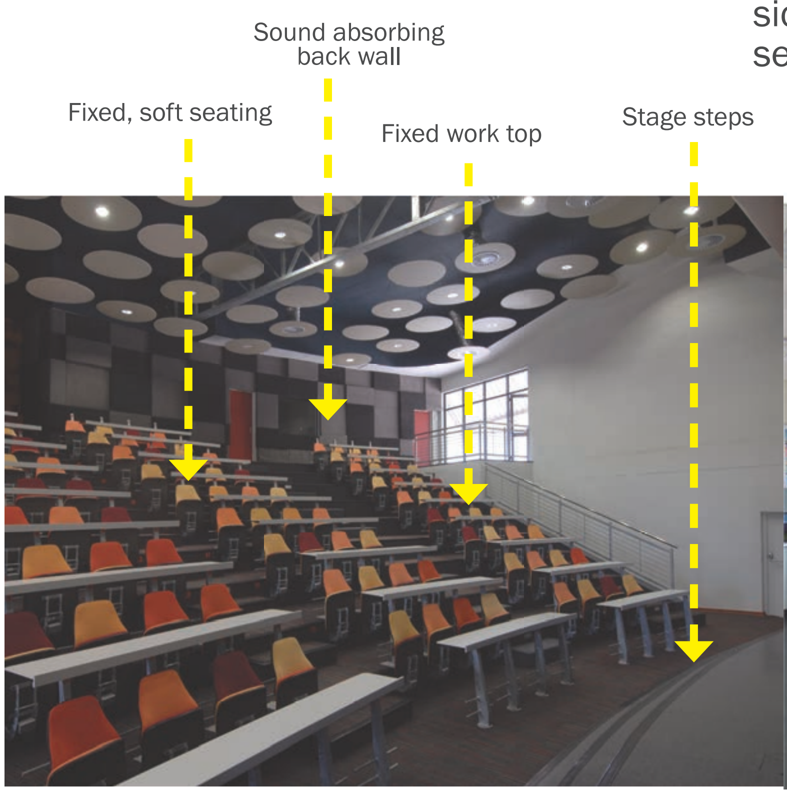


Figure 4.10 Photo of auditorium seating (TJA)

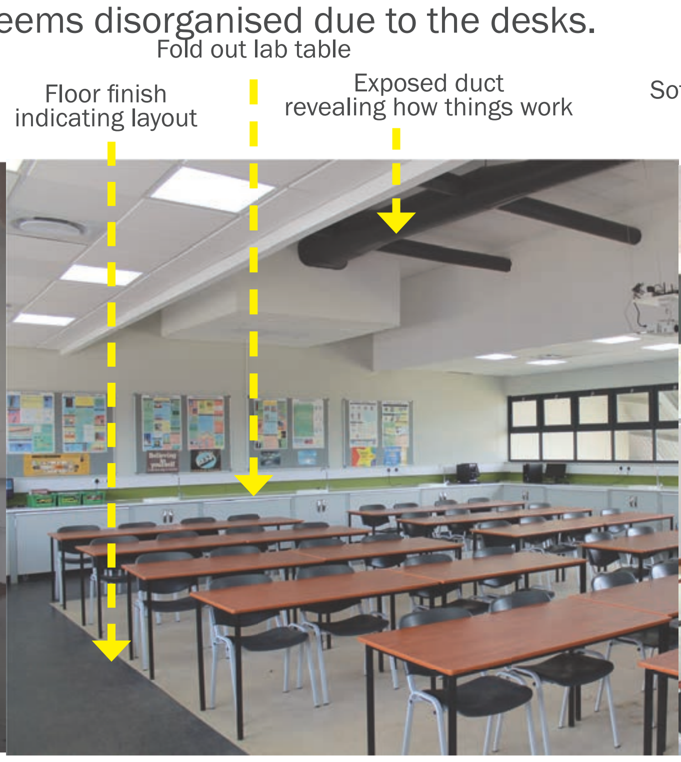


Figure 4.11 Photo of laboratories in Science building (TJA)

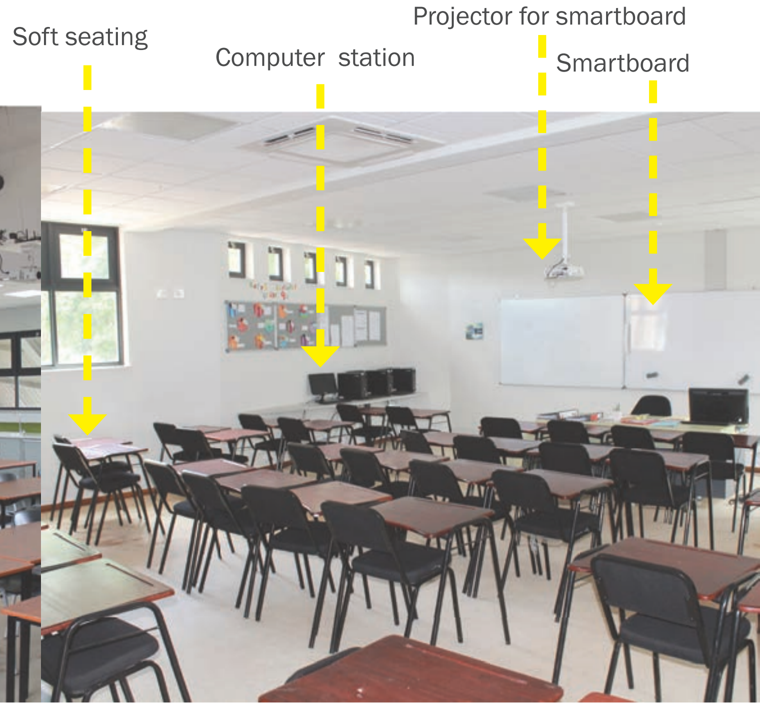


Figure 4.12 Photo of classroom in Mathematics building (TJA)

4.2.3 Sci-Enza
Hands on Science

Typology: Science Centre
Location: University of Pretoria, Hatfield, Pretoria
Organization: Southern African Association of Science and Technology Centres (SAASTEC)
Capacity: 120 pupils in science show and 30 pupils in workshop
Age: Gade R-12
Programme: Camera Obscura, Science Show and Workshop

Background: The Sci-Enza is the oldest interactive Science Centre in South Africa (Nordhoff, 2011).

Reservations need to be made in order to visit the Sci-Enza. They usually visit once a year per grade group. Some visit more than once to cover different topics. Transport costs are covered by the schools and there is a small entrance fee. Schools can request themes. During the school holidays the centre runs a programme for primary schools.

In 1977, the then Exploratorium was founded by Prof. Lötz Strauss. It consisted of an open "laboratory" in the Old Physics Building with the aim of offering students the opportunity to "play" with scientific apparatus in an informal setting. After the Science centre moved to the Natural Sciences Building 1 it became a popular place to visit, for the general public, school students as well as university students. The Camera Obscura was built on the roof of the Natural Sciences Building 1 in 1990. The Exploratorium's name was changed to the Discovery Centre @TUKS. In 2001, the Discovery Centre moved to the Technical Services building. The centre became a truly integrated Science, Engineering and Technology (SET) centre involved in a number of outreach activities.
The centre changed its name to Sci-Enza in 2005 Sci, which stands for sciSnce and Enza for the isiZulu word "sebenza" which means work or to do (Nordhoff, 2011).

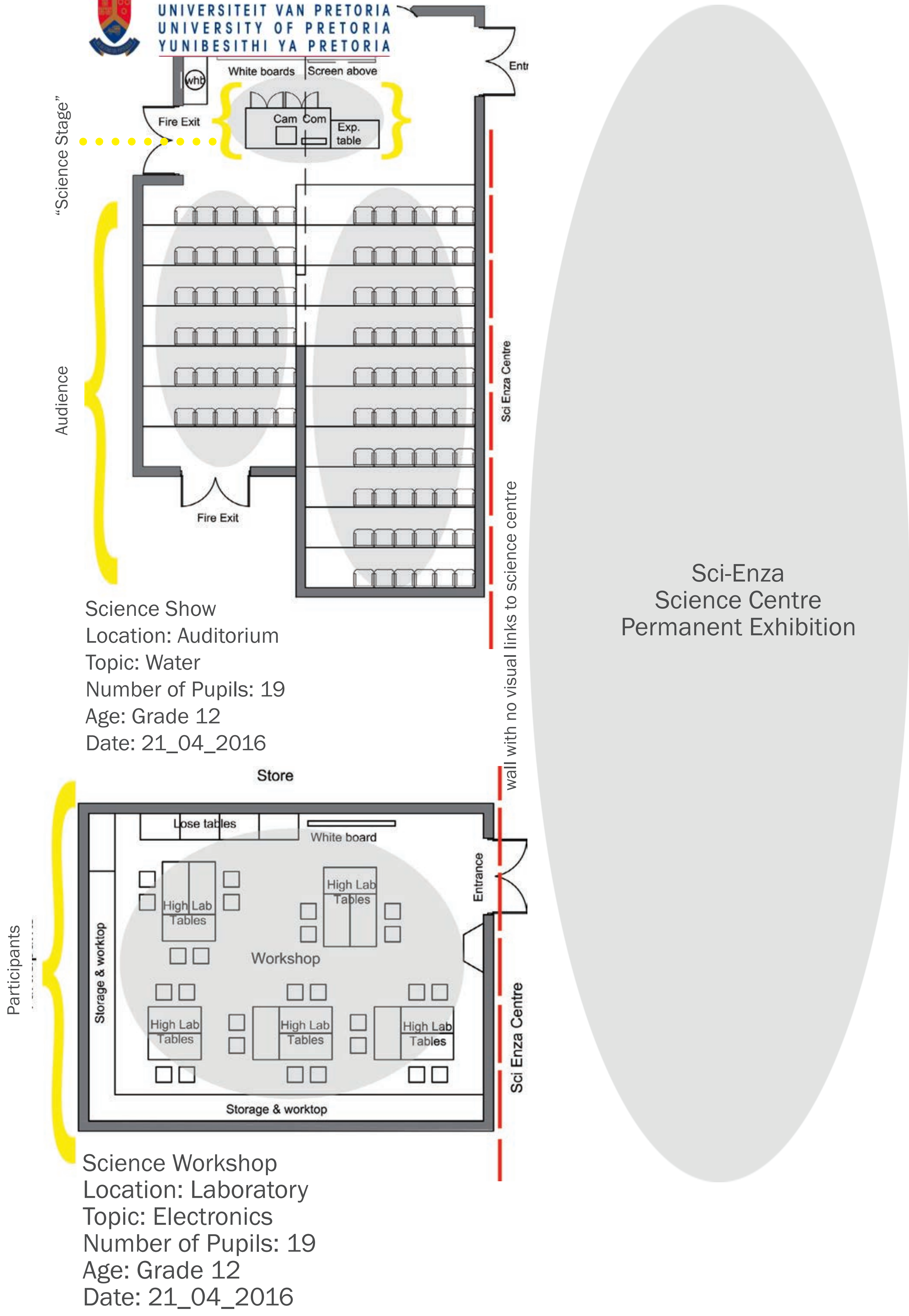


Figure 4.14 Diagrammatic illustration of Sci-Enza plan

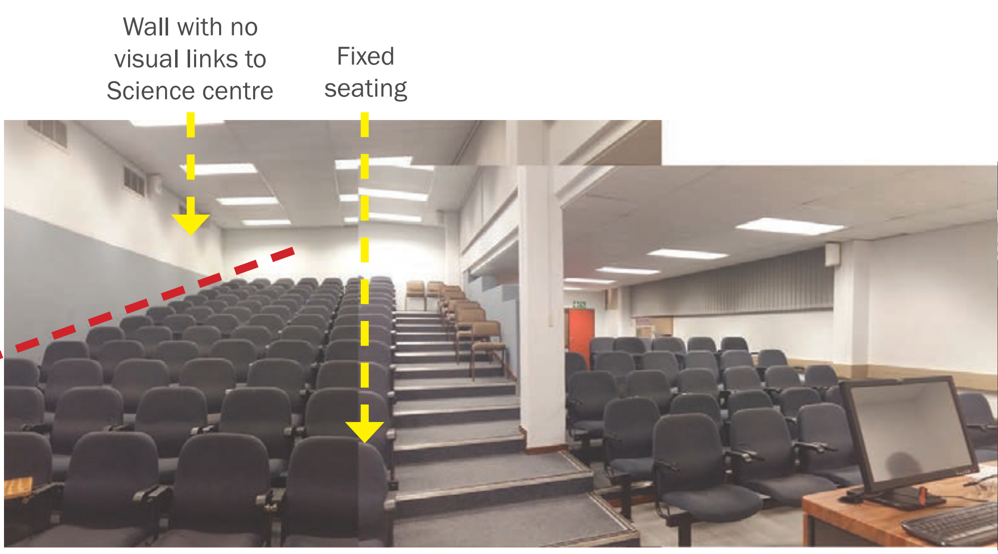


Figure 4.13 Photo of auditorium seating

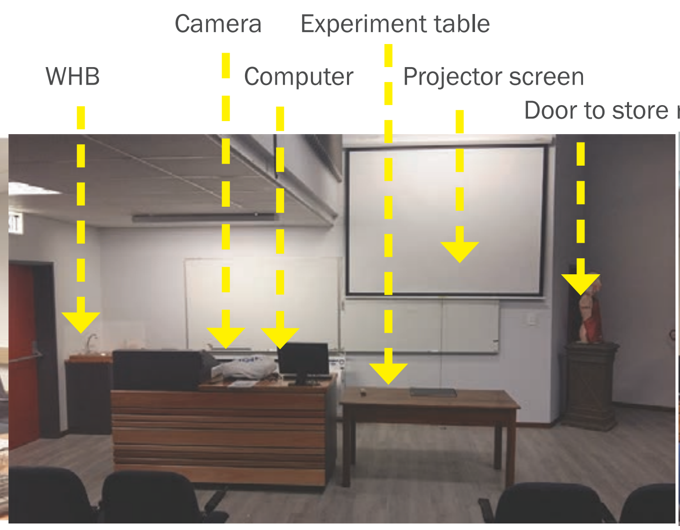


Figure 4.15 Photo of auditorium "Science Stage"

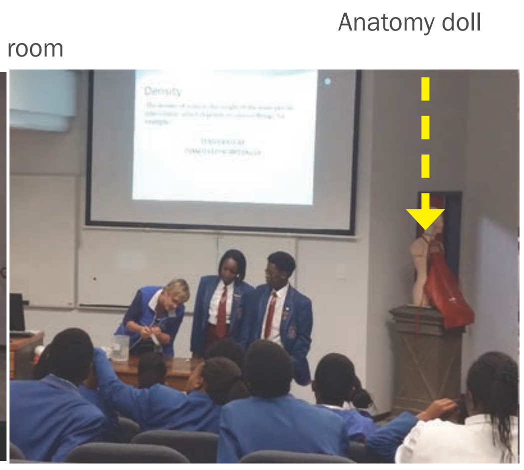
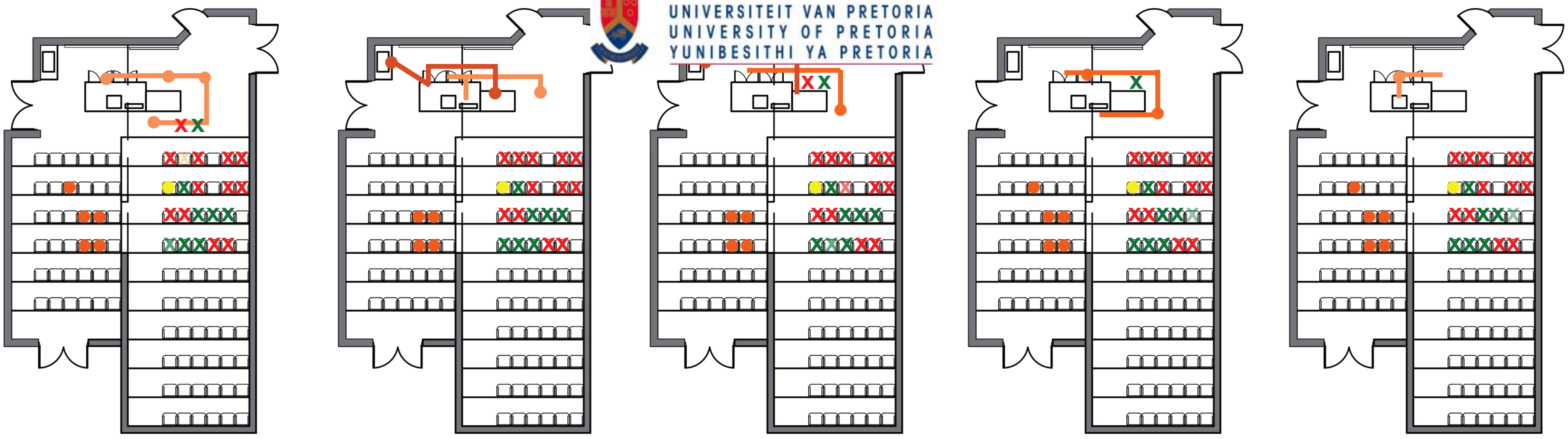


Figure 4.16 Photo of audience participation in science show



Introduction : Ice breaker
Props used : Rope
Participants : 2 pupils & peer assistance

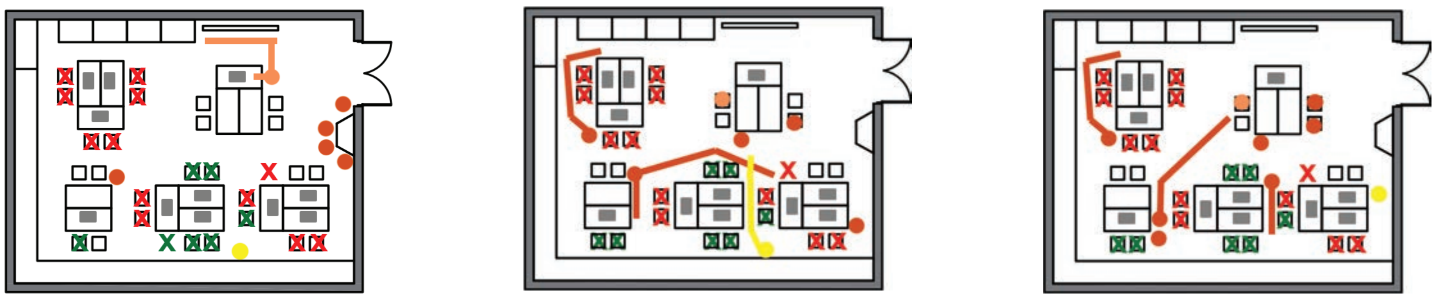
Water Density
Props used: Polystyrene molecule, 2 glasses of water, a kettle food colouring, & dish for spillage
Participants: Instructor & apprentice

Water Solution
Props used: Sugar 2 glasses of water & food colouring
Participants: Instructor, apprentice & 2 pupils

Heat Conduction
Props used: Balloon, candle, water, fire & safetyglasses
Participants: Instructor & a student

Surface Tension
Props used: Bowl, water, pepper, dish washing liquid
Participants: Instructor
Tools: Camera, projector screen

Fig 4.10 Diagrammatic illustration of user interaction in auditorium



Introduction
Instructor explains concepts and how to work equipment.

Workshop exercise
pupils built circuits in pairs from instruction manual.

Workshop exercise
pupils built radio and fan into circuit

Legend
- Main instructor
- Assistant
- Teacher
- X Girl
- X Boy

Figure 4.18 Diagrammatic illustration of user interaction in workshop

The Auditorium: The auditorium is used for Science shows. Here Science experiments are performed with everyday household materials. At the front of the auditorium there is a high level built-in presentation counter and a loose experiment table. The counter has a camera that projects the counter surface onto a screen behind the demonstrator.

The slope of the auditorium's stepped seating is not steep enough, making it difficult for all visitors to see the experiments on the table. The experiment table does not have a video camera even though most of the experiments happen in this space. Pupils are called to the front to become part of the experiments. Access to the storage and water is important in the Science show.

The Workshop: In the workshop room there are experiment tables grouped in clusters of three. The tables and chairs are high so that pupils can stand or sit while working. There is enough room between the tables so that instructors can move from group to group. A movable white board is used to explain the instructions. Pupils work in groups of two and with a larger group of six around a cluster. This enables each student to be part of the exploration but peer assistance from neighboring groups in their cluster is still possible.

There is no connection to gas or water which limits the experiments that can be practised in the space.

Both the auditorium and workshop space are disconnected from the Science Centre. You would not know that there are Science classes happening if you were next door in the centre.

Lessons learned:

- Science and the use of Science should be exhibited in a stimulating way in order to stimulate curiosity and excitement. Here the Camera Obscura achieved this endeavor successfully.
- Students were further enticed through the science show. The space is more of an auditorium than a theatre enabling the demonstrator to include students in the show. Thus, it is better when the experiments are not performed on a stage as this creates a divide.
- Learning could have been extended into the Science exhibition center if there were visual links between these spaces. Passersby could have been drawn in and enticed by visual connections.
- Students working in smaller groups doing practicals stay intrigued and encourage each other to experiment with different solutions.

Workshop table
Projector
Posters on wall promoting engineering
Lab chairs

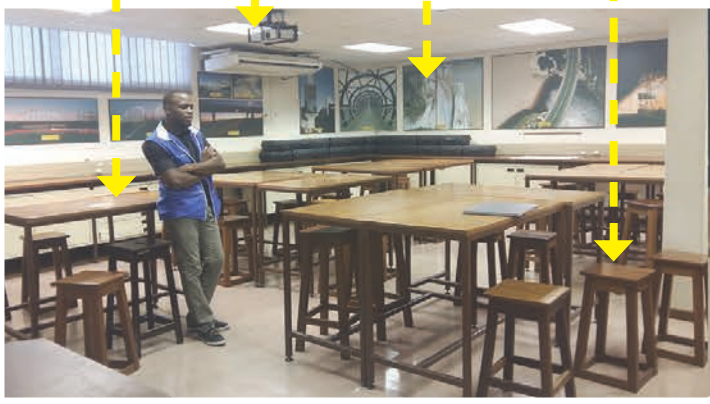


Figure 4.17 Photo of workshop space

Storage around perimeter

Figure 4.19 Photo of storage in workshop space

Experiment kit Ohm's law electrical circuit boards
Manual booklet

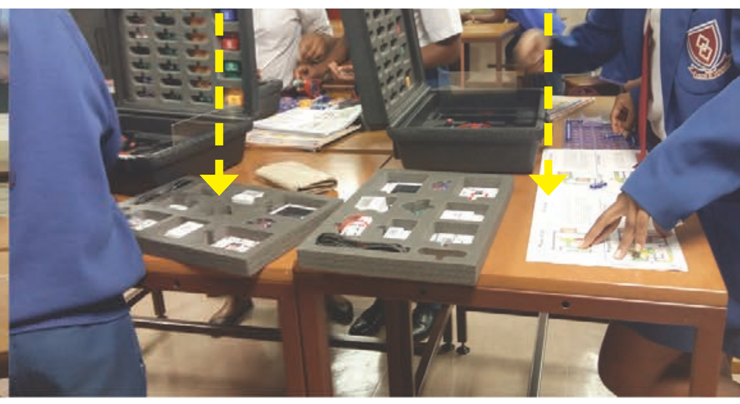


Figure 4.20 Photo of experience-based learning in workshop space

4.3 Precedent Studies

4.3.1 Montessori College Oost, Amsterdam

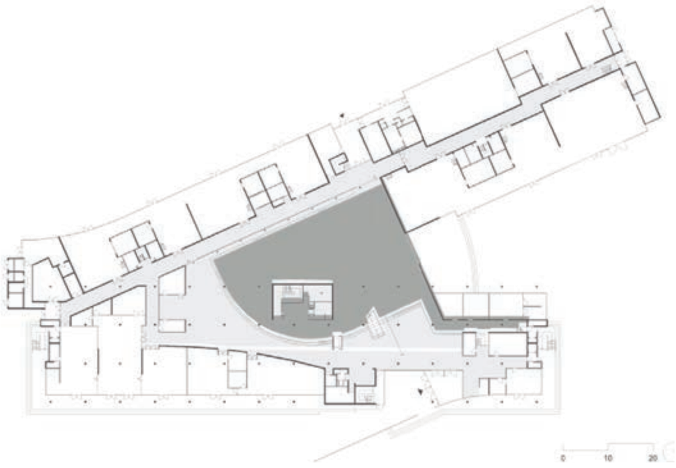


Figure 4.21 Plan of school (Hertzberger:2008)

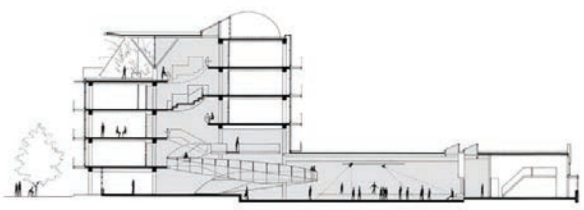


Figure 4.22 Section of school indicating half storeys and circulation (Hertzberger:2008)

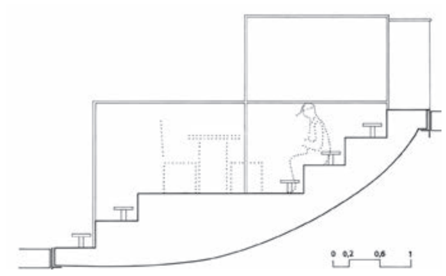


Figure 4.23 Section through working balcony and half storey (Hertzberger:2008)

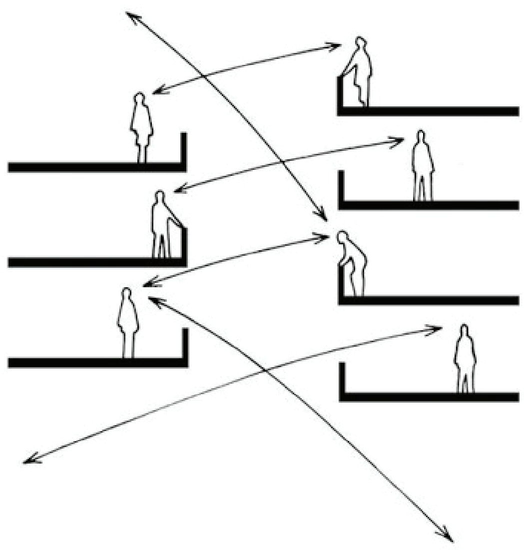


Figure 4.24 Section with visual links created by half storeys (Hertzberger:2008)

Typology: High School
Architects: Herman Hertzberger
Location: Amsterdam, Netherlands
Area: 16.345 m2
Year: 1993-1999

The building: The school was designed to function more like a city than a school. Hertzberger's focus was on the dynamics of movement and circulation through the building. The stairwells are not located directly above each other but they are staggered to create the most number of visual links. The corridors are wider than is necessary. The balustrades contain fold-away workspaces for students to work independently (Eferreiraantunes, 2012).

The central circulation space with its half storeys and working balconies creates spatial complexity and social nodes similar to that present in a city. The half stories strengthen visual links and the working balconies double as stairs. These balconies contain landings that can also accept a chair. They can be used as class space or to meet and hang out (Hertzberger, 2008: 120). The working balconies have lower and higher balustrade details, the higher balustrade screens seated students off while standing students can enjoy the view and connectedness of the space.

The balconies act as a series of small plazas, inviting students to spend time there (Hertzberger, 2008:120).

Classrooms remain a static home base, but the space beyond developed from a traditional corridor into an educational shopping street (Hertzberger, 2008: 124).

The components like the lunch room, library, assembly hall and gymnasium are starting to overlap, absorbed by the school's core. The central space can house activities that were excluded because of lack of space (Hertzberger, 2008:124). These street like spaces have been used by the school's students to shoot a music video. The corridors and squares are used as small stages for different scenes in the video (Pas op je Pas, 2011).

Lessons learned:

- Circulation spaces can become the heart of the school. The arteries that carry the life support of the school. Classrooms should be able to tap into these arteries.
- Visual links should be used to connect students and subjects.
- Social nodes can be used to create a sense of community..

Figure 4.25 Photo of school building exterior (Unknown)

Figure 4.26 Photo of school building interior circulation (Unknown)

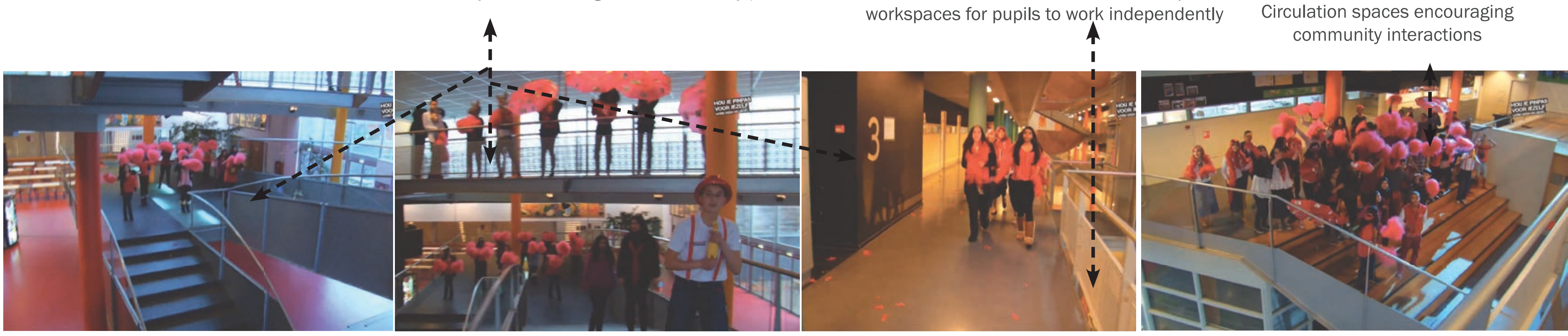


Figure 4.27 Frames from Music Video shot in the school (Bluf Producties, 2011)

partitions in classroom

Custom designed, mobile and flexible storage and workspace furniture enables collaboration.

Wedge-shaped entry space blurs the threshold between private and public

The Window between the lab and cafe defines and blurs the threshold between the two spaces.

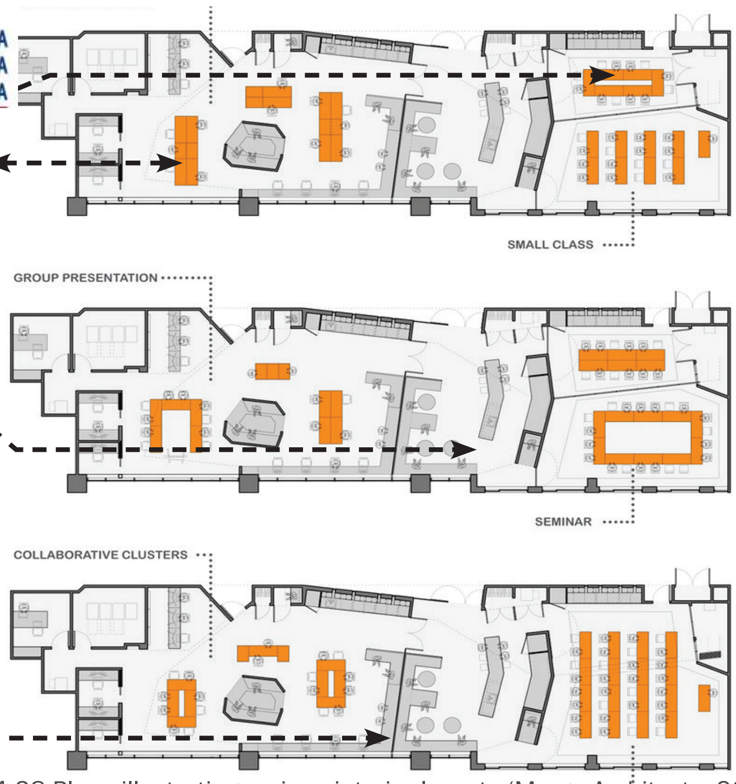


Figure 4.28 Plans illustrating various interior layouts (Merge Architects, 2013).

4.3.2 MIT Beaver Works

Architects: Merge Architects
Typology: Prototyping shop/laboratory
Location: Massachusetts Institute of Technology, Cambridge, USA
Area: 4875.0 ft2
Project Year: 2013

Background: MIT Beaver Works is a multi-use research space designed to encourage collaboration between students, faculty and professionals. The centre works with MIT Lincoln Laboratory and MIT School of Engineering. It serves as a place for work and where ideas can be tested and exhibited. The building consists of a research space, a café/lounge, meeting rooms and prototyping shop (Archdaily, 2014).

The building: Merge Architects met the basic functional requirements of fabrication facilities, together with providing highly flexible custom designed elements. The space has a multi-layered transparency. The architectural language attracts innovative thinkers and enables collaboration between researchers. The prototyping shop encourages creative thinking and ensures social interactions (Archdaily, 2014).

The café/lounge serves as the social node for the project. Situated between the classrooms, laboratory and entrance. The wedge-shaped entry space blurs the threshold between private and public by extending the public space of the hallway into the café. The corridor contains windows into the secured lab/prototyping shop (Archdaily, 2014). The large glass window between the lab and café delineates a secured lab zone and blurs the threshold between the two spaces. The glass also becomes a surface for writing on (Archdaily, 2014). The furniture in the lab space is a custom designed, mobile, flexible storage and workspace enabling collaboration. The classroom furniture consists of mobile tables and chairs. Interior partitions of the classroom are adaptable to create flexibility that can accommodate a wide range of functions.

Lessons learned:

- Collaboration spaces where students can test ideas through making prototypes encourages individuals to exchange knowledge with each other through project-based learning.
- Visual links can intrigue a passerby to enter into the facility and actively participate.
- A space's perimeter does not have to be rectangular with perpendicular walls and corners. The perimeter can have a dynamic shape that encourages creativity as long as the interior space it defines stays functional.
- Floor finishes can help organize flexible space.

Glass partition & writable surface
Cafe fixed seating social node
Kitchen counter

Figure 4.29 Photo of Café space (Horner, 2014).

Boardroom layout
Carpet helps organise layout
Classroom layout

Figure 4.31 Photo of classroom (Horner, 2014).

Adaptable partitioning
Projector

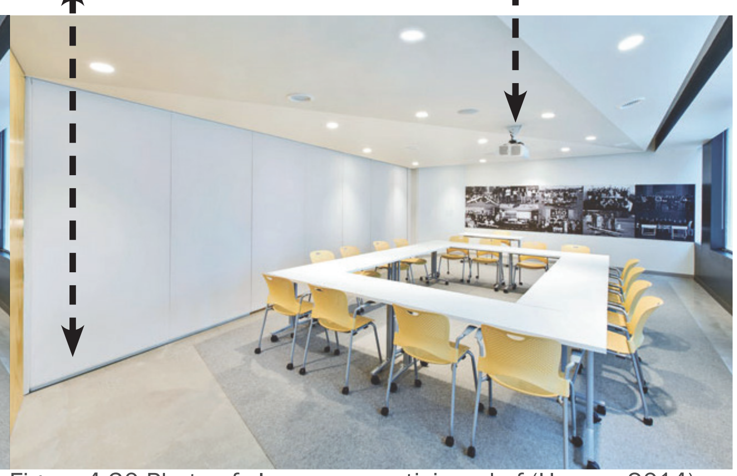


Figure 4.30 Photo of classroom particioned of (Horner, 2014).

Painted areas on floor helps to organize layouts
Nest space for group meetings or individual reflection

Figure 4.32 Photo of prototyping/ laboratory space (Horner, 2014).

Lab sink
Mobile storage units

Figure 4.33 Photo of prototyping shop soldering station & storage units (Horner, 2014).

Mobile workstation
Mobile storage units
Exposed services

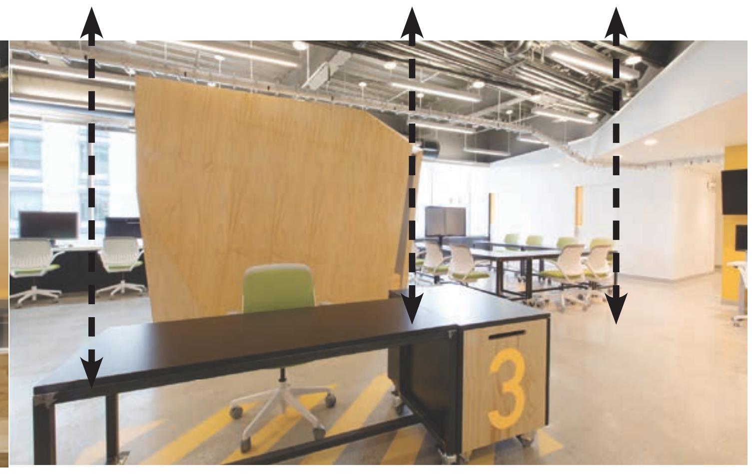


Figure 4.34 Photo of prototyping shop workstation

4.3.3 The Exploratorium: The Museum as a Laboratory

Typology: Museum of Science, Art and Perception
Location: San Francisco, North – America
Building : Adaptive re-use

Background: Through their design for The Exploratorium, the Oppenheimer brothers hoped to restore the sense of wonder and love of the natural world (Hein, 1990:2)

The museum was not built to become a warehouse where ideas could be stored but rather to become a factory, the museum had to resemble nature, a source of raw materials for exploration and the production of new ideas (Hein , 1990:2).

The Exploratorium was modelled on a teaching laboratory. By enabling people to familiarise themselves with the details and procedures of Science and Technology through exploring with unfamiliar apparatus. The aim was to reveal the laboratory as an object of observation and an instrument of inquiry in order to emphasise that Science is found in everyday life (Hein , 1990:2).

A key aspect of the Exploratorium is that teachers, scientists and designers, titled Explainers, work collaboratively to develop exhibits with a learner-centric perspective (Delacote, 1998:2055). The Exploratorium was the first Science museum that broke the tradition of museums, representing Science as a set of achievements already accomplished. The museum was designed to empower people so that they can choose their own future (Hein, 1990:2).

The Exploratorium focused on visitors, rather than on the canon of knowledge of Science. This provides a rationale for reaching out to underrepresented audiences (Hein, 2006:171).

Individual exhibits can be centred on the learner and therefore designed to facilitate individual exploration. The exhibits of the Exploratorium are complex enough to intrigue scientists and simple enough to entice children (Delacote, 1998:2055).

The exhibits: The Exploratorium uses Art and the natural environment to explain Science concepts and scientific phenomena. Through the use of Art knowledge traditionally perceived as exclusive and difficult, becomes accessible to the visitor. Through the use of natural elements like the wind, sun and tide the visitor becomes aware of the all-encompassing role Science plays in everyday life.

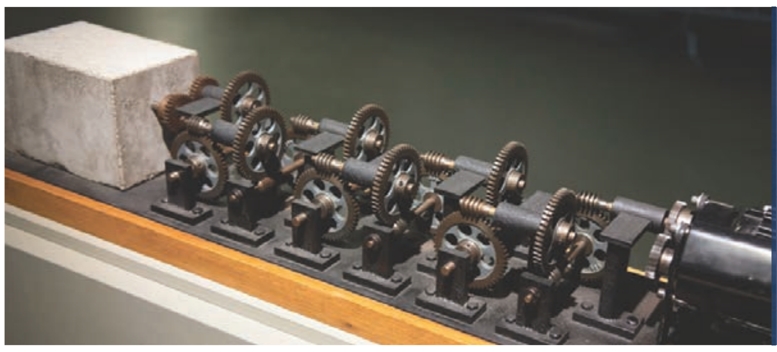


Figure 4.35 Machine with Concrete (Exploratorium).

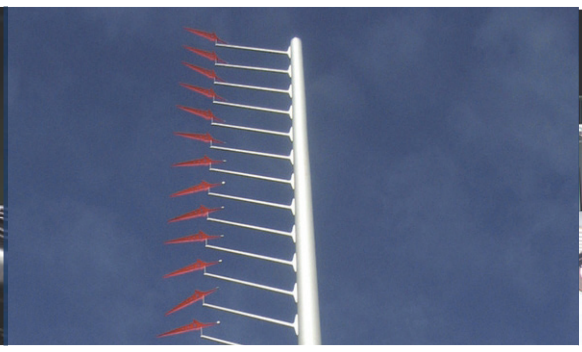


Figure 4.36 Wind Arrows (Exploratorium).

Figure 4.37 Shadow House (Exploratorium).

Art to explain Science: Machine with Concrete by Arthur Ganson

Arthur Ganson's designed a kinetic and mechanical sculpture with this purpose. A motor consisting out of a set of gears is connected to a block of concrete.
The final gear is embedded in the concrete block, the final gear makes one revolution once every 13.7 billion years, but the machine whirls uninterrupted (Exploratorium, 2001). This art piece entices the visitor and encourages self-enquiry to understand the mechanical phenomena on display.

The environment and the elements to create awareness of Science:

One of the exhibits uses wind indicators usually found on a sailboat to expose how the laminar flow of the wind differs depending on height. These indicators are mounted on a flagpole at 30cm intervals. Along San Francisco's shoreline, a difference of only 600 cm in altitude may mean a 90-degree difference in the wind's direction.

Shadow House is a rotating structure made of timber laths and cast shadows. that slowly change in the sunlight. This exhibit reminds the user of the shifting light of a day or season (Exploratorium, 2013).

Lessons Learned:

- Science is all around us and through the use of art and the natural elements it can be highlighted.
- Objects and exhibits should allow for individual exploration.
- Science experiments can be performed with everyday objects.

Figure 4.38 Exploratorium on Pier 15 (Exploratorium).

Figure 4.39 Exploratorium entrance (Exploratorium).

Figure 4.40 Exploratorium interior (Exploratorium).

4.3.4 High Tech High

Typology: Technical High School
Location: Massachusetts Institute of Technology, Cambridge, USA
Area: 4875.0 ft2
Project Year: 2013

Background: The purpose of High Tech High is to provide students with tools so they can learn to make and create things. The school uses computers as tools, just like they use a hammer or a vice grip. Here students are encouraged to find out who they are by mixing the practical application of engineering subjects with art, design and conceptual work. All work spaces in the school represent real environments with real projects, i.e. the type of work that adults would do. This gives clear reason and purpose to school work by grounding it in reality (A4LE, 2009).

The building: The CEO, Mr Larry Rosenstock explains that in many schools the architecture gets in the way. At High Tech High the building looks more like a box than a school. Visitors and students enter into a space that does not recall all the traditional qualities related to a school. The interior feels like a space that a start-up company would have hired. There is a lot of glass in the interior, this reveals what is going on in classrooms and students can see what their peers are doing. The building also acts as a gallery to exhibit students' work. Students get to curate their work, through exhibition they learn from each other. The students start to understand what is good work and what is not and this drives them to produce their best (A4LE, 2009).

The school teachers found that the students are not distracted by all the glass and views. They feel that the students become aware of the movements of their peers and because they can see what is happening they are not stuck in classrooms where they cannot wait to get out of when the bell goes. There are no separate WCs for adults and student. This strengthens the school's philosophy that that students should be treated like responsible adults (A4LE, 2009).

"I want kids behaving like an actress, behaving like a scientist, behaving like a documentary film maker, behaving like a journalist. Not just studying it but being like it" "Adolescence is about trying on new roles and sampling identities" -Larry Rosenstock, CEO, High Tech High (A4LE, 2009).

Lessons learned:

- A school does not have to resemble the traditional school environment.
- Student work should be exhibited and students should have the opportunity to peer review each other's work.
- Engineering subjects can be mixed with art and design to encourage self-discovery.
- Visual links into classrooms does not distract enough to disrupt classes.
- Students should be able to act like professionals would in a career.
- Students should be treated like responsible adults and the built environment should resemble this.

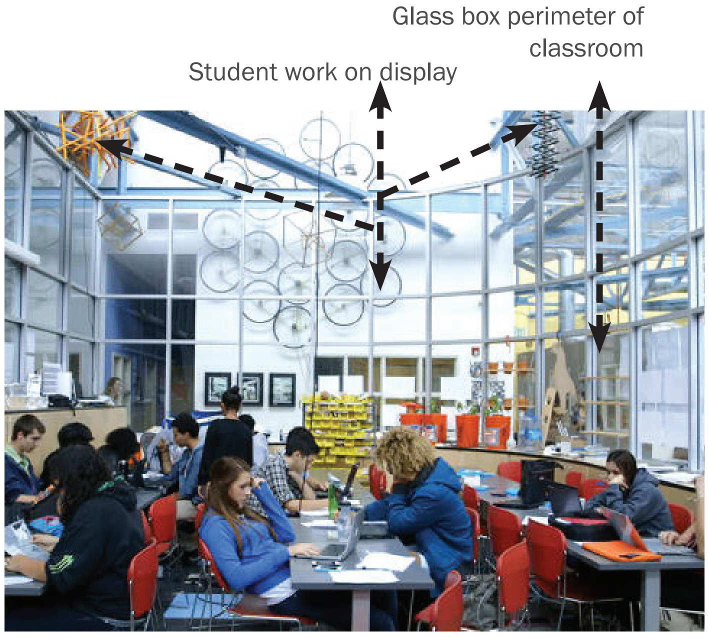


Figure 4.41 Photo of classroom (A4LE, 2009).


Figure 4.42 Photo of student presenting to peers (A4LE, 2009).


Figure 4.47 Photo of project base learning (A4LE, 2009).


Figure 4.43 Photo of CEO demonstrating his passion for tools and making (A4LE, 2009).


Figure 4.44 Photo of school interior (A4LE, 2009).


Figure 4.45 Photo of student work exhibited (A4LE, 2009).

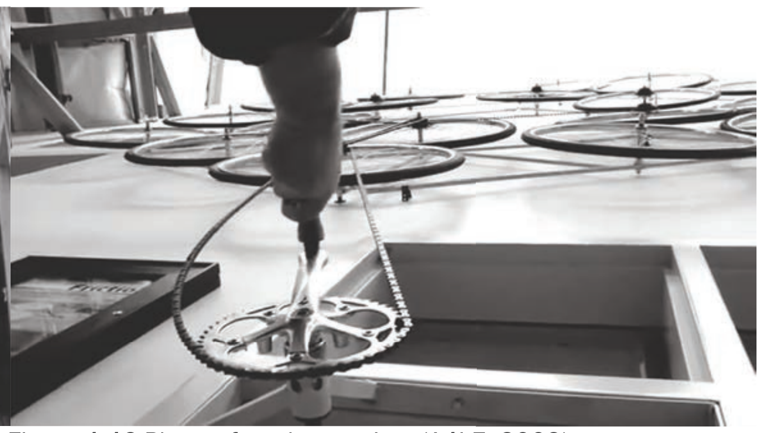


Figure 4.46 Photo of student project (A4LE, 2009).

4.4 Conclusion

Through a thorough investigation of many different educational environments it has been determined that a school environment should be rich with experiences. These experiences can be achieved in many ways. Students do not only learn from their teachers but can also from each other, the environment and they educate themselves. Art should not be separated from MST subjects as it can contribute to the depth of learning. There are lessons to learn and connections to be made all around us and the built environment can reveal these lessons through visual links, by providing appropriate spaces and qualities and by using the natural elements.

05

5. Design development

5.1 Introduction

Through theoretical investigations, context analysis, case studies and precedent studies a succession of conceptual approaches developed. In this chapter, the design development will be discussed from the initial to the final approaches. The strengths and weaknesses of each of the design stages will be identified. These stages followed upon one another and served to inform the final design.

Figure 5.1 Conical Intersect 2. From "Conical Intersect" París, France (Matta-Clark, 1975)

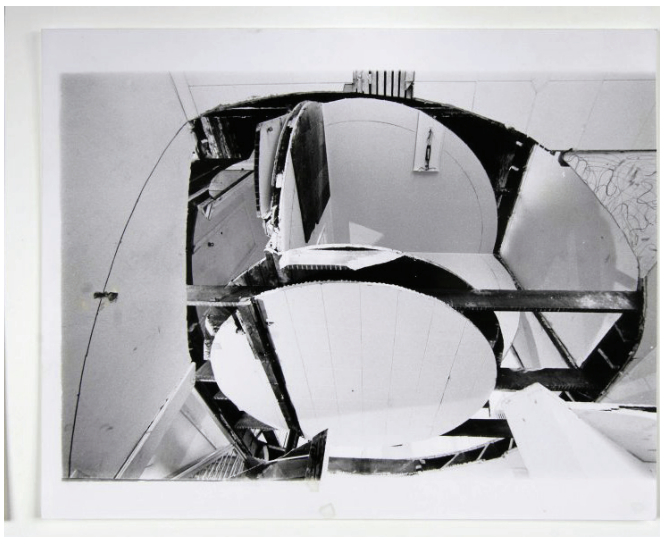


Figure 5.2 Circus 2. From "Circus-Caribbean Orange", Chicago (Matta-Clark, 1978).

(Figure 5.1) Matta-Clark cuts through concrete revealing the structural steel aggregate and thickness of the slab. (Figure 5.2) The floor joist and layering of materials become evident. Both works expose how their structures have been put together.

5.2 Adaptive Reuse

The author altered the building through a method of design intervention. "An altered building is as an inhabited ruin. The ruin is the means by which a building addresses its past, present and future" Scott (2008:126). Scott paraphrases Louis Khan's idea that the ruin is a building that can show how it was made (Scott, 2008:96). In ruined buildings privileged views are formed, that were previously inaccessible, enabling the building to show a fresh explanation of itself (Scott, 2008:96). Scott refers to the works of Matta-Clark who intentionally and programmatically breaks and ruins buildings and in the process he reveals the hidden nature of the building (2008:127-9). Matta-Clark cut through buildings revealing the structure and connecting detached spaces through views and paths of light. His interventions were art pieces and did not leave the spaces functional, structural or safe.

The author aims to break the building to make it more usable as a school structure and, like Matta-Clark, reveal and connect the hidden.

The question of fit is more complex when architecture is reused. The appropriateness of a new use, in an existing building, is usually only coincidence. The search for a solution to manipulate the old, so that the new can exist, is usually the part of the design process which takes the most time (Scott, 2008:173). The author went through numerous iterative processes and investigations to establish how the structure should be broken, in order to enable the new use to fit comfortably within the building. Even though the building has already housed the client for a number of years, the structure prohibited a rich educational environment.

5.3 The MST plug-in as a catalyst.

By moving the student centre to the underutilised roof space, the 3rd floor of the building became available for an MST facility. Just like Bambisanani (c.f.4.2.2), the MST facility was envisioned as an add-on to the current school. The concept of an MST plug-in developed. The facility would have allowed the school to grow into an educational environment of experiential learning.

The MST plug-in would act as a catalyst, connecting subjects and students across the school's currently detached levels (Figure 5.6). The MST level would be rich with experiences. The boundaries between spaces were to be permeable. It was envisioned as a hub where research, collaboration and project-based learning could take place (Figure 5.9).

The science store (Figure 5.13) was seen as an element that could act as a catalyst to activate the space around it. MST was seen as the driving agent to initiate a change in perception and use of school spaces, enabling change in the current educational environment of the school.

This first response was an intuitive investigation. At this point the author still needed to conduct a more in-depth investigation theoretically. This vision helped to juxtapose the idea of a new educational model next to the existing traditional model (Figures 5.10-5.12).

Figure 5.3 Skin

Figure 5.4 Mass

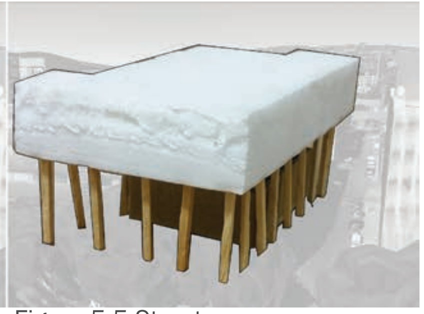


Figure 5.5 Structure

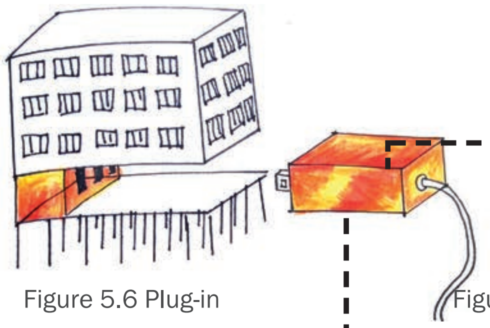


Figure 5.6 Plug-in

Figure 5.7 Plug-in between parking & school

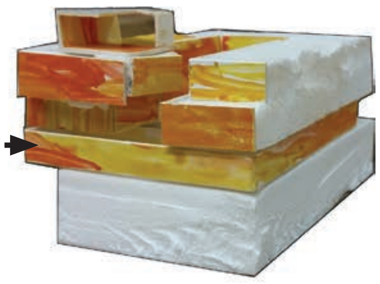


Figure 5.8 Plug-in acting as catalyst

Jeff Masemola

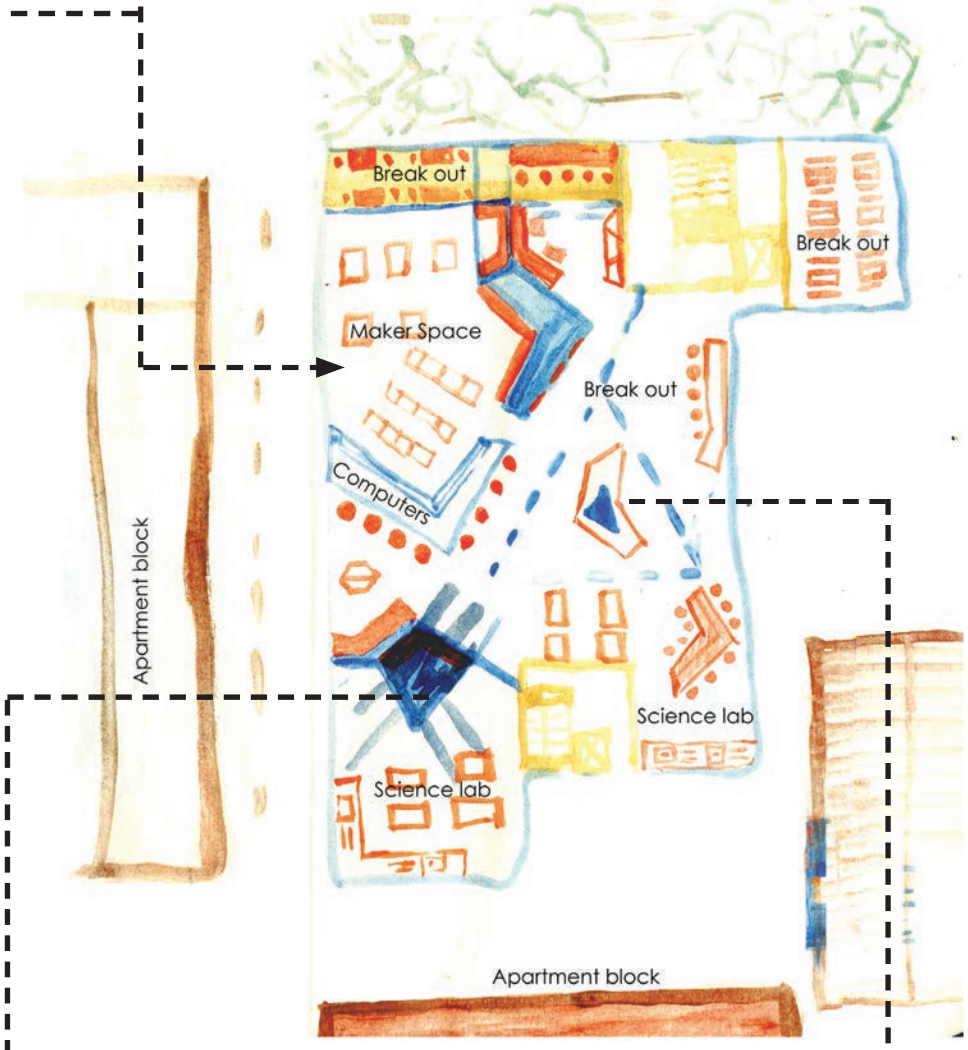


Figure 5.9 conceptual floor plan of MST level

Figure 5.13 Science store becomes display

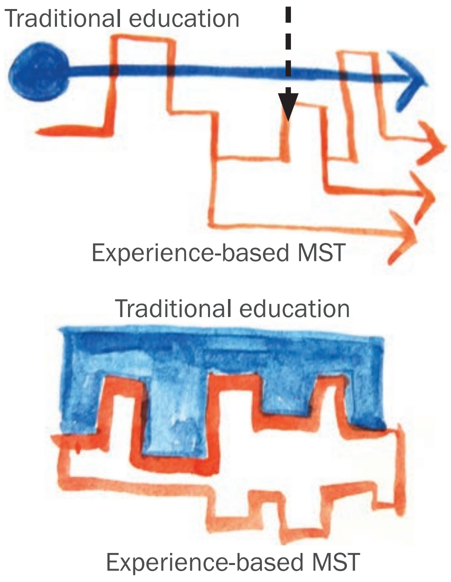


Figure 5.10 Diagram of MST facility plugging into traditional school enviroment

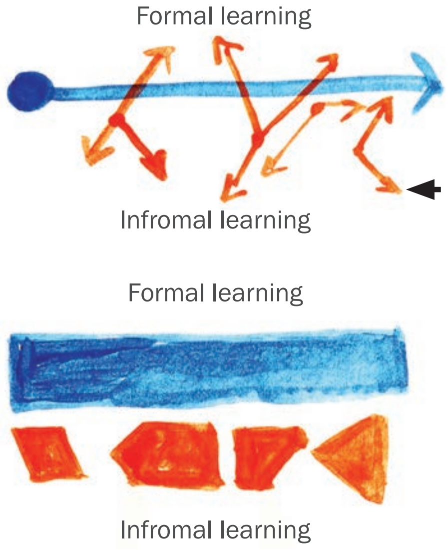


Figure 5.11 Diagram of MST informal learning intersecting with formal learning

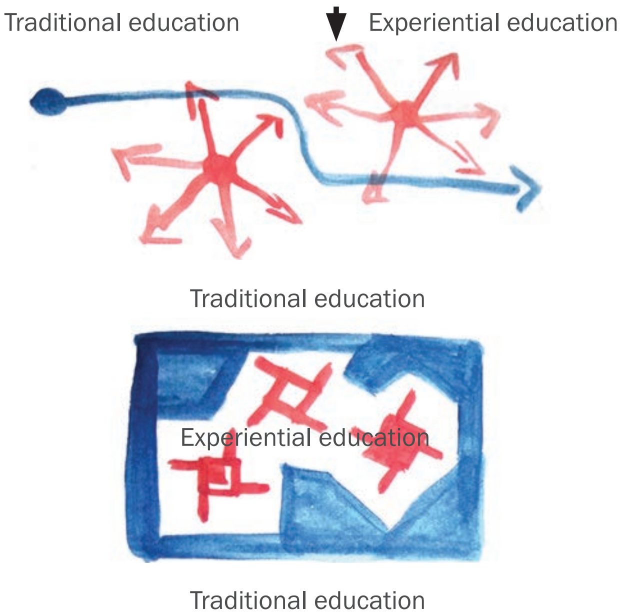


Figure 5.12 Diagram of catalysing experiential learning

Figure 5.14 School as micro-city moodboard

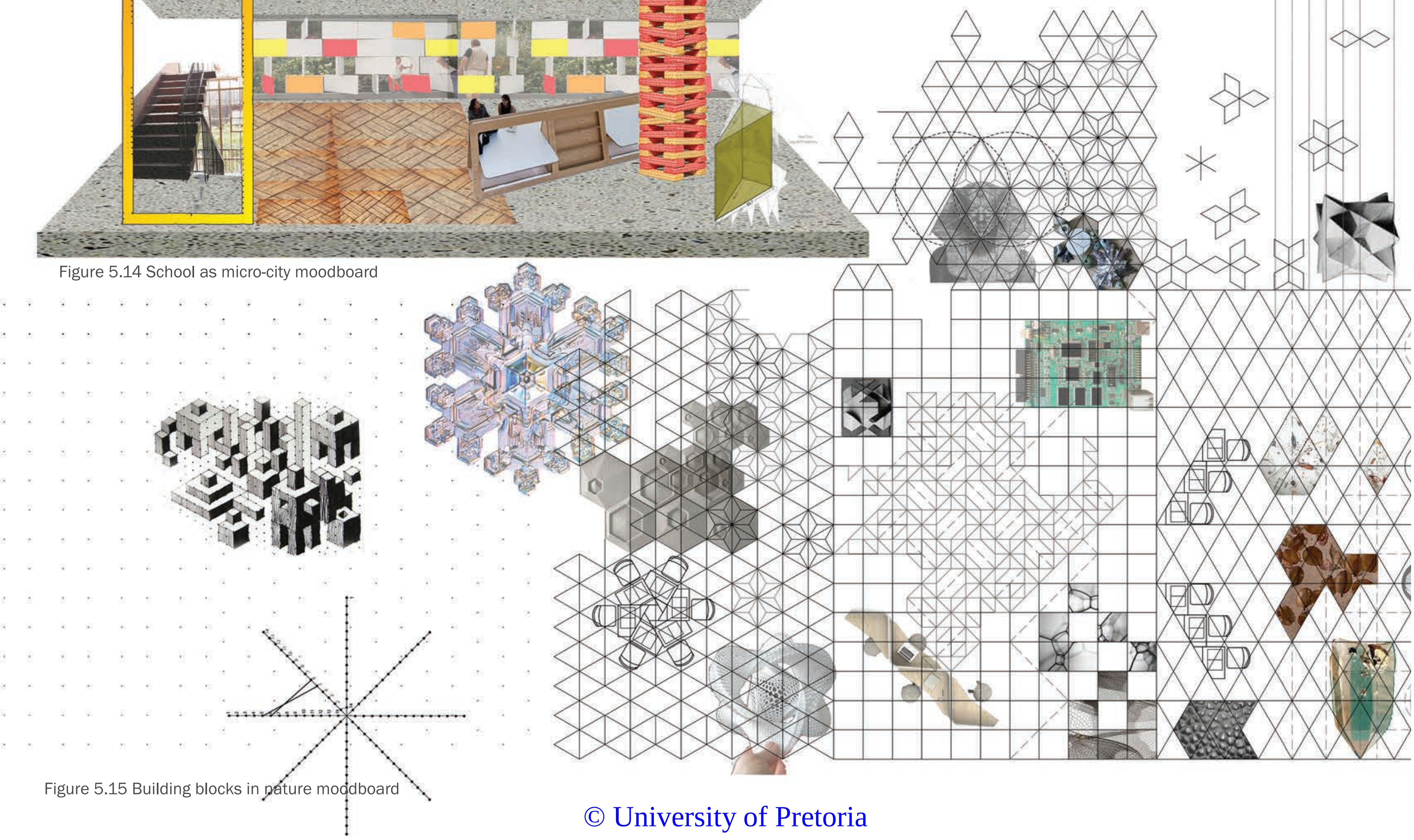


Figure 5.15 Building blocks in nature moodboard

5.4 Two poles

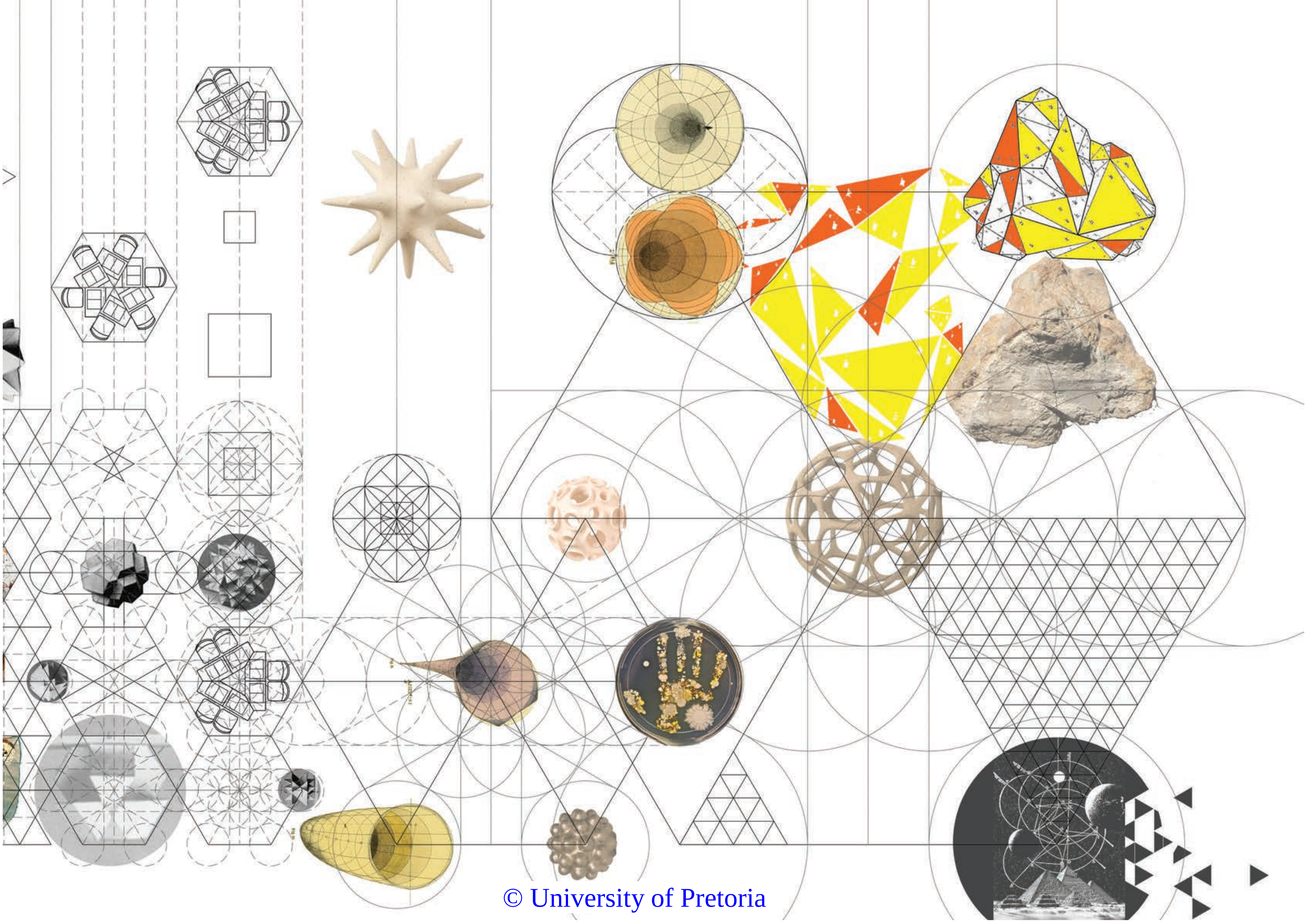
After returning to theory the author realised that the school environment needed to be grounded with real life experiences. To achieve this, the author's investigation was approached from two opposite poles. On the one side, the school as a whole was compared to a city (Chapter 2.3.1) and on the other side, the traditional use of the rectangular classroom with rectangular desks (Chapter 2.2.1) as the building block for a school was challenged.

5.4.1 School as a Micro City

Hertzberger's analogy of the school that resembles a city (c.f. 2.3.1) was investigated and applied on the school's circulation spaces. Through visual links and pause areas the environment became rich with everyday experiences, just like the experiences one would come across in the real world beyond the walls of the school. The walls and shapes of the classrooms were used to create intermediate spaces into which learning could extend. The classrooms were designed to be openable, so that they could become public squares or cul-de-sacs where the students could adapt the spaces to their needs.

5.4.2 Building blocks

In nature different building blocks exist which fulfil different functions. As determined through the theory, the traditional use of the classroom is no longer sufficient and alternative educational environments are needed for the changing educational model. New building blocks were investigated to facilitate new educational functions. Inspiration was drawn from the building blocks found in real life natural phenomena, i.e. in elements, molecules, crystal structures, organic cells, light waves, sound waves and many more of nature's building blocks.



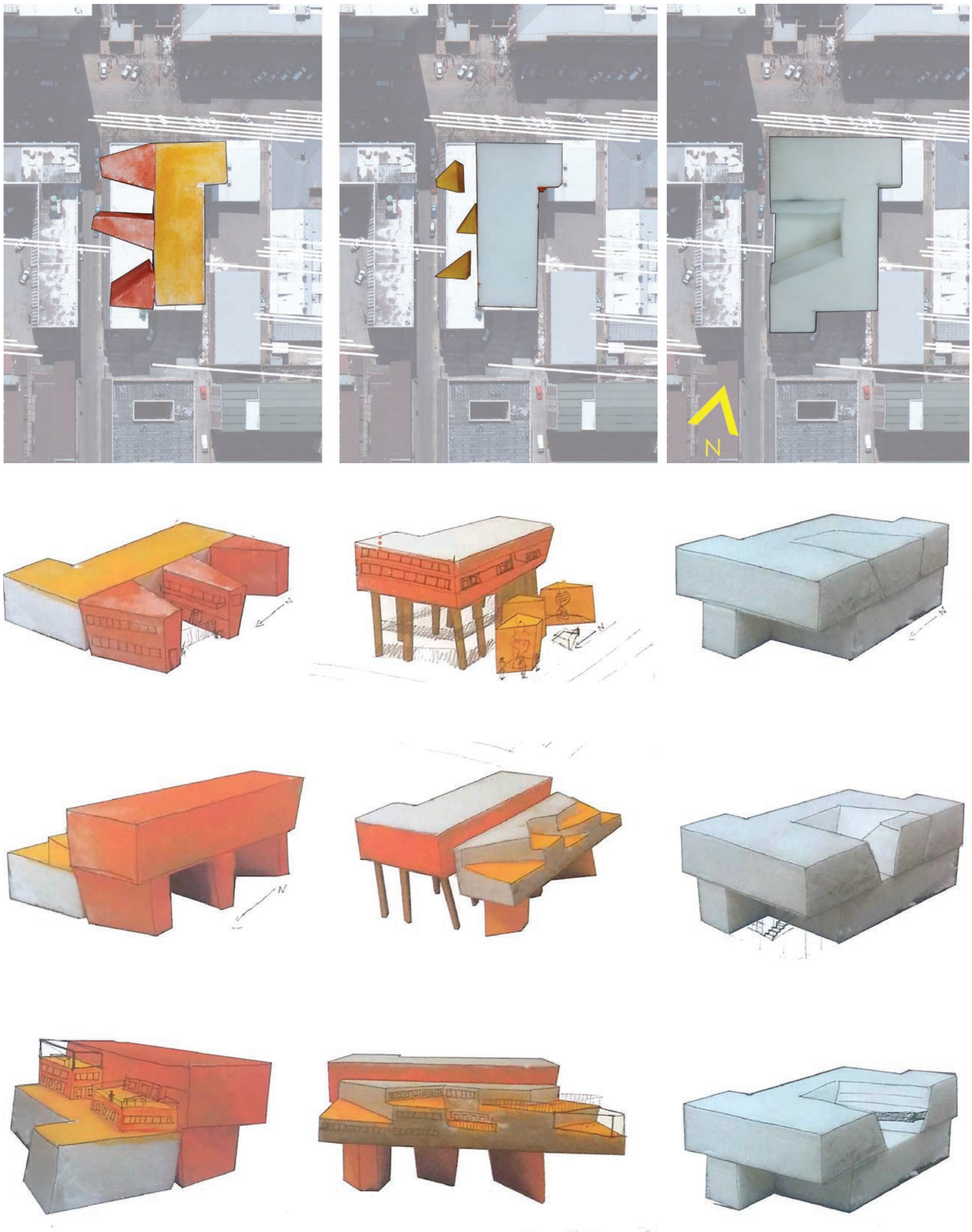


Figure 5.16 Conceptual models

5.4.1 School as a Micro City

Initial Concept Models

Here the author intuitively started to cut away from the building structure, to open the school up to the experiences of the city. The main aim was to create a dialog in the form of 'public space' between the formal educational classrooms and new experience-based learning spaces. These models were to transform the rigid mass of the existing building into a dynamic structure rich with visual links and places of interaction. These models did not take into consideration the building's structural grid or the spatial requirements necessary for different methods of learning to take place.

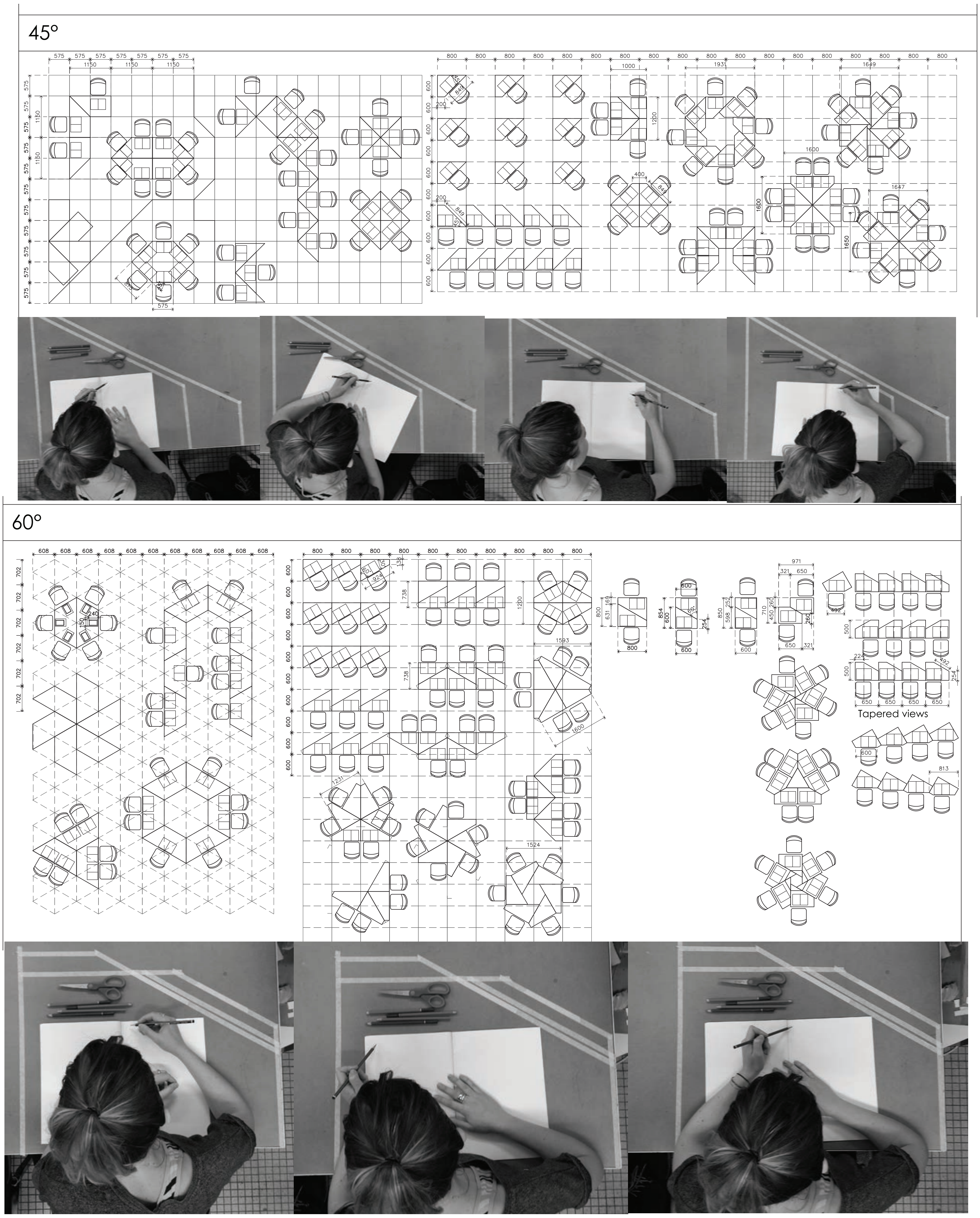


Figure 5.17 Desks as creative spacial organisers

Figure 5.18 Naef Cubicus

Figure 5.19 Exchange by Smart Desks

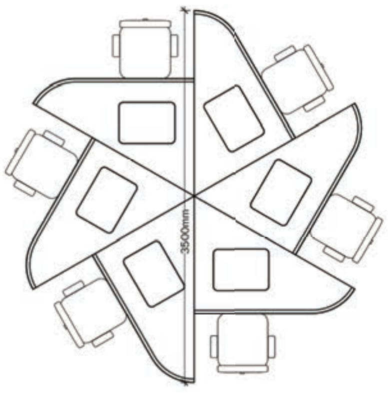


Figure 5.20 Exchange by Smart Desks

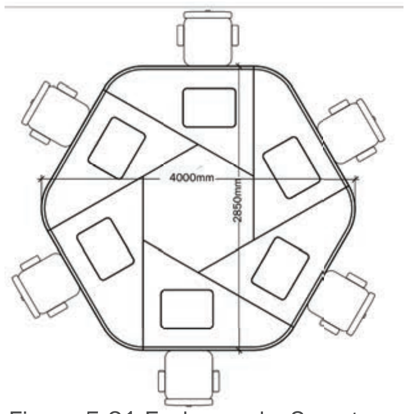


Figure 5.21 Exchange by Smart Desks

Exchange office furniture by Smartdesks was used as a starting point to the investigating. By introducing an angle into their furniture a multitude of different layouts was achieved that made different levels of collaboration possible. These desks were however large and while they could be arranged in group clusters the distance between people opposite each other were not inductive to group discussions.

5.4.2 Building blocks

Desks

As previously stated the traditional classroom as a building block led to a distinct repetitive spatial organisation, which also translated to the form and organisation of the school as a whole (Figure 2.1). The rectangular school desk also forms another building block in the interior spaces and they led to repetitive classroom layouts which encourage little adaptation and exploration of alternative learning environments. The author started to investigate how furniture can influence the learning that takes place and how it can promote self-adaptation of space, to accommodate different teaching and learning methods through layout.

The author started the investigation by introducing 45°and 60°angles into school size furniture and placing them on a seating grid. The 45° group configurations with eight students had too large a distance between opposite ends, whereas the 60° angled desks had a six person group configuration with more intimate distances between opposite ends. From these investigations it was determined that by introducing a 60°angle in combination with 90°angles would make for the most flexible and intriguing new building block solution.

5.5 Programmatically breaking the existing

5.5.1 Cutting away

Before the author could break the structure, the type of concrete slab to be used had to be determined. The following indicators were used to assume that the slab is indeed a reinforced slab and not a pre-stressed or post-tension slab. The structure is a flat slab with drop panels. On the original drawings the slab was drawn to be 260mm thick, whereas with pre- and post-tension slabs, the thickness of the slab is usually thinner. The column spacing is at 5300mm intervals, whereas with pre-stressed construction the spans can be greater and the building would have had fewer columns. These assumptions have been confirmed by a structural engineer (Steyn, 2016).

After the structure of the building was surveyed and analysed, the author started cutting away from the building to visually connect the levels, so as to bring in natural light and create open public spaces.

5.5.2 Programme

The Minimum Norms and Standards for Schools (DOBE, 2013) was consulted as a guideline to determine adequate space for specific functions. Through an iterative process driven by theory, case studies and the micro-context analysis, the programmatic arrangement of the school was determined.

Shift College is an independent school, thus the maximum students per classroom is determined by the school. The fire escape routes of the host building can accommodate 260 users (SANS part T). The school therefore falls within the small school category of the Minimum Norms and Standards (DBE, 2015).

Criteria for Small Public School

CLASSROOM (basic standard)
Minimum 48m ²
Maximum 40 pupils
Gr1-12:
Minimum space allocated per learner = 1m ²
Disabled learner =2m ²
Educator = 7m ²

Optional Education Support Facilities

Shift College places focus on these facilities and is therefore used as spatial indicators in the design development

Private Education

CLASSROOM (in Shift College)
Minimum 48m ²
Maximum 30 pupils

Shift College uses both public education and optional support facilities as a guidline to establish the minimum spatial requirements for Shift College.

Figure 5.22 Minimum Norms and Standards

Intervention Development 1:

Intervention Development 2:

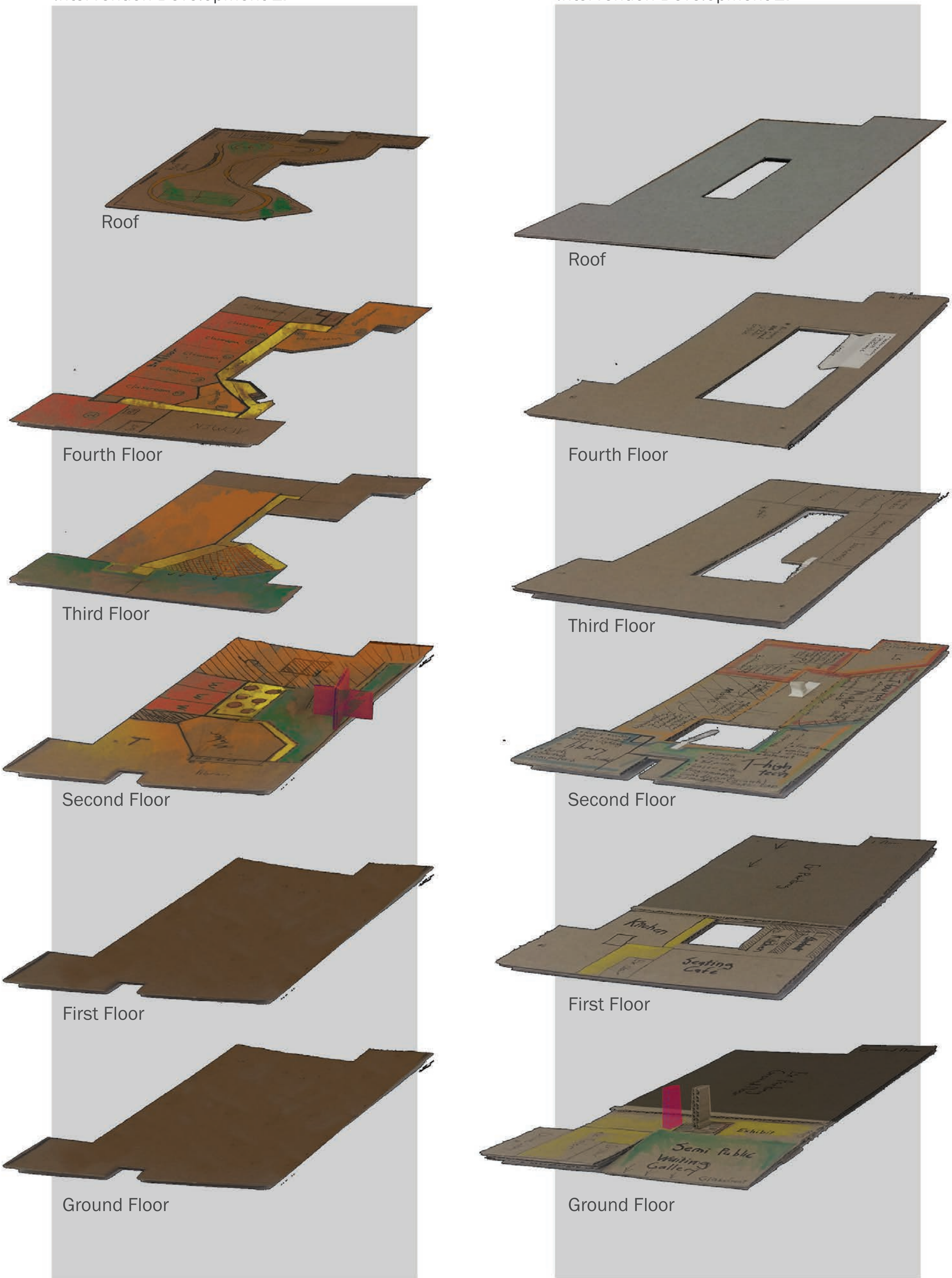
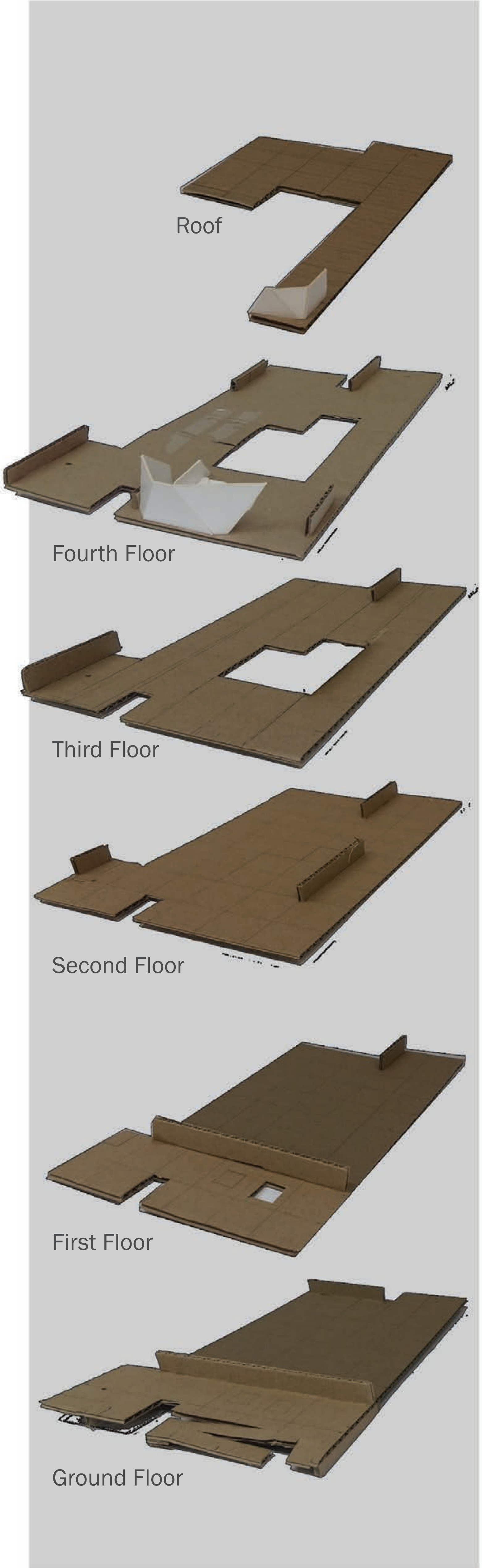


Figure 5.23 Models investigating connection between levels

Intervention Development 3:



Intervention Development 4:

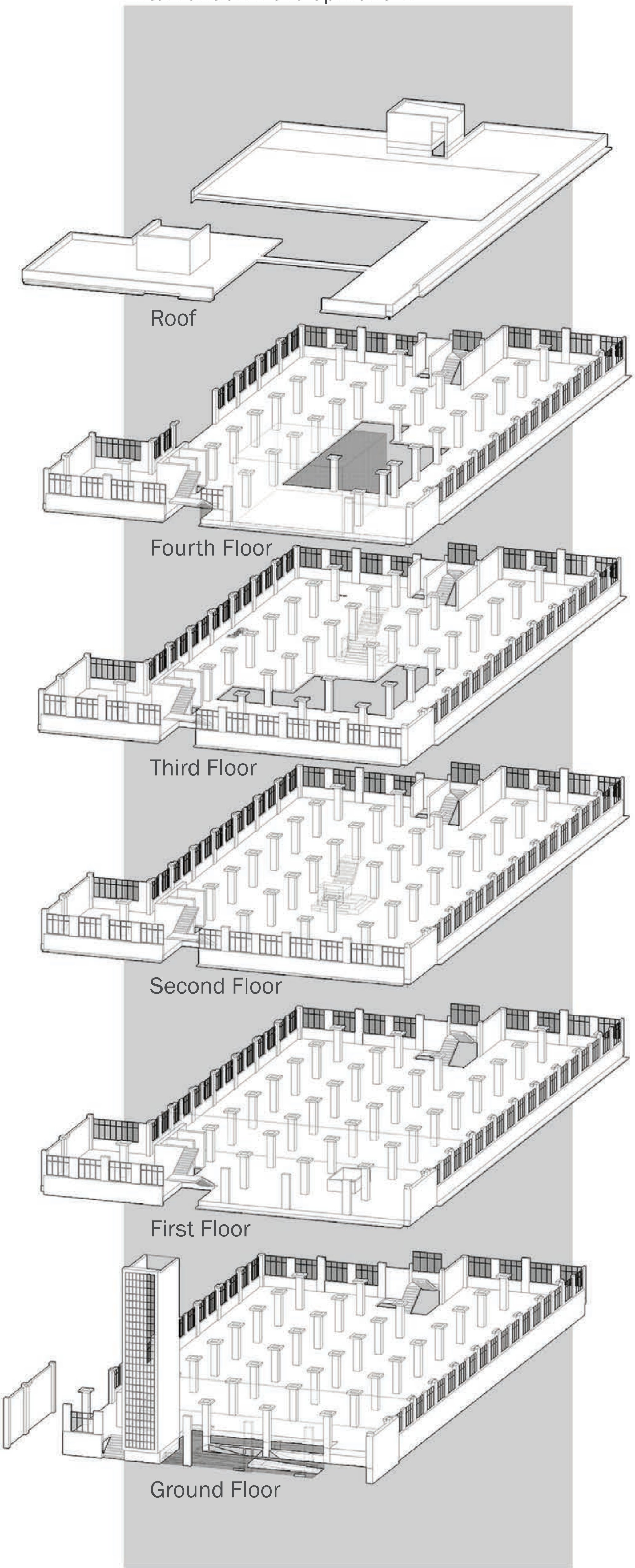
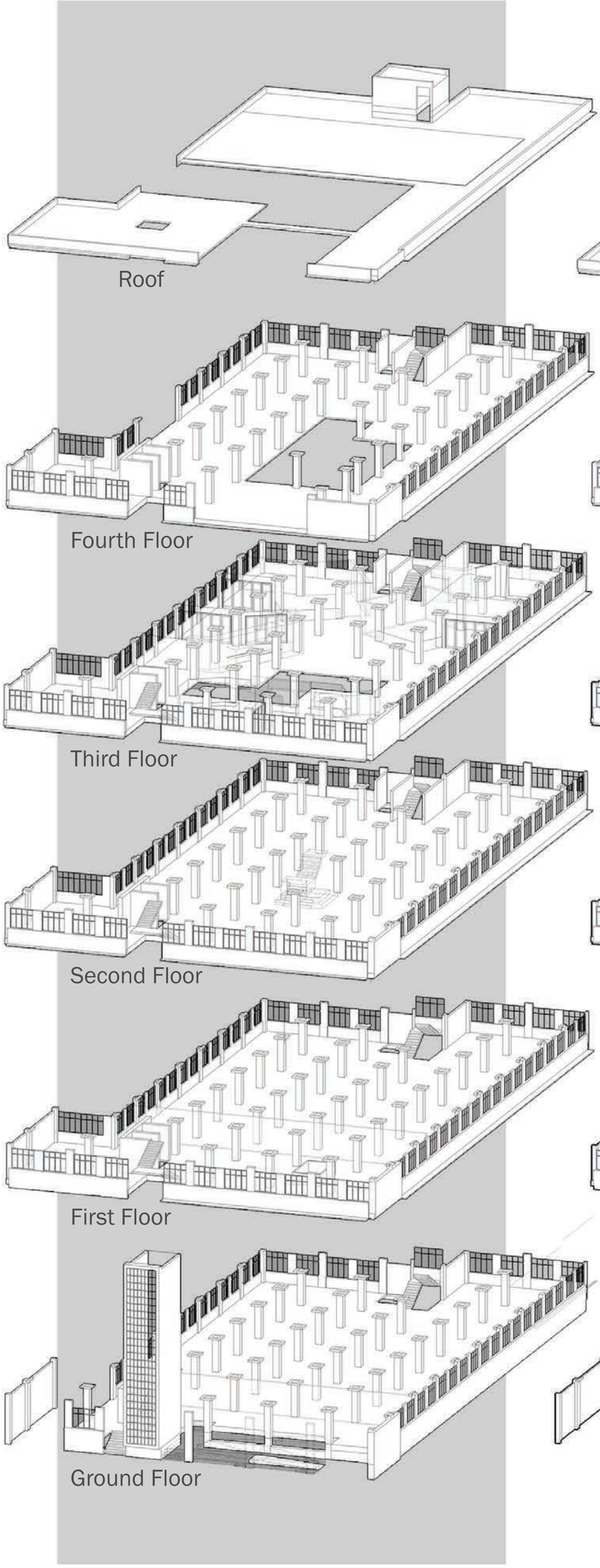


Figure 5.25 Models investigating connection between levels

Intervention Development 5:



Intervention Development 6:

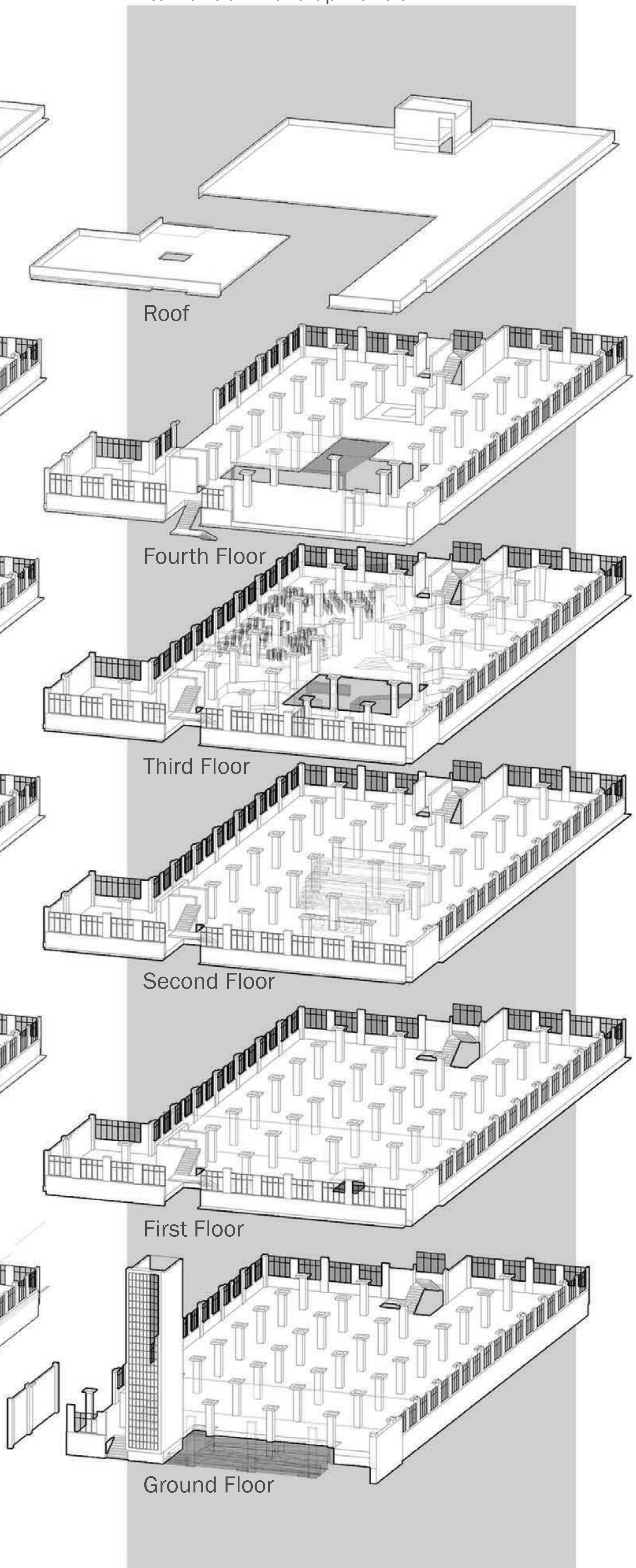
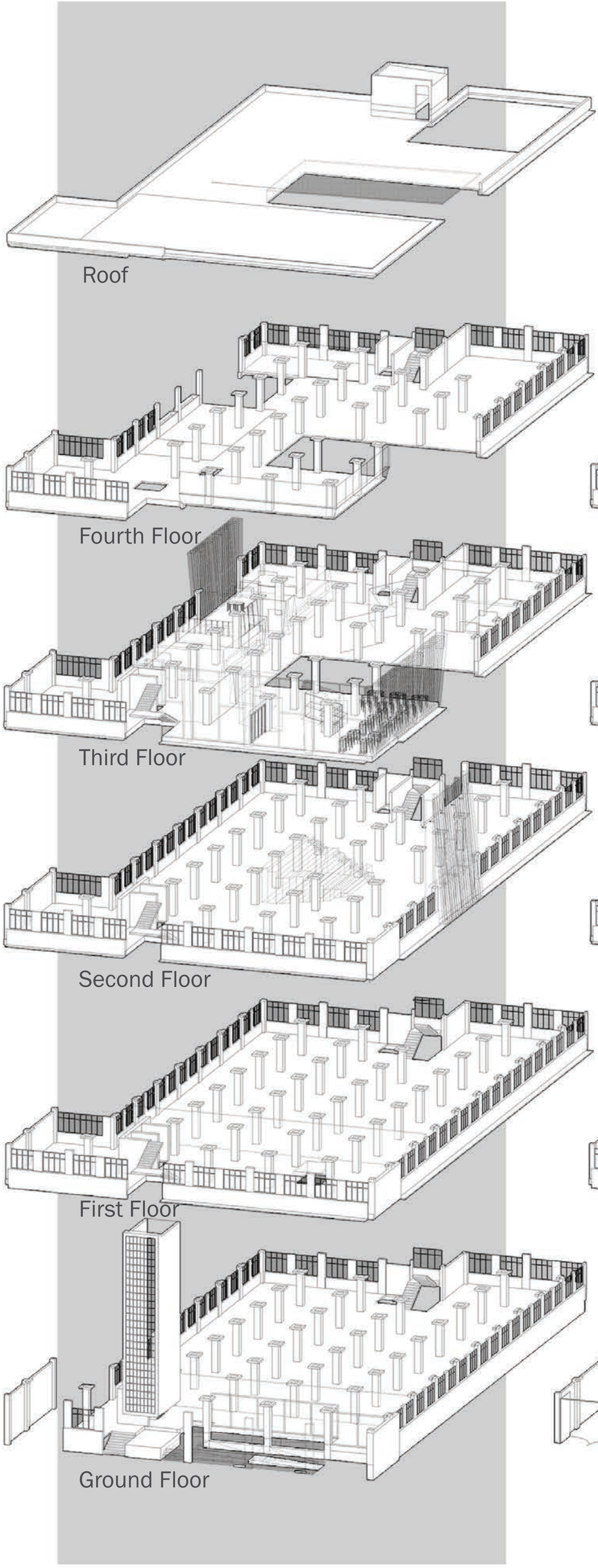


Figure 5.27 Models investigating connection between levels

Intervention Development 7:



Intervention Development 8:

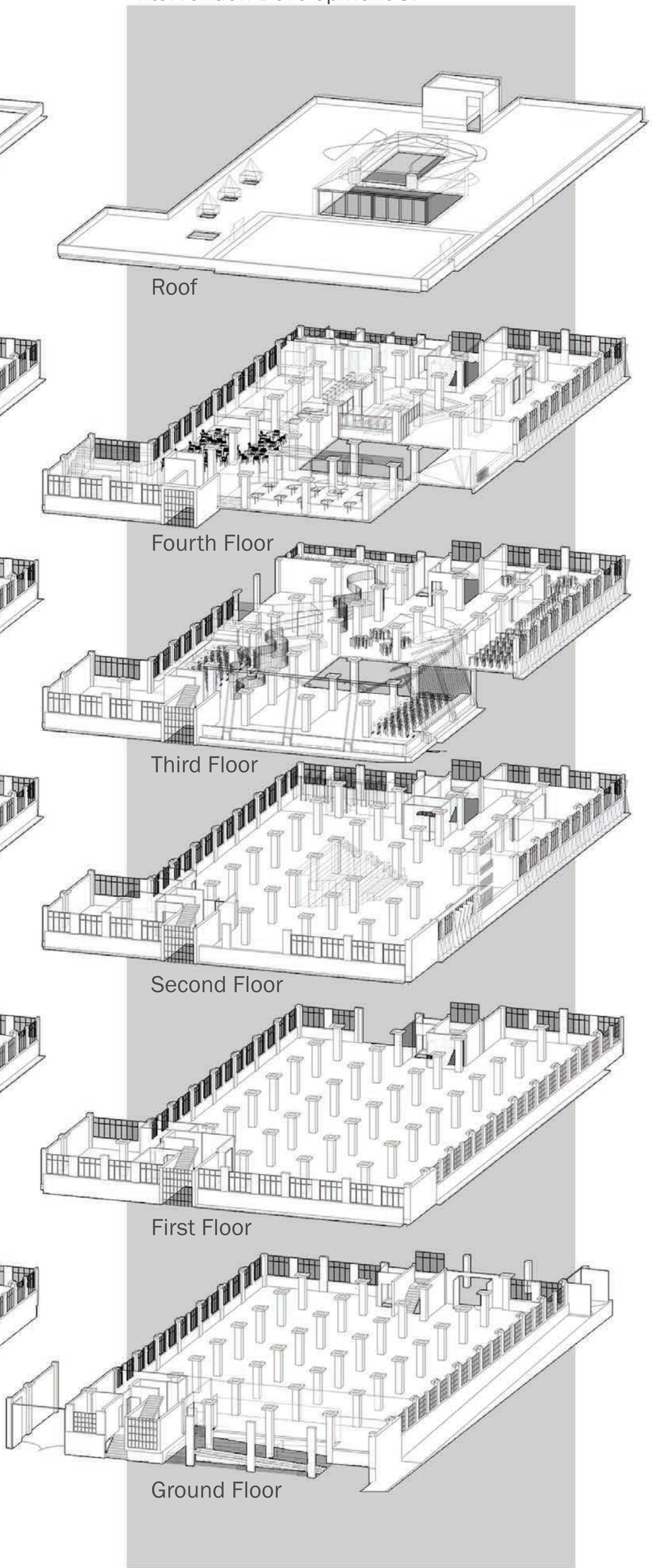


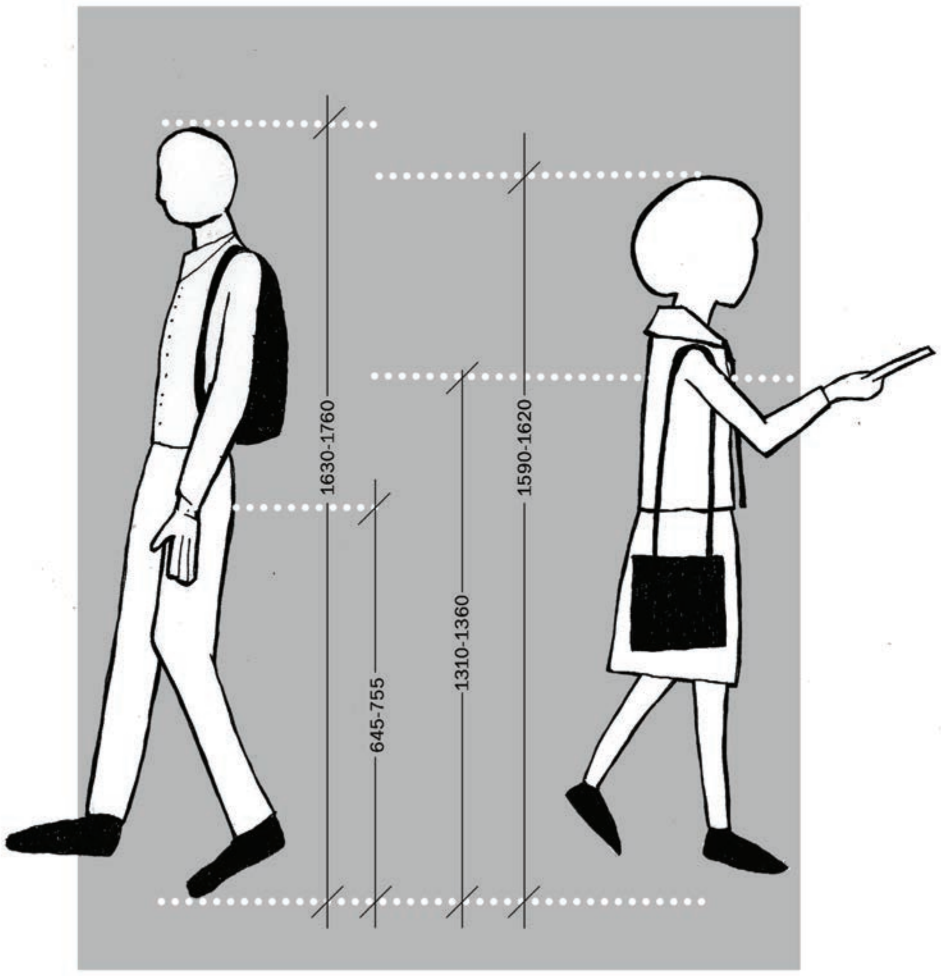
Figure 5.28 Models investigating connection between levels

5.6 Users

The users of the space can be broken up into daily users (teaching staff, administrative staff, cleaning staff and most importantly the pupils) as well as visitors (parents, teaching staff and scholars from other visiting schools).

Peers

Staff /Adults



The Student

Figure 5.29 Everyday users

5.7 Client

The client is Shift College, an independent high school group. The brief was to design an educational environment which shifts the perspective of MST education. The school should be able to fulfill the prescribed academic curriculum while incorporating experiential learning into the traditional educational model.

The students should be exposed to real life situations where they can test and experiment with their skills.

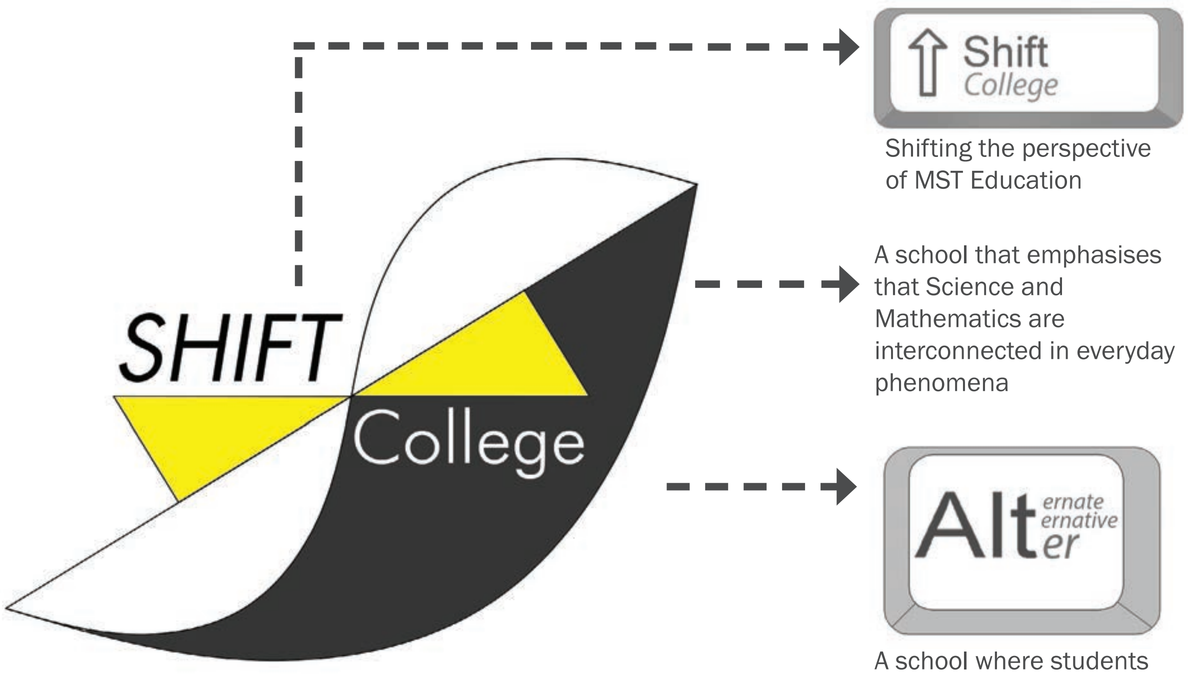


Figure 5.30 New proposed name and logo for the school.

5.8 Conclusion

These design stages determined how the school could spatially, socially and educationally become more interconnected. The relationship between subjects and adjacent spaces were established to enable cross-pollination between different learning activities. This chapter also investigated how students can organise space through furniture to their needs. It was determined that spatial layout plays a major role in enabling different teaching and learning methods.

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06

6. Conceptual Development

6.1 Introduction

Through theory and case studies the notion of four types of teachers in the facilitation of learning were identified. All of these teachers have different environmental requirements to enable them to teach.

Four teachers as design generators:

Adults as teachers;

Peers as teachers;

The student as a teacher;

And finally the environment as a teacher.

Adults as teachers

The traditional model mostly focused on adults being the primary teachers of students. Space should enable the adult to teach and learners to learn through complying with the basic spatial requirements.

Peers as teachers

Peers act as teachers through social interaction, peer assistance and peer review. These teachings happen in places where students cross paths, pause and communicate. It also happens when work is exhibited, presented and discussed, as well as in places which enable collaboration and group work.

Students teach each other MST through peer assistance, project-based learning and by playing educational games against each other.

The student as a teacher

With the information revolution the student should be trained to become a lifelong learner. He/she should be able to become their own teacher.

Technology and the internet have connected the student to a wide knowledge spectrum. Space should enable students to plug into this knowledge.

The environment should entice students to partake in activity that will allow them to become self-learners through making, manipulating and altering their world.

Space should allow for individual learning, research and investigation to enable self-discovery. Students should be able to act like professionals in real life situations.

6.2 The Environment as an Informal MST Teacher

All buildings have lessons to teach. They have Science, Mathematics and Technology hidden away in their structures, materials, services and how they interact with the natural elements around them. These lessons can be exposed by showing how things work. Students can learn through their own experiences and interactions with the building.

Figure 6.2
This art piece shows the movement of wind currents on a micro scale. By installing a similar permanent art piece students will be able to visualize the usually invisible wind currents.

Figure 6.3
The pyramid acts like the inverse of a prism. Subtractive light theory has been applied and when equal amounts of cyan, green and red are present white light is produced.

Lessons in electrical supply

Figure 6.1 Node light by Odd Matter Studio, resembles circuit diagrams

Lessons in the wind

Figure 6.2 Windswept, Charles Sowers

Lessons in the colour of light

Figure 6.3 Electricity Paper vinyl, installation view 5, Daniel Buren, 3013

Lessons in the sun's path

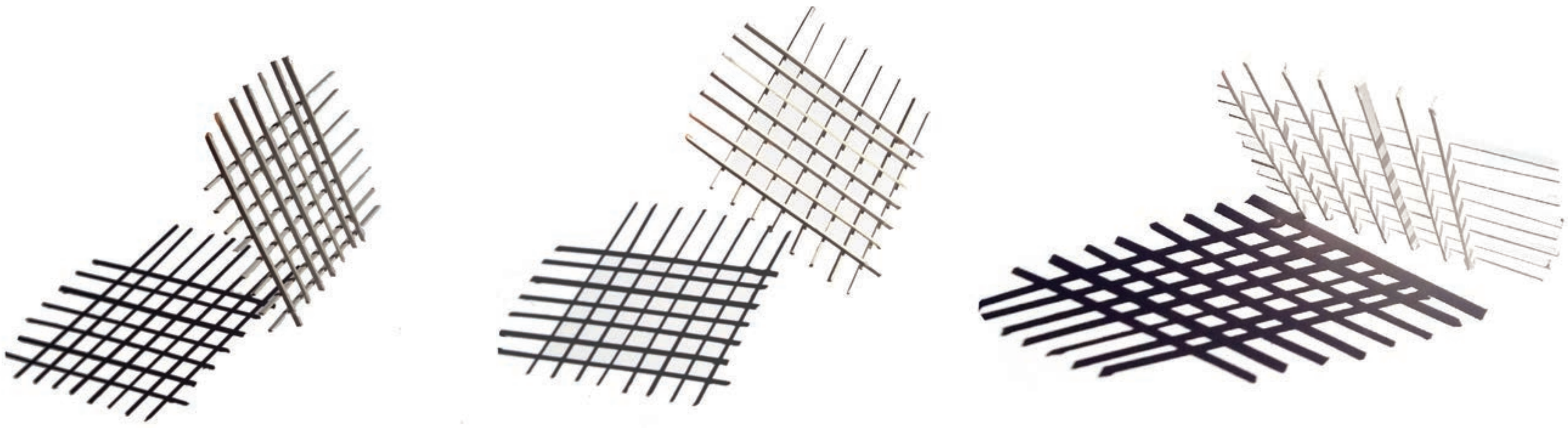


Figure 6.4 Proposed screens for social learning areas.

Figure 6.4
As sunlight interacts with the screens, the angles and lengths of the patterns cast will change. The screens will aim to encourage students to start noticing the Mathematics around them and to appreciate the beauty of it.

Museum Wall - Lessons in objects

By creating a rich environment filled with elements and objects, like one would find in a natural history museum or Science centre, the student can choose to actively engage with an object, thereby unlocking a wonder of the world, forming opinions or actively forming connections between taught concepts and the real world.

Lessons in African Fractals

Ron Eglash talks about the inherent mathematical scaling that exists in African design and by incorporating the African Fractal theories into Mathematics class, how African American students were taught about their Mathematical heritage and this led to an improvement in their understanding of Mathematics (TedGlobal, 2007). The museum wall is envisioned as an African Fractal consisting of 60° triangles (refer to Figure 6.5). Students can interact with this display system by scaling down and scaling up the triangles. The initial concept was to collect seeds, animal carcasses, shells, insects, stones, minerals or any other natural objects and to display them in these museum walls. Through these displays the natural environment (outside) is brought into the school. In the makerspace there will be molds where the students can cast these specimens in modular resin triangles. When inserted into the display wall these triangles become part of the fractal.

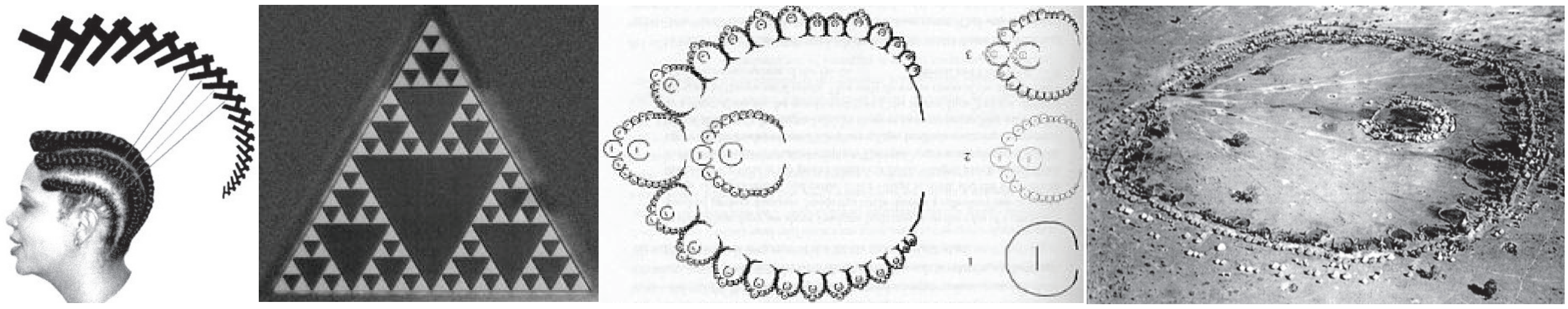


Figure 6.5 African Fractals (TedGlobal, 2007)

Figure 6.6 Museum wall

Science Wall - Lessons in equipment

In all schools there is fascinating Science equipment, materials and specimens locked up in forbidden storerooms only to be revealed to a select few, for a limited period of time. Through exposing these hidden wonders to all, a world of possibilities can be opened up in the students' minds (refer to Figure 6.6 and 6.7).

The Science and Biology storerooms in the school will become glass boxes. Here the shelving system that will become visible through the glass facade will also resemble an African Fractal (refer to Figure 6.5).

A fractal of squares in squares. The change in shape will indicate that the elements on display are functional and should be handled professionally. By exposing the storeroom, students can inquire and assert their educators to teach them through experiential methods.

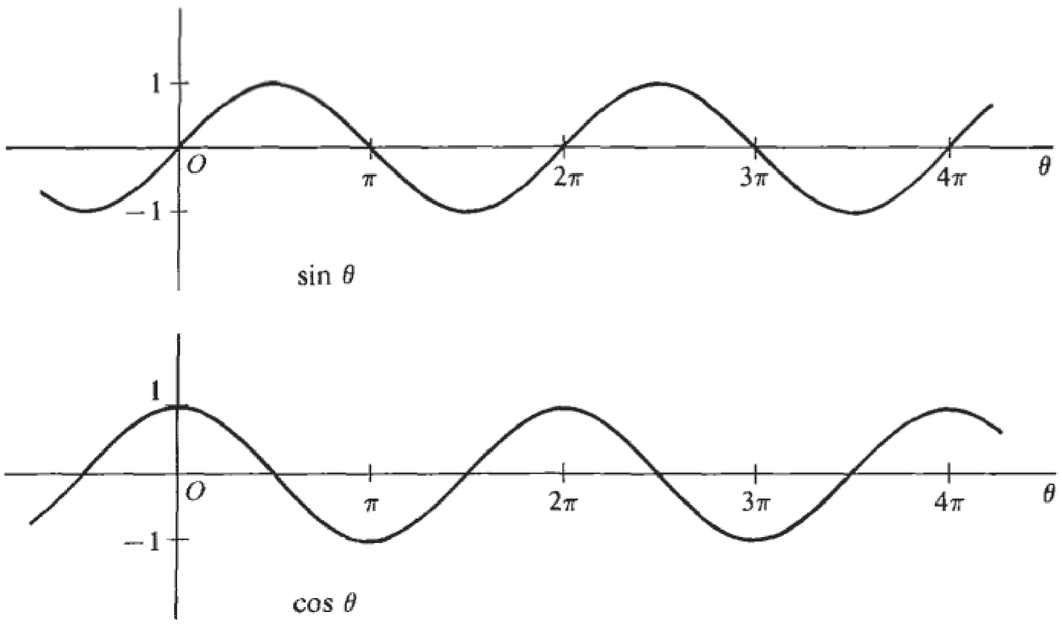
Figure 6.7 Storage wall

Figure 6.8 Conceptual Models

Development of Concept into Physical Form

Structure is generated using the principles of the sine and cosine graphs found in trigonometry. The waves depicted in these graphs are also found in nature, such as sound waves and the movement of light in space. The wave thus combines Mathematics and Science and becomes a symbol to use in the creation of interior structure and functional space.

The seperation of the Science laboratory and main circulation artery is thus inspired by the curving angles of the trigonometric graphs. The curving wall creates nieches for students to work, rest or interact with one another. The wall then not only functions as a sound and visual barrier, but becomes an interactive wall. The curves created within the interior also acts as a spatial gradient, allowing users to interpret the space themselves and adapt it to their needs. The shapes of interior intervention acts as visual cues, further enabling the multifunctionality of the trigonometric wall.



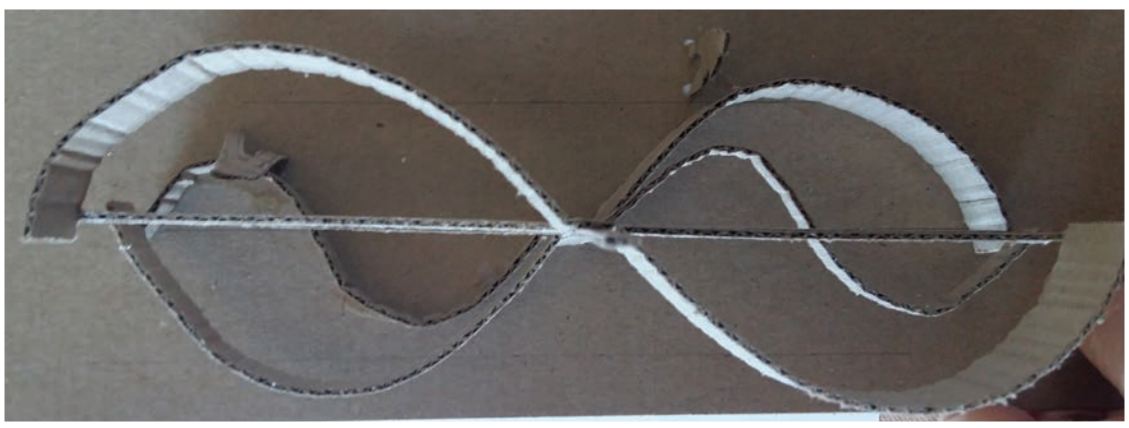


Figure 6.9 Conceptual models developed from Sine and Cosine trigonometric graphs.

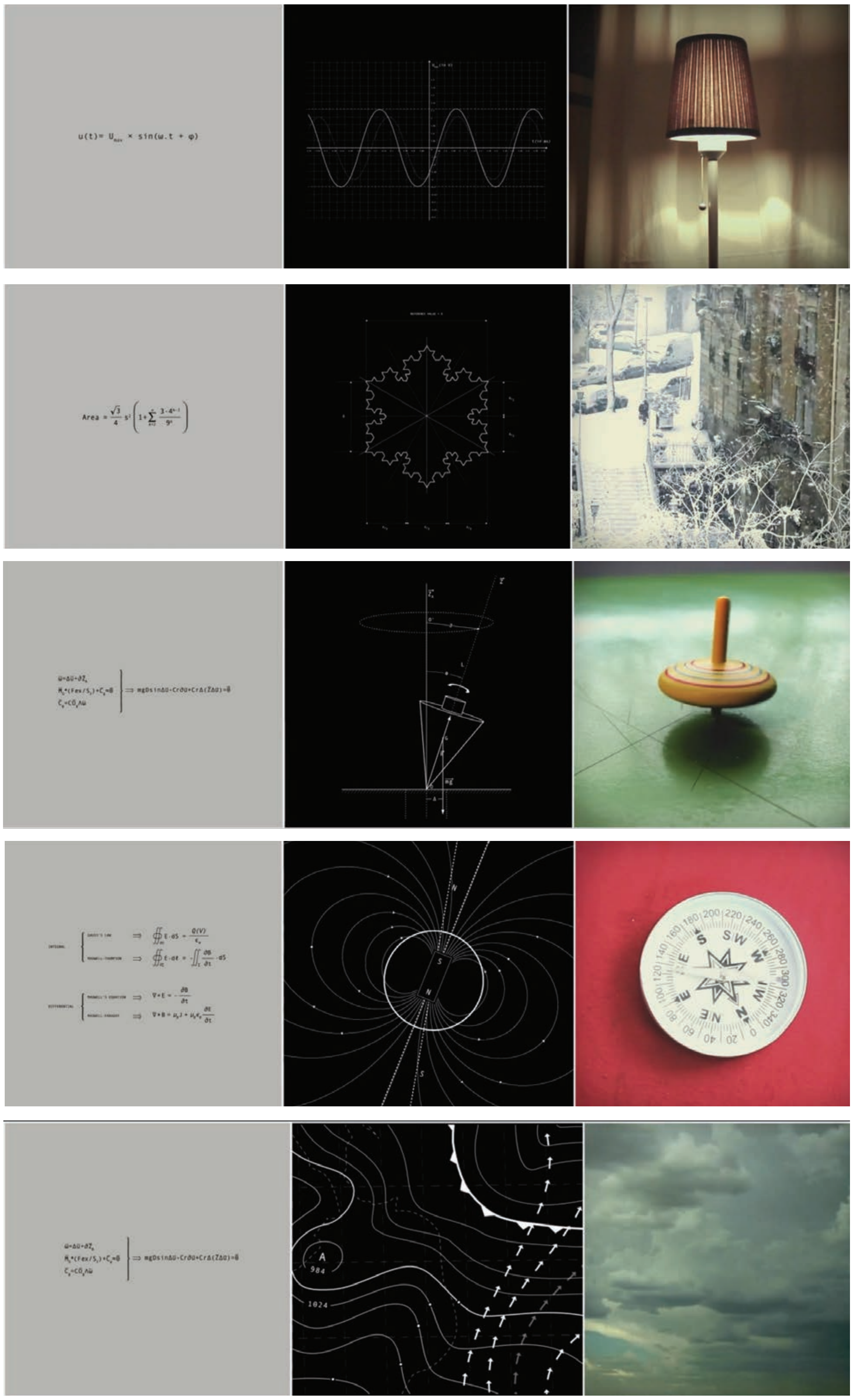


Figure 6.10 Compilation of frames from short film, Beauty of Mathematics (Parachutes, 2013)

Figure 6.10 depicts how, through graphs and equations, it is evident that Mathematics and Science can explain everyday phenomena.

6.3 Conclusion

It is important that the design and the technification thereof allows each of the four types of teachers to teach optimally. This is dependent upon the way space acts as a teacher. The in-depth design focus has been narrowed down to the concept of space as a teacher of MST. Space will be designed to enrich Mathematics, Science and Technology education.

07

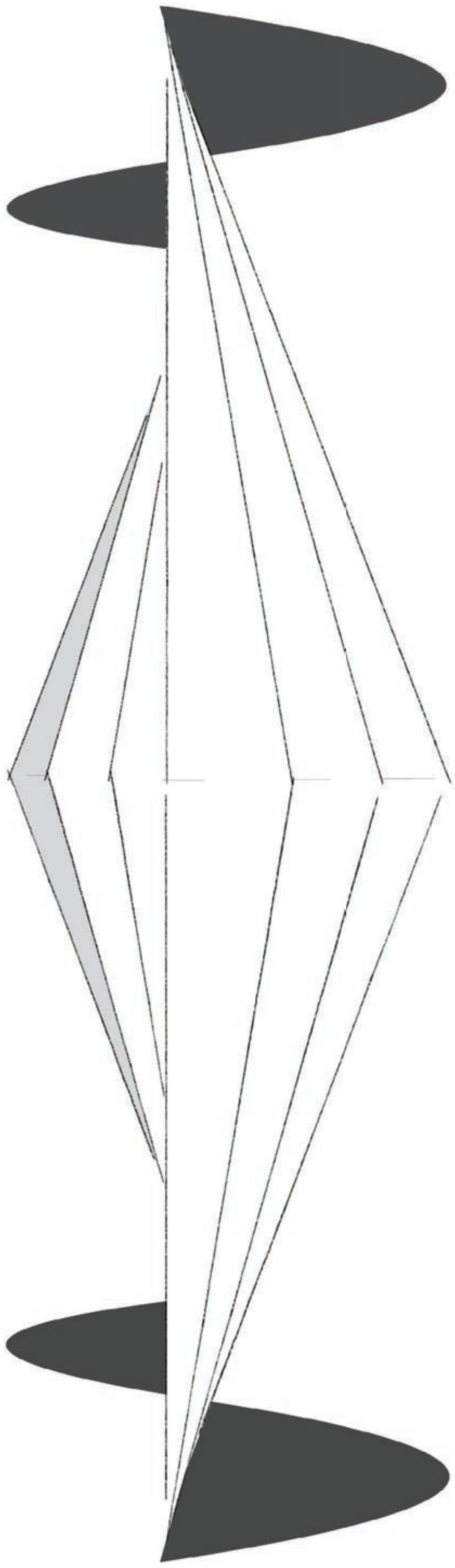
7. Design Discourse

7.1 Introduction

In this chapter, all the previous investigations, research and discoveries manifested in the form of a physical design that facilitates varied learning and teaching methods in the classroom.

The theory dealt with experiential learning. This can be achieved through educational methods, but also through the environment. The design catalyses experiences and displays the experiences of others.

Firstly, the design created spaces of visual exchange and social contact, to enrich the educational experience. Secondly, the design used space to intrigue students, allowing them to discover and experiment with MST. Thirdly, the design allows all four teachers to teach.



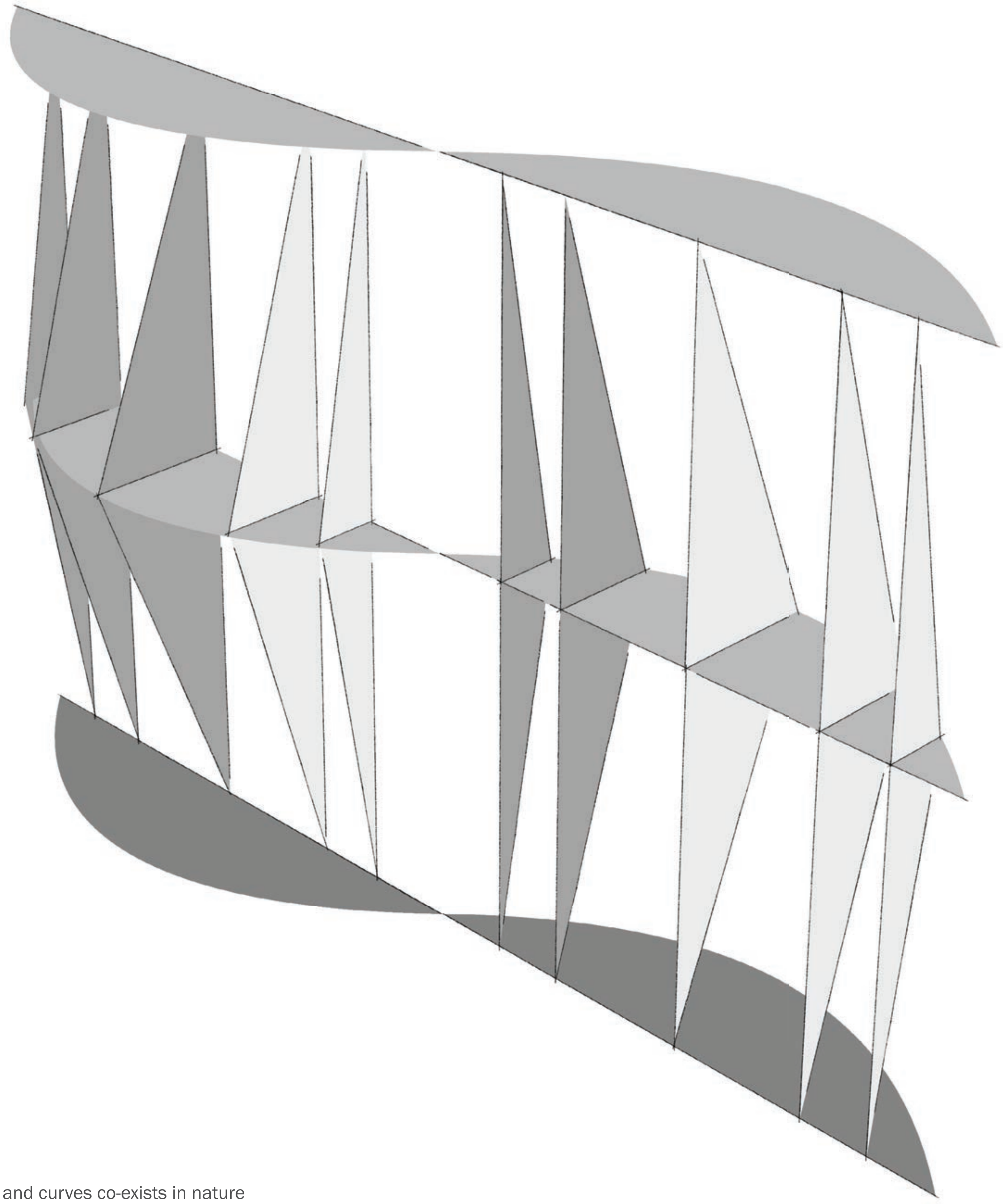


Figure 7.1 Triangles and curves co-exists in nature

By breaking curves up into triangles we can determine their characteristics. The spatial character of Shift College's interior manifest this close relationship between curves and angles.

Shape becomes an informative tool hinting at the method of learning students can expect in a space.

7.2. Plan Development

7.2.1 Ground Floor Plan

Figures 7.2 - 7.4 illustrate design development of the plan.

Figures 7.8 presents the final plan for the ground floor and is discussed in detail:

The ground floor plan deals with access and entrance. A new concrete ramp and steps have been provided, making the school wheelchair accessible. The ramp also enables students to park their bicycles in a secure bicycle parking area. In front of the building stepped seats provide a place for students to wait for their transport after school. In the lobby a security desk is placed so that the guard may control access of the users coming in and out of the building. The entrance is welcoming and opens up to the bustling city sidewalk, whilst still maintaining a safe and secure entrance.

The rest of the ground floor plan remains as it is, as a parking lot. This space has the potential to be programmed in the future to function as a restaurant or a pop-up marketplace.

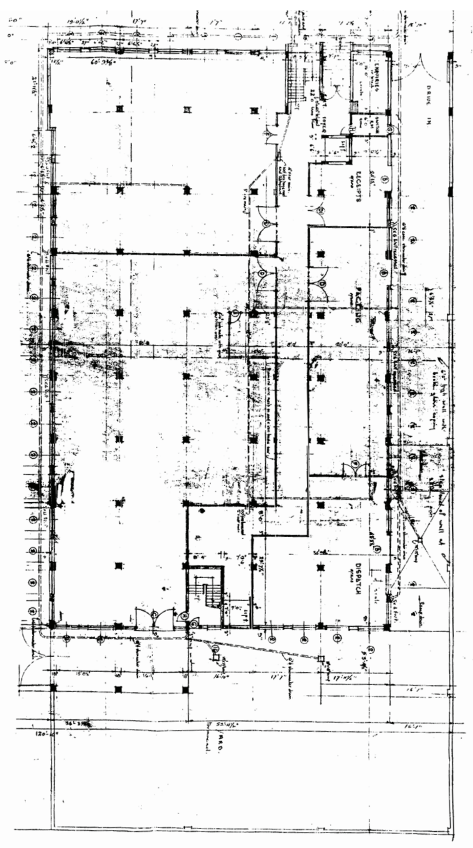


Figure 7.2 Original Ground Floor Plan, 1955

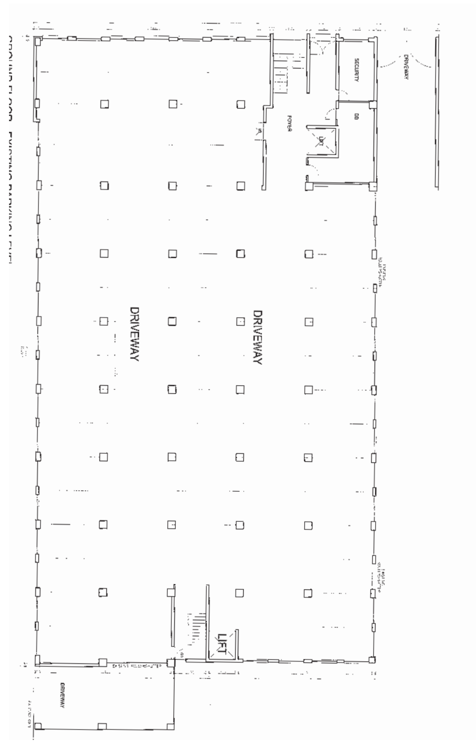


Figure 7.3 City Property Ground Floor Plan, 200[illegible]

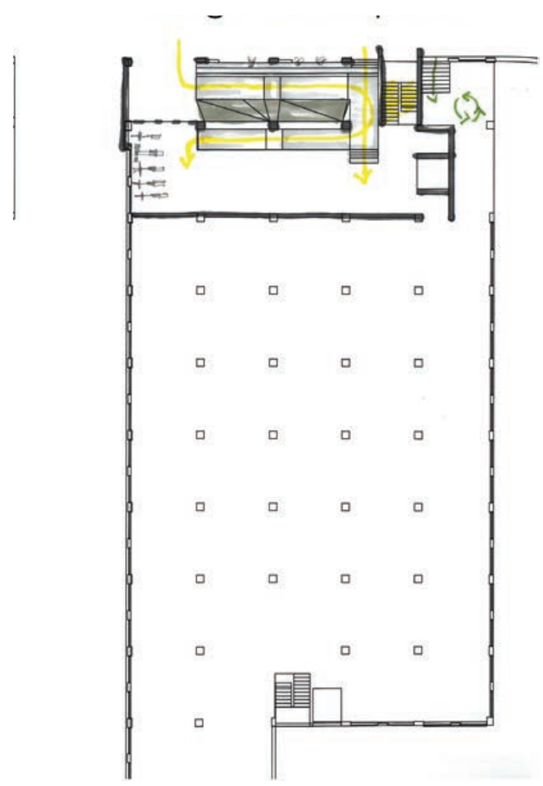
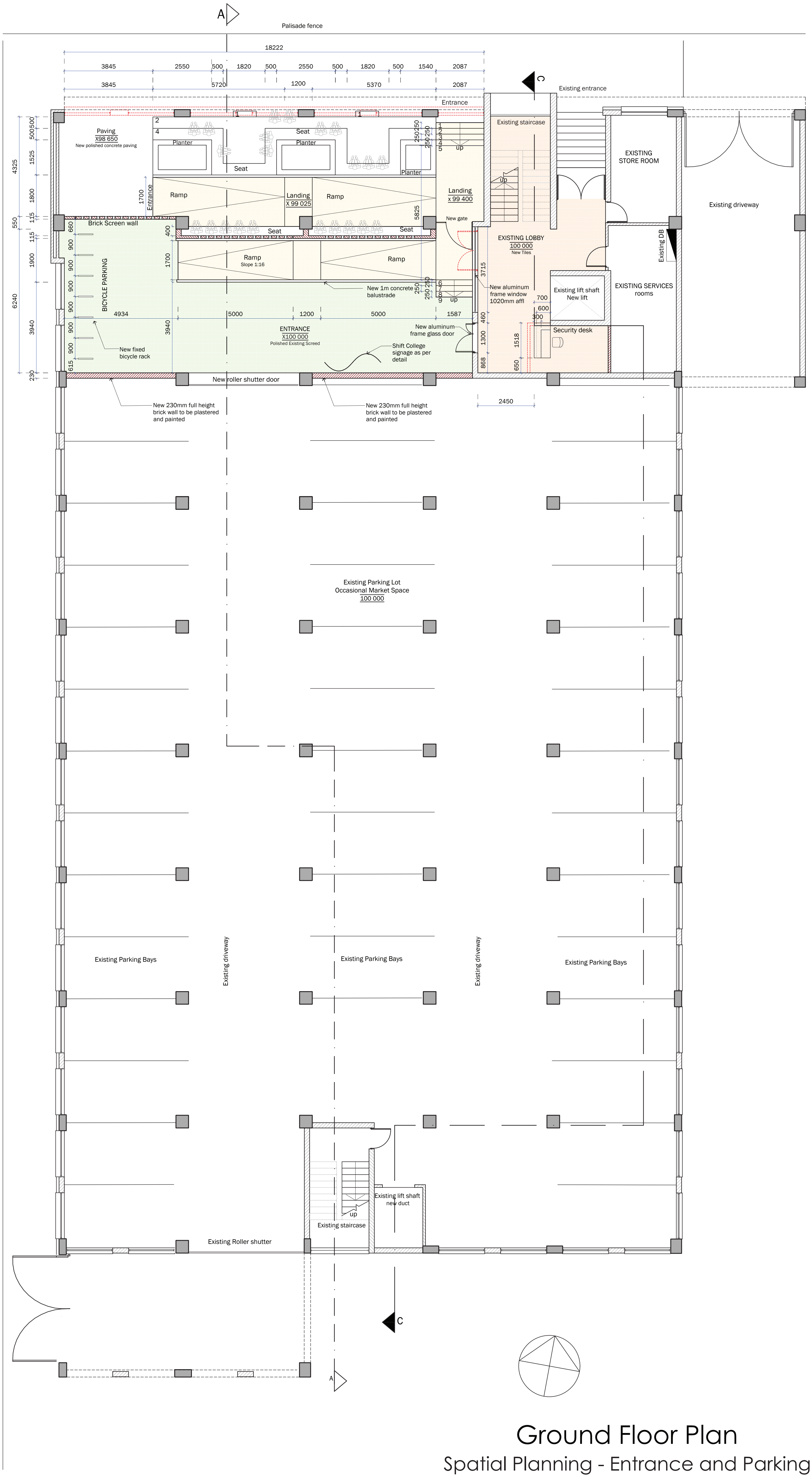


Figure 7.4 Conceptual Ground Floor Plan, June 2016

Ground Floor Plan -Spatial planning



Ground Floor Plan

Spatial Planning - Entrance and Parking

Figure 7.5 Ground Floor Design Plan

7.2.2 First Floor Plan

Figures 7.5 - 7.7 illustrate design development of the plan.

Figures 7.9 presents the zoning plan for the first floor, a spatial planning exercise was performed. The northern side is dedicated to the administration department, staff facilities and sick room. The rest of the floor will remain staff parking.

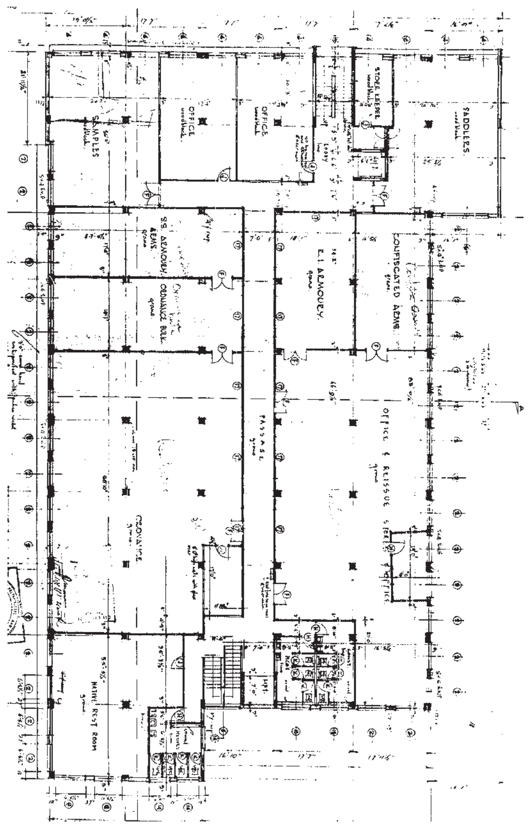
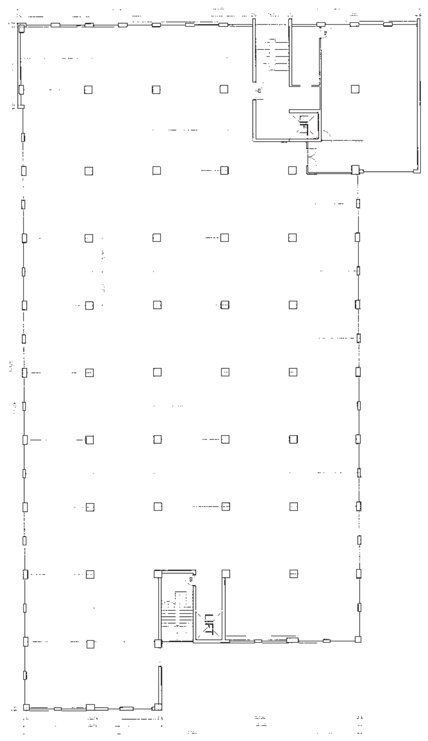


Figure 7.6 Original First Floor Plan, 1955



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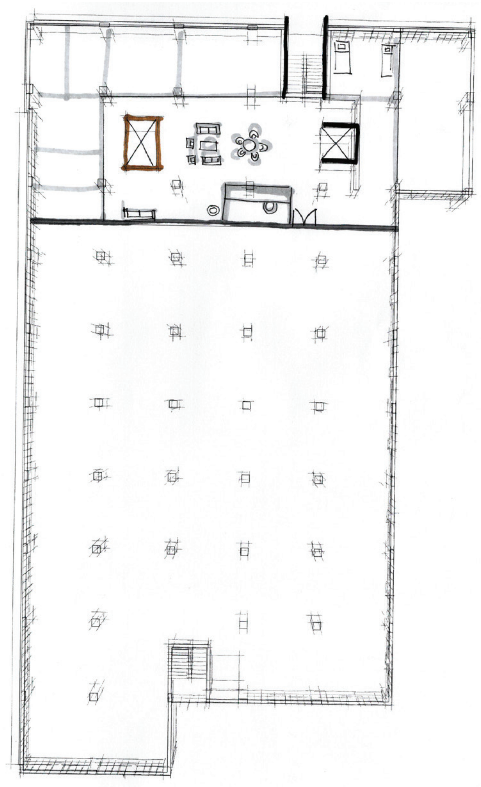
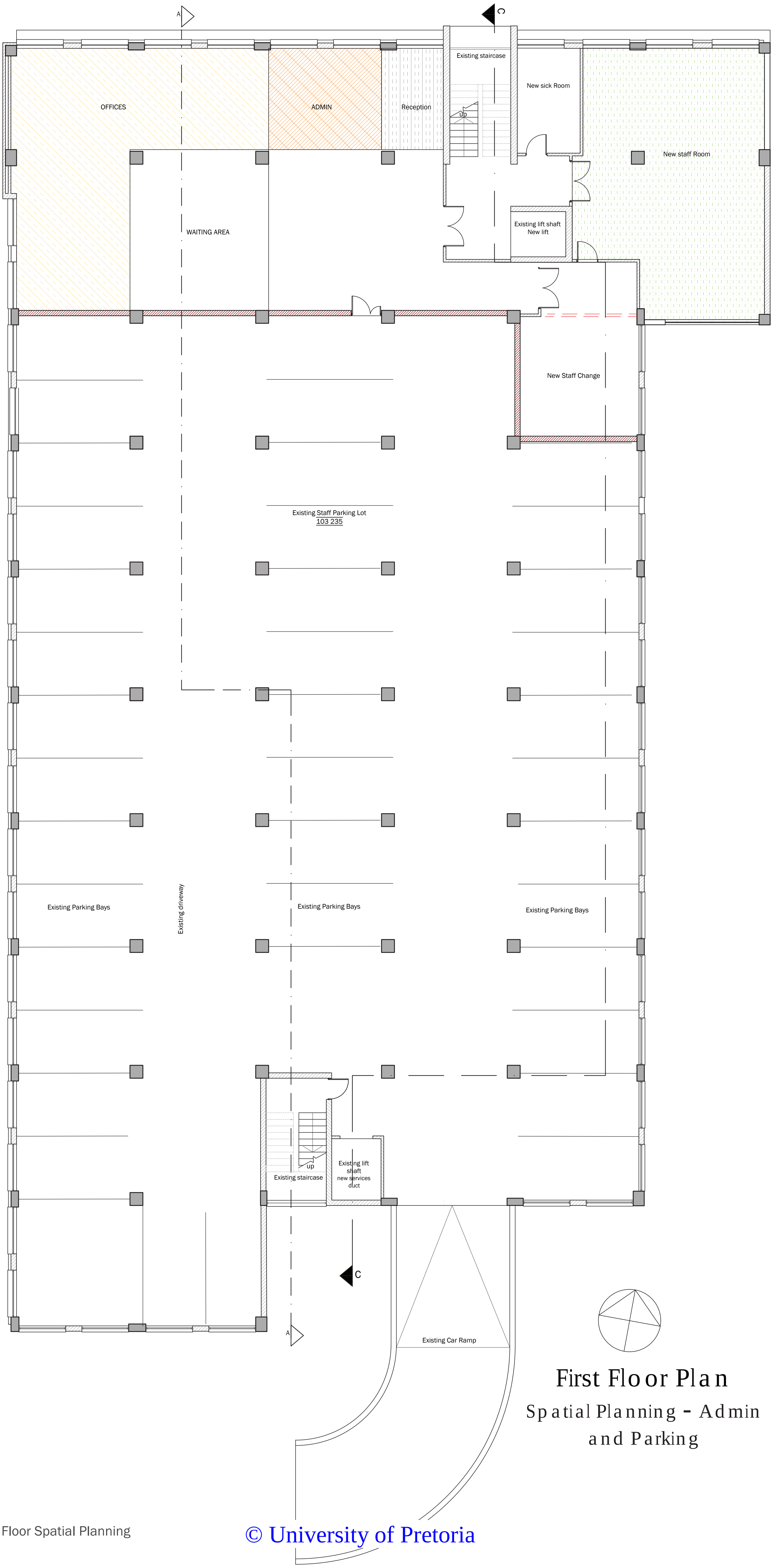


Figure 7.8 Conceptual First Floor Plan, June 2016

First Floor Plan -Spatial planning



First Floor Plan

Spatial Planning - Admin and Parking

Figure 7.9 First Floor Spatial Planning

7.2.3 Second Floor Plan

Figures 7.10 - 7.13 illustrate design development of the second floor plan.

Figures 7.14 presents the final plan for the second floor and is discussed in detail:

On the second floor the educational facilities start. The library is located on the north-western side.

As one enters the third floor from the main circulation core, an atrium space opens up in front of the student. The atrium space serves as an open theatre space, where passersby can stop and view activities. When not used for demonstrations, the atrium will act as a public square which becomes a place where social learning takes place.

Group work spaces are located next to the atrium. Here students can work in a semi-private space on a group project, meet with people from industry or have a meeting with a teacher or counsellor.

The back half of the building contains the theory classrooms. The humanities and language subjects are housed on the second floor.

The passage is wide and allows learning to spill into the central space of the school. Paths of light enter the space through the atrium and windows in the classroom walls.

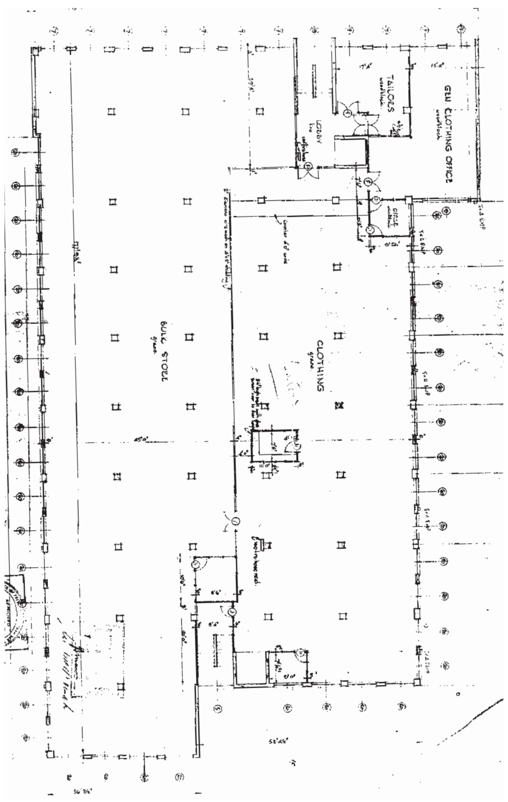


Figure 7.10 Original Second Floor Plan, 1955

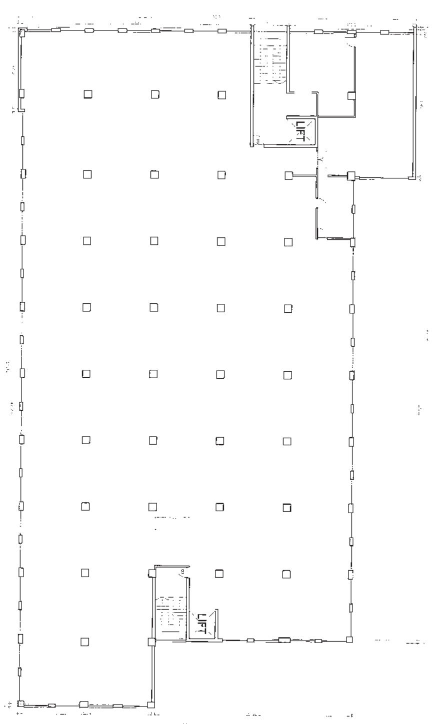


Figure 7.11 City Property Second Floor Plan, 2009

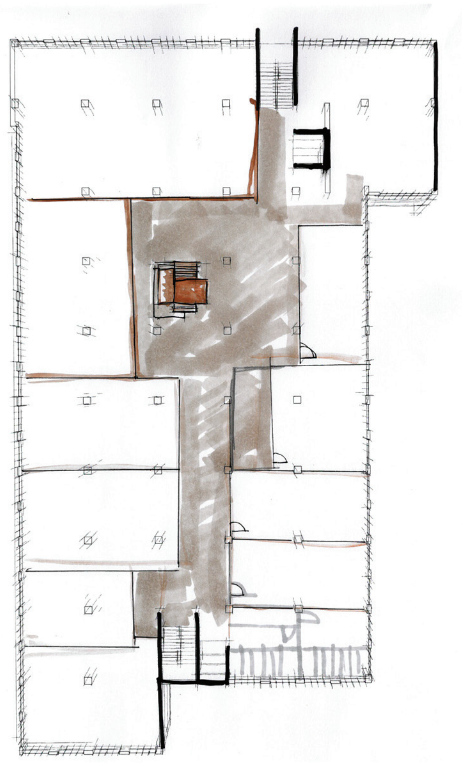


Figure 7.12 Conceptual Second Floor Plan, June 2016

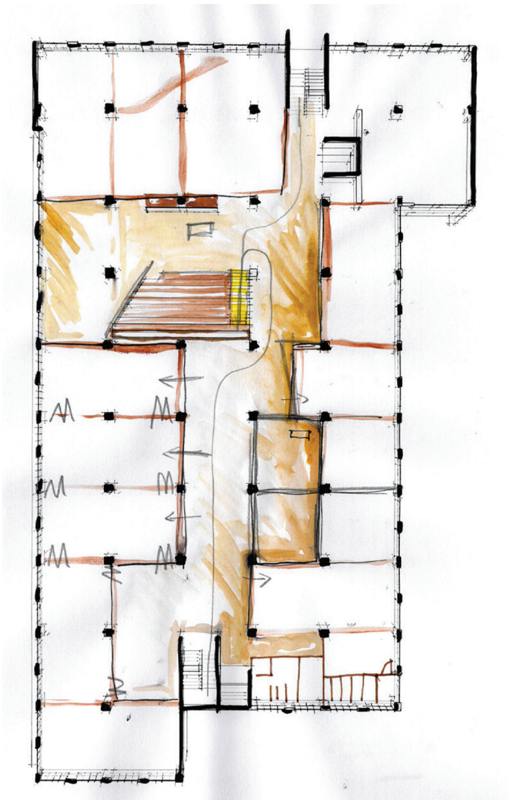
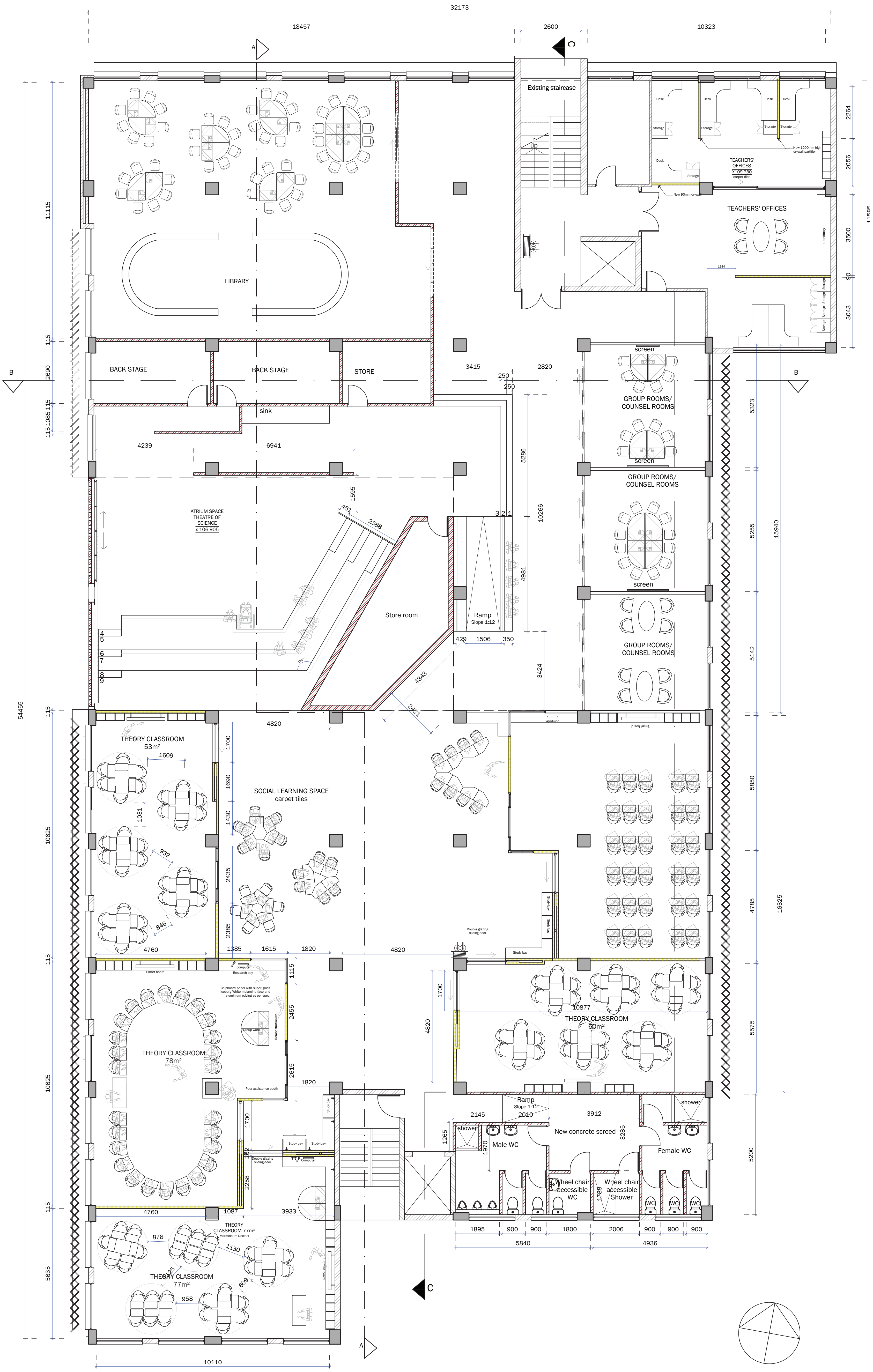


Figure 7.13 Conceptual Second Floor Plan, August 2016



Second Floor Plan

Spatial Planning - Atrium, Library, Languages and Humanities

Figure 7.14 Second Floor Space Planning Plan

7.2.4 Third Floor Plan

Figures 7.15 - 7.20 illustrate design development of the plan.

Figures 7.21 presents the final plan for the third floor and is discussed in detail:

The third floor is the MST level. The low-tech makerspace and Art classroom are located in the north-western corner. These two spaces walk out onto a patio on the northern facade. Activities that happen in the low-tech makerspace are visible from different viewpoints in the school. This corner also becomes the main exterior feature. Here the author broke the structure and added a clip-on intervention. The intervention has honest construction details, revealing how it is put together. Through visual links and exposed details the space invites inspection, inciting further investigation, thereby facilitating self-learning.

The atrium is located next to the makerspace. Here raked seating helps to visually connect activities happening throughout the school. The atrium's clerestory windows together with the angled suspended ceiling allows light to penetrate into the building, lighting up the circulation spaces. The correlating large glazed section of the western facade allows diffused light in while still blocking direct sunlight.

The Science labs are located on the eastern side next to the major circulation artery. The eastern part of the school will be exposed to bright morning light for most of the school day, thus the labs will be naturally lit and will aid in achieving the recommended lux levels for intricate lab work and lowering the need for artificial lighting. These labs are meant for experience-based learning, thus digital technology will be used minimally. Science theory will be taught in the darker theory classrooms.

The Science store becomes the main interior feature on this floor. The equipment, chemicals and prep work are displayed in a tinted glass box. The store resembles a real laboratory and students get a glimpse into the actual physical environment that a scientist works in.

The western side is allocated to theory-based education. The space between the theory classrooms and laboratory spaces is a social learning environment. Passages that widen at places and become narrower at other places facilitate circulation while at the same time accommodating place for students to gather in small groups or to work individually. Here students will have a view of all the activities happening around them. The perforated vinyl decal on windows will allow views into the lighter classroom, but views from the classrooms into the darker social learning space will become obscure.

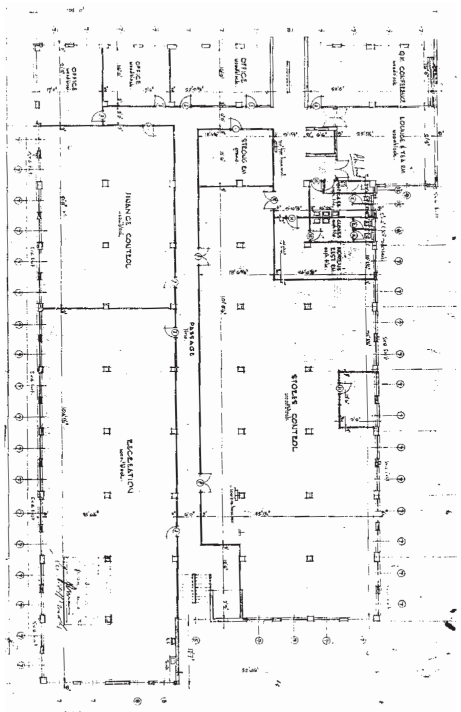


Figure 7.15 Original Third Floor Plan, 1955

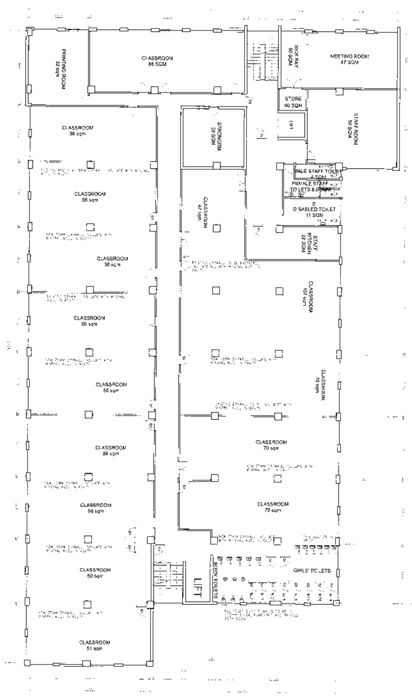


Figure 7.16 City Property Third Floor Plan, 2009

Figure 7.17 Conceptual Third Floor Plan, June 2016

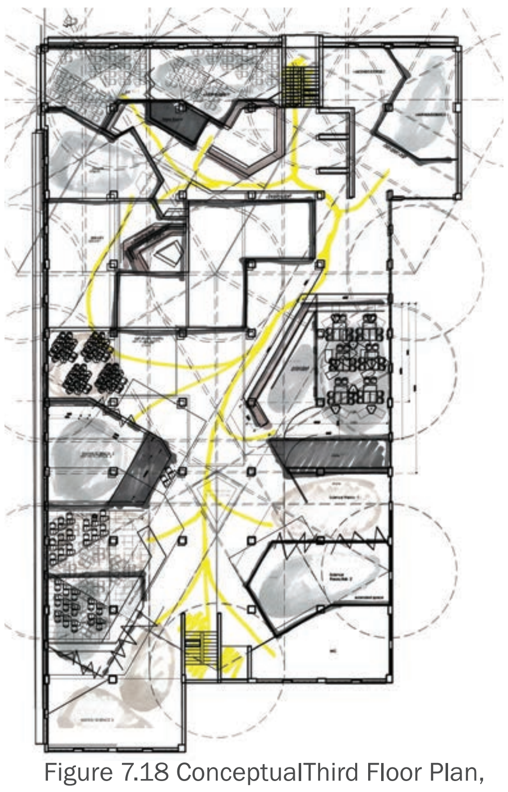


Figure 7.18 ConceptualThird Floor Plan, June 2016

Figure 7.19 Conceptual Third Floor Plan, August 2016

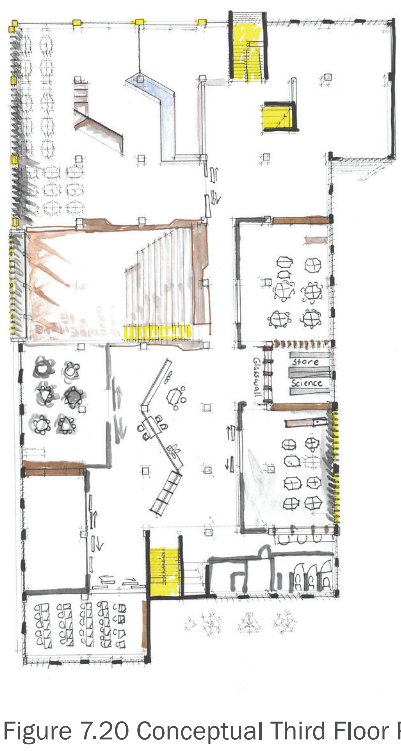


Figure 7.20 Conceptual Third Floor Plan, August 2016

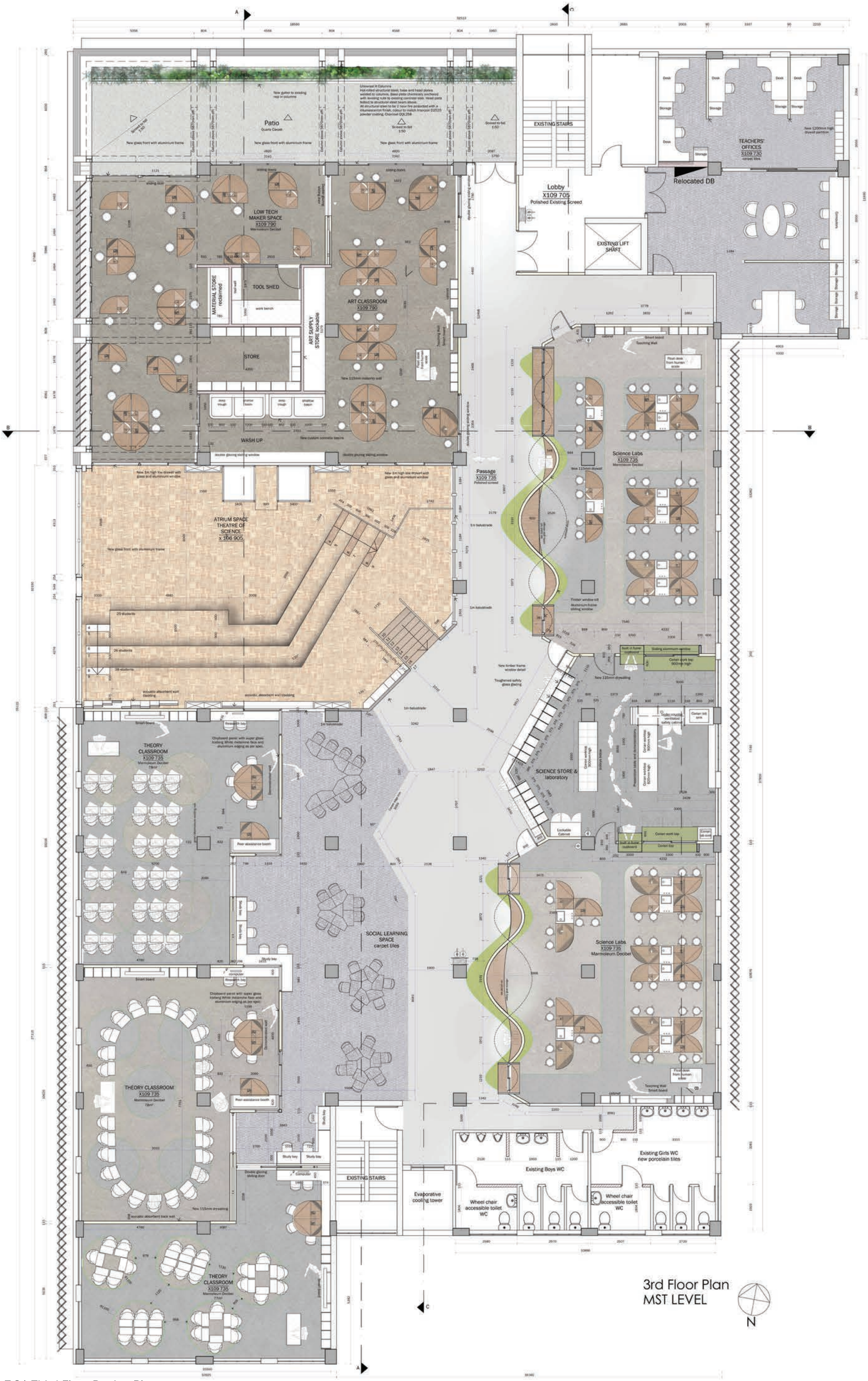


Figure 7.21 Third Floor Design Plan

7.2.5 Fourth Floor Plan

Figures 7.22 - 7.24 illustrate design development of the plan.

The fourth floor forms part of the MST facilities. The high-tech IT lab is located in the north-western corner.

This space looks down onto the low-tech makerspace, again encouraging cross-pollination of uses and experiences. The clip-on intervention connects to the existing structure on this corner. The angled steel columns draw the eye to the spaces below. The intervention emphasises the role it plays in supporting the existing concrete roof. The canteen, with a tuck-shop, and kitchen is located on the eastern side.

Two large classrooms are located on the western side. Dedicated to Biology and Geography these classrooms look out onto a courtyard with an aquaponics system that serves as a real life food chain.

7.2.6 The Roof Plan

Figures 7.25 - 7.28 illustrate design development of the plan.

The roof has been appropriated as a breakout space. A half-size basketball court is located in the north-western corner. The lift shaft has been extended to allow the lift to have access to the roof. On the roof a vegetable garden is created and shaded seating. Students will spend break times here where they can enjoy views out over the city.

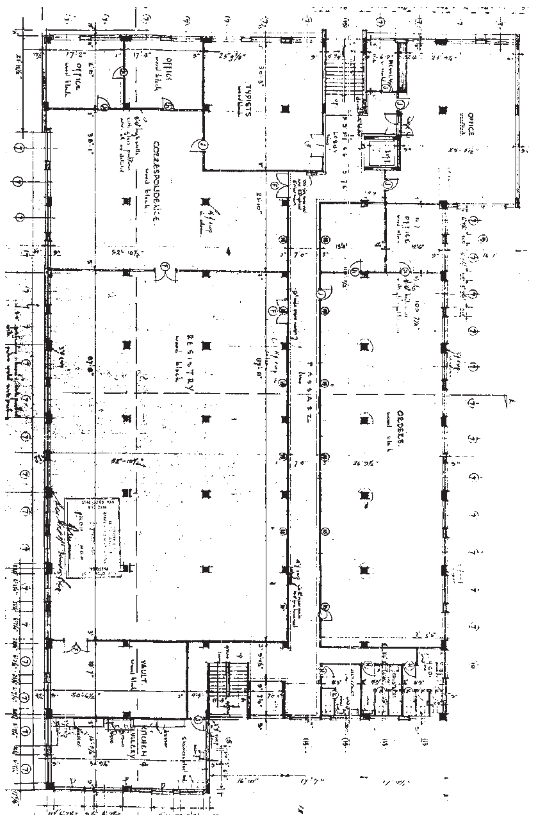


Figure 7.22 Original Fourth Floor Plan, 1955

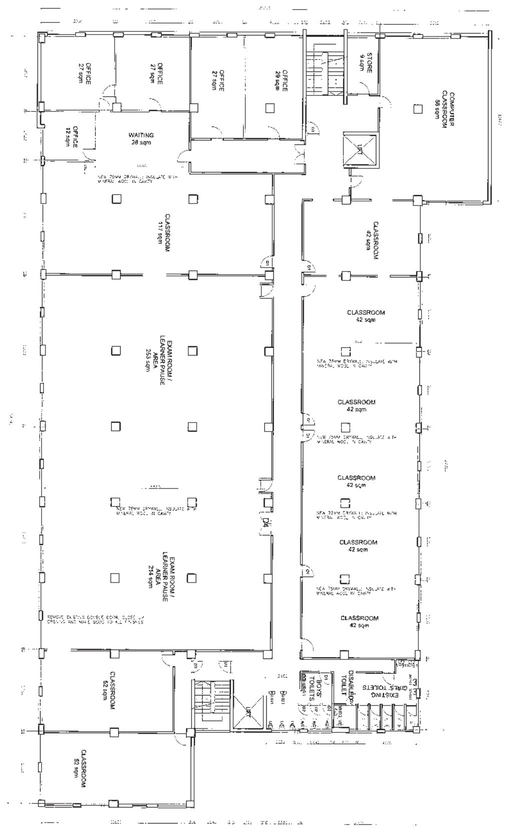


Figure 7.23 City Property Fourth Floor Plan, 2009

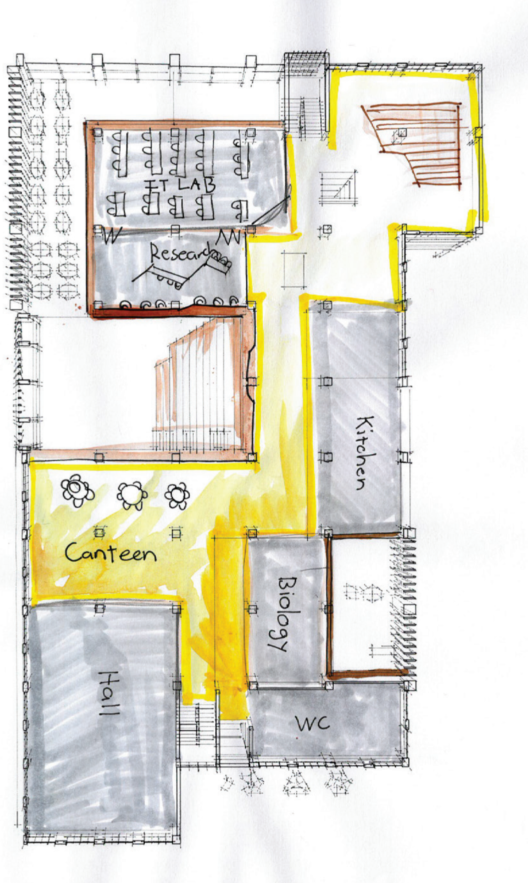


Figure 7.24 Conceptual Fourth Floor Plan, August 2016

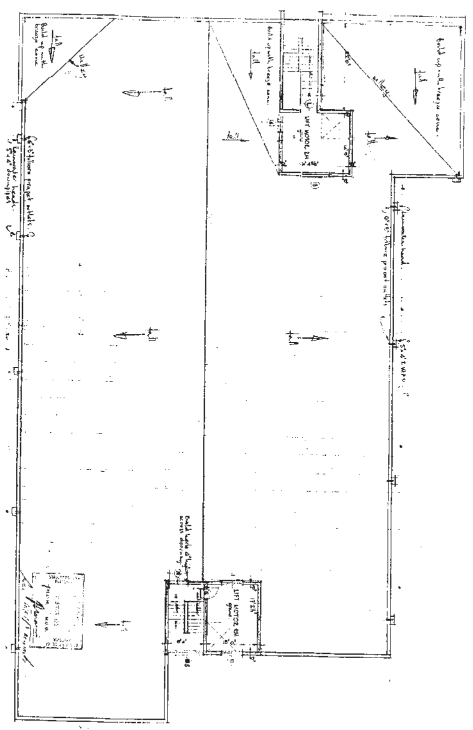


Figure 7.25 Original Roof Plan, 1955

Figure 7.26 Conceptual plan, May 2016

Figure 7.27 Conceptual Roof Plan, June 2016

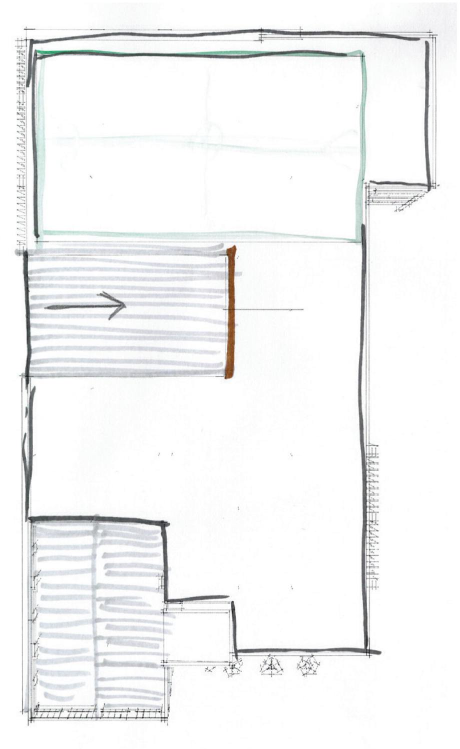


Figure 7.28 Conceptual Roof Plan, August 2016

7.2.7 North-Western Corner

Figures 7.29 - 7.32 illustrate design development of the North-Western corner of the existing building.

On its northern facade, the building is cut back to make way for the new ramped entrance on the ground floor. The dead edge of the building is now transformed into a welcoming shaded space where students can gather before and after school. The existing brick work details are repeated in the screen walls leading to the secured lobby space. The school's signage on the corner suggests movement and shift, graphically reinforcing the name of the school. The top storey on the corner is cut away. The new steel clip-on intervention draws the eye to the corner, exposing the building as an inner city school to passersby.

Again, these shapes suggest movement. The existing concrete roof seems to float and onlookers become aware of gravity and how modern Science and Technology can defy it.

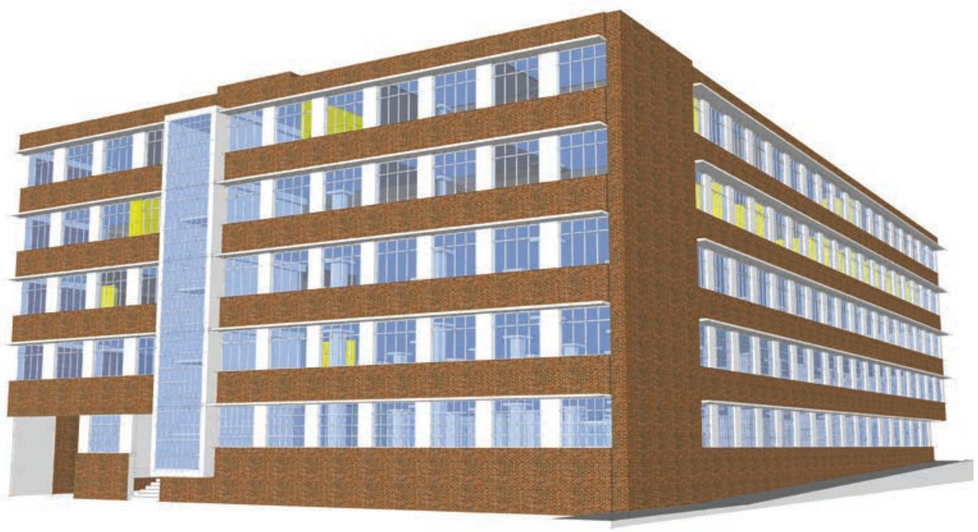


Figure 7.29 Existing Exterior

Figure 7.30 Conceptual Exterior Intervention, June 2016

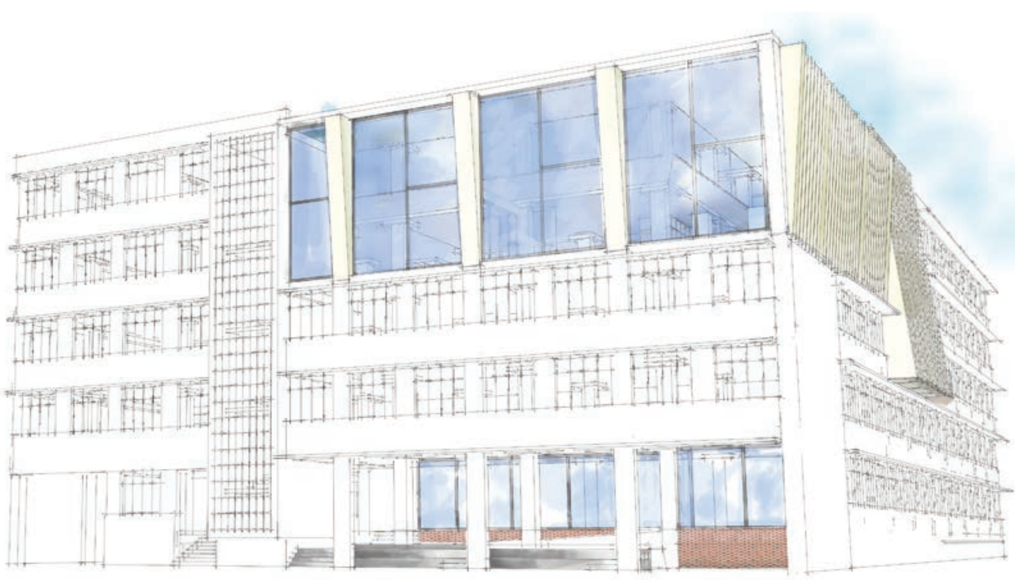


Figure 7.31 Conceptual Exterior Intervention, August 2016

Figure 7.32 Conceptual Exterior Intervention, September 2016

7.2.8 Elevations

The intervention repeats the existing brick bands around the building. By reusing the demolished bricks and laying them brick on edge and against an angle the new becomes distinguishable from the original.

The sun louvres and brick screens on the western facade blocks out the warm afternoon sun and still allows in light.

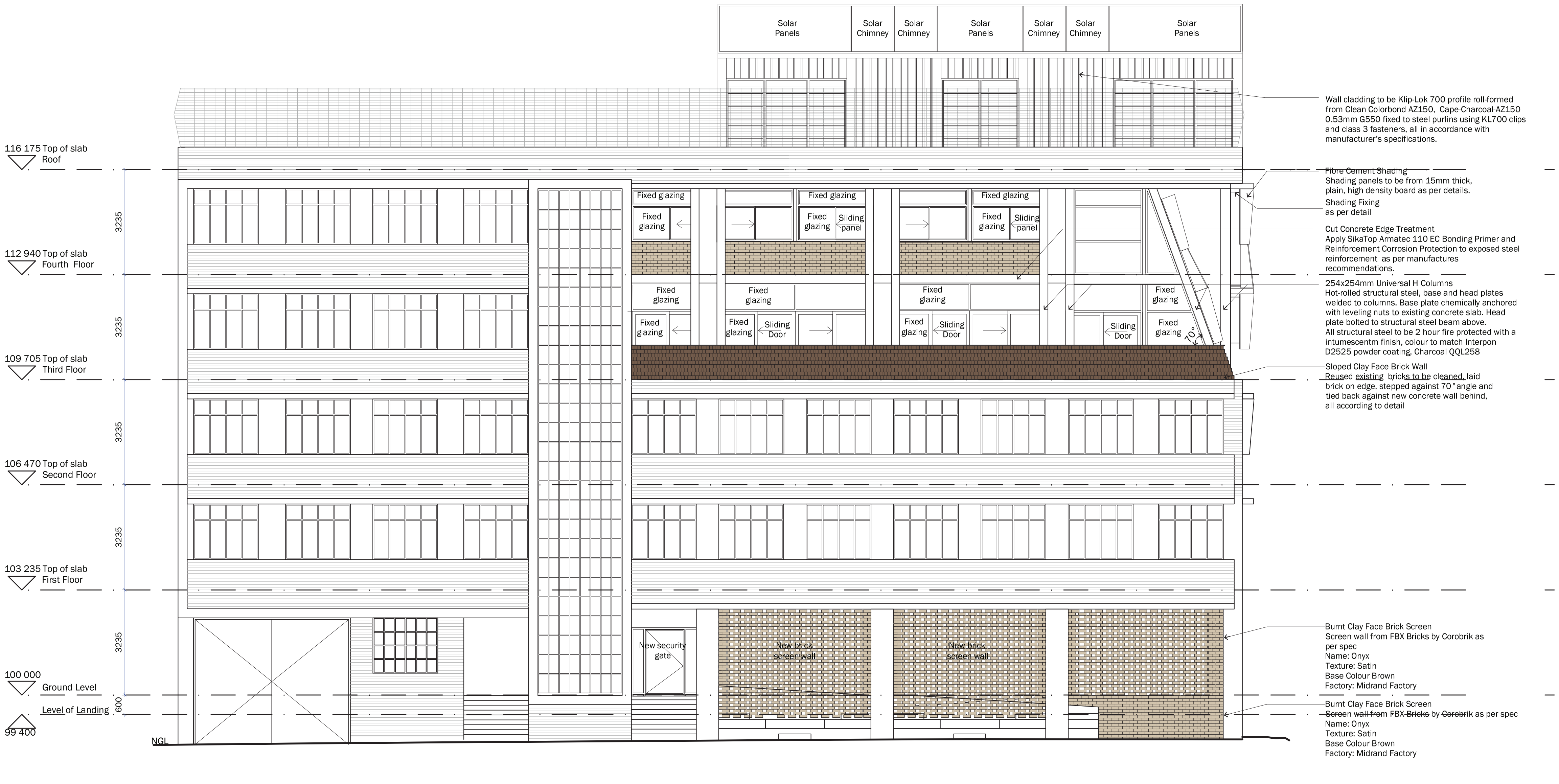


Figure 7.33 Northern Elevation

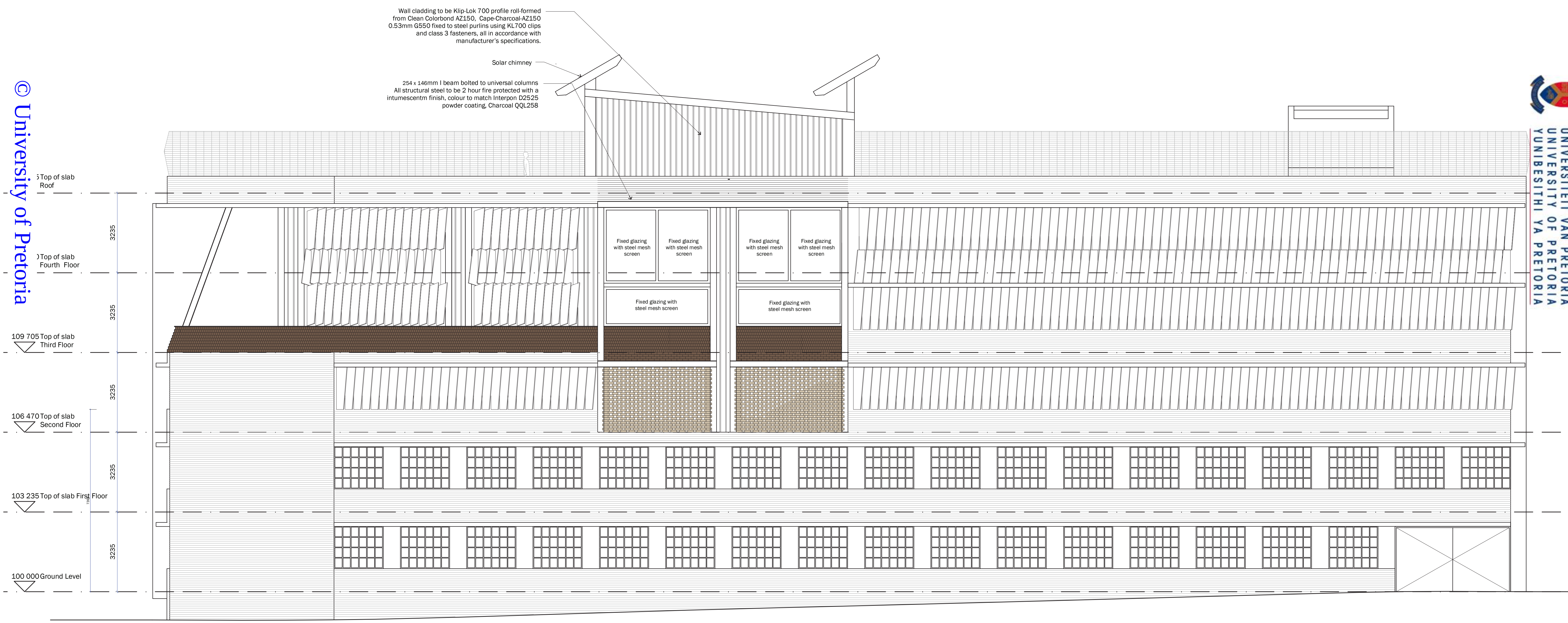


Figure 7.34 Western Elevation

7.2.9 Sections

Section A-A

Figure 7.35 Section A-A
Not to scale

Figure 7.36 illustrates how varied learning methods become exposed through visual links between spaces.

Section B-B

Figure 7.36 Section B-B
Not to scale

7.2.10 Circulation Spaces

Circulation has been used to enrich the school experience and was developed conceptually in Figures 7.36 - 7.39 and Figures 7.43-7.44.

The resolution of circulation through the building is illustrated in Figures 7.40 - 7.42; 7.45.

The entrance on the ground floor becomes a permeable threshold, a space where the bustling city life is still present. A student using the ramp will weave into the front porch space where a brick screen starts to filter out into the city. Once the student has made his way through the access- controlled front doors he will use the existing northern stairs to travel to the top three floors. The staircase looks out on the street, allowing glimpses of the city into the school. From the second floor the student can travel past the open theatre and into a wide social learning space which is surrounded by classrooms allowing views into them.

Another student might use the open theatre's raked seating to travel to the third floor. When travelling on this route the student will be surrounded with experiential learning activities. The student will see into the Science laboratory, the art classroom and the makerspaces. He would arrive in the central social learning space where glimpses into the Science store and theory classes will reveal to him what he can expect from his school career.

Figure 7.37 Conceptual Circulation Narrative, June 2016

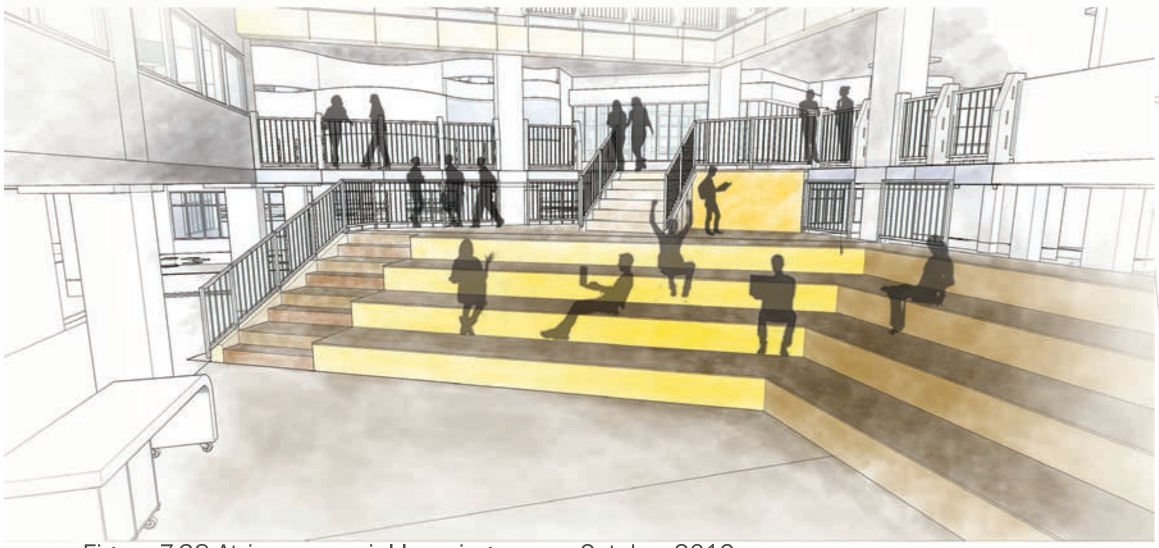


Figure 7.38 Atrium as social learning space, October 2016

Figure 7.39 Atrium as a circulation node, October 2016

Perspectives

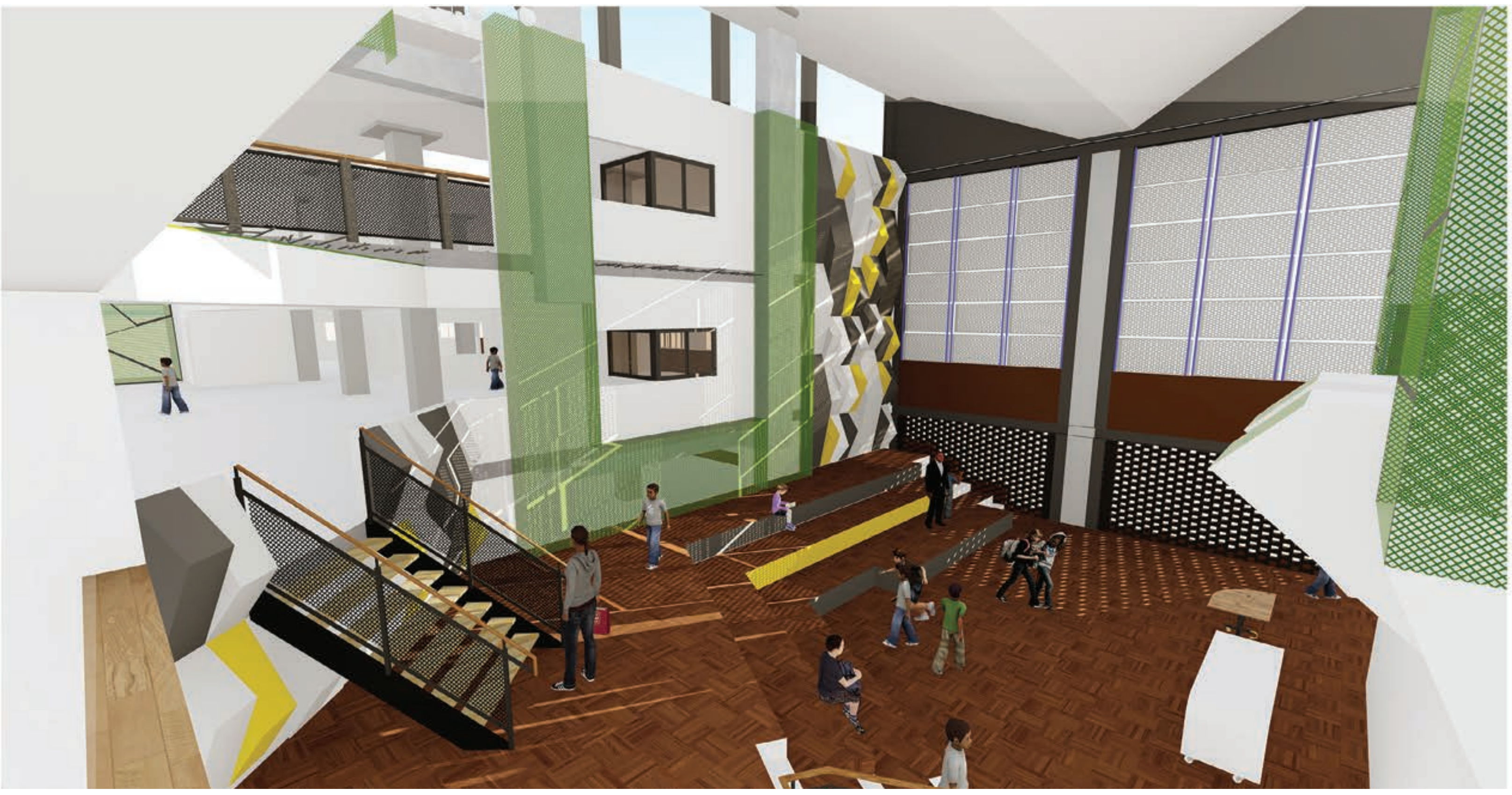


Figure 7.40 Atrium as social learning space, November 2016

Figure 7.41 Atrium as a circulation node, November 2016

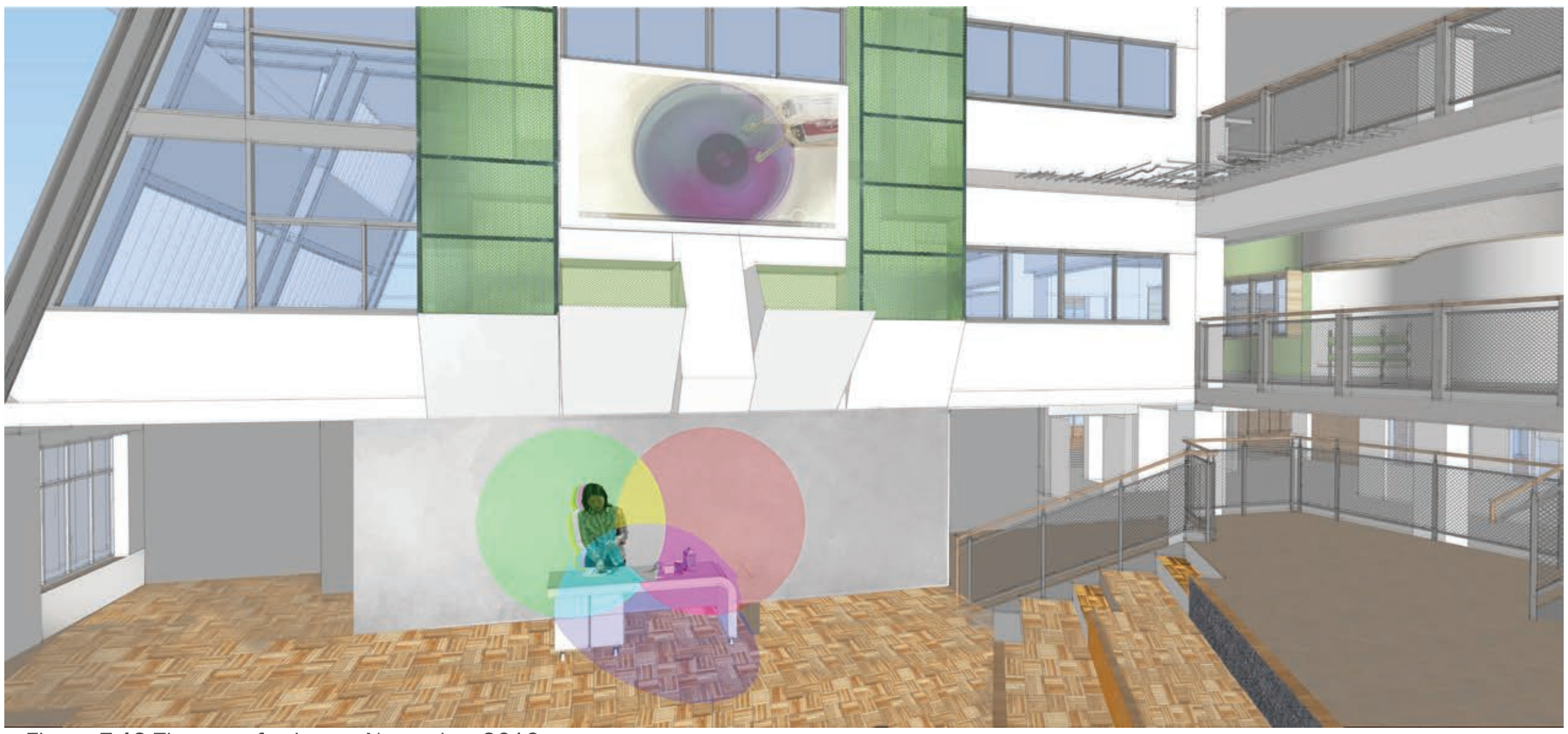


Figure 7.42 Theatre of science, November 2016

Perspectives

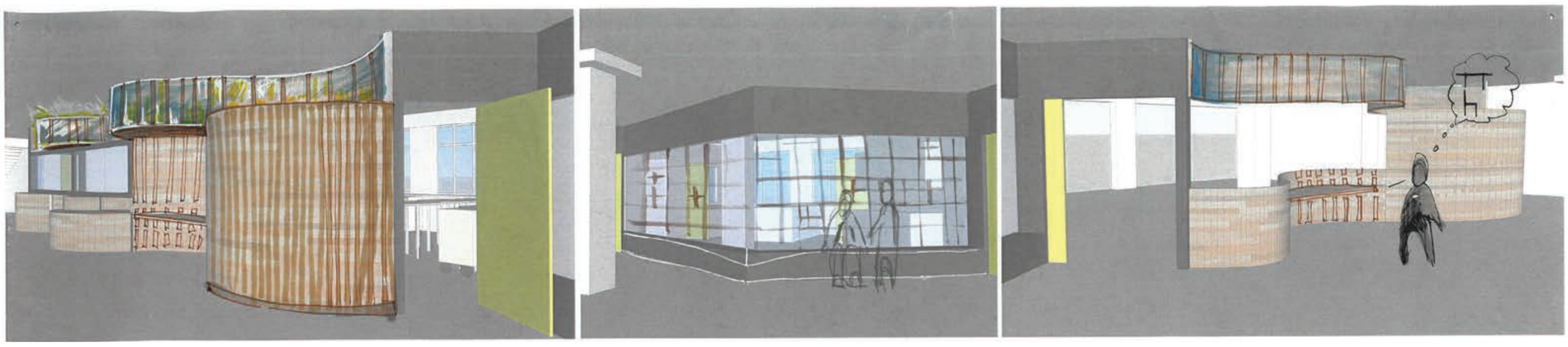


Figure 7.43 Conceptual Circulation Narrative, September 2016

Figure 7.44 Curved wall becoming spatial gradient between lab and passage, October 2016

Figure 7.45 Curved wall with framed views into laboratories, November 2016

Perspectives

Experiential learning has been exposed throughout the school.
The low-tech makerspace is visible from the atrium, encouraging students to make use of the space.

The makerspace is illustrated in Figures 7.46 - 7.47.

Figure 7.46 The makerspace, November 2016

Figure 7.47 View of the makerspace from computer lab, November 2016

7.2.12 Science labs

The Science laboratories are located next to the main circulation artery. Thus, views of experiential learning are maximised. The walls separating the laboratory from the circulation visually resemble a Mathematical 'sine' function, sound waves or light waves. This curved wall suggests movement and forms niches for students to meet, peer through or adapt as a workspace. The dynamic shape indicates a transition from theory-based spaces to a space of active experiential learning.

There are two dedicated Science laboratories with a shared Science store between them. Unlike the theory spaces, the laboratories do not have front and back sides. The Science store is a small laboratory that can be used for demonstrations. The store has a fume box and sliding windows in both walls adjacent to the laboratories.

The curves of the wall are scaled according to the golden ratio, resembling naturally occurring proportions.

Figure 7.48 Conceptual Science classrooms, June 2016

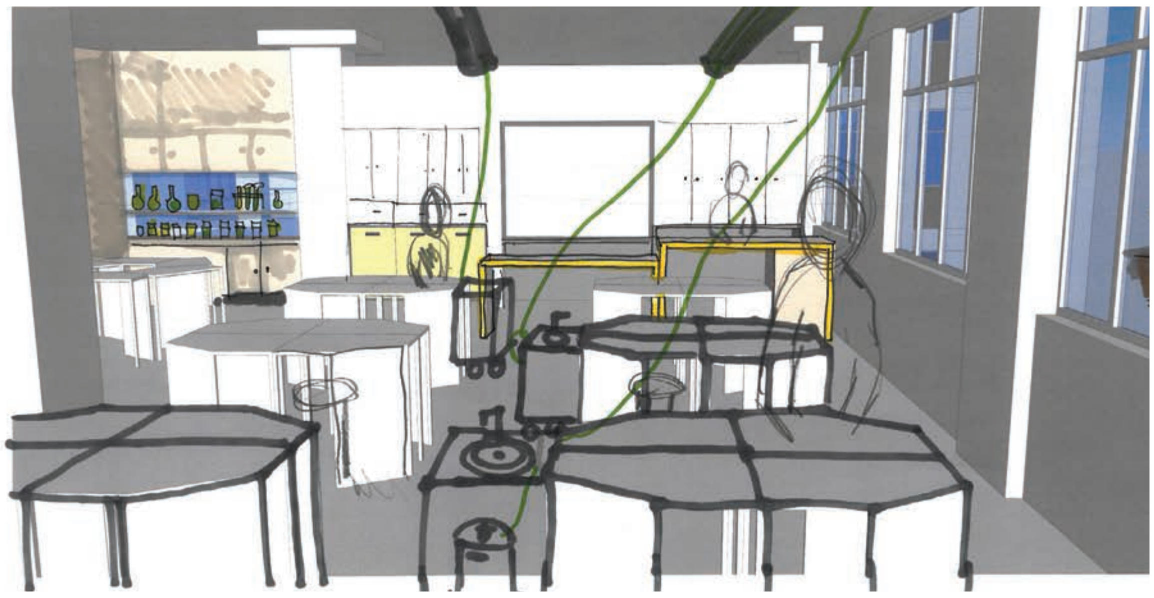


Figure 7.49 Conceptual Science classrooms, June 2016

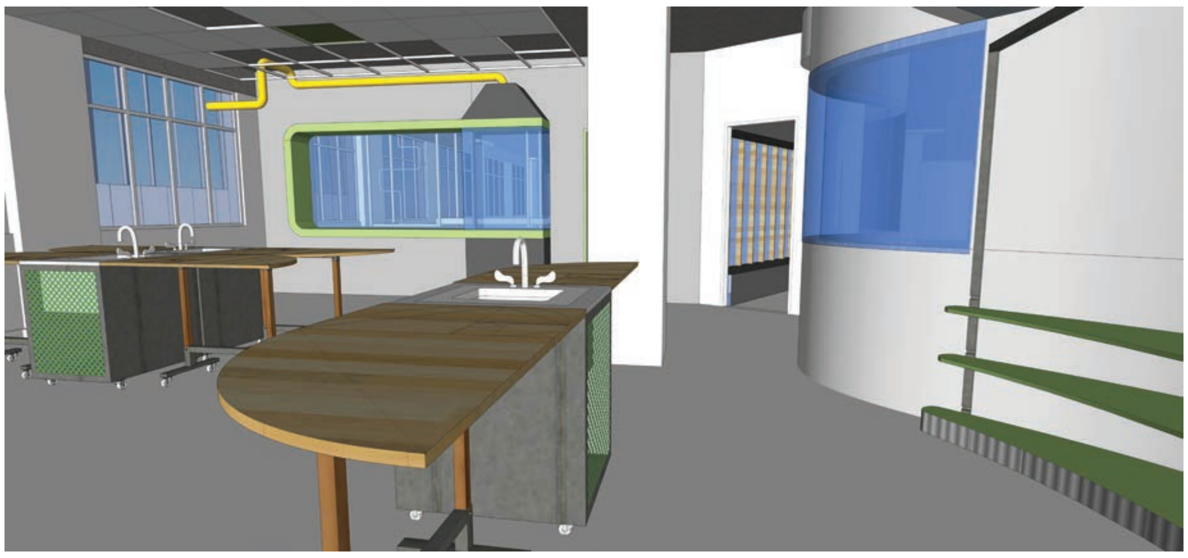


Figure 7.50 Student's view of Science store when in laboratory, October 2016

Figure 7.51 Student's view of teaching wall, October 2016

Section C-C

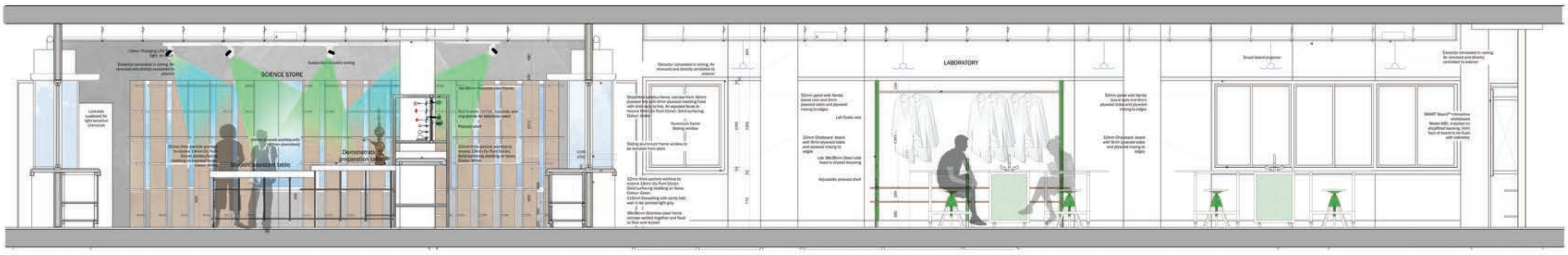


Figure 7.52 Section C-C
Not to scale

Perspectives

Figure 7.53 Student's view of Science store when in laboratory, November 2016

Figure 7.54 Student's view of teaching wall, November 2016

Figure 7.55 Science store, November 2016

Figure 7.56 Science store, November 2016

7.3 Conclusion

The spaces in the school are distinctively different from each other. Each designed to achieve a different educational experience. The spaces encourage students to adapt them to their needs. Teachers are no longer the only educator. The spaces are designed to entice students to become active learners. References to natural scientific phenomena have been used to enrich educational spaces and encouraging students to notice these phenomena in their everyday life.

08

8. Technical Investigation

8.1 Introduction

In this chapter the technical resolution will be discussed. The intervention addressed detailing in a way that informs users how the interior environment was made.

8.2 Design Innovations

8.2.1 Passive solar design

Most of the spaces of the building are either east or west facing. Through the design of fixed sun louvres the heat gain into these spaces are controlled. Right trough the year the fenestration is shaded from direct sunlight. The louvres are rotated over the brickwork to shade the walls in the warmer months and to allow the sun to charge the brickwork in the cooler months, radiating the latent heat into the interior of the school (figure 8.2).

8.2.2 Natural daylight

The east-west orientation of the building led to sunlight that penetrates too deeply into the interior resulting in overexposure, glare and uncomfortable reflections from surfaces and screens. Through the addition of a louvre system this problem was diffused and indirect natural light penetrates the space. Thus the spaces are lit by natural light, without negatively affecting the usability of the classrooms.

The orientation of the theory spaces is designed in such a way that when students are facing the teaching wall, right handed individuals will not cast shadows from the natural light onto work surfaces when they write.

The windows in the classroom walls adjacent to the circulation and social learning spaces are double glazing. Blocking sound to travel between spaces but allowing light to penetrate.

8.2.3 Ventilation

The design makes use of a hybrid system of passive and mechanical ventilation. Stale air is drawn from the circulation routes through the stack effect into the atrium. Solar chimneys have been designed into the atrium roof to ventilate the spaces adjacent to the atrium while still complying with fire regulations. Fresh air is supplied through the old southern lift shaft, the exterior walls have been demolished and a water feature has been added into the shaft to further cool the fresh air. The solar chimneys will also receive mechanical extractor units which will kick in when the air flow is too slow.

8.2.4 Site

The site is located near major public transportation infrastructures and also close to social and affordable housing. Students can thus either walk, cycle or make use of public transport to reach the school.

The site is also located near sport, theatre and informal Science facilities, thus school excursions and extra-curricular activities become more accessible.

The western facade of the building is shaded by neighbouring buildings, reducing the heat gain in the afternoons.

8.2.5 Rain water collection

The water from the atrium roof will be collected as irrigation water for the food garden and aquaponics. These water tanks will be stored on the roof.

The southern half of the existing roof will be drained into a collection point in the basement.

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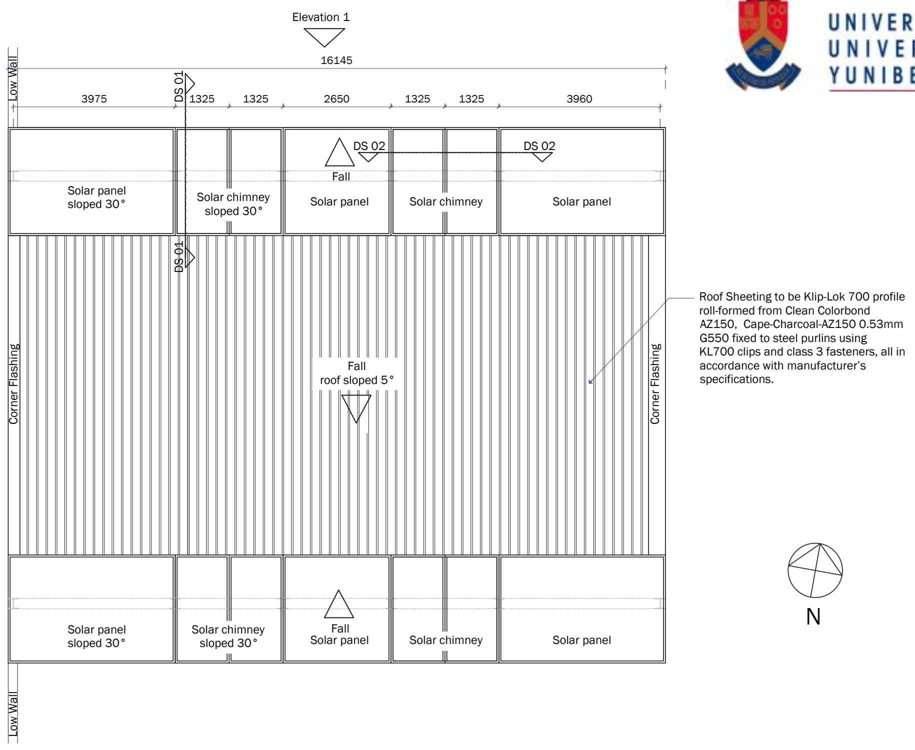
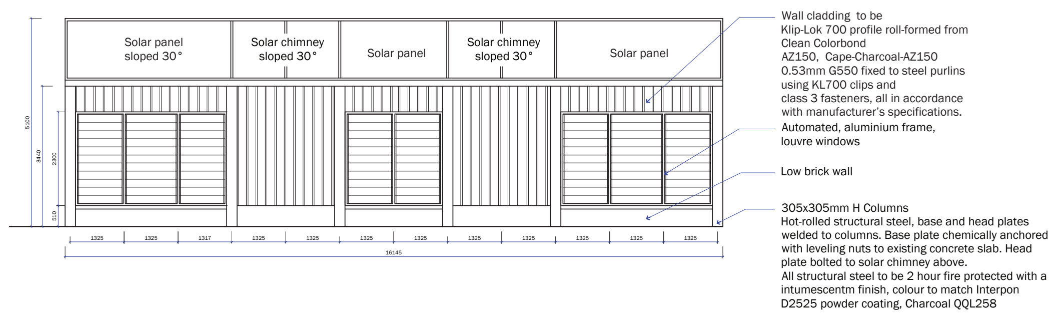
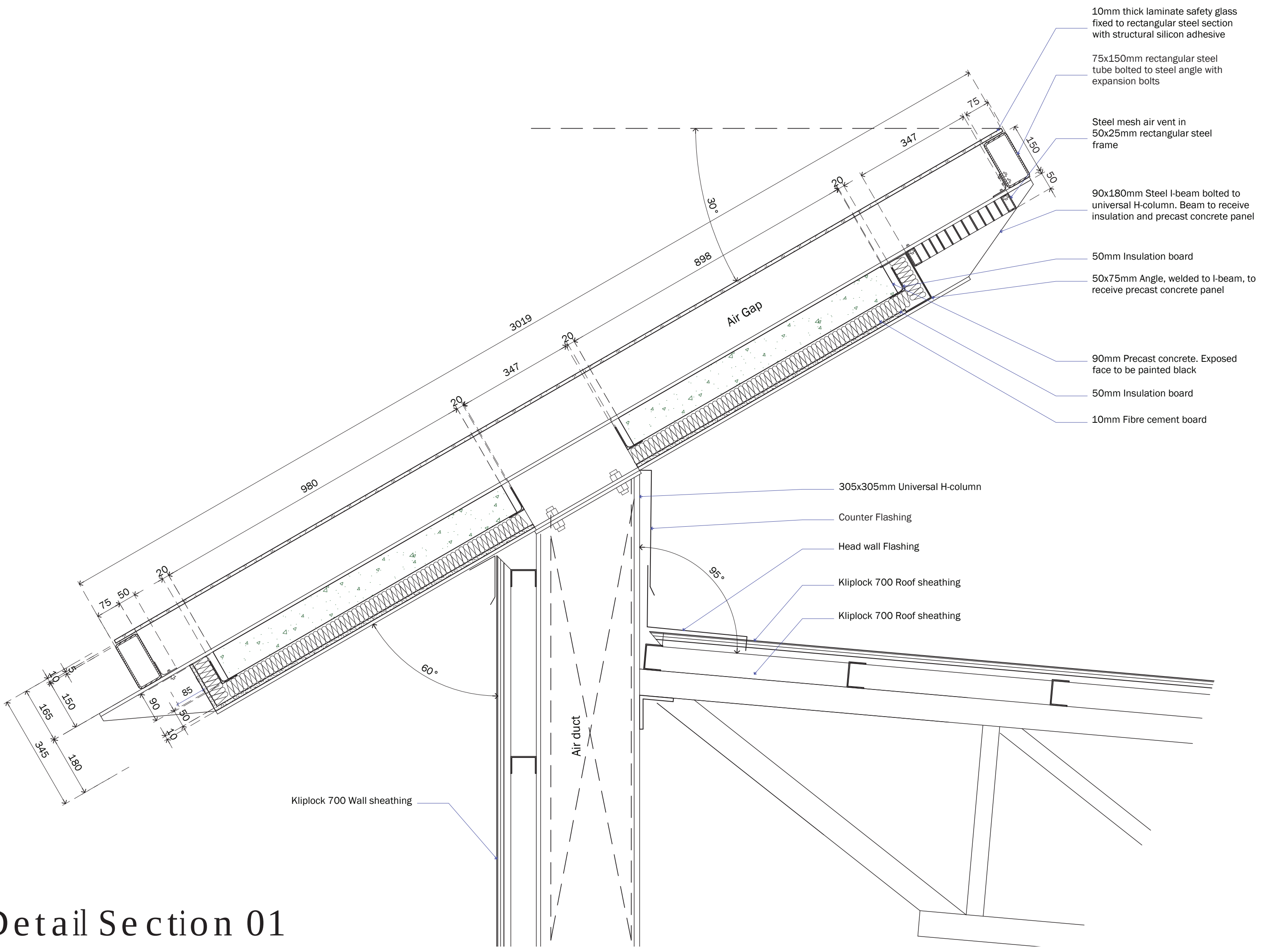


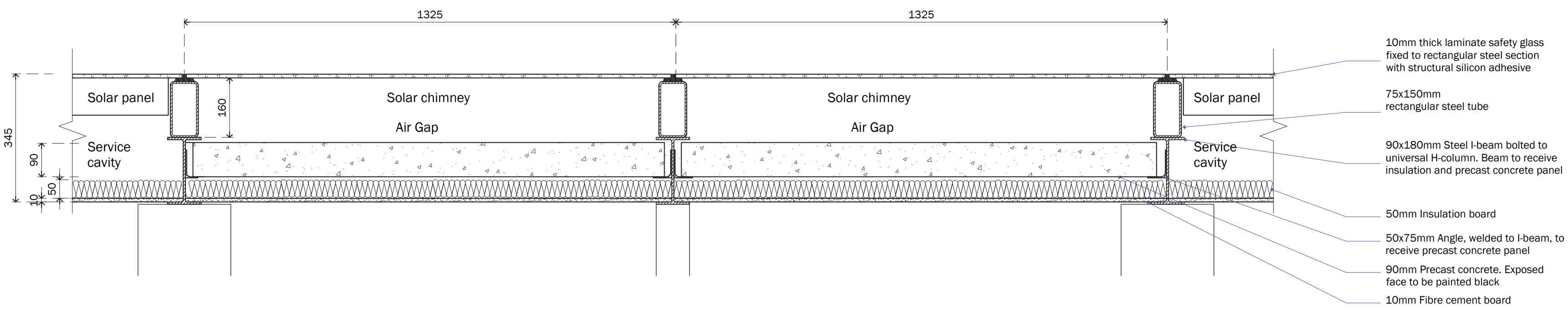
Plan of Atrium Roof



Elevation1

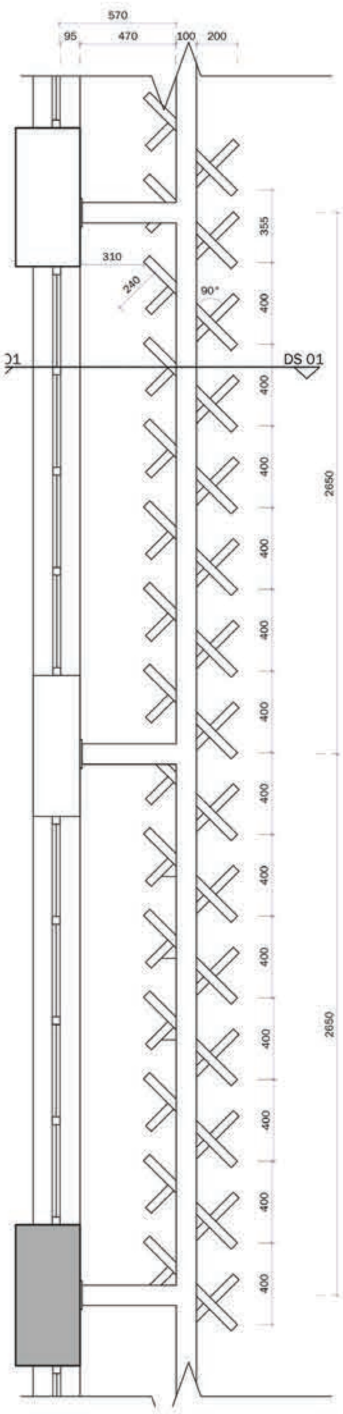


Detail Section 01

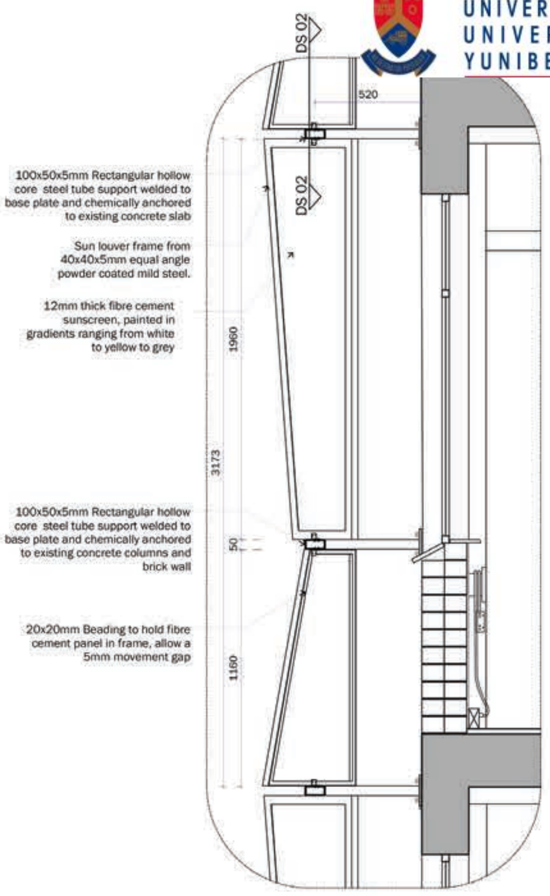


Detail Section 02

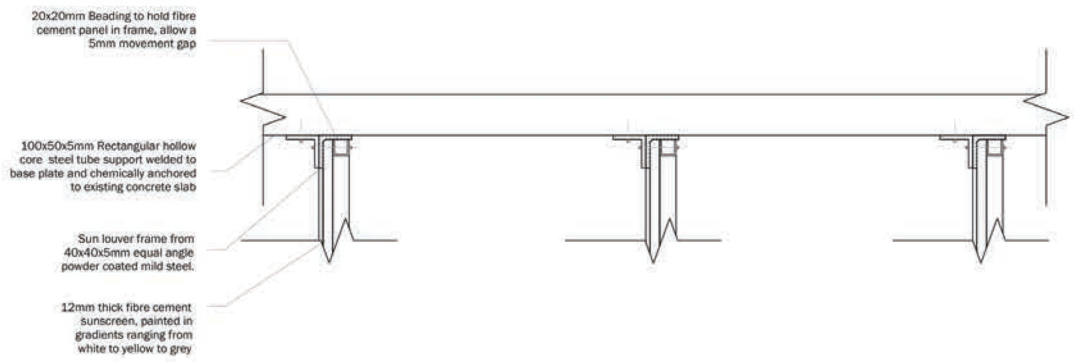
Figure 8.1 Design innovation - Solar chimney



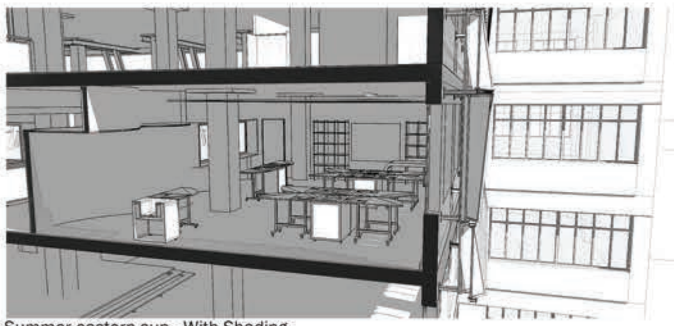
Plan



Detail Section 01

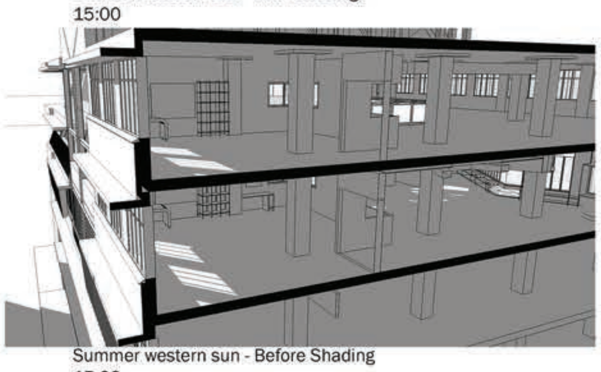


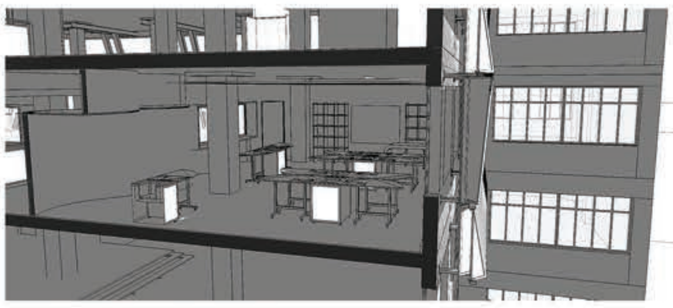
Detail Section 02


Summer eastern sun - With Shading
09:00

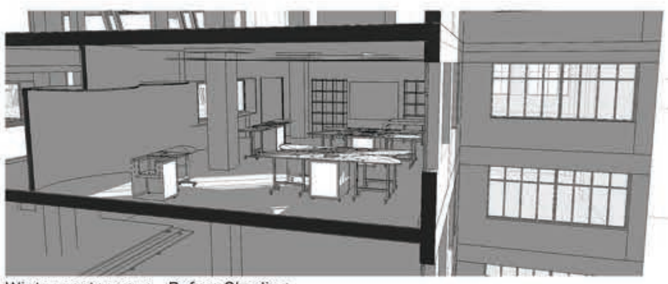

Summer western sun - With Shading
15:00


Summer eastern sun - Before Shading
09:00


Summer western sun - Before Shading
15:00


Winter eastern sun - With Shading
09:00


Winter western sun - With Shading
15:00


Winter eastern sun - Before Shading
09:00


Winter western sun - Before Shading
15:00

Figure 8.2 Design innovation - Sun Shade

8.3 Acoustics

The classrooms and laboratories: Here the drywall partitioning is from Lafarge's LPF 64-120/1 system. These walls are 115mm thick and can reach a sound insulation reduction index of 53dB where the standard 88mm thick drywalling only has a 38dB sound reduction index (Lafarge: 30-34). The classrooms' interior windows are double glazing. All theory spaces will receive an acoustic absorbent ceiling, except at the front of the classroom, in order to aid sound reflection of the teacher's voice. The back walls of the classrooms will receive acoustic absorbent panels to prevent sound bouncing back to the front. The floor finishes in the classrooms are Marmoleum Decibel, thus reducing impact sounds traveling between levels. The theory spaces are designed for speech clarity from a sound source at the front of the classroom.

The social learning spaces: The approach was to minimise sound reverberation. The floors will receive a carpet tile with an Eco Rubber underlay finish and acoustic absorbent ceilings.

The atrium: The volume of the atrium allows sound to travel up. Therefore events happening in the atrium will be audible in the social learning spaces to encourage observation. Sound will be diffused by the angles of the raked seating. The riser on the raked seating will receive carpet cladding to help reduce sound reflections. The ceiling of the atrium will also help to absorb sound.

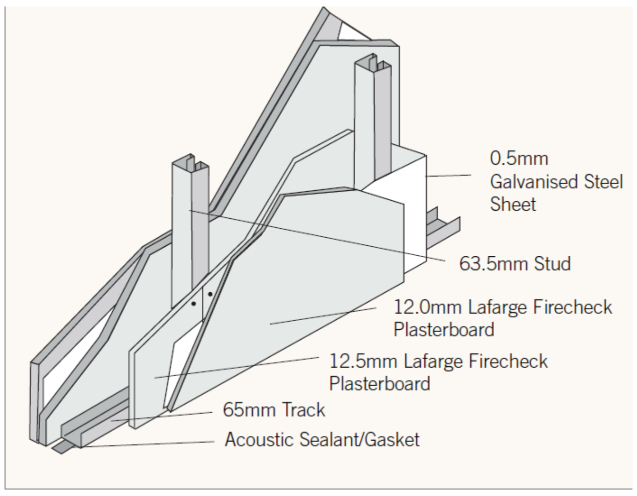


Figure 8.3: Sound insulation wall (Lafarge:7) sound insulation reduction index of 53dB

Figure 8.4: 63mm Glasswool cavitybatt by Isover.- Aids reduction of sound transmittance

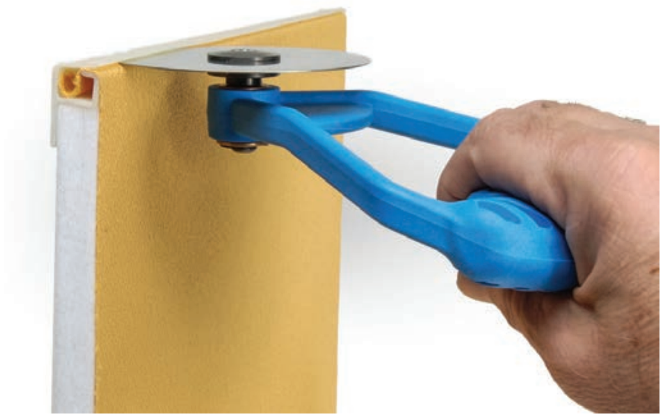


Figure 8.5: Acoustic absorbent wall panels edge track FS110 by Fabricmate

Figure 8.6: 600X600mm Drop in ceiling panels, Cosmos 68/N (Needled) with 49 dB sound reduction index by OWA

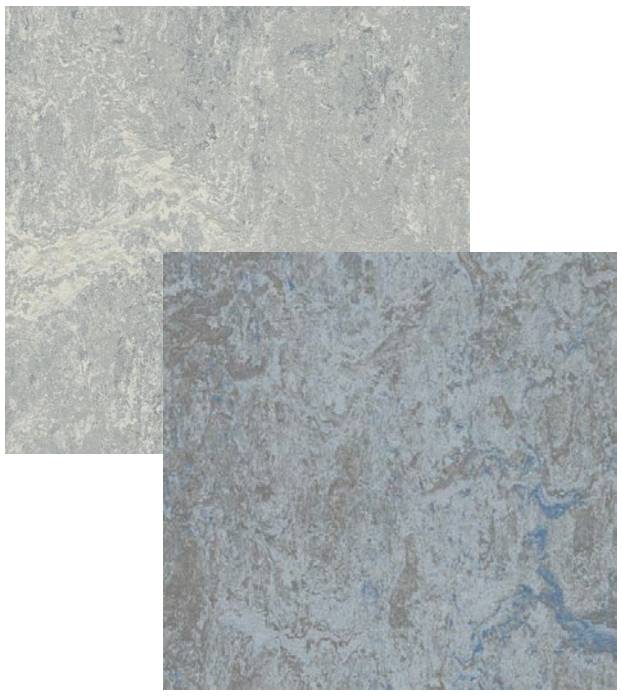


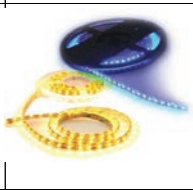
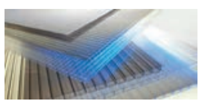
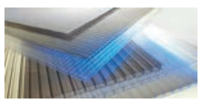
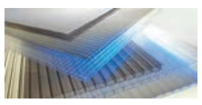
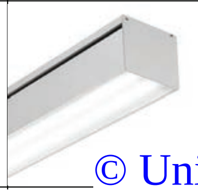
Figure 8.7 Marmoleum Decibel, Dove Grey and Dove Blue with impact sound reduction of 17dB

Figure 8.8 Carpet tile by Van Dyck

8.4 Artificial Lighting

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	22
E (Lux Needed: lx)	150	350	2,47	8,4	91,6	150	350	1,5	100	2,1	100	100	1,7	500	100	500	100	500	100	200
A (Surface Area: m²)	97,27	97,27	97,27	66,22	66,22	90,73	90,73	90,73	38	42,5	52	41	60,72	65,72	12	65,72	12	56	8,58	22,68
E * A	14590,5	34044,5	240,257	556,248	6065,75	13609,5	31755,5	136,095	3800	89,25	5200	4100	103,224	32860	1200	32860	1200	28000	858	4536
F (Lumens: lm)	3050	3050	2,7	350	3050	3050	3050	2,7	3050	2,7	3050	3050	2,7	3050	3050	3050	3050	3050	3050	3050
	13,7	13,7	13,7	7,7	7,7	10,55	10,55	10,55	12,5	12,5	8,8	13,2	13,2	10,6	6	10,6	6	10	3,9	5,4
R (Room Index)	4,32927	4,32927	4,32927	1,65385	1,65385	5,2439	5,2439	5,2439	0,57143	0,57143	1,27731	0,77311	0,77311	4,13333	1,33333	4,13333	1,33333	3,73333	1,46667	2,33333
Width (m)	7,1	7,1	7,1	8,6	8,6	8,6	8,6	8,6	3,4	3,4	7,6	4,6	4,6	6,2	2	6,2	2	5,6	2,2	4,2
Heiht (2h)	1,64	1,64	1,64	5,2	5,2	1,64	1,64	1,64	5,95	5,95	5,95	5,95	5,95	1,5	1,5	1,5	1,5	1,5	1,5	1,8
U (Utilization Factor)	0,5	0,5	0,5	0,45	0,45	0,5	0,5	0,5	0,31	0,31	0,4	0,35	0,35	0,5	0,4	0,5	0,4	0,48	0,4	0,45
M (Maintanance Factor)	0,66148	0,66148	0,66148	0,44129	0,66148	0,66148	0,66148	0,66148	0,66148	0,52557	0,66148	0,66148	0,66148	0,66148	0,44129	0,66148	0,44129	0,66148	0,44129	0,66148
LLMF	0,89	0,89	0,89	0,7	0,89	0,89	0,89	0,89	0,89	0,8	0,89	0,89	0,89	0,89	0,7	0,89	0,7	0,89	0,7	0,89
LMF	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79	0,79
LSF	0,98	0,98	0,98	0,95	0,98	0,98	0,98	0,98	0,98	0,99	0,98	0,98	0,98	0,98	0,95	0,98	0,95	0,98	0,95	0,98
RSMF	0,96	0,96	0,96	0,84	0,96	0,96	0,96	0,96	0,96	0,84	0,96	0,96	0,96	0,96	0,84	0,96	0,84	0,96	0,84	0,96
F*U*M	1008,75	1008,75	0,89299	69,5038	907,876	1008,75	1008,75	0,89299	625,426	0,4399	807,001	706,126	0,6251	1008,75	538,379	1008,75	538,379	968,402	538,379	907,876
n = E*A / F*U*M	14,4639	33,7491	269,047	8,00313	6,68125	13,4914	31,48	152,403	6,07586	202,886	6,44361	5,80633	165,133	32,5749	2,22891	32,5749	2,22891	28,9136	1,59367	4,99627
n (Number of Lamps)	*15*	*34*	*7.1m*	*8*	*6*	*14*	*32*	*4m*	*6*	*5.5m*	*6*	*6*	*4m*	*33*	*3*	*33*	*3*	*29*	*2*	*5*

Figure 8.9 Lighting Calculations

Programme	Spatial zone	Number of lamps	Lamp identification	Lamp specification	Luminaire identification	Luminaire specification	Advantages
1. Science Laboratory (A)	125lx (Total 500lx)	N=15		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		TRES OPAQUE Suspended Fluorescent Pendant, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	• Extremely long service life • Low premature failure • Dimmable for lower energy consumption • Good colour rendering • Uniform illumination
2. Science Laboratory (A)	375lx (Total 500lx)	N=34 (lamps); 11 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		LBR Recessed Fluorescent Luminaire, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	• Extremely long service life • Low premature failure • Dimmable for lower energy consumption • Good colour rendering • Uniform illumination • Modular
3. Science Laboratory (A)	500lx (Together With General lihgting)	N= 7.1m (3.2m + 1.2m + 1.2m + 1.5m)		DECO FLEX RGB LED strip lights, Osram 3,6W/640mm 12V 50mm cut intervals	(No luminaire; Plexiglass ceiling) 	N/A	• Suitable for curved illumination • Dimmable for energy efficiency • Colour change suitable for chronobiologically-adaptive LED lighting for improved well-being and productivity
5. Store Room (Science)	100lx	N=8 (lamps)		LIGHTIFY PAR16 TW LED, Osram GU10 base 6Watt/240V 50mm diameter TUNABLE WHITE Colour Temp: 2700 - 6500K Colour rendering (Ra) = 80-89 Lifespan: 20 000h Energy efficiency class A		MIO SPOT TRACK, for LED From: Spazio Product code: 4127.1 Colour: Silver Lamp fitting: GU10	• Adjustable colour temperature • Colour controllable via smart devices (iOS; Android) • Dimmable via LIGHTIFY app; enhances energy efficiency • Good colour rendering • Allows teachers/learners to adapt environment; enhances comfort; allows versitility for chemical storage lighting needs.
5. Store Room (Science)	100lx	N=6 (lamps); 2 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		LBR Recessed Fluorescent Luminaire, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	• Extremely long service life • Low premature failure • Dimmable for lower energy consumption • Good colour rendering • Uniform illumination • Modular
6. Science Laboratory (B)	125lx (Total 500lx)	N=14 (luminaires); 7 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		TRES OPAQUE Suspended Fluorescent Pendant, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	• Extremely long service life • Low premature failure • Dimmable for lower energy consumption • Good colour rendering • Uniform illumination
7. Science Laboratory (B)	375lx (Total 500lx)	N=32 (lamps); 11 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		LBR Recessed Fluorescent Luminaire, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	• Extremely long service life • Low premature failure • Dimmable for lower energy consumption • Good colour rendering • Uniform illumination • Modular
8. Science Laboratory (B)	500lx (Together With General lihgting)	N= 4m (2m + 2m)		DECO FLEX RGB LED strip lights, Osram 3,6W/640mm 12V 50mm cut intervals	(No luminaire; Plexiglass ceiling) 	N/A	• Suitable for curved illumination • Dimmable for energy efficiency • Colour change suitable for chronobiologically-adaptive LED lighting for improved well-being and productivity
9. Corridor (Section A)	100lx	N=6 (lamps); 3 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		DUPLO Surface 2 FLUORESCENT From: Spazio Size: 1190mm x 85mm x 70mmm Opal Diffuser Panels	• Surface-mounted illumination to existing structure • Suitable for continuous linear applications (such as corridors). • Extremely long service life • Low premature failure • Dimmable for lower energy consumption • Good colour rendering • Uniform illumination
10. Corridor (Section A)	100lx	N= 5.5m (2m + 2m + 1.5m)		DECO FLEX RGB LED strip lights, Osram 3,6W/640mm 12V 50mm cut intervals	(No luminaire; Plexiglass ceiling) 	N/A	• Suitable for curved illumination • Dimmable for energy efficiency • Colour change suitable for chronobiologically-adaptive LED lighting for improved well-being and productivity
11. Corridor (Section B)	100lx	N=6 (lamps); 3 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		DUPLO Surface 2 FLUORESCENT From: Spazio Size: 1190mm x 85mm x 70mmm Opal Diffuser Panels	• Surface-mounted illumination to existing structure • Suitable for continuous linear applications (such as corridors). • Extremely long service life • Low premature failure • Dimmable for lower energy consumption • Good colour rendering • Uniform illumination
12. Corridor (Section C)	100lx	N=6 (lamps); 3 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		DUPLO Surface 2 FLUORESCENT From: Spazio Size: 1190mm x 85mm x 70mmm Opal Diffuser Panels	• Surface-mounted illumination to existing structure • Suitable for continuous linear applications (such as corridors). • Extremely long service life • Low premature failure • Dimmable for lower energy consumption • Good colour rendering • Uniform illumination

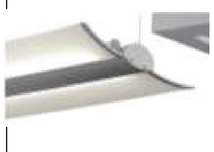
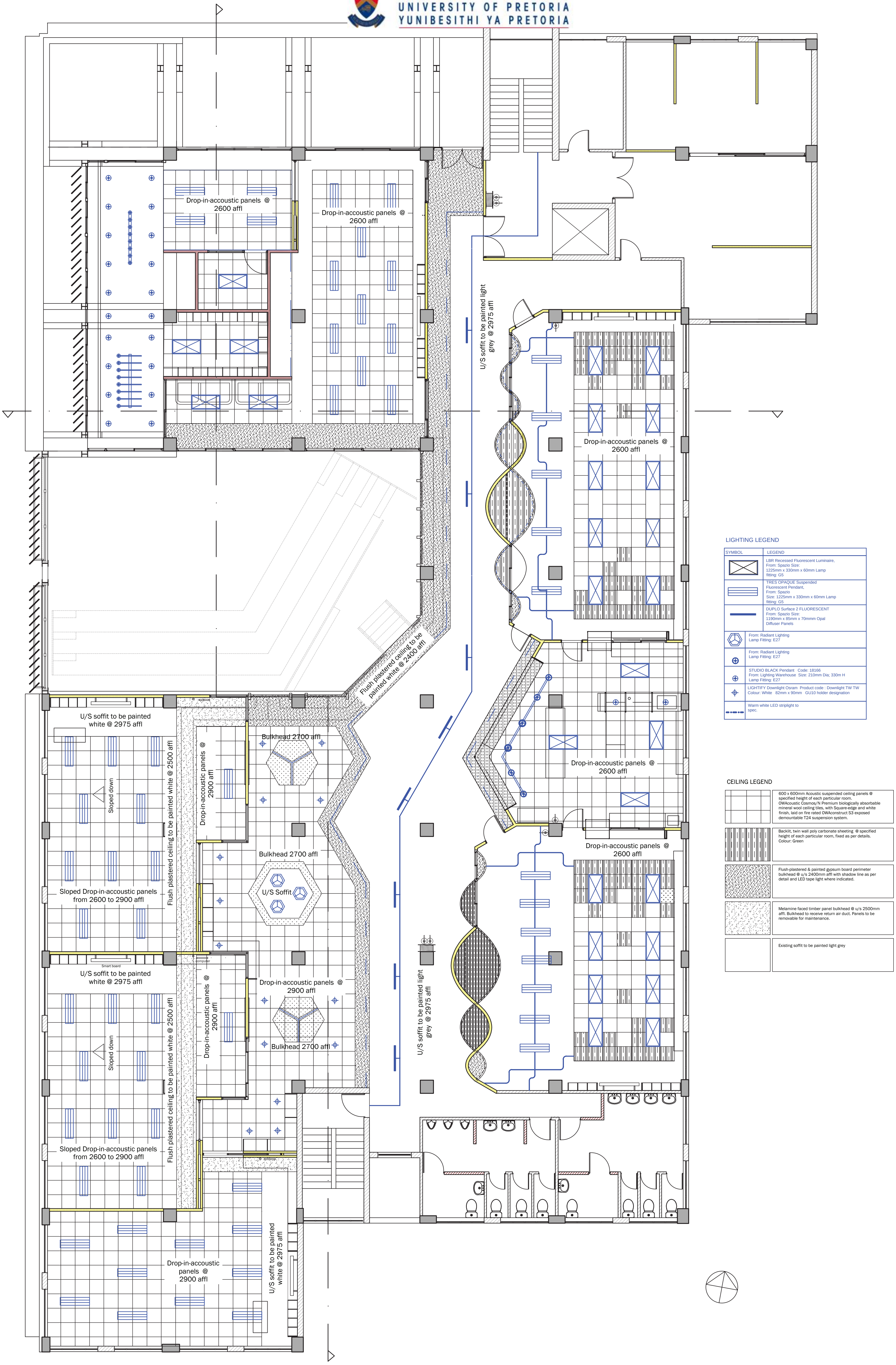
13. Corridor (Section C)	100lx	N= 4m (2m + 2m)		DECO FLEX RGB LED strip lights, Osram 3,6W/640mm 12V 50mm cut intervals	(No 		...e for curved illumination •Dimmable ...y efficiency •Colour change ...or chronobiologically-adaptive LED lighting for ... well-being and productivity
14. Classroom (A)	500lx	N=33 (luminaires); 10 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		TRES OPAQUE Suspended Fluorescent Pendant, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	•Extremely long service life •Low premature failure •Dimmable for lower energy consumption •Good colour rendering •Uniform illumination
15. Classroom (A) Lobby	100lx	N=3 (luminaires); 2 1 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		TRES OPAQUE Suspended Fluorescent Pendant, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	•Extremely long service life •Low premature failure •Dimmable for lower energy consumption •Good colour rendering •Uniform illumination
16. Classroom (B)	500lx	N=33 (luminaires); 17 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		TRES OPAQUE Suspended Fluorescent Pendant, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	•Extremely long service life •Low premature failure •Dimmable for lower energy consumption •Good colour rendering •Uniform illumination
17. Classroom (B) Lobby	100lx	N=3 (luminaires); 2 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		TRES OPAQUE Suspended Fluorescent Pendant, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	•Extremely long service life •Low premature failure •Dimmable for lower energy consumption •Good colour rendering •Uniform illumination
18. Classroom (C)	500lx	N=29 (luminaires); 10 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		TRES OPAQUE Suspended Fluorescent Pendant, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	•Extremely long service life •Low premature failure •Dimmable for lower energy consumption •Good colour rendering •Uniform illumination
19. Classroom (C) Lobby	100lx	N=1 (luminaires); 1 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		TRES OPAQUE Suspended Fluorescent Pendant, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	•Extremely long service life •Low premature failure •Dimmable for lower energy consumption •Good colour rendering •Uniform illumination
20. Social Learning Spill-Out Space (student common room)	N/A	N/A		DECO FLEX RGB LED strip lights, Osram 3,6W/640mm 12V 50mm cut intervals		From: Radiant Lighting Lamp Fitting: E27	•Suitable for curved illumination •Dimmable for energy efficiency •Colour change suitable for chronobiologically-adaptive LED lighting for improved well-being and productivity
21. Social Learning Spill-Out Space (student common room)	N/A	N/A		LED STAR PAR16 LED reflector Osram Product code: 50 36° 5,5 W/827 GU10 base 230V 50mm diameter WARM WHITE Colour Temp: 2700K Colour rendering (Ra) = 80 Lifespan: 25 000h Energy efficiency class A		LIGHTIFY Downlight Osram Product code : Downlight TW TW Colour: White 82mm x 90mm GU10 holder designation	•Long lamp life •Shock proof •low energy consumption
22. Maker Space (Craft/Workshop)	200lx	N=5 (lamps); 3 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		TRES OPAQUE Suspended Fluorescent Pendant, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	•Extremely long service life •Low premature failure •Dimmable for lower energy consumption •Good colour rendering •Uniform illumination
23. Maker Space (Craft/Workshop)	180lx generated (Total 500lx with other fittings and natural sunlight)	N=16 (lamps); x2 Luminaires.		MAXI GLOBE CFL (E27) Eurolux Code: G626 (Frosted) Colour: Warm White (2700K) Lamp Life: 6000hours+		HAYWIRE CHANDELIER by David Krynauw Lamp Fitting: E27 Dimmable Standard Size: x8 lamp shades/fittings Available in variety of powdercoating colours, timber and finishes.	•Ample Service life •Good colour rendering •Closer to natural daylight than other fluorescent options; warmer atmosphere •Most Energy Efficient compared to other lamp types to fit luminaire •South African designer; locally manufactured luminaire •Magnetic technical design solution for adaptibility & versatility of space illumination •Exposed joins to show how lumaire works
24. Maker Space (Craft/Workshop)	250lx generated (Total 500lx with other fittings and natural sunlight)	N= 22 (lamps); 22 (luminaires)		MAXI GLOBE CFL (E27) Eurolux Code: G626 (Frosted) Colour: Warm White (2700K) Lamp Life: 6000hours+		STUDIO BLACK Pendant Code: 18166 From: Lighting Warehouse Size: 210mm Dia; 330m H Lamp Fitting: E27	•Ample Service life •Good colour rendering •Closer to natural daylight than other fluorescent options; warmer atmosphere •Most Energy Efficient compared to other lamp types to fit luminaire
25. Art Room	750lx	N= 32 (luminaires); 11 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		TRES OPAQUE Suspended Fluorescent Pendant, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	•Extremely long service life •Low premature failure •Dimmable for lower energy consumption •Good colour rendering •Uniform illumination
26. Wash-up room	300lx	N=4 (lamps); 2 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		LBR Recessed Fluorescent Luminaire, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	•Extremely long service life •Low premature failure •Dimmable for lower energy consumption •Good colour rendering •Uniform illumination •Modular
27. Workshop/Tool Shed	500lx	N=4 (lamps); 2 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		LBR Recessed Fluorescent Luminaire, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	•Extremely long service life •Low premature failure •Dimmable for lower energy consumption •Good colour rendering •Uniform illumination •Modular
28. Storage/ Stock Room	100lx	N=2 (lamps); 1 (luminaires)		T5 HE XT fluorescent tube, Osram Product code: 35W/865 G5 base 16mm diameter LUMILUX cool daylight Colour Temp: 6500K Colour rendering (Ra) = 80-89 Lifespan: 45 000h Energy efficiency class A+		LBR Recessed Fluorescent Luminaire, From: Spazio Size: 1225mm x 330mm x 60mm Lamp fitting: G5	•Extremely long service life •Low premature failure •Dimmable for lower energy consumption •Good colour rendering •Uniform illumination •Modular

Figure 8.10 Lamp Quantities



3rd Floor Ceiling Plan

Figure 8.11 Ceiling Plan
not to scale

8.5 Detail Call-outs

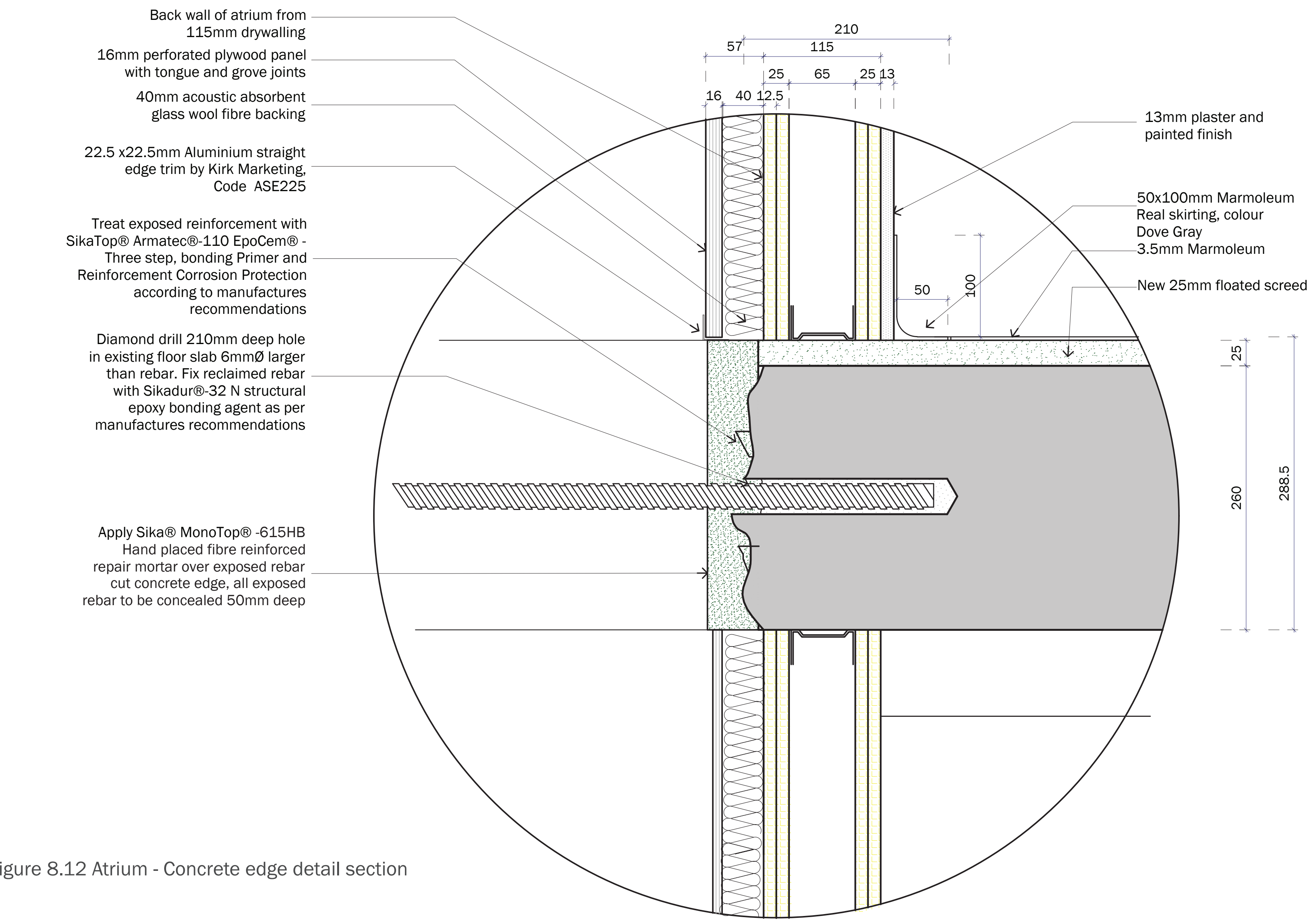


Figure 8.12 Atrium - Concrete edge detail section

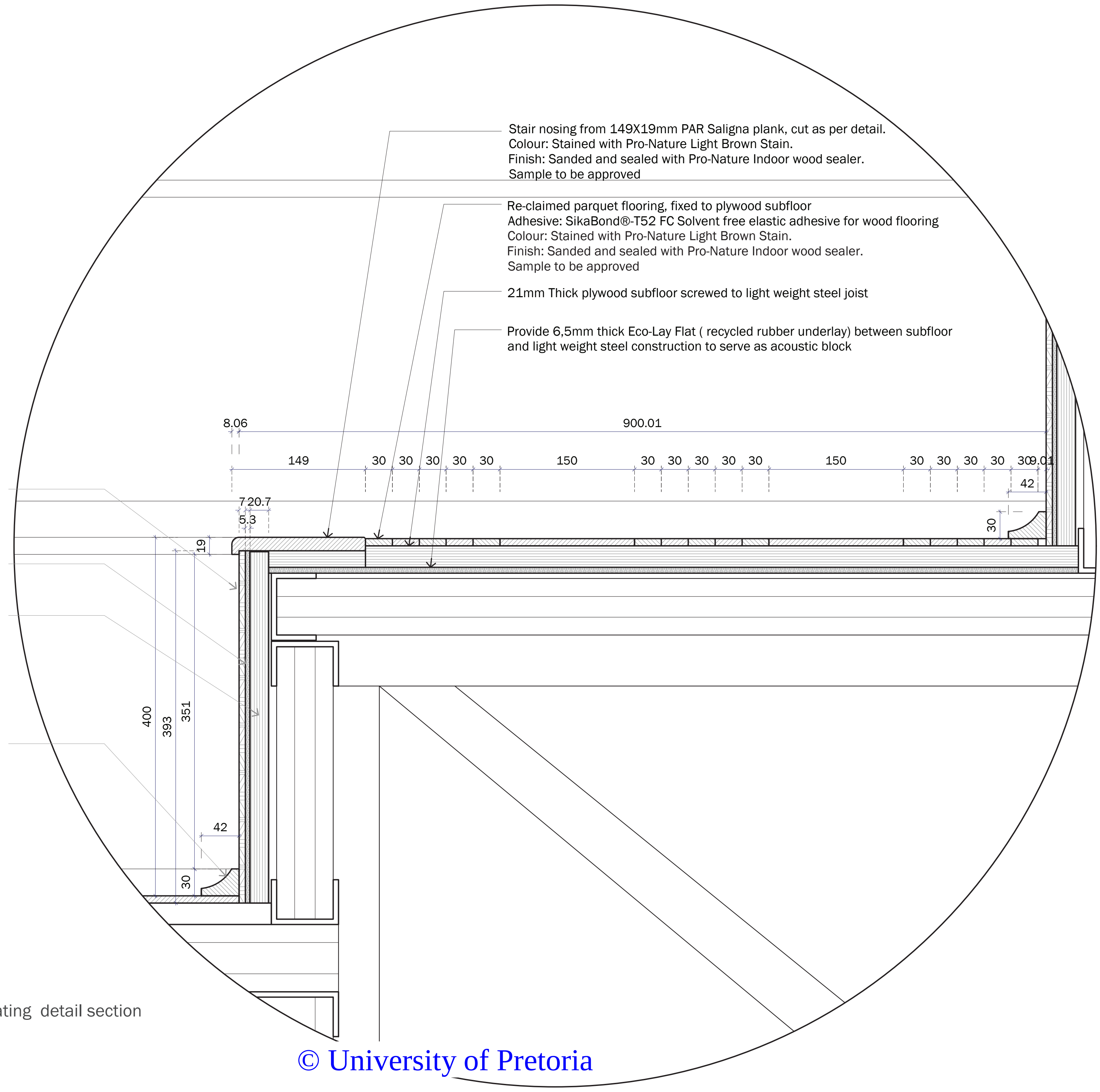
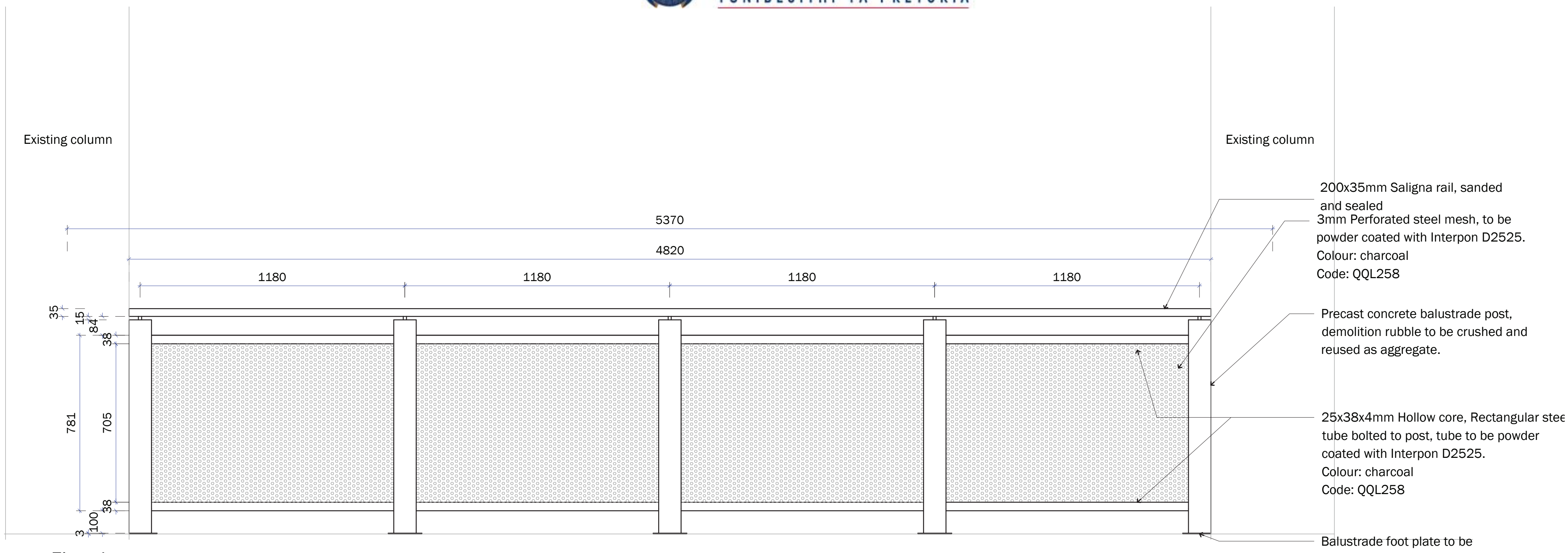
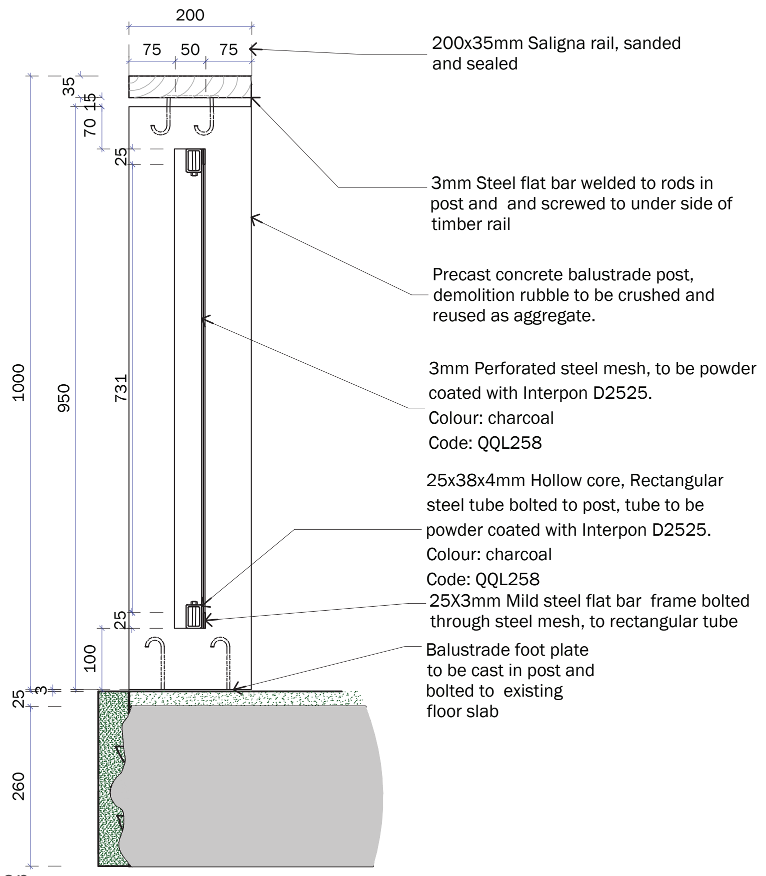


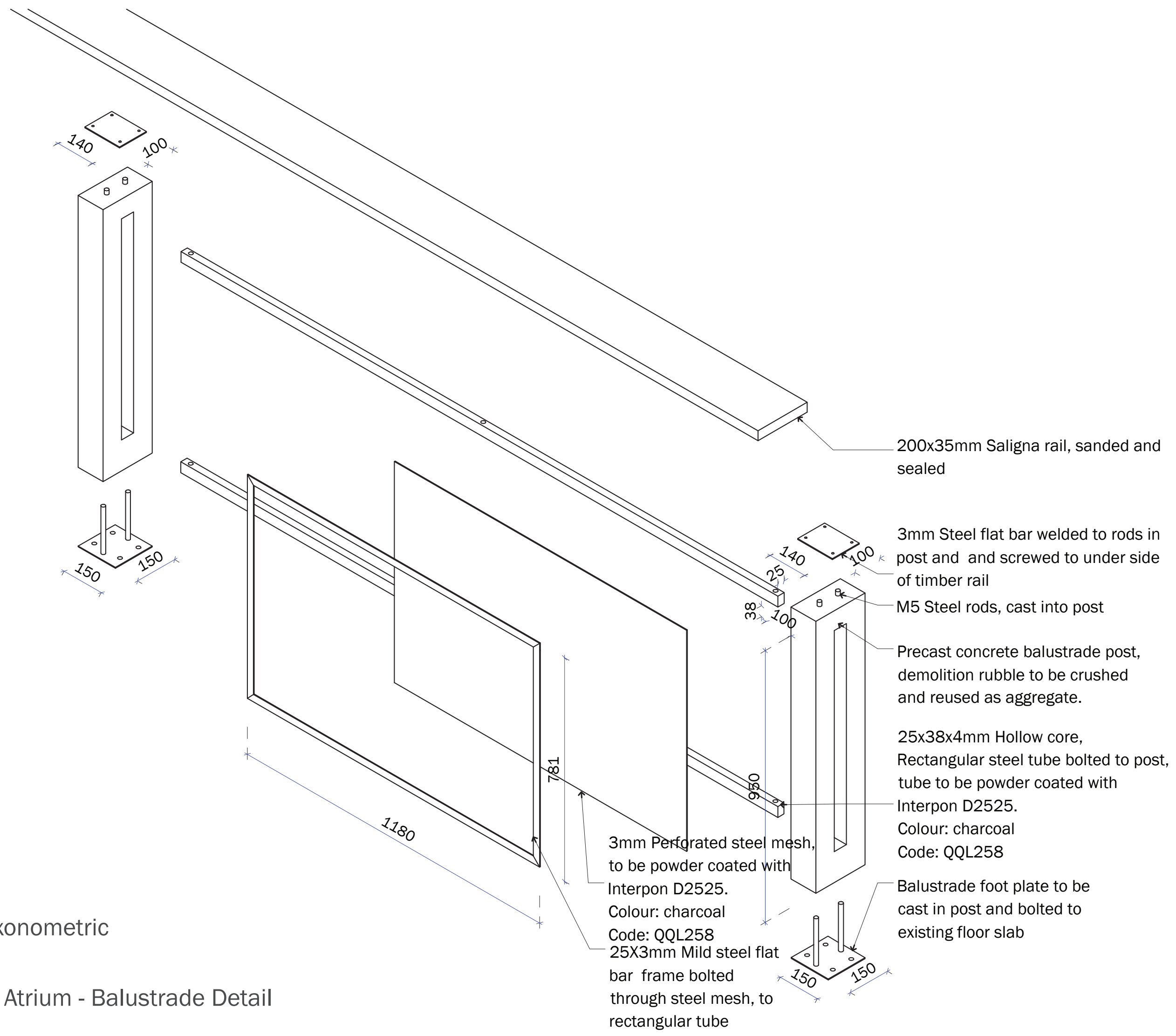
Figure 8.13 Atrium - Raked seating detail section
not to scale



Elevation
not to scale

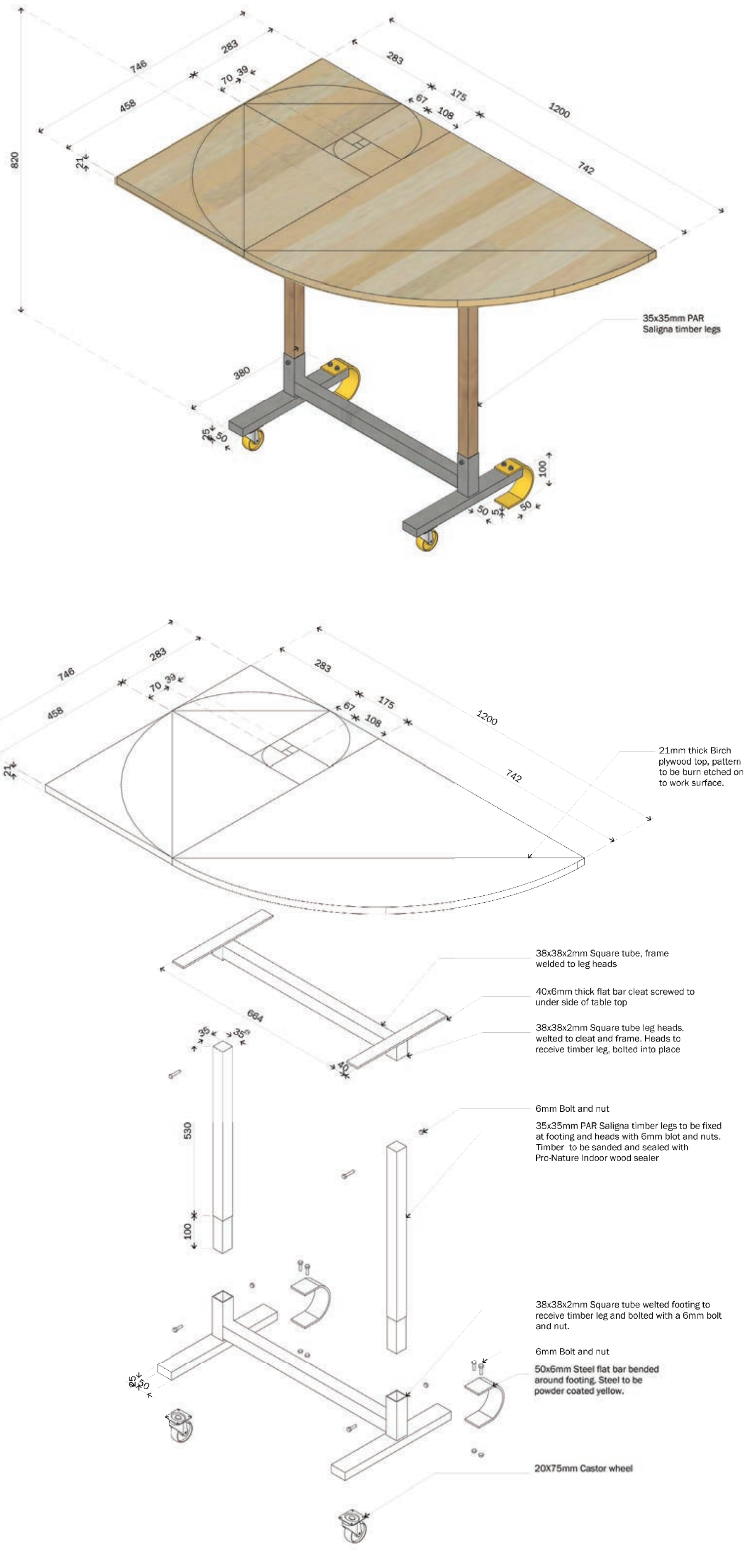


Section
not to scale



Exploded axonometric
not to scale

Figure 8.14 Atrium - Balustrade Detail



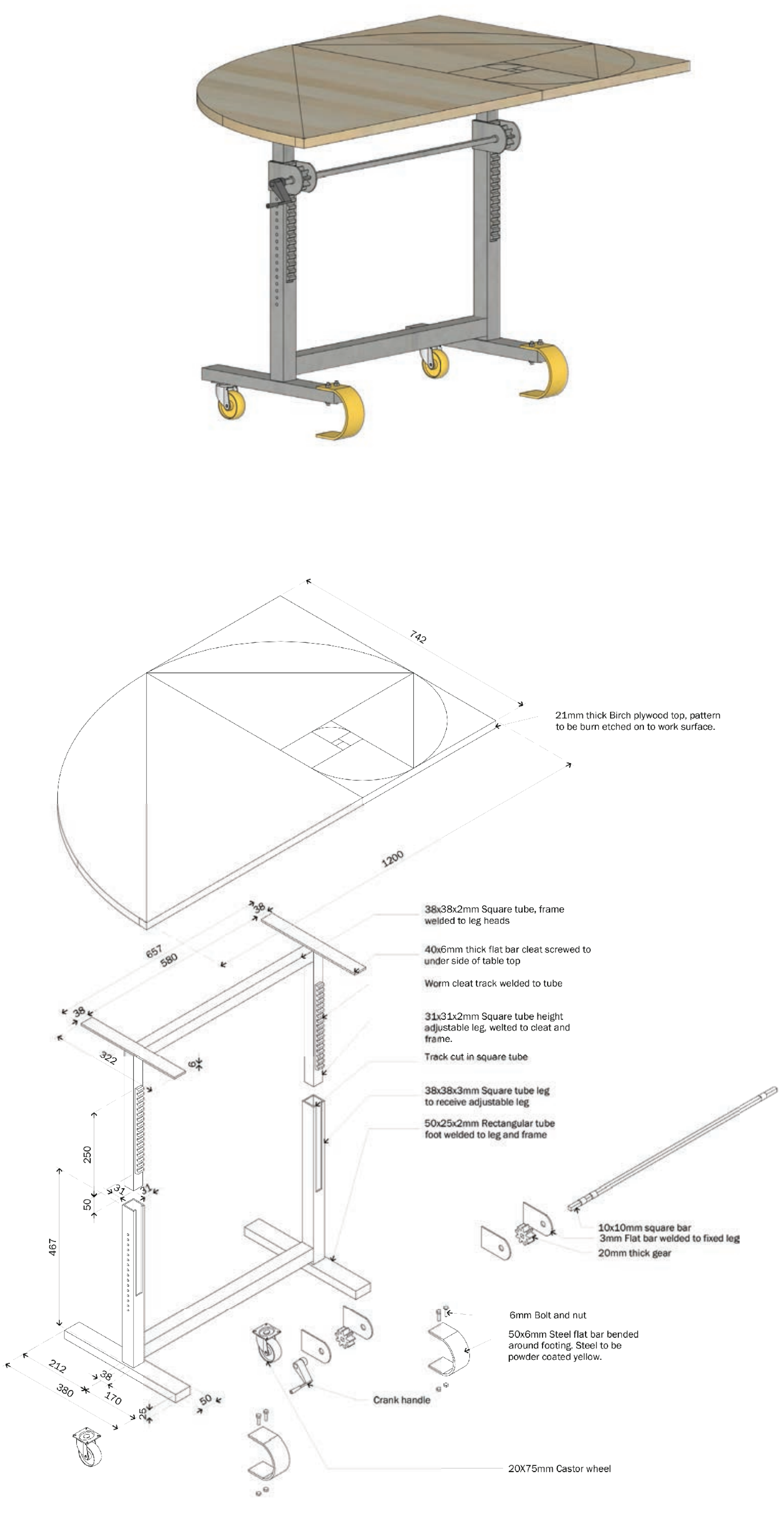
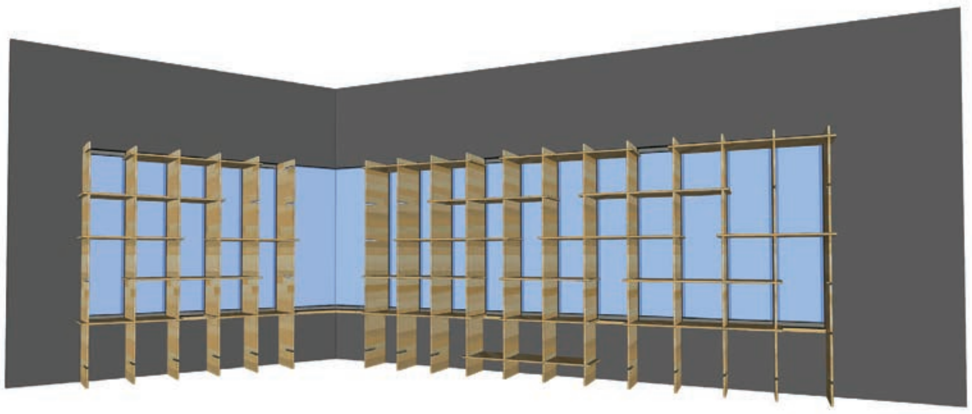
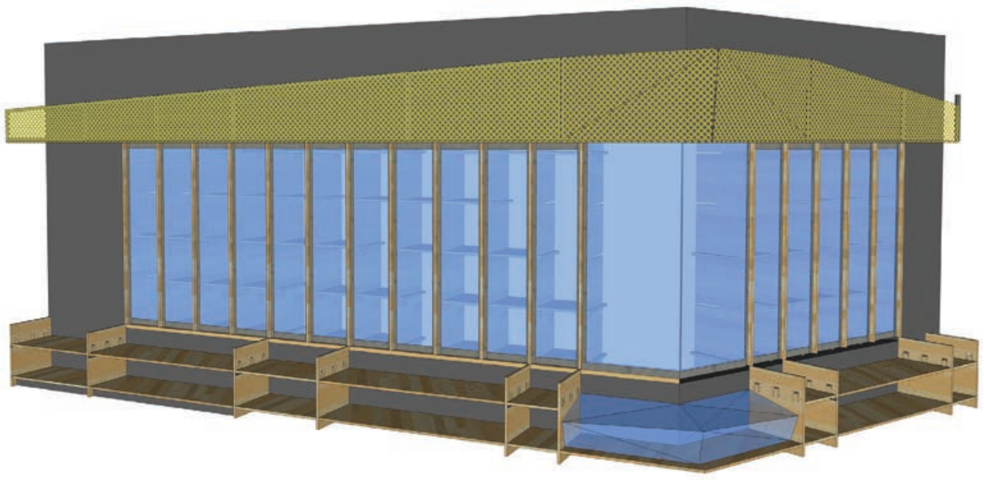


Figure 8.15 Exploded axonometric - Golden Ratio table fixed

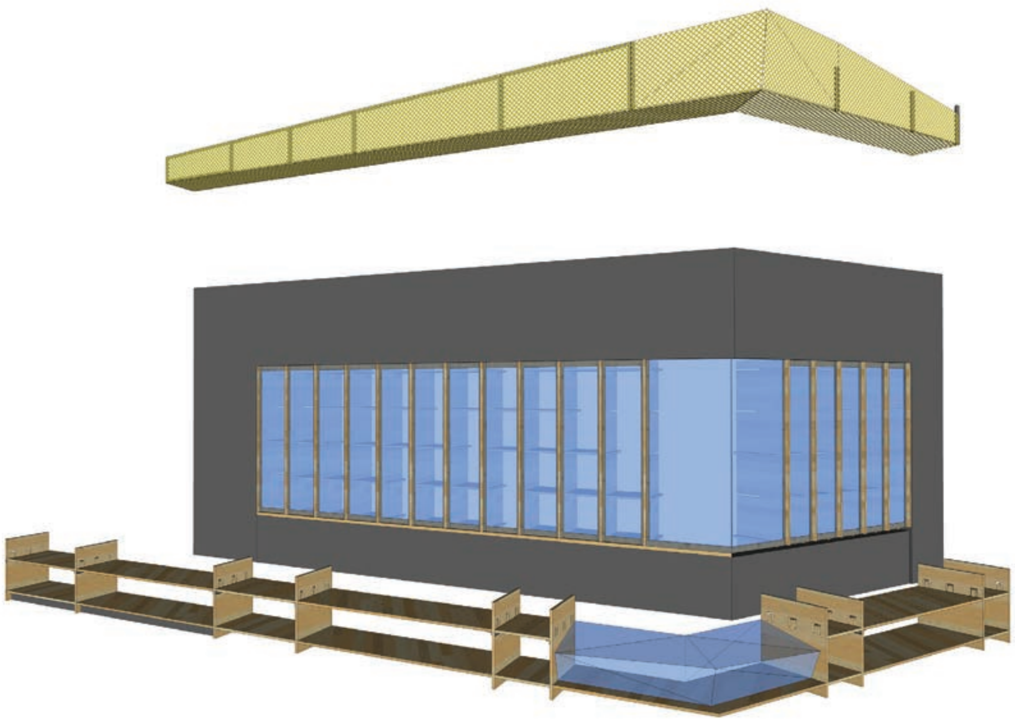
Figure 8.16 Exploded Axonometric - Golden Ratio table with crank mechanism



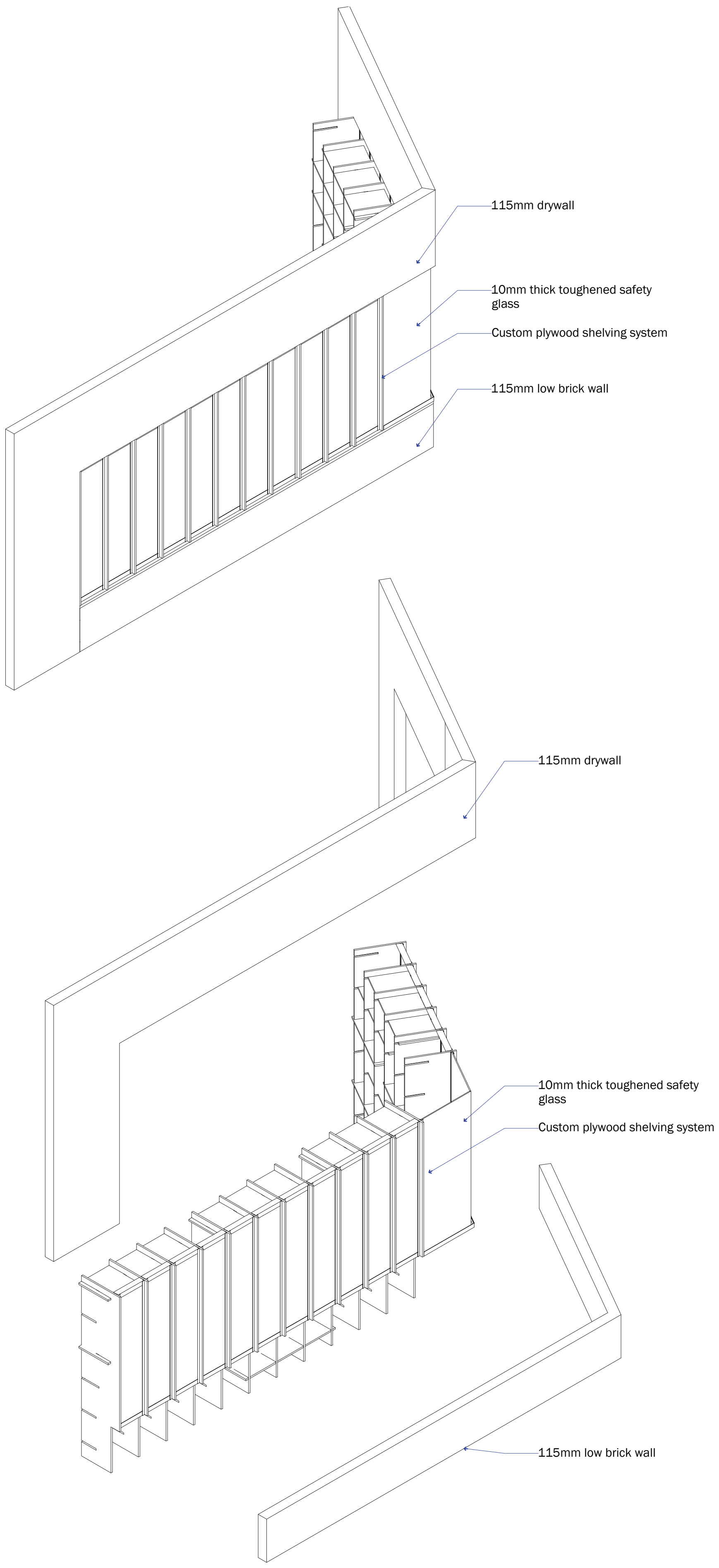
View of science store storage wall - View from inside store



View of science store storage wall - View from passage



View of science store storage wall - Exploded



Exploded Axonometric storage wall

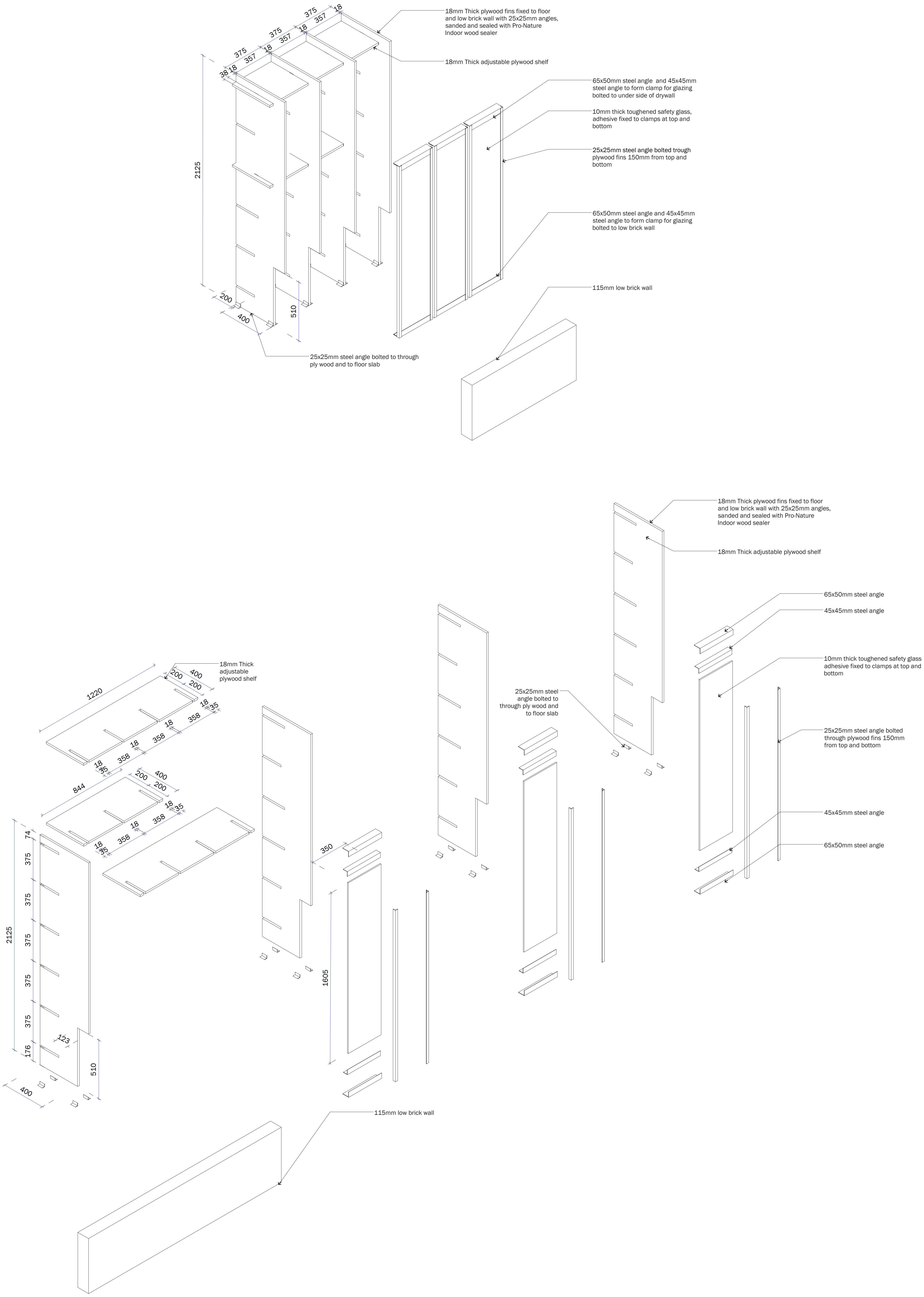


Figure 8.17 Exploded axonometric - Science store

8.6 Sample board

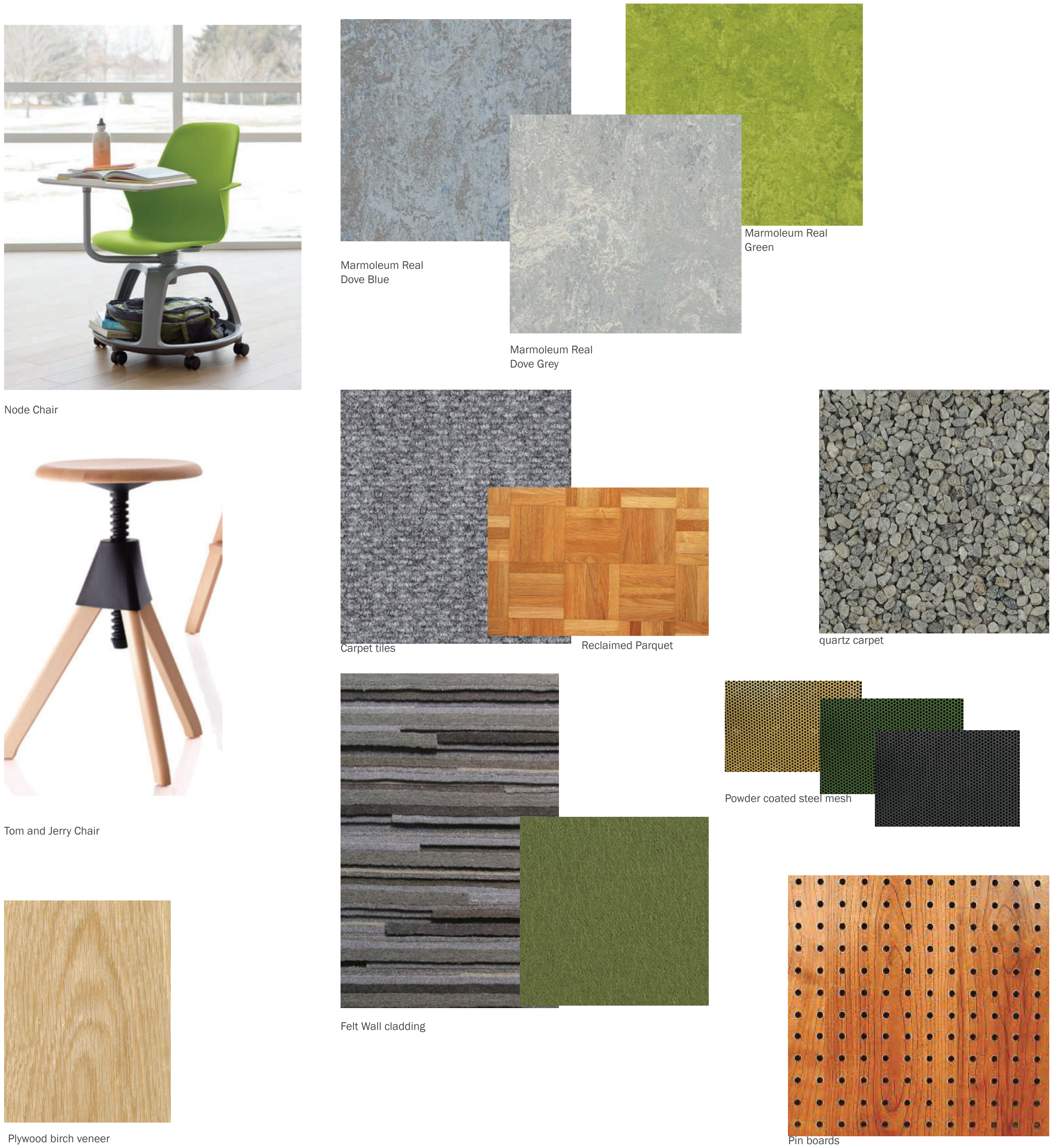


Figure 8.18 Sample board

8.7 Sustainable building assesment

SUSTAINABLE BUILDING ASSESSMENT TOOL RESIDENTIAL

1,04

		Achieved
SB	**SBAT REPORT**	**3,2**

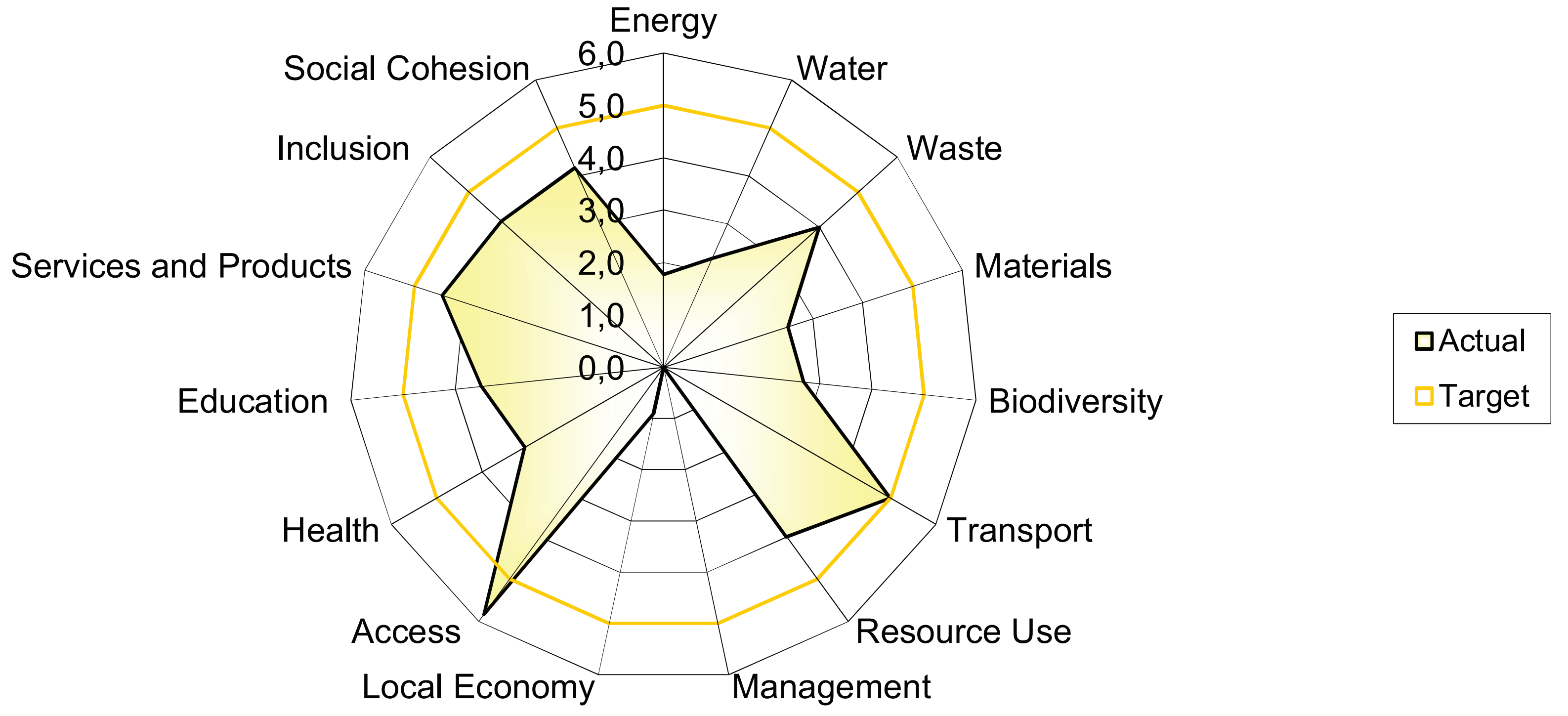
SB1 Project

0

SB2 Address

0

SB3 SBAT Graph



SB4 Environmental, Social and Economic Performance	Score
Environmental	2,6
Economic	3,1
Social	3,9
SBAT Rating	3,2

SB5 EF and HDI Factors	Score
EF Factor	3,5
HDI Factor	2,9

SB6 Targets	Percentage
Environmental	53
Economic	63
Social	77

SB7 Self Assessment: Information supplied and and confirmed by

Name	Date
Signature	

SB8 Validation: Documentation validated by

Name	Date
Signature	

SB9 Validation Report Version

IVR

Figure 8.19 Sbat report

8.8 Conclusion

This chapter resolves the concepts and design into a technified product that embodies the tangible and intangible objectives of Shift College.

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09

9. Conclusion

The physical environment can play a major role in the way students are able to learn. This dissertation then investigates the value of MST education and establishes how, through interior intervention, a model of experiential learning can be catalysed.

All buildings are rich with informal MST learning opportunities and the design sets out to expose these lessons hidden in structure. By emphasising the presence and occurrence of Mathematics and Science in the everyday, students are encouraged to notice the beauty of the world and the interconnected role MST plays therein. As explored in the theoretical investigation, the concept of the environment as an informal teacher of MST was developed. In providing a variety of spaces, different teaching and learning activities can be accommodated. The design solution, through interior expression, developed new methods of enriching the physical environment of the school using real life experiences, thus contributing to the field.

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10

10.1 List of references

Association for Learning Environments (A4LE) (2009) Project-Based Learning at High-Tech High. Available at: https://www.youtube.com/watch?v=6rv_rmJYorE (Accessed on: 10 May 2016)

Alexander, C, Ishikawa, S and Silverstein, M, 1977, A pattern language : towns, buildings, construction, Oxford University Press, New York

Bambisanani Learning Community Project (2013) What is the Bambisanani Project ? . Available at: https://www.youtube.com/watch?v=NR-zMu_xwA8 (Accessed: 28 April 2016)

Bambisanani Learning Community Program (2013) Bambisanani. Available at: http://www.bambisanani.org.za/ (Accessed:28 April 2016)

Brinkmann, S. 201. Qualitative inquiry in everyday life. SAGE, London

Brittin J, Sorensen D, Trowbridge M, Lee KK, Breithecker D, Frerichs L, et al. (2015) Physical Activity Design Guidelines for School Architecture. PLoS ONE 10(7). Available at: http://eds.a.ebscohost.com.uplib.idm.oclc.org/ehost/pdfviewer/pdfviewer?sid=23ff478c-467a-47fa-9270-058f9edbc389%40sessionmgr4010&vid=1&hid=4110 (Accessed: 10 March 2016)

Brooker, G and Stone, S. 2004. Rereadings : interior architecture and the design principles of remodelling existing buildings, RIBA Enterprises, London.

City of Tshwane (2005) Tshwane Inner City Development and Regeneration Strategy, 2005. (online). Available at : http://www.tshwane.gov.za/sites/Departments/City-Planning-and-Development/RELATED%20DOCUMENTS/InnerCityDevelopmentRegenerationStrategy.pdf (Accessed: 23 May 2016)

Cooper, J, 2013, Designing a School Makerspace, Edutopia. Available online at: http://www.edutopia.org/blog/designing-a-school-makerspace-jennifer-cooper (Accessed on 19 August 2016)

D'Acquisto, L, 2013, Museums at School, Educational Leadership, vol. 70, no.5. Avialable online at: http://www.ascd.org/publications/educational-leadership/feb13/vol70/num05/Museums-at-School.aspx (Accessed: 19 Augustus 2016)

Delacôte, G. 1998. Putting science in the Hands of the Public. Science, New Series, (280)5372. (online) Available at: http://science.sciencemag.org.uplib.idm.oclc.org/content/280/5372/2054 (Accessed: 30 March 2016)

Department of Basic Education. 2015. Basic Education focuses on improving maths, science and technology education, Media statements [online]. Available at: http://www.gov.za/speeches/dbe-focused-improving-maths-science-and-technology-education-17-jul-2015-0000 (Accessed: 22 March 2016)

Du Toit, P (2009) Abandoned spaces, abandoned design, unpublished master's thesis, University of Pretoria, Pretoria, Gauteng.

Du Plessis, D. 2010. Apollo: Towards Integrated Urban Education in Pretoria. Pretoria , unpublished master's thesis, University of Pretoria, Pretoria, Gauteng.

Eferreiraantunes (2012) Montessori College Oost, Amsterdam.wmv. Available at: https://www.youtube.com/watch?v=pyIT6L-SftA (Accessed: 30 April 2016)

Exploratorium. 2011. Machine with Concrete [online] Available at: http://www.exploratorium.edu/arts/works/machine-concrete (Accessed: 28 August 2016)

Fataar, A. 2007. Schooling, youth adaptation and translocal citizenship across the apartheid city. Journal of Education. (online) Available at: http://reference.sabinet.co.za/webx/access/journal_archive/0259479X/36.pdf (Accessed: 30 March 2016)

Hannafin, M,J, Land, S,M, 1997, The foundations and assumptions of technology-enhanced student-centered learning environments, Instructional Sciences, vol. 25, Kluwer Academic Publishers, Netherlands. Available online at: http://www.jstor.org/stable/23371252 (Accessed: 18 April 2016)

Harrison, A and Hutton, L , 2014, Design for the Changing Educational Landscape: Space, Place and the Future of learning, Routledge, New York

Hein, G,E, 2006, Progressive Education and Museum Education, The Journal of Museum Education, Vol. 31, No. 3. Avialable online at: http://www.jstor.org/stable/40479559 (Accessed: 08 March 2016)

Hein, H,S, 1990, The Exploratorium : the museum as laboratory, Washington : Smithsonian Institution Press

Hein, H,S, 1990, The Exploratorium : the museum as laboratory, Washington : Smithsonian Institution Press

Hertzberger, H. 2008. Space and learning: lessons in architecture 3, English ed, 010 Publishers, Rotterdam.

Hooper, S, and Hannafin, M,J, 199, The effects of group composition on achievement, interaction, and learning efficiency during computerbased cooperative instruction. Educational Technology Research and Development, vol. 39, no.3. Available on line at http://link.springer.com/article/10.1007/BF02296436 (Accessed: 18 April 2016)

Jacob, S. 2015, 24 September. School. Architectural Review

Khan, S, 2012, The One World Schoolhouse: Education Reimagined, Twelve, New York

Karolia, S. 2016. Re-imagine Urbanism Conference. Presentation presented at: Re-imagine Urbanism Conference, Freedom Park, 13 June 2016

Kolb, D, 2015, Experiential Learning: Experience as the Source of Learning and Development, Second Edition, Pearson Education, Inc, New Jersey. Available at: http://proquestcombo.safaribooksonline.com.uplib.idm.oclc.org/book/social-sciences/9780133892512 (Accessed: 3 March 2016)

Lynch, K (1972) What Time is This Place?, MIT Press, Cambridge.

Matshed, M. Digital learning for Gauteng schools. South African Government News Agency (online) Availble at : http://www.sanews.gov.za/south-africa/digital-learning-gauteng-schools [Accessed: 23 September 2016)

McCombs, B,L, and Whisler, J S 1997, The learner-centered classroom and school: Strategies for increasing student motivation and achievement. San Francisco: Jossey-Bass.

MIT Beaver Works / Merge Architects" (2014) ArchDaily. Available at: http://www.archdaily.com/551175/mit-beaver-works-merge-architects/ (Accessed : 28 February 2016)

Nkosi, B. 2014, August 01. Matric Maths Scrapped at 300 schools. Mail Guardian [online] Available at: http://mg.co.za/article/2014-08-01-matric-maths-scrapped-at-300-schools (Accessed: 25 March 2016)

Nordhoff ,H (2011) Edited, Sci-Enza: Hands-on Science! Wetenskap in Aksie! Available at: http://archivedpublicwebsite.up.ac.za/default.asp?ipkCategoryID=2064&subid=2064&ipklookid=11 (Accessed: 28 April 2016)

O'Donnell Wicklund Pigozzi and Peterson, Architects Inc., VS Furniture., & Bruce Mau Design, 2010, The third teacher: 79 ways you can use design to transform teaching & learning, Abrams, New York

Palm, R,R. 1940. The Origins of Progressive Education, The Elementary School Journal, Vol. 40, No. 6. Available online at: http://www.jstor.org/stable/997312 (Accessed: 8 March 2016)

Pas op je Pas, (2011) Lipdub Arm Rijkrap, Montessori College Oost, Amsterdam.mp4. Available at: https://www.youtube.com/watch?v=dgMbD6Kdf2c (Accessed: 30 April 2016)

Pilane, P. 2015. Is Gauteng ready for paperless schools?. The Daily Vox (online) Available at: http://www.thedailyvox.co.za/is-gauteng-ready-for-paperless-schools/ [Accessed: 23 September 2016]

Steyn, J. Professional Civil Engineer, Jeffares and Green. Consultation regarding the structure of the project building (15 March 2016)

Searching for space: on the architect Herman Hertzberger 2010, DVD, Interakt, Rotterdam

SolidGreen (2016) Streetlight Schools: Leading the Way in Green Education. Available at: http://www.solidgreen.co.za/streetlight-schools-leading-the-way-in-green-education/ (Accessed : 11 July 2016)

TEDtalk. 2013. Ken Robinson: How to escape education's death valley (online) Available at: https://www.ted.com/talks/ken_robinson_how_to_escape_education_s_death_valley?language=en (Accessed: 22 February 2016)

Wright, N. M. (2015). Future Schools. Newcastle : RIBA.

Yang, X. (2015). Reserach on Application Method of Intuitive Design. Applied Mechanics and Materials, 513-516.

Yin, R. (2003). Case Study Research: Design and Methods. 3rd edition Los Angeles : SAGE.

Image Internet sources

http://www.aluglass.co.za/wp-content/uploads/2015/02/Fabricmate-brochure.pdf (Accessed: 10 October 2016)

http://www.archdaily.com/551175/mit-beaver-works-merge-architects (Accessed: 5 April 2016)

http://www.archdaily.com/420645/vittra-school-sodermalm-rosan-bosch (Accessed: 23 February 2016)

http://www.detail-online.com/inspiration/montessori-college-oost-in-amsterdam-103696.html (Accessed: 25 June 2016)

http://www.dezeen.com/2016/04/29/node-lights-odd-matter-studio-jesmonite-copper-circuit-diagram-milan-design-week/ (Accessed: 29 April 2016)

http://www.dezeen.com/2012/11/06/windswept-installation-by-charles-sowers/ (Accessed: 30 April 2016
https://dprbcn.wordpress.com/2012/01/26/gordon-matta-clark/ (Accessed: 1 October 2016)
http://ewn.co.za/2015/07/20/Over-300-Gauteng-public-schools-to-get-tablets (Accessed: 20 September 2016)
//www.exploratorium.edu/ (Accessed: 15 March 2016)
http://www.forbo.com/flooring/en-gl/products/linoleum/acoustic-linoleum/marmoleum-decibel/bnruhx (Accessed: 20 June 2016)

http://www.isover.co.za/glasswool (Accessed: 10 October 2016)

http://www.jimtheillustrator.co.uk/ (Accessed: 16 August 2016)

http://www.lafarge.co.za/LAF_514917_Partition_Brochure_F.pdf (Accessed: 15 September 2016)

http://milwaukeeidscohort.wikispaces.com/John+Dewey+Page (Accessed: 03 May 2016)

https://onlinelearninginsights.wordpress.com/category/instructional-design/page/2/ (Accessed: 03 May 2016)

http://www.owa.co.za/products/OWAcoustic_cosmos_intro.html (Accessed: 10 October 2016)

http://www.owa.de/en/products/owaconsultcollection/owaconsult-collection/cloud/ (Accessed: 20 August 2016)

http://www.petzel.com/exhibitions/2013-01-10_daniel-buren/(Accessed: 05 August 2016)

http://www.smartdesks.com/collaboration-tables/exchange-design-ideas-cc.pdf (Accessed: 30 May 2016)

https://www.ted.com/talks/(Accessed 2 September 2016)

http://www.thecreativehome.com/products/naef-cubicus-blue (Accessed: 1 October)

http://thethirdteacherplus.com/international-school-of-indiana/(Accessed: 10 July 2016)

http://thethirdteacherplus.com/international-school-of-indiana/ (Accessed: 10 July 2016)

http://thethirdteacherplus.com/nscd/ (Accessed: 10 July 2016)

http://thethirdteacherplus.com/nscd/ (Accessed: 10 July 2016)

http://thethirdteacherplus.com/hamilton-southeastern-school-district/ (Accessed: 10 July 2016)

https://www.wired.com/2011/07/ff_khan/ (Accessed: 20 September 2016)

http://vandyckcarpets.com/browse/flooring-for-the-office/ (Accessed 10 October 2016)

https://vimeo.com/87280061(Accessed: 30 September 2016)

https://www.youtube.com/watch?v=dgMbD6Kdf2c (Accessed: June 5 2016)

https://www.youtube.com/watch?v=6rv_rmJYorE (Accessed: 2 July 2016)

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