

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

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

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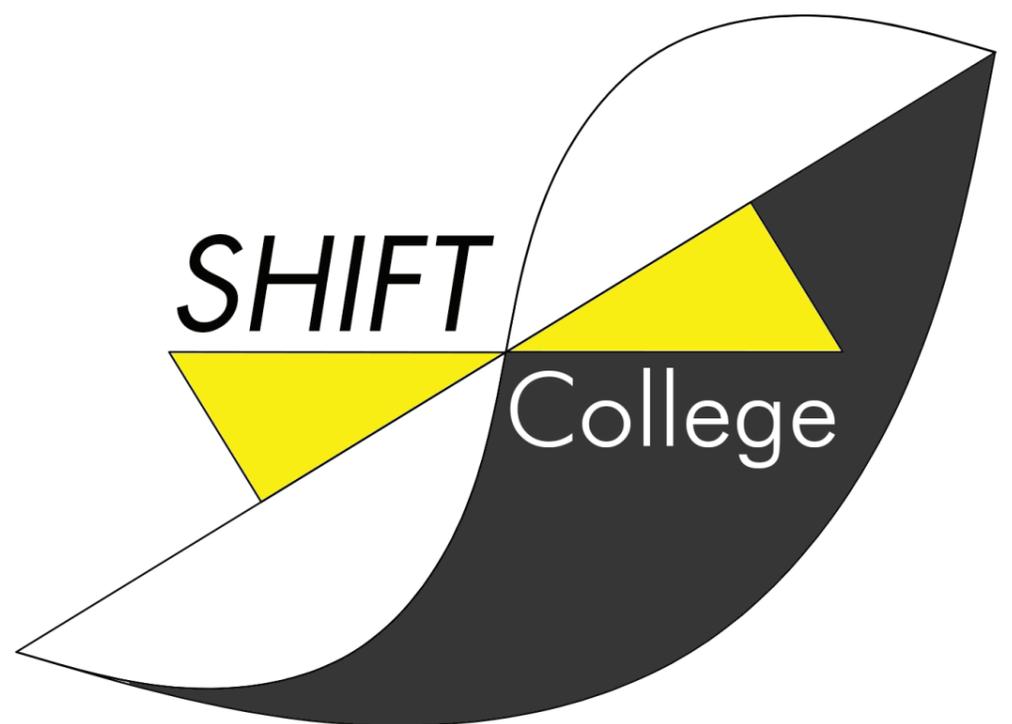
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In accordance with Regulation 4(e) of the general Regulations (G.57) for dissertations and theses, I declare that this thesis, which I hereby submit for the degree Masters of Interior Architecture (Professional) at the University of Pretoria, is my 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.

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Liné Visser



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

## Project Summary

Project description:

Programme:

Site Description:

Site location:

Address:

Research Field:

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.

High school design.

Adaptive Reuse of a 1955 building.

ERF 3134, Pretoria, Tshwane.

193 Jeff Masemola St, Pretoria, Gauteng

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.

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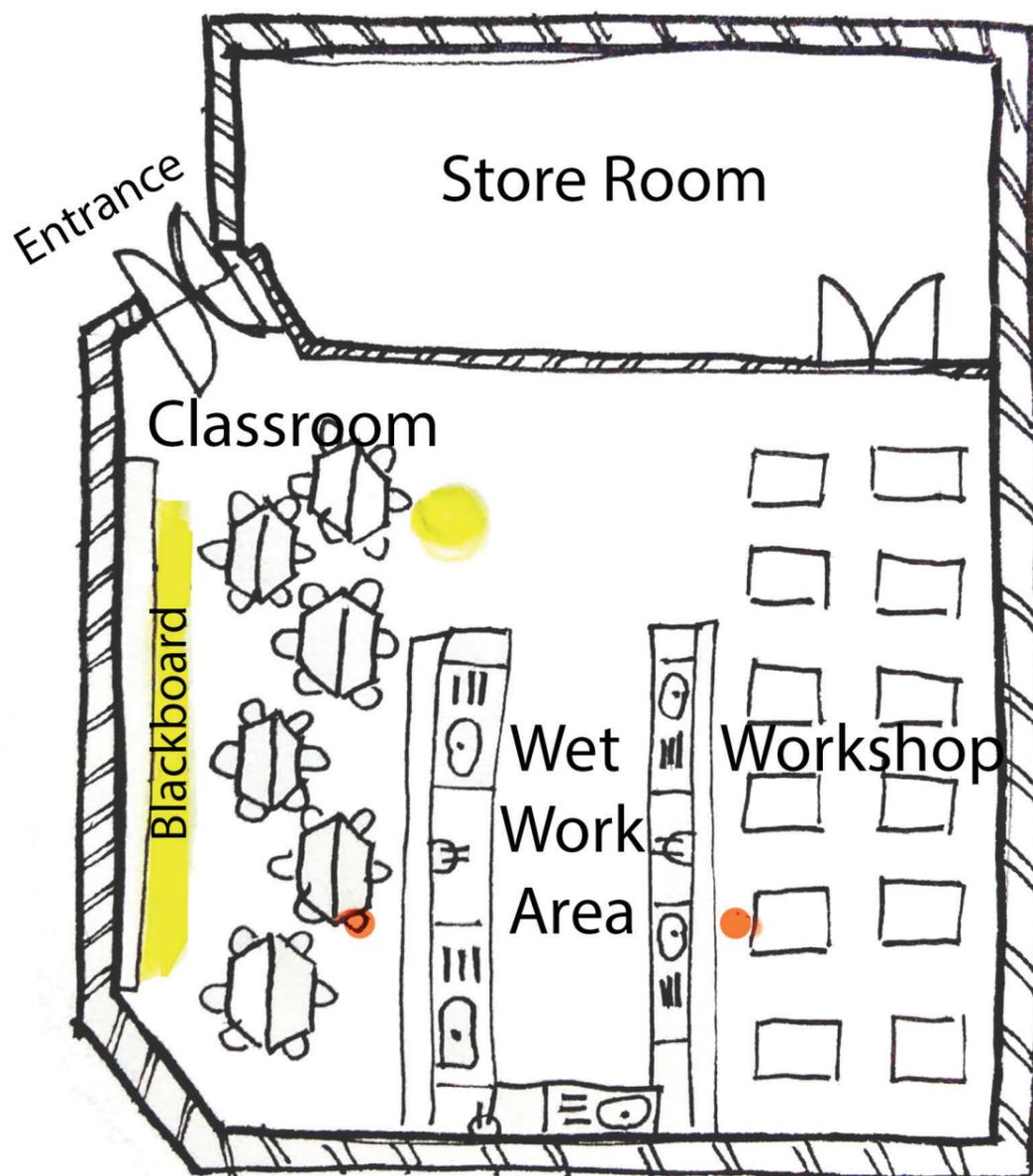
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- Teacher's position
- Author's position

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.





# 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.

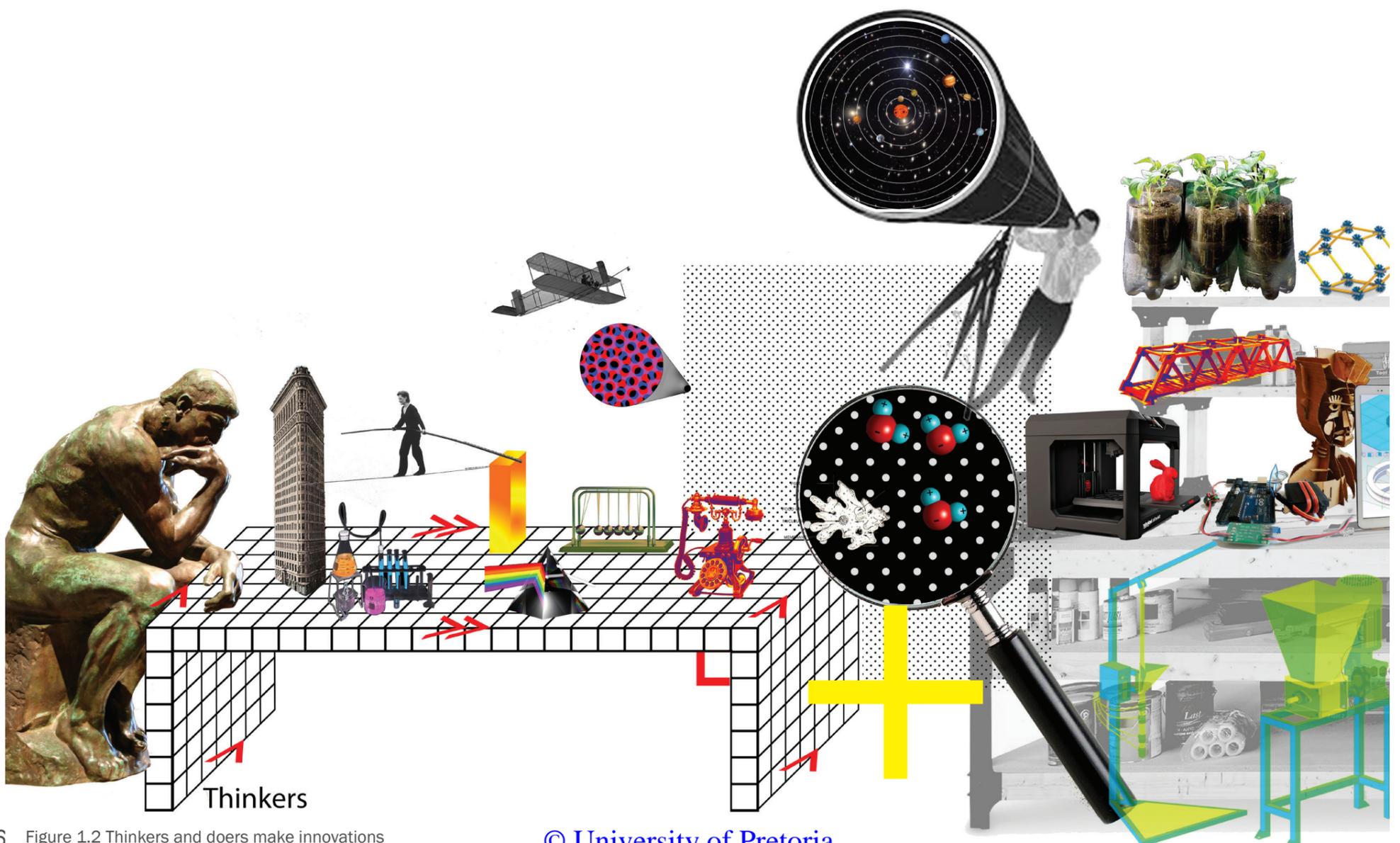
In South Africa, the Department of Basic Education focuses on improving Mathematics, Science and Technology education (DBE, 2015). However, the enrolments for Further Education and Training (FET) Mathematics has decreased from 263 000 students in 2010 to 143 000 students in 2013 (Nkosi, 2014). Through 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.



6 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).

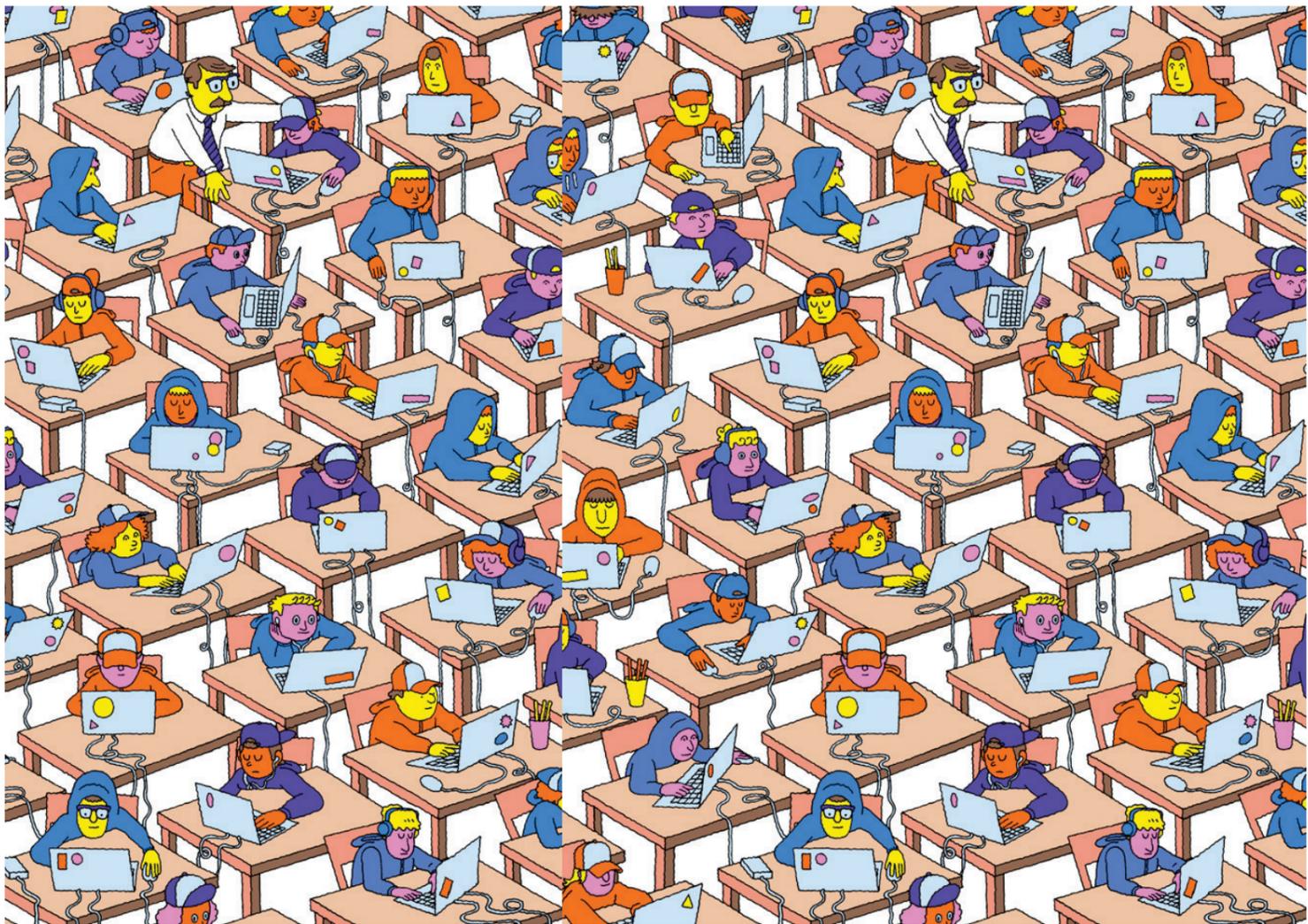


Figure 1.3 Jim Stoten Illustration - Traditional physical environment with technology.

## 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.