Design of a Model University Classroom for Collaborative and Interactive Learning

BY

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This thesis, written by ***Mohammed Alhaji Mohammed*** under the direction of his thesis advisor and approved by his thesis committee, has been presented to and accepted by the Dean of Graduate Studies, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in ARCHITECTURAL ENGINEERING.**

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Dedicated to my Parents and family

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All praise is due to Allah; we praise Him and seek His help, and beg for His forgiveness, we seek refuge of Allah from the evil of our souls, and from the wickedness of our deeds. Whosoever Allah guides cannot be led astray, and whosoever is less astray shall find no other to guide him. I bear witness that none has the right to be worshipped but Allah and Muhammad (SAW) is His slave and Messenger.

All praise is due to Allah for his mercy and endless bounties. I appreciate the support and patience from my family throughout my studies in the Kingdom of Saudi Arabia and special acknowledgement is also due to the King Fahd University of Petroleum and Minerals, especially the department of Architectural Engineering, for supporting this research.

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ABSTRACT

FULL NAME OF STUDENT : MOHAMMED ALHAJI MOHAMMED

TITLE OF STUDY : DESIGN OF A MODEL UNIVERSITY CLASSROOM FOR COLLABORATIVE AND INTERACTIVE LEARNING

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Nowadays, universities recognize that to recruit and retain good students and faculty, modern well-equipped instructional facilities are as important as state-of-the-art research facilities. It is established that qualities of indoor environment, instructional technology, and physical set up of the classroom are related to students' performance. This study presents a comprehensive and critical review of literature on the nature of the university classroom for collaborative and interactive learning being a learner-centered style, seeking to replace the widely used traditional teacher-centered learning style with the aim of providing an enabling environment of higher learning in universities. This thesis discusses the impact of indoor environmental quality, instructional technology and physical set up of the classroom on the students' performance. The objective is to develop a model of university classroom for collaborative and interactive learning. This has been achieved by generating a generic model with three different furniture design alternatives (i.e. hexagonal, trapezoidal, and triangular) and arrangement set-up. The alternatives are very flexible and can be reconfigured to any collaborative and interactive learning style. Classroom equipment and technology, as well as, lighting and acoustic requirements of the model university classroom are also presented. Moreover, the research has also established a methodology for adapting the generic classroom model in any university, as the implementation of the generic model depends on the university's vision, resources, faculty, IT skills, students' awareness, academic development entities within the university, and the nature of existing classroom spaces. The rectangular shape classroom was adopted for the KFUPM case study for easy implementation. The thesis outcome is a generic Model University Classroom for Collaborative and Interactive Learning, considering all the influential parameters, including physical set-up, instructional equipment and technology, and indoor environmental quality.

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في الوقت الحاضر تدرك الجامعات أن سعيها لاستقطاب الطلاب وأعضاء هيئة التدريس المتميزيين والاحتفاظ بهم في بيئة تعليمية حديثة مجهزة تجهيزا جيدا لا يقل أهمية عن توفير مرافق البحث العلمي على أحدث طراز. وبناء على نتائج أدبيات البحث، ثبت أن خصائص البيئة الدراسية، وتكنولوجيا الوسائل التعليمية، وإعداد وتجهيز الفصول الدراسية ترتبط مباشرة مع أداء الطلاب. وتقدم هذه الدراسة استعراضاً شاملاً وناقداً لأدبيات البحث عن طبيعة الفصول الجامعية الدراسية التي تصلح لنمط تعليمي تعاوني وتفاعلي، سعياً لاستبدال طرق التعليم التقليدية المنتشرة وذلك بهدف توفير بيئة مواتية للتعلم أمثل في الجامعات. وتناقش هذه الأطروحة تأثير جودة البيئة الداخلية ، والتكنولوجيا التعليمية المكانية وإعداد الفصول الدراسية على أداء الطلاب. ويتمثل هدف هذه الدراسة في تطوير/ تصميم نموذج للفصل الدراسي الجامعي للتعلم بطريقه تعاونية وتفاعلية. وقد تحقق ذلك من خلال تطوير نموذج عام مع ثلاثة بدائل مختلفة لتصميم الأثاث المناسب (سداسي، شبه منحرف، ومثلث) وهي بدائل مرنة يمكن إعادة تشكيلها لتصلح لأي نمط تعلم تعاوني أو تفاعلي. ويشمل النموذج أيضا المعدات والتجهيزات اللازمة ، فضلا عن متطلبات الإضاءة والصوتيات. وعلاوة على ذلك قدم البحث منهجية لتطبيق وتعديل النموذج العام في أي جامعة ،اعتماداً على رؤية الجامعة، ومواردها، ومهارات تكنولوجيا المعلومات لأعضاء هيئة التدريس ووعي الطلاب وكيانات التطوير الأكاديمي، وأيضا طبيعة الفصول الدراسية بها. وقد أعتُمد الشكل المستطيل للفصول الدراسية عند دراسة حالة جامعة الملك فهد للبترول والمعادن حيث وجد أن من السهل تطوير و تطبيق النموذج المستطيل الشكل. ويخلص البحث بنموذج الفصل الدراسي الجامعي الأمثل لنمط تعلم تعاوني وتفاعلي آخذاً في الاعتبار جميع العوامل المؤثرة من حيث الفراغ والشكل والتأثيث ووسائل ومعدات التعليم وجودة البيئة الداخلية.

CHAPTER ONE

1 INTRODUCTION

1.1 Background

A classroom is a room where teaching and learning activities can take place in a safe and proper environment without interruption or distraction by other activities. Information exchange between the student and teacher happens both ways with vocal and visual communication as the basic medium, requiring a learning environment equipped with proper communication and presentation tools for exchanging knowledge and ideas supported by the right environment free from any source of disturbances. This will improve the effective exchange of knowledge and enhance level of comprehension. Based on the preliminary research findings, it is established that qualities of indoor environment, high-tech instructional technology, recent developments in teaching and learning styles (pedagogies) and the physical set up of the classroom are related and significantly impact on student performance. Today, colleges and universities recognize that the need for modern and well-equipped instructional facilities is as important as modern research facilities. Therefore, due to the rapid changes in learning styles, high-tech pedagogies as a result of emerging instructional technologies and an efficient university futuristic classroom with proper indoor environment quality (IEQ) suitable for

accommodating up-and-coming teaching and learning styles with highly developed educational amenities are very much essential. This study will aim at developing a model university classroom that takes into account the above-mentioned components and factors with the aim of providing an enabling learning environment in universities and other institutes of higher learning.

Over the last few decades, the understanding of learning and the conditions under which it is facilitated have substantially improved. In most contemporary theories, learning is conceived as a constructive and social activity, as a result of which the roles of the teacher and the learner within the classroom have been redefined. Development in technologies that can be used to enhance and support learning has been even more rapid. Nevertheless, the majority of the classrooms in today's schools and universities remain untouched by these developments (Mäkitalo-Siegl, et al 2010).

The need for establishing suitable layouts that will accommodate different learning styles is of great importance, as no single layout is perfect for all types of teaching. However, some layouts are far more versatile than others; whereas other layouts are particularly well suited to certain types of teaching situation (Smawfield, 2007).

1.2 Statement of Problem

The university classroom being a place where exchange of information or knowledge is going on from the instructor to the students and sometimes vice versa, the need for a proper physical set-up integrated with efficient instructional equipment and technology, while maintaining indoor environmental ambience appropriate for collaborative and interactive learning, can never be over emphasized.

Previous studies have confirmed that factors like classroom physical set-up, equipment/technology and indoor environmental quality have a great impact on students' performance and achievements. These factors are currently not integrated as a single entity to have a high-quality model university classroom for collaborative and interactive learning. Hence, it is important to develop a model classroom with the aim of integrating all the influential factors affecting student performance and collaborative learning outcomes in the university classroom.

1.3 Significance of the Study

The study of a model university classroom for collaborative and interactive learning is of great importance as a guide for setting up a conducive and efficient environment for collaborative and interactive learning. The need for effective technology to support emerging teaching and learning pedagogies is required as students are required to gain a greater amount of knowledge and develop skills that are needed for proper understanding and comprehension. The study, once successfully completed and implemented, is expected to help in improving student's performance in university classrooms. As many studies has been conducted with the aim of improving classroom environments, but few achievements have been made in the literature to integrate all factors affecting the comfortability and efficient instructional delivery in university classroom. Hence, the development of a model university classroom for collaborative and interactive learning is a significant contribution not only for academia but also professionals in the design and planning industry because the study will serve as a stepping stone to build future research work in similar areas. The significance of the study is summarised in the following points:

The study is expected to:

- Help in identifying the optimum classroom with efficient indoor environmental quality and suggest the best interior arrangement. Hence it will improve collaborative teaching and learning pedagogy.
- Contribute in improving the level of education among university students by creating the required atmosphere.

- Help in integrating all the effective collaborative teaching and learning styles and pedagogies as a result emerging/new technologies.
- Contribute generally to the professionals of the building construction industry by establishing a certain standards classroom.
- Pave the way towards standardizing classroom design for collaborative learning in contemporary universities.

1.4 Objectives of the Study

The objectives of this study are as follows:

- To investigate the state-of-the-art concepts and technologies used in modern classrooms in light of futuristic ideas appropriate for the emerging teaching/learning pedagogies in university classroom. Various factors affecting teaching, learning and students' learning performance will be examined.
- To develop/design a model university classroom with the proper (1) physical setup, integrated with (2) efficient educational/instructional technology and (3) indoor environmental ambience appropriate for the collaborative and interactive new (4) emerging teaching/learning pedagogical requirements.

1.5 Scope and Limitation of the Study

The study of the model university classroom of the future for collaborative and interactive learning will consider a classroom size that can accommodate around 20-30 students. This is due to the fact that many studies conducted have concluded that a small size classroom is more important to student achievement. Schneider, M. (2002) 'TEACHERS SURVEY OF PUBLIC AGENDA IN RELATION TO CLASSROOM SIZE' shows that seventy percent of the respondents agreed that a small class size is better. According to the study conducted by Kokkelenberg, et al, (2005) average grade point of students declines as class size increases abruptly up to class sizes twenty and more and gradually but monotonically through larger class sizes. Emory College Classroom Working Group (2008) recommends 8 to 25 seats in a collaborative classroom as it requires more space per person. Stecher and Bohrnstedt, (2000) confirm in their studies that students in smaller classes performed better on achievement tests than in larger classes and Pritchard's (1999) research concluded that reducing class size to below 20 students leads to higher student achievement. In a collaborative classroom it is recommended to have a fewer number of students to avoid rowdiness. Hence, classroom design to accommodate a higher number of students will not be considered.

1.6 Work Plan and Methodology

In order to accomplish the study objectives, the following research methodology will be implemented:

- **A comprehensive literature review** will be conducted to address the main issues regarding the university classroom for collaborative and interactive learning. The literature will cover areas of classroom physical set-up, seating arrangements, instructional equipment and technology, indoor environmental qualities, and collaborative learning/teaching pedagogies as illustrated in **Figure 1.1**.

- **Architectural design of the Model University Classroom (MUC)** will be carried out based on the review of literature to consider all the essential requirements of the classroom. Hence the generic model of the MUC will be developed.

- **A multi method study approach** will be applied to carry out the research in order to avoid bias. These methods include; Theoretical Analyses of the literature; Interviews among course instructors and students; and other methods deemed necessary in the process of this study will be carried out with the aim of obtaining reliable results and summarising views of the users on the outcomes of the study.

- **A Case Study of King Fahd University of Petroleum and Minerals** will be conducted by administering an interactive interview survey based on the proposed generic Model University Classroom (MUC) to suite the requirement of the university.

- **Comparison with existing standards** in the areas of indoor environmental qualities will be studied based on data gathered from existing standards. The compliance to adopted standards will be conducted based on advantages of these standards over similar standards in the literature. The research methodology showing comprehensive conceptual framework to be followed in arriving at the Model University Classroom (MUC) has been illustrated in **Figure 1.2.**

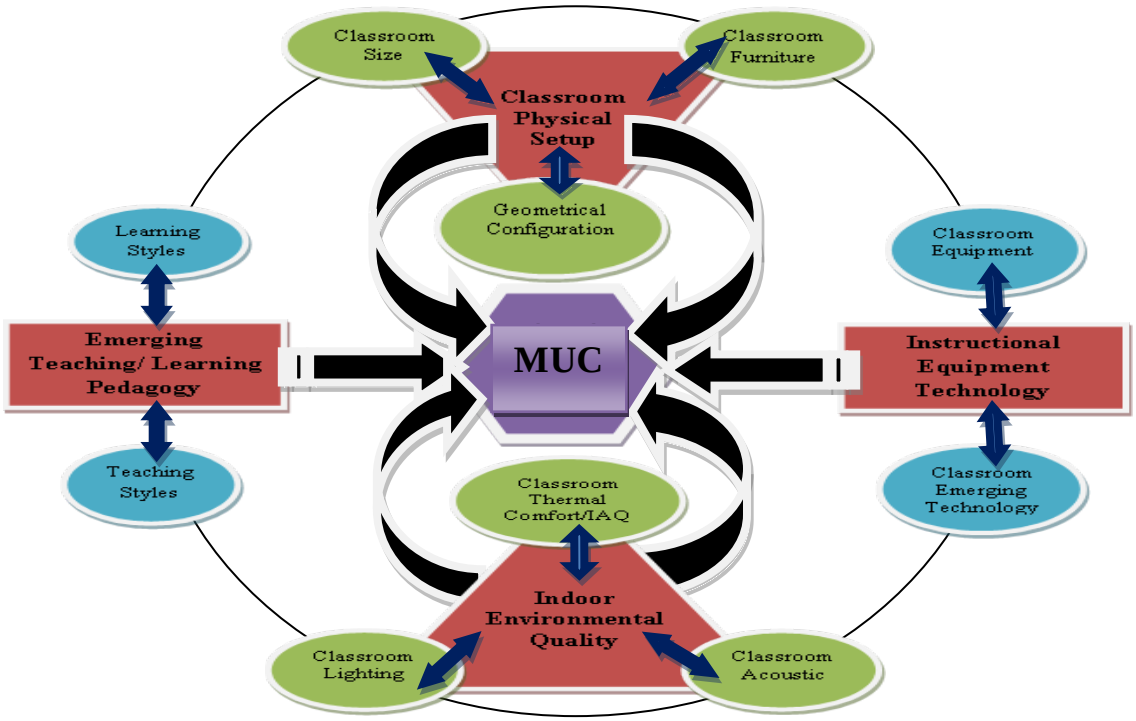


Figure 1.1 Relationship between various influential components on the design of university future classroom

(Note: IAQ = Indoor Air Quality)

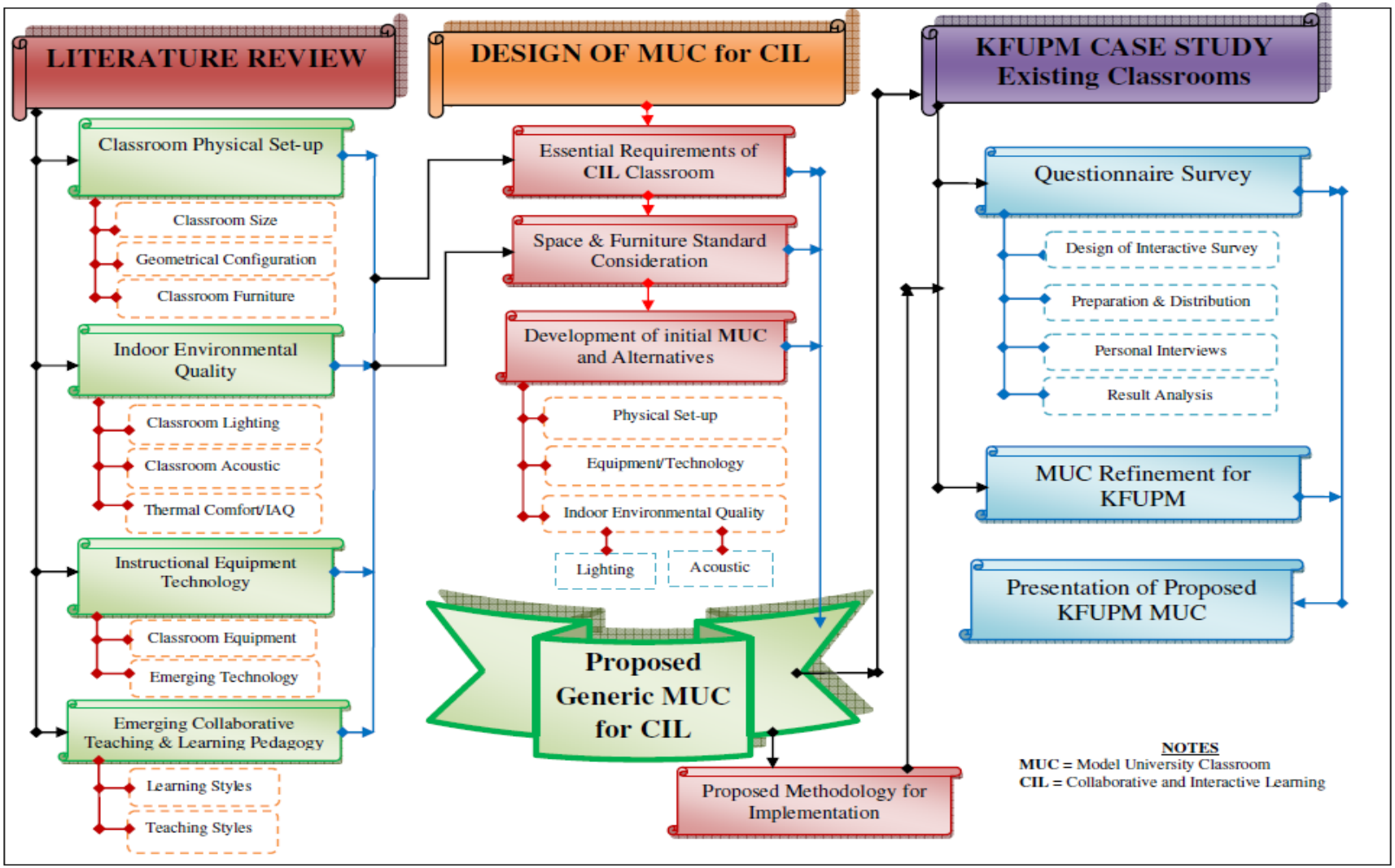


Figure 1.2 Research Methodology

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Ideal Classroom of the Future

In recent times, understanding of learning and the circumstances under which it is facilitated have considerably improved. In most contemporary theories, learning is conceived as a constructive and social activity, as a result of which the roles of the teacher and the learner within the classroom have been redefined. This is informed by the rapid development in technologies that can be used to enhance and support learning rapidly in classroom. Mäkitalo-Siegl, et al. (2010) in their studies *"Classroom of the Future: Orchestrating Collaborative Spaces, 1–12"* affirm that the majority of the classrooms in today's schools and universities remain unreached by these technological developments. The classroom of the future promotes not only a sense of comfort and produces a favourable atmosphere with technically well equipped interior, but it is also designed for effective learning activities (Molnar, 2007).

Brett Hunter, as cited in (Gillian, 2001), believes that classrooms need Internet access for research, distributed multimedia curriculum, online access to digital libraries, distance education courses and remote collaborative tools. Information on demand for students also includes video, live video broadcast, desktop videoconferencing and 3D modelling. "The use of voice (for activities such as interviews, speeches, background

music, explanations) and video (for live conferences within and between schools) would change the way schools operate".

The classroom of the tomorrow, according to (Gillian, 2001) was characterised by the following features:

- Access to on-line resources which use a powerful combination of video, multimedia, text and graphics, prepared by specialists in a centralised resource development facility and delivered to individuals or groups by technology.
- Provision for the teacher to teach the whole class or part of the class, assisted by technology, is appropriate.
- Provision for all students to learn the same way or to choose ways which suit their own individual learning styles, assisted by technology as appropriate.
- Access to individualised curriculum pathways, managed by technology.
- Access to individualised diagnostic testing and assessment of progress, managed by technology.
- Students moving independently between learning areas as necessary, managed by technology.
- Flexible room layout and furnishing.
- Large-screen video display.
- Individualised access to network resources like wireless networking; cheap, light-weight notebook computers and e-books.
- Continuity of access to network resources away from school.

According to (Tocco, 2009), the ideal classroom tries to create an environment where students can move freely from a traditional classroom to computer resources located at the back of the room. Desks can be shuffled around for easy division into groups. One

group member might be doing research on the computer while others are discussing their project. Group presentations using PowerPoint and a digital projector are good examples of technology in service of traditional functions such as group presentations. Presenters can tab back and forth to a web browser, tapping into the nervous system of the entire world, the World Wide Web, and its billions of web pages.

The digital, wired classroom is still relatively new, possibly 10-15 years old, but it has been millenniums in the making. While there is much advancement yet to come, it is clear that in the past 15 years or so, there has been advancement which is a major rung on the ladder of progress in education. Schools are still settling in to this new era as they continue to balance old with new. Teachers are constantly finding new innovation. It is clearly not necessary for every student to be in front of a computer at all times. Most classroom activities do not involve computers. Students can always access computers at home or in libraries. Files can be transported via thumb drives or even email. Obviously, lecturing to students sitting in front of computers is not particularly conducive to learning; in fact it would probably distract students. Thus schools must decide how much computer use is appropriate. The correct student/computer ratio must be determined. The keyword is sharing. How can expensive computers best be shared? One convenient method of sharing is to have a computer lab in the rear of the class. Computers can be used by the individual class or made available to other classes while not in use. Thus, Tocco's (2009) ideal class is a combination classroom/computer lab. The arrangement fits neatly into a footprint of 38" x 24" (11.6m x 7.3m), with 24 regular desks, two teacher desks, and 24 computer stations as illustrated in **Figure 2.1** (Tocco, 2009).

Computers and other digital resources are no doubt useful to the modern classroom, but older technology such as a telephone, TV screen, overhead projector, and DVD player are still quite useful. The classrooms of 2009 are incubators for the leaders of tomorrow, and by balancing old and new teaching tools, it is expected to stand the best chance of producing a new generation of problem solvers able to meet the world's great challenges (Tocco, 2009).

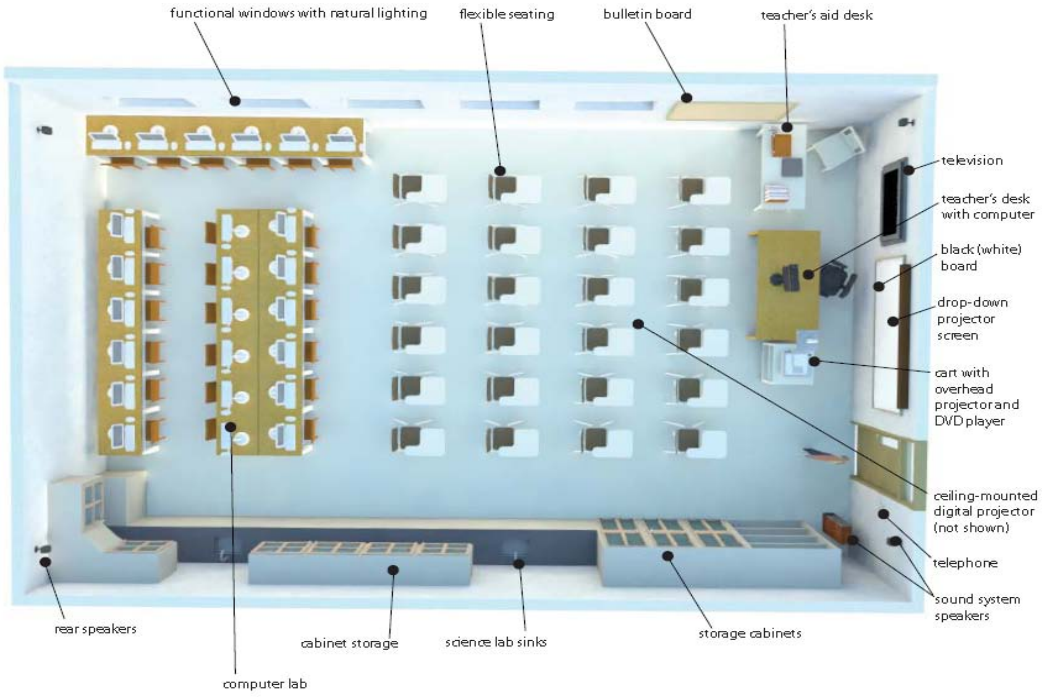


Figure 2.1 Collaborative Classroom Furniture Layouts

2.2 Emerging Teaching and Learning Pedagogy

2.2.1 Collaborative Learning

Collaborative learning provides an environment to enliven and enrich the learning process. Introducing interactive partners into an educational system creates more realistic social contexts, thereby increasing the effectiveness of the system. Such an environment would help sustain the student's interests and would provide a more natural learning habitat (Durfee, et al, 1989). The term "collaborative learning" refers to an instruction method in which students at various performance levels work together in small groups toward a common goal (Gokhale, 1995).

Collaboration is described as an active process and a coordinated effort by which learners pursue joint goals, solve problems, and build a mutual understanding of a particular issue. Collaborative learning crucially depends on the existence of appropriate instructional, physical, and social conditions. Simply putting people into groups and asking them to solve problems or perform tasks does not necessarily induce the kind of interaction that makes learning more likely. Collaboration should rather be comprehended in a wider sense. Learning can include collaborative as well as individual and collective activities, distributed across multiple places (physical, virtual, or a combination of the two), and can be supported by multiple tools. Meaningful and efficient collaboration requires a specific place which formally or informally enhances collaborative learning. In opening up new channels for collaboration, technology is also stretching the limits of physical space. With the help of new technology, collaboration and community thinking are no longer limited to the

inside of the classroom but can also occur in a number of other places (Mäkitalo-Siegl, et al 2010).

The goal of encouraging groups of learners to engage collaboratively in problem-solving activities has much merit. Social interaction fosters deep learning in which students develop intellectual structures that allow them to create their own knowledge. It promotes social skills that help people participate in the social construction of their shared reality. It increases student engagement and brings out the relevance of learning. It allows the educational process to be more student-centered, less disciplinary, and more exciting. For educational change to succeed, teachers must be supported in changing from an isolated teaching model to one of collaborative learning with other educators (Stahl, et al, 1995).

Learning in teams is crucial in a knowledge intensive society. Presently, organizations increasingly rely on teams to solve a variety of complex tasks and problems. In order to be effective and successful in the solving of problems, it is crucial that knowledge is continuously shared and constructed in teams (Leinonen, 2007). Studies have shown that collaborative learning is often more effective than learning alone, and the effects of collaborative learning depend on the quality of interactions during collaboration (Dillenbourg, et al 2005). Proponents of collaborative learning claim that the active exchange of ideas within small groups not only increases interest among the participants but also promotes critical thinking. The shared learning gives students an opportunity to engage in discussion, take responsibility for their own learning, and thus become critical thinkers. Students are capable of performing at higher intellectual levels when asked to work in collaborative situations than when asked to work individually. Group diversity in terms of knowledge and experience contributes

positively to the learning process. A collaborative learning medium provides students with opportunities to analyze, synthesize, and evaluate ideas cooperatively (Gokhale, 1995).

The central element of collaborative learning is collaborative in relation to individual work and the analysis therefore focuses on how collaboration influences learning outcomes. The results of existing meta-studies on this question are consistent. In a review of 90 years of research, Johnson, Johnson and Smith as cited in (Prince, 2004) found that cooperation improved learning outcomes relative to individual work across the board. Springer et al., as cited in (Prince, 2004) found similar results looking at 37 studies of students in science, mathematics, engineering and technology. Reported results for each of these studies as adopted from (Prince, 2004) are shown in **Table 2.1**, using effect sizes to show the impact of collaboration on a range of learning outcomes.

Table 2.1 Collaborative vs. Individualistic learning: Reported effect size of the improvement in different learning outcomes

References	Learning outcome	Effect Size
Johnson, Johnson and Smith	Improved academic achievement	0.64
	Improved linking among students	0.60
	Improved self-esteem	0.44
	Improved perceptions of greater social support	0.70
Johnson, Johnson and Smith	Improved academic achievement	0.53
	Improved quality of interpersonal interactions	0.55
	Improved self-esteem	0.29
	Improved perceptions of greater social support	0.51
Springer et al	Improved academic achievement	0.51
	Improved student attitudes	0.55
	Improved retention in academic programs	0.46

2.2.2 Collaborative Learning Spaces Requirements

Collaborative learning spaces are characterised with special requirements that will provide an enabling atmosphere for collaborative pedagogical activities. Brook, (2009) has classified collaborative learning space requirement in the following classes.

- Areas for small group work
- Connection to outdoor spaces with line of sight for teacher supervision
- Circular desks or flexible furniture
- Interactive equipment such as white boards placed at student height.

The study conducted by (Leidner and Fuller,1997) found that students working collaboratively in either small or large groups were more interested in the material and perceived themselves to learn more than students that worked individually, but students who worked individually outperformed students collaborated in small or large groups before working individually. Therefore, based on the literature review, the present trends in instructional styles is more tailored towards a learner centered collaborative classroom rather than teacher centered individual one way information flow learning.

2.2.3 Collaborative Learning Enhances Critical Thinking

The concept of collaborative learning and its features of grouping and pairing of students with the purpose of attaining an academic objective has been extensively researched and advocated throughout the professional literature. In collaborative learning, the students are responsible for one another's learning as well as their own. Thus, the success of one student helps other students to be successful. The advances in technology and changes in the organizational infrastructure put an increased emphasis

on teamwork within the workforce. Workers need to be able to think creatively, solve problems, and make decisions as a team. Therefore, the development and enhancement of critical-thinking skills through collaborative learning is one of the primary goals of technology education. There is convincing evidence that cooperative teams achieve at higher levels of thought and retain information longer than students who work quietly as individuals and collaborative learning fosters the development of critical thinking through discussion, clarification of ideas, and evaluation of others' ideas. Hence, the shared learning gives students an opportunity to engage in discussion, take responsibility for their own learning, and thus become critical thinkers. Therefore, if the purpose of instruction is to enhance critical thinking and problem solving skills, then collaborative learning is more beneficial (Gokhale, 1995).

2.2.4 Characteristics of collaborative learning

Collaborative learning can be effective when students work and interact, traditionally face-to-face, and more technically through video conferencing and instant messaging. A group project in which students divide tasks among members such that the portions of the project are not merged until the final draft promotes little if any connection of knowledge between group members. It also likely results in repetitious project sections because students have not compared their section’s information to what is included in other sections. Interacting with a group will require that students begin to develop the kinds of interpersonal skills that they will need for working with other professionals in their careers.

Collaborative learning should involve a group of students who are dependent upon each other to complete an objective. Hence, each student is not only individually

responsible for a share of work, but also for the entire final product. As a group, students are responsible for distributing work fairly and ensuring that each member contributes adequately. The group should evaluate its progress towards the goal and productively critique each component. As students comment on each other's work or ideas, they are also evaluating their own knowledge or beliefs within a new context (Project, C. 2008).

2.2.5 Collaborative learning activities

Collaborative learning can range from one-time class discussion to long term multi-component projects. Short collaborative learning not only asks students to think about their own knowledge, but also to report to the instructor about which concepts students struggle to understand. Implementing cooperative learning can be divided into steps as described below ((Project, C. 2008).

Step 1: Identify the goal. This is typically done by providing instructions or guidelines that students will use to complete an assignment or activity.

Step 2: Divide students into teams.

Step 3: Provide guidelines for the extent, style, or type of collaboration expected. Do you expect each member to fulfill a specific role within the group? Who selects the team leaders? What communication rules will be in place?

Step 4: Observe and/or facilitate group progress. For example, this can be accomplished with incremental deadlines, progress review meetings or reports. For discussion-based activities, the instructor might check in on group progress and add evidence or opposing viewpoints to stimulate additional discussion in stalled groups.

Step 5: Assess the final product. For discussion-based activities, it is important for students to value what they discussed. To conclude the activity, student groups could report their consensus or summarize their ideas for the group. The instructor may add comments or follow-up on new questions raised by the students.

2.2.6 Characteristics of Collaborative Classroom

The characteristics of a collaborative classroom that could be benefited from include the sharing between teacher and students, sharing planning responsibilities, grouping of students, and the roles of the students and teacher (etools4Education, 2005).

1. **Sharing between teachers and students in a collaborative learning classroom.**

In traditional classrooms instructors are the all knowing, mostly information giver. In a collaborative learning classroom the teacher and students share knowledge about content, skills and instruction. In a collaborative classroom, the teacher also builds upon the knowledge, personal experiences, language, strategies, and culture that students bring to the learning situation (Stephen et al. 2003). Working together toward a common goal will strengthen the connections made in the learning process.

2. **Sharing planning in the collaborative learning classroom.**

In most traditional classrooms the teacher is responsible for designing lessons and assessing what the students are learning. In the collaborative learning classroom the teacher will provide options for activities or end products, which will engage the student in critical thinking. The structure will also encourage students to assess what they learn. In a collaborative classroom, the teacher encourages students' use of their own knowledge, ensures that students share their knowledge, expertise and their

learning strategies, treat each other respectfully, and focus on high levels of understanding (Stephen et al. 2003).

3. **Grouping of students in a collaborative learning classroom.**

When teachers are trying to enrich learning in classrooms, all perspectives, backgrounds, and experiences of the students are important. Everyone can learn from someone else. If students are grouped with similar interests or abilities it could weaken the collaborative learning and limit students the opportunity to learn from and with other students.

4. **Role of the teacher and student in the collaborative learning classroom.**

The teacher as the facilitator provides opportunities for collaborative work and problem solving, while offering students authentic learning tasks. The classroom should take on a collaborative learning look. Arrange small meeting areas where planning and collaboration can occur. The classroom should be organized into various resources for the students. A computer station could be used for collecting information, collaborating with web software, or creating a product from the research data. A station with a variety of magazines, newspapers, and audio equipment would allow students to experience diverse media. Everyone will benefit from learning from each other and will strive to teach their group about their interests.

5. **Challenges in the collaborative learning classroom.**

When teachers move from a traditional classroom to a collaborative learning classroom several issues are going to arise. These issues are concerns for teachers, administrators, and parents. One of the issues would be the classroom environment. A

collaborative learning classroom will be noisier and some believe a noisy classroom lacks discipline and no learning can occur. Students need opportunities to move, talk, and ask questions. These activities will create more noise than a traditional classroom. Another issue could be individual responsibility for learning. Usually in a traditional classroom students are graded for individual work but in a collaborative learning classroom it is often difficult to assign individual grades. Teachers will be pleased that effective ways of grading are being tried in the collaborative learning classroom. One way is making individuals responsible for subtasks in group work. This could allow the teacher to give both group grades and individual grades.

The collaborative learning classroom will strengthen the student's learning in the classroom, provide authentic experiences and will help students become lifelong learners.

2.2.7 Interactive Classroom Organization

Since an interactive classroom is based on various ways in which students interact, there is a need for a smooth way of organizing the classroom for the subsequent flow of student's activities easily, into whatever configuration is called for in a particular simulation or interactive unit, without any confusion or loss of control on the part of the instructor. Following are the four basic grouping options used in simulations (Innovative Teaching Concepts, 2006).

I. **Individuals in Large Groups**

This grouping system involves putting students in evenly numbered rows with boys and girls in alternate rows (as much as possible). This arrangement is used when all

students are having a common learning activity such as a lecture or film that likely precedes one of the cooperative learning activities.

II**. Study Pairs**

This grouping system involves arranging the students turning pairs of rows to face each other. The pairs should have some space around to give them the illusion of privacy and circulation ability.

III. **Triads or Quads**

This grouping system involves arrangement of even rows turned to face each other and then spread apart to form threes and/or fours. These groups have a little space around them to give them the illusion of privacy.

IV. **Activity Groups**

This is the combination of the three and/or four students into small activity groups of six to eight members. In a collaborative classroom, heterogeneous groupings of students enrich learning in the classroom since the perspectives, experiences, and backgrounds of all students are important for enriching learning in the classroom (Stephen et al. 2003).

2.2.8 Creating an Interactive Classroom

One of the unique features of an interactive classroom is the ability of the instructor to actively interact with the students during an exercise (i.e. the creation of a virtual blackboard). Using features of 'NetMeeting' from Microsoft Corp., a classroom session will be conducted where the instructor will share a single application between

three workstations. This arrangement creates a virtual blackboard on each computer monitor where each student could contribute to the same project. A student participates in the class exercise by taking control of the software package when requested without leaving his/her workstation (Upchurch, and Thai, 2002).

2.2.9 Types of Interactive Sessions

Interactive classrooms are particularly useful in teaching subject areas that have extensive software already developed for them and that "knowledge and understanding" can be "built" from discrete blocks or modules. Through 'Classrooms', various formats of synchronous-collaborative classes are conducted (Upchurch, and Thai, 2002):

1. **Teacher-Led Demos**

Students can mimic the teacher's actions on their own Personal Computers - PCs (and thus can keep a record of their own personal work). The desktop from the instructor's workstation (server) is displayed on the front screen, and the students perform the same operations as the instructor.

2. **Independent Study**

In this type of session, the instructor can directly intervene on a student workstation from the teacher station by viewing the remote workstation. This feature is useful during exercises when students work independently on an exercise (e.g. design an amplifier circuit) especially when a student reaches an impasse. The instructor can assist the student by sharing the student's application. When sharing control (the student desktop is displayed on the instructor workstation), the teacher and the student

actually are sharing simultaneously the student application with two sets of mouse and keyboard. Control of the application is transferred to whomever double-clicked and used the mouse previously in the session.

3. **Collaborative Learning**

A more interesting and truly asynchronous-collaborative learning mode is implemented by sharing a single application with the class. To setup a collaborative exercise, an application such as MultiSim 2001 or LabVIEW is launched on one of the student workstations. Subsequently, the teacher switches to a mode where the single application is shared to all Personal Computers (PCs) in the lab (students & teacher alike). An application running on a single PC with 12 other keyboards, mouse and monitors connected to it has been established. Any PC can take control of the first student's application and modify it using their keyboard and mouse. It might be necessary to combine this mode with the selective locking/unlocking feature to have an orderly teaching process. Once the first student starts the building process, the teacher can pass control to the next selected student to add the next construct to the total project, and so on until the project is completed. The final product becomes a collective effort and record of all student activities.

2.2.10 Types of Group Work in Classroom

The coming together of students into organized grouping for achieving a sort of collaboration among themselves, according to (Davis, 2003) is generally divided into three types of group work: informal learning groups, formal learning groups, and study teams (adapted from Johnson, Johnson, and Smith, 1991).

I. Informal Learning Groups

Informal learning groups are ad-hoc temporary clustering of students within a single class session. Informal learning groups can be initiated, for example, by asking students to turn to a neighbor and spend two minutes discussing a question posed by the teacher. The teacher can also form groups of three to five to solve a problem or pose a question. The teacher can organize informal groups at any time in a class of any size to check on students' understanding of the material, to give students an opportunity to apply what they are learning, or to provide a change of pace (Davis, 2003).

II. Formal learning group

Formal learning groups are teams established to complete a specific task, such as perform a lab experiment, write a report, carry out a project, or prepare a position paper. These groups may complete their work in a single class session or over several weeks. Typically, students work together until the task is finished, and their project is graded.

III. Study teams

Study teams are long-term groups (usually existing over the course of a semester) with stable membership whose primary responsibility is to provide members with support, encouragement, and assistance in completing course requirements and assignments. These teams also inform their members about lectures and assignments when someone has missed a session. The larger the class and the more complex the subject matter, the more valuable study teams can be (Davis, 2003).

2.2.11 Teacher Roles in a Collaborative Classroom

In collaborative classrooms, teachers are defining their roles in terms of mediating learning through dialogue and collaboration. This mediation includes facilitating, modelling, and coaching the students in the collaborative instruction session. Most teachers engage in the practice of mediation in a collaborative classroom from time to time, as these behaviours serve as (1) a driving force for instructional delivery in collaborative classrooms, and (2) have specific purposes in collaborative contexts (Tinzmann, et al. 1990).

2.2.12 Student Roles in a Collaborative Classroom

Students also assume new roles in the collaborative classroom by mainly serving as collaborators and active participators. It is useful to think how these new roles influence the processes and activities students conduct before, during, and after learning. For example, before learning, students set goals and plan learning tasks; during learning, they work together to accomplish tasks and monitor their progress; and after learning, they assess their performance and plan for future learning. As mediator, the teacher helps students fulfil their new roles (Tinzmann, et al. 1990).

2.2.13 Models of Learning Styles

Learning style is a distinctive and habitual manner of acquiring knowledge, skills or attitudes through study or experience. It is reasonably static and is the typical way an individual learner approaches learning (Peter and Jennifer, 2005). The strengths and weaknesses of learning styles can influence task success and overall achievement in

classrooms. Various models of learning styles exist in the literature including the following.

A. Kolb Learning Styles

David Kolb published his learning styles model in 1984, called Kolb's Learning Theory. Kolb's learning theory sets out four distinct learning styles (or preferences), which are based on a four-stage learning cycle. (This might also be interpreted as a 'training cycle'). In this respect Kolb's model is particularly elegant, since it offers both a way to understand individual people's different learning styles, and also an explanation of a cycle of experiential learning that applies to us all. Following are brief descriptions of the four Kolb learning styles (businessbalss, 2010):

i. **Diverging (feeling and watching)**: These learners are able to look at things from different perspectives. They are sensitive and prefer to watch rather than do, tending to gather information and use imagination to solve problems. They are best at viewing concrete situations from several different viewpoints. Kolb called this style 'Diverging' because these learners perform better in situations that require generating ideas, for example, brainstorming. People with a 'Diverging' learning style have broad cultural interests and like to gather information. They are interested in people; tend to be imaginative and emotional, and strong in the arts. People with the 'Diverging' style prefer to work in groups, to listen with an open mind and to receive personal feedback.

ii. **Assimilating (watching and thinking):** The 'Assimilating' learning preference is for a concise, logical approach in which ideas and concepts are more important than people. These learners require good clear explanation rather than practical opportunity. They excel at understanding wide-ranging information and

organising it in a clear logical format. People with an ‘Assimilating’ learning style are less focused on people and more interested in ideas and abstract concepts. ‘Assimilating’ learners are more attracted to logically sound theories than approaches based on practical value. This learning style is important for effectiveness in information and science careers. In formal learning situations, people with this style prefer readings, lectures, exploring analytical models, and having time to think things through.

iii. **Converging (doing and thinking):** People with a ‘Converging’ learning style can solve problems by using their learning to find solutions to practical issues. They prefer technical tasks, and are less concerned with people and interpersonal aspects. People with a ‘Converging’ learning style are best at finding practical uses for ideas and theories. They can solve problems and make decisions by finding solutions to questions and problems, while remaining more attracted to technical tasks and problems than social or interpersonal issues. A ‘Converging’ learning style enables specialist and technological abilities to experiment with new ideas, to simulate, and work with practical applications.

iv. **Accommodating (doing and feeling):** The ‘Accommodating’ learning style is 'hands-on', and relies on intuition rather than logic. These learners use other people's analysis, and prefer to take a practical, experiential approach. They are attracted to new challenges and experiences, and to carrying out plans. They commonly act on 'gut' instinct rather than logical analysis. People with an ‘Accommodating’ learning style will tend to rely on others for information rather than carry out their own analysis. This learning style is prevalent and useful in roles requiring action and

initiative. ‘Accommodating’ learners prefer to work in teams to complete tasks. They set targets and actively work in the field, trying different ways to achieve an objective.

B. VAK (Visual, Auditory, Kinesthetic) Learning Styles

The ‘VAK’ (Visual, Auditory, Kinesthetic) learning styles model provides a very easy and quick reference inventory by which to assess people's preferred learning styles, and then most importantly, to design learning methods and experiences that match people's preferences (businessbalss, 2010):

i. **Visual (spatial) learning style:** This involves the use of seen or observed things, including pictures, diagrams, demonstrations, displays, handouts, films, flip-chart, etc.

ii. **Auditory learning style:** This involves the transfer of information through listening; to the spoken word, of self or others, and of sounds and noises.

iii. **Kinesthetic/Tactile learning:** This involves physical experience like touching, feeling, holding, doing, and practical ‘hands-on’ experiences such as building models or doing laboratory experiments (Joy, 1987).

C. The Dichotomous Learning Style

The Felder-Silverman model of ‘Dichotomous’ learning dimensions models, including (sensing/intuitive, visual/verbal, inductive/deductive, active/reflective, and sequential/global) are continua and not either/or categories. A student’s preference on a given scale (e.g. for inductive or deductive presentation) may be strong, moderate, or almost nonexistent, may change with time, and may vary from one subject or learning environment to another (Felder, 1993).

i. Sensing and Intuitive Perception: People are constantly being bombarded with information, both through their senses and from their subconscious minds. The volume of this information is much greater than they can consciously attend to as they select a minute fraction of it to admit to their "working memory" and the rest of it is effectively lost. In making this selection, sensing learners (sensors) favour information that comes in through their senses and intuitive learners (intuitors) favour information that arises internally through memory, reflection, and imagination. Sensors tend to be practical; inductors tend to be imaginative. Sensors like facts and observations; inductors prefer concepts and interpretations. A student who complains about courses having nothing to do with the real world is almost certainly a sensor. Sensors like to solve problems using well-established procedures, don't mind detailed work, and don't like unexpected twists or complications. Inductors like variety in their work, don't mind complexity, and get bored with too much detail and repetition. Sensors are careful but may be slow while intuitors are quick but may be careless (Felder, 1993).

ii. Visual and Verbal Input: Visual learners acquire more information from visual images (pictures, diagrams, graphs, schematics, demonstrations) than from verbal material (written and spoken words and mathematical formulas), and vice versa for verbal learners. If something is simply said and not shown to visual learners (e.g. in a lecture) there is a good chance they will not retain it.

Most people (at least in western cultures) and presumably most students in science classes are visual learners, while the information presented in almost every lecture course is overwhelmingly verbal, written words and formulas in texts and on the chalkboard, and spoken words in lectures, with only an occasional diagram, chart, or demonstration breaking the pattern (Felder, 1993).

iii. Inductive and Deductive Organization: Inductive learners prefer to learn a body of material by seeing specific cases first (observations, experimental results, numerical examples) and working up to governing principles and theories by inference, while deductive learners prefer to begin with general principles and to deduce consequences and applications. Since deduction tends to be more concise and orderly than induction, students who prefer a highly structured presentation are likely to prefer a deductive approach while those who prefer less structure are more likely to favour induction.

Research shows that of these two approaches to education, induction promotes deeper learning and longer retention of information and gives students greater confidence in their problem-solving abilities. The research notwithstanding, most college science instruction is exclusively deductive probably because deductive presentations are easier to prepare and control and allow more rapid coverage of material (Felder, 1993).

iv. Active and Reflective Processing: Active learners tend to learn while doing something active by trying things out, and bouncing ideas off others, while reflective learners do much more of their processing introspectively, thinking things through before trying them out. Active learners work well in groups and reflective learners prefer to work alone or in pairs.

The research is quite clear on the question of active and reflective versus passive learning. In a number of studies comparing instructor-centered classes (lecture/demonstration) with student-centered classes (problem-solving/discussion), lectures were found to be marginally more effective when students were tested on

short-term recall of facts. Active classroom environments were better when the criteria involved comprehension, long-term recall, general problem-solving ability, scientific attitude, and subsequent interest in the subject. Substantial benefits are also cited for teaching methods that provide opportunities for reflection, such as giving students time in class to write brief summaries and formulate written questions about the material just covered (Felder, 1993).

v. Sequential and Global Understanding: Sequential learners absorb information and acquire understanding of material in small connected chunks, while global learners take in information in seemingly unconnected fragments and achieve understanding in large holistic leaps. Sequential learners can solve problems with incomplete understanding of the material and their solutions are generally orderly and easy to follow, but they may lack a grasp of the big picture, the broad context of a body of knowledge and its interrelationships with other subjects and disciplines. Global learners work in a more all-or-nothing fashion and may appear slow and do poorly on homework and tests until they grasp the total picture, but once they have it they can often see connections to other subjects that escape sequential learners.

Before global learners can master the details of a subject they need to understand how the material being presented relates to their prior knowledge and experience, but only exceptional teachers routinely provide such broad perspectives on their subjects. As consequence, many global learners who have the potential to become outstanding creative researchers fall by the wayside because their mental processes do not allow them to keep up with the sequential pace of their science courses (Felder, 1993).

D. Honey and Mumford Learning Styles Model

Honey and Mumford (Peter and Alan) are best known for their learning style questionnaire. This self-administered questionnaire determines ones preferred learning style (Swinton, 2004). This learning style helps learners identify their learning styles and avoid repeating mistakes by undertaking activities that strengthen other styles.

i. Activitists (Do): These are 'hands-on' learners and prefer to have a go and learn through trial and error (Peter Honey Publications, 2010). Some of the characteristics of this type of learner are as follows;

- Immerse themselves fully in new experiences
- Enjoy here and now
- Open minded, enthusiastic, flexible
- Act first and consider consequences later
- Seek to centre activity around themselves

ii. Reflectors (Review): These are 'tell me' learners and prefer to be thoroughly briefed before proceeding (Peter Honey Publications, 2010). Some of the characteristics of this type of learner are as follows;

- Stand back and observe
- Cautious, take a back seat
- Collect and analyze data about experience and events, slow to reach conclusions
- Use information from past, present and immediate observations to maintain a big picture perspective.

iii. Theorists (Conclude): These are 'convince me' learners and want reassurance that a project makes sense (Peter Honey Publications, 2010). Some of the characteristics of this type of learner are as follows;

- Think through problems in a logical manner, value rationality and objectivity
- Assimilate disparate facts into coherent theories
- Disciplined, aiming to fit things into rational order
- Keen on basic assumptions, principles, theories, models and systems thinking

iv. Pragmatists (Plan): These are 'show me' learners and want a demonstration from an acknowledged expert (Peter Honey Publications, 2010). Some of the characteristics of this type of learner are as follows;

- Keen to put ideas, theories and techniques into practice
- Search new ideas and experiment
- Act quickly and confidently on ideas, gets straight to the point
- Are impatient with endless discussion

E. Anthony Gregorc Learning Styles Model

Anthony Gregorc based his learning styles on brain hemisphere research. Gregorc's Styles model provides an organized way to consider how the mind works (Santo, 2010). The style represents two types of preferences:

i. Perceptual preference

- abstract (reason and intuition)
- concrete (the senses)

ii. Ordering preference

- Sequential (linear)
- Random

Combining the above two preferences will lead to four types of learners as follows:

i. Concrete Sequential Learner: These learners prefer direct, hands-on activities, hepatic (tactile) methods, step-by-step instructions, and real life examples (Santo, 2010). They use workbooks with detailed instructions, diagrams, flowcharts, computer-assisted instruction, documentation, and hands-on activities as instructional methods.

ii. Concrete Random Learner: These learners prefer a trial and error approach, with breakthroughs through intuitive insight. They like a stimulus rich environment. They thrive on competition, especially if they can use their wits. These learners rarely accept anything on outside authority. They are implementers of change and tend to be impulsive. They don't like to read directions and dislike structure (Santo, 2010). Correct random learners use independent study, computer games and simulations, multimedia, and "playing" with software as instructional methods.

iii. Abstract Sequential Learner: These learners prefer a highly verbal, logical and analytical approach based on intellect. They like solitude, prefer well-organized material, and are highly sceptical, while having trouble in picking up subtle nonverbal cues and dislike distractions. They will accept change only after much deliberation and like written, verbal, and visual instruction (Santo, 2010). They use lectures, reading, outlines, conducting Internet searches, email, and audiotapes as instructional methods.

iv. **Abstract Random Learner:** These learners like to focus on relationships and their emotions. They respond to visual methods of instruction, group discussion, and time for reflection. They may be uncomfortable with distance education because it does not include the emotional involvement of meeting face to face, unless the instructor is careful to build rapport as part of the learning experience and enjoy evaluating personal experiences (Santo, 2010). Abstract random learners use video clips, group discussion, videoconferencing, television, case studies, chat-rooms, and guest speakers as instructional methods.

F. Other Learning Styles Model

i. **Verbal (linguistic):** The verbal style involves both the written and spoken word. Pursuits that use the verbal style include public speaking, debating, politics, writing and journalism (Learning Style-Online, 2009).

ii. **Logical (mathematical):** logical learners prefer using logic, reasoning and systems. People with a strong logical style are likely to follow such pursuits as the sciences, mathematics, accounting, detective work, law and computer programming (Learning Style-Online, 2009).

iii. **Social (interpersonal):** social learners prefer to learn in groups or with other people. If people have a strong social style, they communicate well with people, both verbally and non-verbally. People listen to them or come to them for advice, and they are sensitive to their motivations, feelings or moods. They listen well and understand other's views. They may enjoy mentoring or counselling others (Learning Style-Online, 2009).

iv. **Solitary (intrapersonal):** solitary learners prefer to work alone and use self-study. If people have a solitary style, they are more private, introspective and independent. They can concentrate well, focusing on their thoughts and feelings on their current topic. They are aware of their own thinking, and they may analyze the different ways they think and feel (Learning Style-Online, 2009).

Table 2.2 describe various learning styles models and their inventors.

Table 2.2 Learning styles Descriptions and Models

S/N	Learning styles	Description/Comments	Models/Inventor
1.	Diverging learning style	Feeling and Watching, Work in group (brainstorming)	The four Kolb learning styles (businessballs, 2010)
2.	Assimilating learning style	Watching and Thinking Reading, Lectures, and Exploring analytical models. Less focus on people	
3.	Converging learning style	Doing and Thinking Less concern with people Prefer technical task Experiment, simulate and practical applications.	
4.	Accommodating learning style	Doing and Feeling Hands-on learners Rely on others for information Works in teams trying different ways.	
5.	Visual (spatial) learning style	Seeing and Reading in observation. Pictures, diagrams, demonstrations, display, handouts, and films.	The VAK learning styles model (businessbalss, 2010)
6.	Auditory learning style	Listening and Speaking	
7.	Kinesthetic learning	Touching and Doing Physical experience	
8.	Sensing and intuitive perception	Sensors are practical and inductors are imaginative. Sensors like facts & observations, and inductors like concept & interpretation.	The dichotomous learning style dimensions of this model (Felder, 1993).
9.	Visual and verbal input	Visual learners get info from visual images. Pictures, diagrams, graphs, schematics & demonstrations. Verbal learners get info from verbal material, written & spoken words, and maths formulas. A lecture is verbal while experiment is visual.	
10.	Inductive and deductive organization	Inductive learners use observation, experiment & numerical Science instructions are deductive. Deductive is more conscience & orderly than inductive	
11.	Active and reflective processing	Active learners learn by doing & work well in group Reflective learners use to think and work alone or in pairs. Most lecture classes do very little for the two	
12.	Sequential and global understanding	Sequential learners absorb information and acquire understanding of material in small connected chunks. Global learners take in information in seemingly unconnected fragments and achieve understanding in large holistic leaps.	

13.	Activitists (Do)	These are 'hands-on' learners Immerse themselves fully in new experiences Enjoy here and now Open minded, enthusiastic, flexible Acts first, consider consequences later Seek to centre activity around themselves	Honey and Mumford Model learning style (Swinton, 2004).
14.	Reflectors (Review)	These are 'tell me' learners Stand back and observe Cautious, take a back seat Collect and analyze data about experience and events, slow to reach conclusions Use information from past, present and immediate observations to maintain a big picture perspective.	
15.	Theorists (Conclude)	These are 'convince me' learners Think through problems in a logical manner, value rationality and objectivity Assimilate disparate facts into coherent theories Disciplined, aiming to fit things into rational order Keen on basic assumptions, principles, theories, models and systems thinking	
16.	Pragmatists (Plan)	These are 'show me' learners and want a demonstration. Keen to put ideas, theories and techniques into practice Search new ideas and experiment Act quickly and confidently on ideas, gets straight to the point Are impatient with endless discussion.	
17.	Concrete Sequential Learner	Direct hands on activities Active (tactile) methods Use Workbooks, diagrams, flowchart and demonstrations for instruction. Computer assisted instructions	Anthony Gregorc learning styles of brain (Santo, 2010).
18.	Concrete Random Learner	Prefer trial & error approach. Independent study, computer games, simulations, multimedia & software.	
19.	Abstract Sequential Learner	Verbal, logical & analytical approach. Like written, verbal & visual instruction. Lectures, reading, outlines, conducting Internet searches, email, list serves, and audiotapes.	
20.	Abstract Random Learner	Responds to visual instruction. Group discussion & face to face meetings Uncomfortable with distance education Instructional methods: video clips, group discussion, videoconferencing, television, case studies, chat-rooms, and guest speakers.	
21.	Verbal (linguistic)	Involves both written and spoken words Public speaking, debating, politics, writing & journalism.	Other Models
22.	Logical (mathematical)	Use logic & reasoning, as in sciences, mathematics, accounting, detective work, law & computer programming.	
23.	Social (interpersonal)	Prefer to learn in group Communicate both verbally & non verbally well	
24.	Solitary (intrapersonal)	Prefer to work alone & use self study More private & independent	

2.2.14 Teaching Styles

Just as people have individual learning styles; teachers have teaching styles that work best for them. It is important to be aware of one's preferences when creating and delivering classroom instruction. Instructors develop a teaching style based on their beliefs about what constitutes good teaching, personal preferences, their abilities, and the norms of their particular discipline. Some believe classes should be teacher-centered, where the teacher is expert and authority in presenting information. Others take a learner-centered approach, viewing their role as more of a facilitator of student learning. Anthony Grasha identified the following five teaching styles as description of prevalent aspects of faculty presence in the classroom (NTLF, 2009).

- Expert
- Formal Authority
- Demonstrator
- Facilitator
- Delegator

1. Expert: These teachers possess knowledge and expertise that students need while strive to maintain status as an expert among students by displaying detailed knowledge and by challenging students to enhance their competence, Concerned with transmitting information and insuring that students are well prepared (NTLF, 2009).

2. Formal Authority: These are teachers who have a formal authority teaching style and tend to focus on content. This style is generally teacher-centered, where the teacher feels responsible for providing and controlling the flow of the content and the student is expected to receive the content.

Teachers with this teaching style are not as concerned with building relationships with neither their students nor their students form relationships with other students. This type of teacher doesn't usually require much student participation in class (Teaching Styles Categories, 2002).

3. Demonstrator or Personal Model: Teachers who have a demonstrator or personal model teaching style tend to run teacher-centred classes with an emphasis on demonstration and modelling. These types of teacher act as a role model by demonstrating skills and processes and then as a coach/guide in helping students develop and apply these skills and knowledge (Teaching Styles Categories, 2002).

Instructors with this teaching style are interested in encouraging student participation and adapting their presentation to include various learning styles. Students are expected to take some responsibility for learning what they need to know and for asking for help when they don't understand something (Teaching Styles Categories, 2002).

4. Facilitator: Teachers who have a facilitator model teaching style tend to focus on activities. This teaching style emphasizes student-centered learning and there is much more responsibility placed on the students to take the initiative for meeting the demands of various learning tasks. This type of teaching style works best for students who are comfortable with independent learning and who can actively participate and collaborate with other students. Teachers typically design group activities which necessitate active learning, student-to-student collaboration and problem solving. This type of teacher will often try to design learning situations and activities that require

student processing and application of course content in creative and original ways (Teaching Styles Categories, 2002).

5. Delegator: Teachers who have a delegator teaching style tend to place much control and responsibility for learning on individuals or groups of students. This type of teacher will often give students a choice, designing and implementing their own complex learning projects, and will act in a consultative role. Students are often asked to work independently or in groups and must be able to maintain motivation and focus for complex projects. Students working in this type of setting learn more than just course specific topics as they also must be able to effectively work in group situations and manage various interpersonal roles (Teaching Styles Categories, 2002).

2.2.15 Student (Learner) Centered Teaching Style

In a student-centered classroom, students are encouraged to participate actively in learning the material as it is presented rather than being passive and perhaps taking notes quietly. Students are involved throughout the class time in activities that help them construct their understanding of the material that is presented. The instructor no longer delivers a vast amount of information, but uses a variety of hands-on activities to promote learning activities (Karen Timberlake, 2002).

Student-centered teaching methods shift the focus of activity from the teacher to the learners. These methods include active learning, in which students solve problems, answer questions, formulate questions of their own, discuss, explain, debate, or brainstorm during class; cooperative learning, in which students work in teams on problems and projects under conditions that assure both positive interdependence and individual accountability; and inductive teaching and learning, in which students are

first presented with challenges (questions or problems) and learn the course material in the context of addressing the challenges. Inductive methods include inquiry-based learning, case-based instruction, problem-based learning, project-based learning, discovery learning, and just-in-time teaching. Student-centered methods have repeatedly been revealed to be superior to the traditional teacher-centered approach to instruction. This is a conclusion that applies whether the assessed outcome is short-term mastery, long-term retention, or depth of understanding of course material, acquisition of critical thinking or creative problem-solving skills, formation of positive attitudes toward the subject being taught, or level of confidence in knowledge or skills (Felder, 2010).

2.2.16 Teacher-Centered Teaching Style

This is a traditional approach of teaching, where the teacher determines the content to be taught, plans for instruction, implements the instructional plan, and evaluates the students' progress. This method puts the responsibility of learning directly on the instructor.

Teacher-centered instruction is useful for conveying new information and materials to small or large groups at one time. Even when working with one student, using teacher-centered instruction may be the most effective way to convey new material for the day's lesson. Teacher-centered instruction literally means that the teacher is the person who is imparting knowledge or information to the student. The student is the receiver of this knowledge. In order to do this effectively, it is important to identify the student's current level of skill or knowledge in the subject being taught. If the level of instructional content is too high or low, the student will not effectively receive the

information. Lessons are often designed to address the gap between what students currently know and what schools think they ought to know. The classroom teacher will help select the material best suited to meet the academic needs of the student and will provide instruction that reflects a preferred instructional format (Para eLink (2004). The difference between the student centered and teacher centered teaching styles has been articulated in **Table 2.3** as deduced from (NCLRS, 2009)

Table 2.3 Teacher vs. Learner-Centered Instruction

Teacher-Centered	Learner-Centered
Focus is on instructor	Focus is on both students and instructor
Focus is on language forms and structures (what the instructor knows about the language)	Focus is on language use in typical situations (how students will use the language)
Instructor talks; students listen	Instructor models; students interact with instructor and one another
Students work alone	Students work in pairs, in groups, or alone depending on the purpose of the activity
Instructor monitors and corrects every student utterance	Students talk without constant instructor monitoring; instructor provides feedback/correction when questions arise
Instructor answers students' questions about language	Students answer each other's questions, using instructor as an information resource
Instructor chooses topics	Students have some choice of topics
Instructor evaluates student learning	Students evaluate their own learning; instructor also evaluates
Classroom is quiet	Classroom is often noisy and busy

Source: (NCLRS, 2009)

2.3 Classroom Indoor Environmental Requirements

2.3.1 Lighting Requirements

Lighting is and always has been an important factor in designing and operating schools. Until the 1950s, natural light predominated as a means of illuminating most school spaces. Classroom design was based in large part on time-honoured relationships between window sizes and room dimensions. As electric power costs declined and designers began to take advantage of the increased flexibility provided by electric lighting, daylighting took a secondary role (Benya J. R 2001). “A major challenge is to provide classroom lighting that increases teacher control, reduces glare, improves lighting and optimizes visual comfort while minimizing lighting power and energy use to their lowest possible levels.” (Project Frog team, 2008)

Based on the results of Public Interest Energy Research (PIER) Lighting Project 4.5, the benefits of an Integrated Classroom Lighting System are well tested and documented. School districts and their architects and lighting designers should consider the following criteria for classrooms (PIER Lighting Research Program, 2005):

- Use of indirect luminaires to provide general classroom illumination. Light a 30 x 32-foot (9.14m x 9.8m) classroom with 2 rows of a high-performance, indirect suspended luminaire with 3100 lumen Tubular 8 (T8) lamps and 1.2 Ballast Factor (BF) T8 electronic ballasts.
- Provide an Audio Visual (AV) appropriate lighting mode in classrooms. During AV mode, reduce light on the front teaching wall while keeping an

appropriate level of light on the students' desks for note-taking and class interaction.

- Provide the teacher with control at the front of the classroom to change between General and AV modes of operation and to control other functions and options.
- Provide ways to control the electric light to reflect the amount of daylight in the classroom. Depending upon the nature of the daylight in the classroom, use manual control, stepped switching, or automatic dimming based on daylight levels.
- Allow the teacher to keep the lights on during periods of quiet time for tests or periods of individual study or work. Position the occupancy sensors in the ceiling to minimize obstruction by objects in the room.
- Select a system with plug-and-play sensors and controls and that have a single manufacturer as the point of support for applications, pricing, and field support.
- Provide modularity and options to deal with different classroom layouts, teaching and AV requirements, and daylighting conditions.

A. Classroom Lighting Quality and Student Performance

The original daylighting in schools study, by Heschong Mahone Group (1999) completed for Pacific Gas and Electric, found a compelling statistical correlation between the amount of daylighting in elementary school classrooms and the performance of students on standardized math and reading tests. Heschong Mahone Group (2003) studies of the classrooms showed that windows and the resulting

lighting quality in classrooms are very much a key issue in learning, and can have both positive and negative impacts on student performance.

Another study conducted by New Building Institute, 2002, on behalf of the California Energy commission PIER Program, also expanded and validated previous research by Heschong Mahone Group that found the statistical correlation between the amount of daylight in elementary school classrooms and the performance of students on standardized math and reading tests.

2.3.2 Acoustical Requirement

Acoustic comfort is one of the essential factors for the development of class activities, especially those that require a high level of concentration (Kruger and Zannin 2004). Acoustical performance is an important consideration in the design of classrooms. Research indicates that levels of background noise and reverberation, little noticed by adults, who are mature and skilful listeners, adversely affect learning environments for young children, who require optimal conditions for hearing and comprehension. Kids whose home language is different than the teaching language are also at additional risk of educational delay and failure (Thibault, 2005). Poor acoustics can impact on a student's ability to learn and a teacher's ability to teach in the classroom. Excessive background noise or reverberation in the classroom interferes with speech communication and thus presents an acoustical barrier to learning. With good classroom acoustics, learning is easier, deeper, more sustained, and less fatiguing. Teaching should be more effective and less stressful with good acoustical characteristics in a classroom (Acoustical Society of America, 2002).

A. Classroom Acoustical Quality and Student Performance

The research linking acoustics to learning is consistent and convincing: good acoustics are fundamental to good academic performance (Schneider M. 2002). Crandell et al. (1995) and Nabelek and Nabelek (1994) reviewed the literature linking the acoustical environment in a classroom to the academic achievement of children and have linked levels of classroom noise and reverberation to reading and spelling ability, behaviour, attention, concentration, and academic achievement. Proper and accurate hearing is essential to a student's ability to learn in the classroom. The ability to clearly hear and understand what is being spoken is a prerequisite for effective learning. When this ability is impaired through unwanted noise students do not perform well. (Earthman, Glen I. 2002).

According to Benjamin, et al (2000), the following guidelines should be kept to limit noise level while designing a new classroom:

1. Locate rooftop mechanical equipment, Variable Air Volume (VAV) boxes, and fan-coil units away from critical listening spaces such as classrooms. Positioning units over hallways and running ducts to nearby classrooms is one good solution. Avoid placing any major mechanical equipment inside, above, below, or adjacent to classrooms.
2. Select air handlers with low sound-level ratings.
3. Size ducts large enough to permit low air velocities. Select diffusers with Noise Criterion (NC) ratings below 20 to 25.
4. Spend a little extra on longer duct runs. This pays dividends in reduced mechanical noise and crosstalk (the transmission of sound between rooms via ductwork).

5. Avoid using unit ventilators, fan coil units and ductless split systems in classrooms. These units contain fans and sometimes compressors that are notoriously loud and difficult to treat due to their position in the classroom.

Interior Noise Sources

Noise from adjacent rooms disrupts the learning process, especially during quiet reading times or test-taking. Fifty years ago, when school walls were typically built of heavy brick or concrete block, this was not as much of a problem. In recent decades, the need to lower construction costs has led to the use of thin, lightweight wall materials that provide little noise reduction. Even worse, in the 1960s and 1970s many open plan classrooms were built with no partitions whatsoever between classrooms. In some schools, such spaces have since been partitioned, but noise reduction between rooms may still be insufficient (Benjamin et al 2000).

Exterior Noise Sources

The noise reduction of exterior walls is also important since many noisy and potentially disruptive activities go on outside the school. Most schools are built with brick or concrete block exterior walls, which are good sound barriers, but with inadequate windows that permit considerable sound transmission. To provide noise reduction, windows must be well sealed. Double-paned glass provides better noise reduction than single-paned glass (as well as better thermal insulation and decreased energy costs). Other common sound leakage culprits are wall-mounted unit ventilators that duct directly outside. These units not only transmit exterior noise but generate ample noise themselves; they should be avoided whenever possible. During site planning, consider external noise sources that could disrupt learning and attempt to

locate classrooms away from such areas. Common noise sources include: aircraft flyovers, busy roads, idling school buses, playgrounds, playing fields, exterior mechanical equipment, dumpsters being emptied by garbage trucks, lawn mowers, and noisy machinery in nearby buildings (Benjamin et al 2000).

2.3.3 Thermal Comfort Requirements

A. Classroom Thermal Comfort and Student Performance

Good thermal environment of a classroom is very important to efficient student performance. Various researchers have provided a long history of research on thermal conditions in the business and industrial workplace as cited in Earthman, Glen I. (2002). The conclusion of these researchers was that increases in temperatures in the workplace tends to decrease worker efficiency and increases the risk of work related accidents. As a result, proper control of the thermal environment is needed in the workplace.

Following is a summary of research carried out by Ed Young et al. on thermal quality and their effect on educational outcomes (Ed Young, et al. 2003).

- Eight of nine studies found a significant relationship between the thermal environment of a classroom and student achievement and behaviour.
- There was a consistent pattern of higher achievement in air-conditioned schools.
- Achievement was greater in facilities that allowed for individual preferences for heat.
- Excessive temperatures caused stress in students.

- Solar heating through glass is a major contributor to overheated classrooms.

2.3.4 Classroom Indoor Air Quality Standards and Strategies

A. Classroom Indoor Air Quality

Indoor air is an intriguing, complex environment that contains a myriad of visible and invisible contaminants. Airborne pollutants, including potential carcinogens, reproductive toxins and human irritants, are 2 to 10 times higher indoors when compared with outdoor levels and can be as much as 1,000 times higher in newly constructed and renovated indoor spaces. Among the most prevalent of all indoor air constituents are volatile organic compounds, with as many as 100 to 1,000 different VOCs in the air where children can easily inhale them. Some VOCs can cause eye, nose and throat irritation; cough; headache; general flu-like symptoms, skin irritation and some may cause cancer (Air Quality Sciences, 2009).

The United States Environmental Protection Agency (EPA) has recommended the following IAQ Design tools for classrooms (EPA, 2010).

- When specifying a new classroom, ensure that the Heating Ventilation and Air Conditioning (HVAC) system can:
- Provide a minimum of 450 cfm (based on 30 occupants at 15 cfm/occupant) of outside air; and
- Heat and cool this volume of outdoor air at design outdoor temperatures for the specific geographic location where each classroom is installed.

- Installation of an outdoor air intake must be specified as part of the exhaust system. Lack of an exhaust in the HVAC system with an outdoor air intake will result in inadequate removal of pollutants from the room.
- Outdoor air should be supplied continuously when a classroom is occupied.
- Demand-controlled HVAC package systems should operate only when the temperature of a space is different from the thermostat's set point. In order to provide a continuous outdoor air supply, it is important to ensure that the HVAC thermostat fan switch is set in the "on" or continuous mode when occupied.
- Air filters are needed for protection of HVAC components and reduction of airborne dust, pollens and microorganisms from re-circulated and outdoor air streams. Air filters should have a dust-spot rating between 35% and 80% or a Minimum Efficiency Rating Value (MERV) of between 8 and 13.
- If carpet is specified, use carpet that has been tested under the Carpet and Rug Institute's Indoor Air Quality Carpet Testing Program.
- Do not use carpet in entryways to classrooms with direct outdoor access. Supply waterproof mats over carpeted entryways and other areas used for drying clothing and umbrellas.
- Locate classroom away from locations where: (a) vehicles idle, (b) water accumulates after rains, or (c) there are other major sources of air pollution.
- Ensure that at least one supply air outlet and return air inlet are located in each enclosed area.
- Ensure that building air intakes are located away from any exhaust outlet(s) or other contaminant sources.
- Specify operable windows to provide user-controlled ventilation when needed.

- Consider covered entries with an exterior entry mat.
- Check that special-use classrooms (e.g., for chemistry, biology, fine arts, etc.) have local exhaust ventilation (e.g., hoods or window fans) and appropriate ventilation rates.
- Locate HVAC and air handler units as far away as possible from teaching areas to reduce noise.
- If specifying duct board or internal duct lining for thermal and/or acoustical control, be sure to consider the potential for uncontrolled moisture to enter the duct over the life of the system.
- Ensure that HVAC ducts and plenums have easy access for inspection and cleaning.
- Specify that low Volatile Organic Compounds (VOC) emitting building materials be used in construction.
- Specify complete documentation of operation and maintenance requirements.

B. Classroom Indoor Air Quality and Student Performance

Evidence continues to emerge showing that poor indoor air quality (IAQ) can cause illness requiring absence from school, and can cause acute health symptoms that decrease performance while at school. In addition, recent data suggests that poor IAQ may directly reduce a person's ability to perform specific mental tasks requiring concentration, calculation, or memory, (EPA, 2003).

Even though (Mendell and Heath 2005) concluded that there have been no satisfactory studies of how poor air quality in classrooms directly affects the performance of schoolwork by children, Wargocki and Wyon, (2007), research have shown that poor

indoor air quality can lead to absenteeism as a result of chemicals in indoor air which do affect asthma and increase respiratory dust.

Wargocki and Wyon, (2007) in their studies "Indoor Environmental Effects on the Performance of School Work by Children", their Final Report observed that increasing the outdoor air supply rate to mechanically ventilated classrooms from about 3.0 to 8.5 L/s (6.4 to 18 cfm) per person improved the speed at which 10 to 12 year old children performed two numerical and two language-based tasks. Shaughnessy et al. (2006) demonstrated a modest association between class room ventilation rates and student performance in math standardized test scores, and also a need for further studies with larger sample sizes and more comprehensive assessment of indoor environmental quality (IEQ).

Following is a summary of research carried out by Ed Young et al. on indoor air quality and their effect on educational outcomes (Ed Young, et al. 2003).

- Substantial numbers of schools across the nation have inadequate ventilation systems.
- Poor air quality causes respiratory infections, aggravates allergies, and causes drowsiness and shorter attention spans.
- Tightly sealed buildings, allergy-triggering floor coverings, and toxic emissions from cleaning fluids, paints, and other frequently used substances are major contributors to indoor air pollution.
- When students do not feel well when they are in school, or miss school due to air quality problems, learning is adversely affected.

C. Indoor Air Quality standards

Most indoor air quality standards for toxic pollutants are designed for occupational settings. These standards are based on protecting healthy workers exposed to time-weighted average concentrations less than, or equal to, specified levels for up to 8 hr/day, 40 hr/week. It is recommended that estimated occupancy, for 50 persons per 100 m^2/per floor area is 12.5 (L/s) per person, and 2.5 (L/s) per person for outdoor air requirements (Wadden, and Scheff, 1983).

D. Typical IAQ Problems in Schools

Indoor air contaminants can originate within the school building or be drawn in from the outdoors. If pollutant sources are not controlled, indoor air problems can develop even if the HVAC system is properly designed, operated, and maintained. Air contaminants consist of particles, dust, fibers, biological agents (e.g., bacteria, viruses, and mold), and gases or vapors. Sources of indoor air contamination include polluted outdoor air and underground sources (e.g., radon, pesticides, and leakage from underground storage tanks). Indoor air contamination can also be caused by a variety of indoor sources (e.g., equipment, furnishings, and housekeeping supplies). Indoor concentration levels of air pollutants can vary by time and location within the school building, or possibly a single classroom. Pollutants can be emitted from point sources, such as science storerooms, or from area sources, such as newly painted surfaces. Pollutants can vary with time, such as only when floor stripping is done, or continuously such as fungi growing in the HVAC system. Indoor air often contains a variety of contaminants at concentrations that are well below any standards or guidelines for occupational exposure. It is often difficult to relate complaints of specific health effects to exposures to specific pollutant concentrations, especially

since the exposures may be attributed to low levels of pollutant mixtures (Pennsylvania Department of Health, 2002).

E. General Guidelines to Prevent or Help Resolve IAQ Problems

To prevent or help resolve indoor air quality problems effectively and efficiently, schools must ensure that recommended temperature and relative humidity ranges be maintained in the indoor air and that the HVAC system is working properly. In addition, monitoring for carbon dioxide (CO2) may be useful for indicating when outdoor air ventilation may be inadequate. A properly designed and functioning HVAC system controls temperature and relative humidity levels to provide thermal comfort, distributes adequate amounts of outdoor air to meet the ventilation needs of school occupants, and isolates and removes odors and other contaminants through pressure control, filtration, and exhaust fans. The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Standard 55-1992 describes the temperature and humidity ranges that are comfortable for most people. Generally, temperature and humidity should be maintained within the comfort zone of 68 to 78 degrees and 30% to 60% relative humidity, depending on the season. ASHRAE's Standard 62-1989 should be followed for recommended outdoor air ventilation levels in schools. These levels are described in the EPA's report, Indoor Air Quality Tools for Schools. Generally, a range of 15 to 60 cubic feet per minute of outdoor air for each person in the area served by the HVAC system is recommended. Additionally, CO2 can be used as a rough indicator of the effectiveness of ventilation. CO2 levels above 700 parts per million (ppm) above background levels indicates inadequate ventilation with outdoor air. Finally, good housekeeping practices and common sense approaches used in the routine maintenance and upkeep of schools

helps to protect the quality of the indoor environment and the health and well being of school occupants. There are six basic control methods for lowering concentrations of indoor air pollutants in school buildings (Pennsylvania Department of Health, 2002):

1. **Source Management**

Source Management includes source removal, source substitution, and source encapsulation. It is the most effective control method when it can be practically applied. The best prevention method is never to bring unnecessary pollutants into the school building.

2. **Local Exhaust**

Local Exhaust is very effective in removing point sources of pollutants before they can be dispersed into the indoor air by exhausting the contaminated air outside. Examples where local exhaust is used include restrooms, kitchens, science labs and housekeeping storage rooms, printing and duplicating rooms, and vocational/industrial areas such as welding booths.

3. **Ventilation**

The ventilation system, when properly designed, operated, and maintained, will automatically take care of normal amounts of air pollutants. For certain situations, such as painting, temporarily increasing the ventilation can help dilute the concentration of fumes in the air.

4. **Exposure control**

Exposure control includes adjusting the time, amount, and location of use to reduce potential exposures.

5. **Air cleaning**

Air cleaning primarily involves the filtration of particles from the air as the air passes through the HVAC equipment.

6. **Education**

Education of the school occupants regarding IAQ is critical. If people are provided information about the sources and effects of pollutants under their control, and about the proper operation of the ventilation system, they can act to reduce their personal exposure. University officials should appoint an IAQ Coordinator who will serve as the primary university contact for problem solving and problem prevention.

F. Indoor Air Quality Control Methods

Methods for controlling indoor air quality fall into three categories;

1. Elimination at the source or source control
2. Dilution with less contaminated air ventilation
3. Extraction with some types of cleanser or filtration

These three categories can be further broken into more precise measures of design, operation, or maintenance to help identify the needed control action (Burroughs, and Hansen, 2004). Those control methods that are related to the university classroom has been selected as follows;

1. **Elimination**

The complete removal of the following parameters;

a) The biological agent,

b) A toxic substance,

c) A hazardous condition and/or

d) The source.

Elimination procedures include maintenance actions to remove the breeding grounds for bioaerosols, removal of friable asbestos, the banning of smoking, or the use of air cleaning devices at contaminant sources.

2. **Substitution**

The deliberate purchase or use of less hazardous materials (e.g. pesticides) and selection of latex/water-based paints over oil-based paints wherever possible are some of the measures employed to control indoor air problems.

3. **Isolation**

Containment, encapsulation, sealing, timing, and the use of distance are all means of isolating a contaminant or a source from exposure to humans. Distancing may be accomplished through location and or times of use.

4. **New construction/renovation design**

Many design steps can be taken to prevent problems from occurring including ventilation effectiveness, thermal comfort, lighting, the selection of building materials and maintenance needs. Filter selection and access, for example, is an often overlooked but critical design consideration.

5. **Housekeeping and dust suppression**

Actions that keep surfaces clean of contaminants, prevent their redispersion, and/or eliminate personal contact entirely are important control measures. Some very common place controls are windbreaks, care in preventing vacuum cleaner leaks, improved vacuum cleaner bag performance etc.

6. **Maintenance and work practice**

Specifications for the proper work procedures to reduce or control contaminants release for purposeful reasons, such as pesticides, need to be spelled out and should be part of the training procedures. Maintenance practices are vital, especially in the automated control and HVAC areas.

7. **Replacement**

Insulation, carpeting, wall coverings etc., which, when wet, can serve as breeding grounds for microorganisms, need to be checked regularly and replaced immediately when damaged.

8. **Education, training and warning procedures**

Some training, labelling and warning procedures are required by law. Whether required or not, workers and management must be educated as to the nature of hazardous materials and ways to minimize risk in their use.

9. **Filtering and air cleaning**

The use of adequate and properly selected filters and purification devices in the air distribution systems, with outdoor air and mechanically re-circulated air, is an

essential control factor. Filters and purification devices appropriate to the need should be used and maintained/replaced on a regularly scheduled basis.

10. Ventilation

Ventilation through increased outside air or exhausted with controlled make-up air is required. Dilution and capture is a preferred control when the contaminant/source is unknown. Source treatment is too costly, as an intermediate step during investigation, or when the source is localized. Ventilation control means much more than the amount of outside air brought into a facility. It includes the quality of outside air; the effectiveness with which it reaches occupants; and its efficiency in reducing contaminant levels.

G. Preventive maintenance to control biocontaminants

To control biocontaminants in a building or HVAC system, the following task should be performed as a minimum requirement (Hays, et al. 1995):

1. Inspect HVAC system components on a monthly basis for the presence of moisture or standing water.
2. Inspect areas of the building for moisture on a monthly basis.
3. Maintain areas below 70% Relative Humidity.
4. Keep building areas subject to exposure to water vapor well ventilated and well maintained while maintaining monthly inspections.
5. Install filtration (50 to 70 percent dust spot efficiency) in areas or systems subject to moisture.

H. Emission Limits for Building Materials and Furnishing

A low emission characterization of various building materials, furnishings, and office equipment based on an engineering assessment and the Total Volatile Organic Compounds (TVOC) theory of exposure and mucous membrane irritation is summarized by Godish, (2001) as illustrated in **Table 2.4.**

Table 2.4 Low TVOCs Recommended Emission Limits for Building Materials and Furnishings

S/N	Material/product	Maximum acceptable emission rate mg/h/m2
1.	Flooring Materials	0.6
2.	Floor Coatings	0.6.
3.	Wall Coverings	0.4
4.	Wall Coatings	0.4
5.	Movable Partitions	0.4
6.	Office Furniture	2.5 mg/h/workstation

Source: (Godish, 2001)

I. IAQ Strategies Guide for Improving Academic Performance

Innovative Design (2009) has recommended the following strategies for improving indoor air quality and student performance in the university classroom. These strategies are useful both in new designs and retrofitting.

- Define a level of indoor air quality desired during occupied times.
- Place limitations on the use of materials, products, or systems that create biological, chemical, or physical IAQ problems; and require monitoring equipment.
- The American Society of Heating, Refrigerating, and Air-Conditioning Engineers recommends:

- Relative Humidity - 30% to 60% (ASHRAE 55-1992)

- Temperature - 68 degrees to 78 degrees (ASHRAE 55-1992)
- Ventilation Rate - minimum of 15 cubic feet per minute per person (ASHRAE 62-1989)
- Carbon Dioxide - maximum 1000 parts per million (ASHRAE 62-1989)

- The US Environmental Protection Agency recommends:
    - Radon - maximum of four picocuries (pCi/L) per litre

J. Mechanical & Ventilation Systems

According to Innovative Design (2009) mechanical and ventilation systems should follow the following strategies;

- Comply with ASHRAE Standards
- Consider different strategies to efficiently ensure adequate fresh air in occupied areas, including capability to introduce one hundred percent of outdoor air during mild weather
- Incorporate carbon dioxide and VOC pollutant sensors to control amount of ventilation air required
- Do not oversize cooling equipment because it will not adequately remove humidity
- Use night time ventilation strategies in the cooling season to flush out air prior to morning occupancy
- If a particular mechanical system serves more than one space, insure that each space served has the same orientation and fulfils similar functions
- Install ductwork that has smooth surfaces and transitions to minimize the collection of microbial growth

- Design ductwork and plenums to minimize accumulation of dirt and moisture and provide access areas in key locations for inspection, maintenance, and cleaning
- Locate outdoor-air intakes a safe distance from polluted and/or overheated exhaust grilles and away from loading docks
- Separate vehicle traffic and parking from fresh air inlets or spaces employing natural ventilation strategies
- Locate exhausts in such a way that prevailing winds carry exhausts away from building
- Create landscaping buffers between high traffic areas and building intakes or natural ventilation openings
- Separate and ventilate highly polluting spaces (e.g., copy rooms)
- Incorporate outdoor spaces that can be used for:
    - Teaching
    - Breaks and lunch
    - Recreation

K. Environmentally-Sensitive Building Products and Systems

According to Innovative Design (2009) the following strategies should be followed when using environmentally sensitive building products and systems;

- Improve indoor air quality by eliminating or minimizing:
    - VOCs in paints, carpet, floor base materials, and adhesives
    - Products that may release particulates

- Formaldehyde in plywood, particleboard, composite doors, and cabinets
- Toxic termite control

- Select low-VOC emitting, environmentally-friendly cleaning agents
- Eliminate or minimize building materials and furnishings containing toxins
- Incorporate interior planting strategies
- Develop an indoor pollutant source assessment and control plan
- Insist on materials and equipment with low maintenance requirements
- Incorporate air and vapour retarders in the building envelope to control unwanted air movement through walls
- Separate polluting materials by carefully considering placement, encapsulation, or the creation of architectural barriers
- If necessary, implement radon mitigation strategies
- Select local products

L. Contaminants Evaluation of Carpet and Vinyl Floor Tile in Schools

According to the study conducted on behalf of Minnesota Department of Health in 2008, Contaminants were significantly higher in carpeting (79 areas sampled) in schools compared to vinyl floor tile (65 areas sampled). Levels were 9 - 20 times greater in carpet. All the differences were statistically significant (Mann-Whitney U Test). The results are shown in contaminant units per square meter of flooring area. Carpet also had significantly higher levels when contaminants were expressed in contaminant units per gram floor dust. As such, the difference (in units per square meter of allergen) between carpet and vinyl tile is about attributable to both greater dust loading and allergen density per gram of dust. The p-values indicate that the

probabilities that the difference is due to chance are virtually zero as illustrated in **Table 2.5** (MDH, 2008).

Table 2.5 Comparison of Carpet and Vinyl Floor Tile in Schools

Contaminant	Average Concentration		
	Carpet	Tile	p-value
Cat ($\mu g/m^2$)	0.284	0.0137	<0.0001
Dog ($\mu g/m^2$)	0.446	0.0300	<0.0001
Dust (g/m^2)	0.269	0.0305	<0.0001
Mold (cfu/m^2)	17900	955	<0.0001

Source: MDH (2008)

M. IAQ Control Measures for HVAC Equipment Protection

The following protocol will be used to control sources of pollution affecting HVAC equipment (Der, and Meehan, 2009):

- Whenever possible, HVAC systems will be shut down during alteration activities.
- Mechanical rooms will not be used to store construction or waste materials.
- HVAC ductwork ends and outlets will be protected from construction dust and debris.
- If air handling units servicing work zones must be run during the course of the project, the units will be protected from dust with the use of filtration media. Filtration media must have a Minimum Efficiency Reporting Value (MERV) of 8 or higher and be placed at each return air grille.

N. IAQ Control Measures for Building Materials

Building materials with desired emission profiles will be considered and, where practical, selected for inclusion in the project. Absorptive materials will be protected from moisture damage until project completion. The following measures will be observed (Der, and Meehan, 2009):

- Selection of building materials (adhesives and sealants, paints and coatings, flooring systems, composite wood and agrifiber products, furniture and furnishings, and ceiling and wall systems) for installation in schools will be guided by the testing and product requirements of the California Department of Health Services' Standard Practice for The Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, including 2004 Addenda.
- Construction site storage of building materials will include measures for protecting against rain and humidity.
- Materials will be kept in factory sealed containers until installation or application.
- Installed materials will be protected from moisture damage throughout the project.

2.4 Classroom Physical Set Up

2.4.1 Class Size

Class size is an important factor in school design and drives a host of costly facility-related issues that are part and parcel of the school building's planning, design, construction, cost, maintenance, and operation. Given that education is labour intensive, class size is a big factor in determining the number of teachers needed and, hence, how much education will cost. While social scientists are engaged in an intense debate over the effects of class size on educational outcomes, there is widespread popular belief that smaller classes are better (Schneider M. 2002). Of the teachers surveyed by Public Agenda, seventy percent said that small class size is more important to student achievement than small school size (Schneider M. 2002).

A study conducted by Stecher and Bohrnstedt, (2000) confirm that third grade students in smaller classes performed better on achievement tests than in larger classes for the second year in a row. In 1998-1999, over 1.8 million students in 92,000 classrooms (K-3) in USA benefited from reduced class size. The percentage of fully certified teachers in grades K-3, which had dropped from 98 percent in 1995 to 88 percent in 1997, remained fairly steady in the third year of class-size reduction, dropping only 1 percent further in 1998 (to 87 percent). Reducing class size to below 20 student's leads to higher student achievement as it represents a considerable commitment of funds and its implementation can have a sizable impact on the availability of qualified teachers. Strengthening teacher quality also leads to higher student achievement (Pritchard, 1999)

Seating capacity desired will be a major determining factor for room size. Adequate space must be allotted for the instruction area which contains the instructor's workstation, environmental controls, projector, screen, and white board. Additional space should be planned for a technology storage closet (Emmons et al 2001).

2.4.2 Classroom Furniture

Classroom furniture is generally classified in movable and fixed seating arrangements. The adoption of these seating arrangements depends largely on the nature of the classroom and activities carried out. Surveys have shown that approximately half of the faculty prefer fixed seating and half prefer movable seating; 10 percent like seminar-style rooms; and 5 percent like continuous desk seating (Niemeyer, D. 2003). Tables should be adjustable in height (between 23 and 31 inches) and if this is not feasible, tables of different heights should be spread throughout the room (Butin, 2000).

Different pedagogical techniques require different types of learning spaces. Emory College Classroom Working Group (2008) has defined six basic classroom types that are prevalent on the university campus as follows:

A. Classroom Loose Seating

These seating arrangements are most common in learning spaces as they have moveable furniture and flexible spaces. Furniture can be configured for a lecture, seminar, group work, or any learning style the instructor might require. Spaces often require more daily maintenance attention, as instructors do not always return furniture to its original location at the end of class. These rooms can be generally described as

having; 20 to 50 seats, Flat floors (not tiered or sloped), tablet arm chairs or movable tables and chairs in rows, 9 feet from the front of the room to the first row of seats, and 10 square feet for an instructor station **Figure 2.2.**

Figure 2.2 Classroom Loose Seating Furniture Arrangement

B. Classroom Seminar

Seminar rooms generally accommodate smaller numbers of students seated in either circular or rectangular format. Characteristics of these spaces include 8 to 25 seats, face-to-face seating arrangement, the instructor sometimes sits with students, and movable tables and chairs on casters as shown in **Figure 2.3.**

Figure 2.3 Classroom Seminar Seating Furniture Layout

C. Classroom Conference

Conference rooms sometimes serve as seminar rooms, particularly at the level of academic departments. However, they are often more formal than seminar rooms, and have the following characteristics including 8 to 25 seats, one large conference table or several tables configured together into one large seating area, chairs on casters, th instructor sits at table with students, normally the need to account for the peripherals in the room including bookcases, displays, credenza tables for food when designing space, and space used as teaching and meeting space, as shown in the **Figure 2.4.**

Figure 2.4 Classroom Conference Furniture Layout

D. Classroom Collaborative

Collaborative space designs are catching on and they are characterized by having 8 to 25 seats, require more space per person, may have a SMART board, which requires floor space, expanded instructor space to use interactive displays seating may be larger than standard specifications and should be easily reconfigured, with comfortable and movable chairs and tables, as illustrated in **Figure 2.5.**

Figure 2.5 Collaborative Classroom Furniture Layouts

E. Classroom Fixed Seating

Fixed seating classrooms have a well-defined “front” or main lecture area in the centre or front of the room. Students tend to be more distant from the instructor due to the increased room size. Rooms are usually tiered or sloped to insure proper sightlines for both students and instructors; 40 or more seats, normally a sloped or tiered space, and fixed table and seats or fixed table and moveable chairs or fixed tablet chairs, as illustrated in **Figure 2.6.**

Figure 2.6 Classroom Fixed Seating Arrangement

F. Auditorium

The Auditorium is a space for large classes, meetings, presentations, and performances. Auditorium facilities may include assembly halls, exhibition halls, auditoriums, and theatres. As such, they tend to have wide spans and are multiple storeys high in order to accommodate seating, sightline, and acoustical requirements. Raised stage floors and special lighting equipment are often required as well. Design features and characteristics that differentiate Auditorium space types from other gathering spaces includes;100 or more seats, sloped or tiered space, fixed seating, usually with tablet arm or fixed seating with fixed tables, increased distance between faculty and students, and special acoustic design including wall treatments or coverings. Because of large their size, automated room controls include lighting, shades, drapes and AV equipment, and sound reinforcement for the lecturer, as illustrated in **Figure 2.7.**

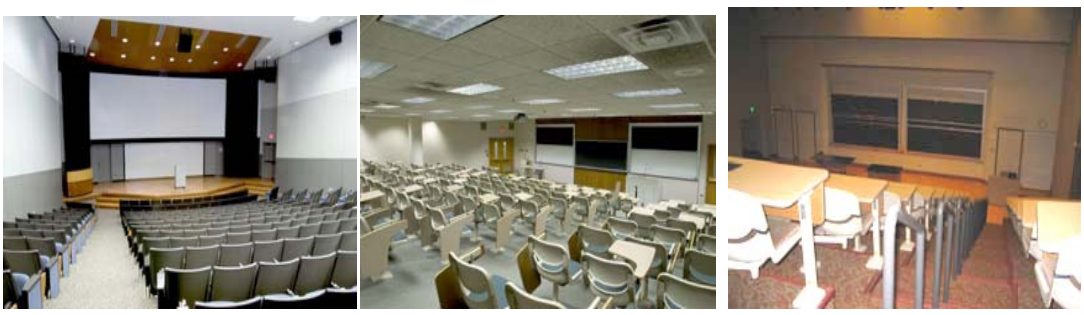


Figure 2.7 Auditorium Furniture Arrangement

2.5 Classroom Geometric Configuration

2.5.1 Classroom Seating Arrangement Styles

Effective communication in the classroom is essential to the success of both the student and the teacher. The kind of communication as well as the amount of communication that occurs in the classroom has long been thought to be partially a function of the seating arrangement of students. While there are probably many infinite numbers of ways of arranging a classroom, three are most common: traditional, horseshoe, and modular (McCorskey, and McVetta, 1978).

Emmons et al (2001) in his study classified classrooms into the following seating styles. The “demo” room is designed for a presentation to a passive audience. The “lab” is for hands-on work without teaching. The “classroom” combines elements of the demo room and the lab and they described the layouts consisting of classrooms that also take into consideration the need for student interaction when learning. Each layout assumes the electronic instruction room will hold 24 computers. The classroom comparison of various classroom layouts in relation to teaching and learning styles has been illustrated in **Table 2.6**.

A. Traditional Classroom Arrangement

The traditional way to arrange computers in an electronic classroom is facing forward in rows, with the instructor workstation at the front of the room **Table 2.6** (see Layout No 1). This layout is ideal for lectures and demonstrations as it provides excellent sight lines, but it does not serve the needs of collaborative learning very well, and in

fact promotes the power of the teacher over the students. Students find it difficult to form small groups when sitting shoulder to shoulder and it is awkward for the instructor to move between the workstation and behind students in order to provide feedback. A variation on the traditional model places the instructor at the back of the room. The instructor can then monitor student workstations but loses visual contact with students (Emmons et al 2001). The traditional straight-row arrangement is predominate in most educational settings, particularly in college and upper elementary through high school settings (McCorskey, and McVetta, 1978).

B. Computers around the Edge of the Room Facing the Walls

This is another common way to arrange electronic classrooms which includes placing computers around the edge of the room facing the walls (Layout No 2). The instructor can easily see student monitors, but students are forced to turn their entire bodies to switch attention between their monitors and the instructor (Emmons et al 2001).

C. Horseshoe Shape Arrangements

In this arrangement it is possible to place tables behind the students. Straight tables organized into a horseshoe shape give students space to spread out materials (Layout No 3).

D. Circular table arrangements

The circular table's arrangement (Layout No 4) gives the added advantage of making it easier for students to form collaborative learning groups (Emmons et al 2001).

E. Peninsular arrangement of computers

This is another way to arrange a classroom in which computers are placed on tables jutting out from the walls like peninsulas (Layout No 5). With the instructor workstation at the front of the room, sightlines are preserved and it is a simple matter to provide feedback and form collaborative learning groups (Emmons et al 2001).

F. Round Tables inside an L Arrangement

This is one of the interesting classroom layouts which combines the elements of all three arrangements mentioned above. Half of the computers face forward and the other half face the side walls, forming several "L" shapes. In the centre space of each "L", there is a round table that students can use to spread out print materials and to work in collaborative learning groups (Layout No 6) (Emmons et al 2001).

G. U or V computer lab seating arrangement

Niemeyer (2003) currently recommends that within a computer lab classroom, the U or V shape shown in Layout No 7 and 8 allows the presenter sight of all of the students' computers. He believes that this design is beneficial to computer-enhanced courses that use instructional methods such as computer-based independent work, lectures, group discussion, and presentations.

H. Cluster arrangement

The cluster arrangement shown in Layout No 9 is similar to the conventional straight row layout. The main difference is that the computer tables are placed perpendicular to the front of the room. This layout is ideal for small groups, collaboration, and dialectic instruction (Niemeyer, 2003).

I. Conventional straight row layout

The conventional straight row layout shown in Layout No 10 resembles a standard lecture classroom. This configuration consists of rows that are parallel to the front of the classroom. These layout characteristics allow for collaboration among students or the typical lecture/training method. Typically, the teacher presents at the front of the room. The disadvantage of the front lectern station is that the instructor cannot see the students' computer screens. Therefore, the ideal setup would provide a front and rear lectern (Callahan 2004).

J. Pod seating arrangement

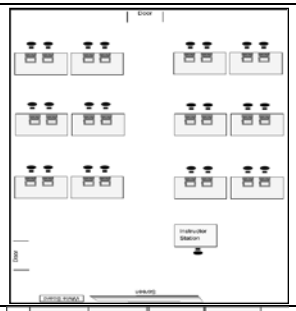
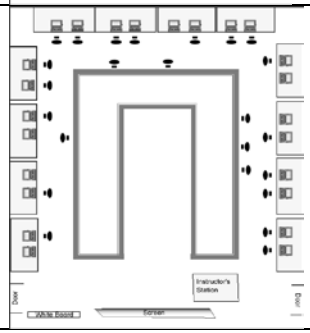
The pod configuration is shown in Layout No 11. Review of research indicates that the instructional purpose of the pod layout is intended to support collaborative computer-based work (Callahan 2004).

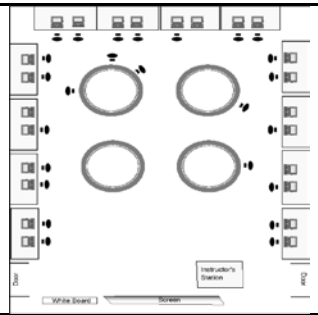
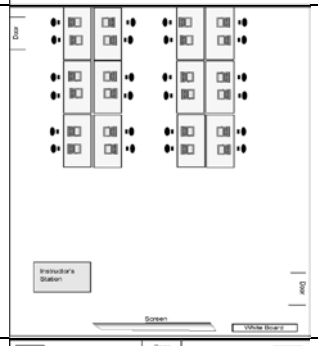
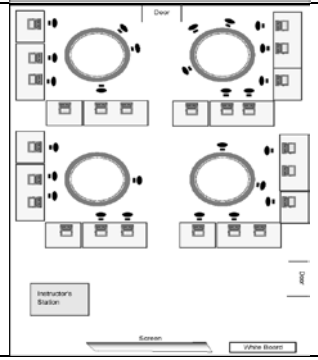
K. The "L" Shaped Classroom

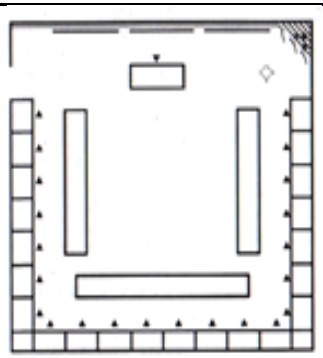
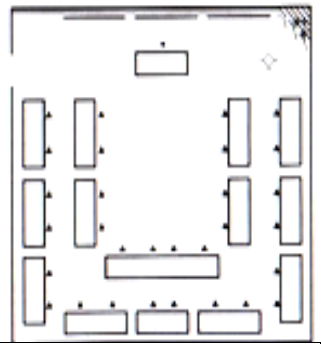
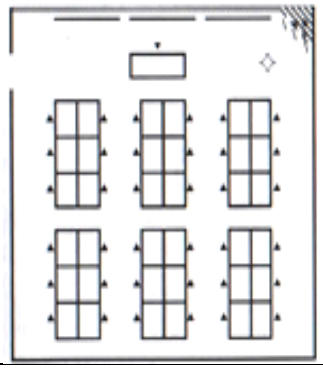
The "L" shaped classroom may offer some flexibility beneficial to the multidimensional elementary classroom of the future. The general shape offers many design opportunities as explained in the next paragraph and is shown in Layout No 12 (Franklin H. 2008):

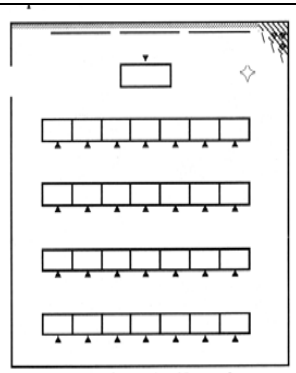
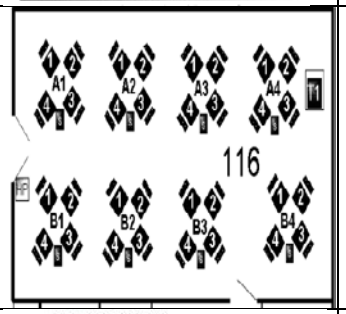
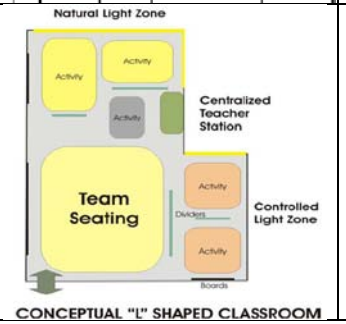
The graphic to the right shows a simplified version of how such a classroom might be arranged. There are three distinct macro-level zones available for very different educational activities including large group and individual desks, art or robotics, and team-based group activities with electronics.

Table 2.6 Comparison of Classroom Layout with Their Merits and Demerits and Applicable Teaching/Learning Styles

Classroom Layout		Layout Diagram	Merits	Demerits	Learning Styles	Teaching Styles
No	Description					
1.	Traditional computer arrangement in an electronic classroom		Ideal for lectures Provide direct sight line Good for demonstration	Not suitable for group/collaboration learning Promotes power of the teacher over the student. Awkward for instructor to move between workstations. Instructor may lose visual contact with some students.	Diverging Assimilating Visual learners Auditory learners Verbal Inductive Reflective Sequential	Formal Authority Teacher centered Demonstrator
2.	Computers around the edge of the room facing the walls		Instructor can easily see the students. Good for individual learning	The student is forced to turn their entire bodies to switch attention to the instructor Cannot accommodate collaborative activities	Converging Visual Reflective Activist Concrete sequential Concrete random Abstract random Logical Solitary	Expert Facilitator Delegator Student centered
3.	Horseshoe arrangement of tables		Enough space to spread out materials. Instructor can easily see the students. Can accommodate both single and collaborative learning.	The student is forced to turn their entire bodies to switch attention to the instructor	Converging Visual Reflective Activist Concrete sequential Concrete random Abstract random Logical Solitary Diverging	Expert Facilitator Delegator Student centered Teacher centered Demonstrator

Classroom Layout		Layout Diagram	Merits	Demerits	Learning Styles	Teaching Styles
No	Description					
4.	Circular table arrangements		Easy to form collaborative learning groups. Instructor can easily see the students. Enough space to spread out materials.	The student is forced to turn their entire bodies to switch attention to the instructor	Converging Visual Reflective Activist Concrete sequential Concrete random Abstract random Logical Solitary Diverging	Expert Facilitator Delegator Student centered Teacher centered demonstrator
5.	Peninsular arrangement of computers		Sightlines are preserved. Easy to provide & communicates feedbacks. Easy to form collaborative learning.	View between students and the instructor need students to turn in 90^{o} Difficulties in demonstrative lecture.	Diverging Visual & verbal Sequential & global Abstract Random Social	Facilitator Delegator Student centered
6.	Round tables inside an L		Good for collaborative learning. Enough space for spread out materials	No direct view between most of the students and the instructor. Uneasy circulation for the instructor	Converging Visual Reflective Activist Concrete sequential Concrete random Abstract random Logical Solitary Diverging	Facilitator Delegator Student centered Experts

Classroom Layout		Layout Diagram	Merits	Demerits	Learning Styles	Teaching Styles
No	Description					
7.	U or V computer lab seating arrangement		Allows the presenter sight of all the students. Suitable for independent work.	Students need to turn all their body to see the instructor.	Diverging Assimilating Visual learners Auditory learners Verbal Inductive Reflective Sequential Visual & verbal	Experts Demonstrator Facilitator Delegator Student centered
8.	U or V computer lab seating arrangement		Allows the presenter sight of all the students. Suitable for independent work.	Students need to turn all their body to see the instructor.	Diverging Assimilating Visual learners Auditory learners Verbal Inductive Reflective Sequential Visual & verbal	Experts Demonstrator Facilitator Delegator Student centered
9.	Cluster seating arrangement		Ideal for small groups. Suitable for collaborative studies. Good for dialect instruction.	No direct sight between students and instructor.	Diverging Visual & verbal Sequential & global Abstract Random Social	Facilitator Delegator Student centered Demonstrator

Classroom Layout		Layout Diagram	Merits	Demerits	Learning Styles	Teaching Styles
No	Description					
10.	Conventional straight row seating arrangement		Ideal for lectures Provide direct sight line Good for demonstration	Not suitable for group/collaboration learning Promotes power of the teacher over the student. Awkward for instructor to move between workstations. Instructor may lose visual contact with some students. Instructor cannot see student's computer screens.	Diverging Assimilating Visual learners Auditory learners Verbal Inductive Reflective Sequential	Formal Authority Teacher centered Demonstrator
11.	Pod seating arrangement		Very good for collaborative computer work.	Some students in disadvantaged positions need to turn their entire body to see the instructor.	Diverging Visual & verbal Sequential & global Abstract Random Social	Facilitator Delegator Student Centered
12.	The "L" shape classroom		Centralized teacher station. Spaces for different activities. Good for collaborative work. Suitable for practical activities.	Some students in disadvantaged positions need to turn their entire body to see the instructor.	Diverging Visual & verbal Sequential & global Abstract Random Social Assimilating Converging Kinaesthetic	Facilitator Delegator Student Centered Experts

2.6 Instructional Equipment Technology

2.6.1 Classroom Equipment

The following classroom equipment exists as shown in **Table 2** (MCC, 2010)

Table 2.7 Examples of Classroom Equipment

Figure No	Equipment Name	Photo	Description
1.	**Smart carts**		An LCD data/video projector connected to a PC, VCR, and DVD player with speakers on a portable cart
2.	**Smart consoles**		An LCD data/video projector connected to a PC, VCR, and DVD player with speakers
3.	**Videoconferencing carts**		A motion-tracking camera attached to an IP-based videoconferencing computer
4.	**Portable Elmo document cameras**		Outputs a TV signal for use with a TV or data projector

5.	**Lecterns(podium)**		Includes a built-in mic stand and reading light
6.	**Podium**		All in one

2.6.2 Classroom Equipment Quality and Student Performance

The quality of equipment, availability and level of its sophistication are some of the most important factors of consideration while developing university classrooms. Classroom equipment remains the only major tool used for both physical and remote communication in pedagogical delivery. Following is a summary of research carried out by Ed Young et al. on age and condition of facility quality and their effect on educational outcomes (Ed Young, et al. 2003).

A. Age of the Facility

Students had higher achievement scores in newer facilities. Indeed, as the age of the facilities decreased, there was a corresponding increase in scores in mathematics, reading, and composition.

- There were fewer disciplinary incidents in newer facilities.
- Attendance records were better in the new facilities.
- Social climate factors perceived by students were considerably more favourable in a new school.

B. Condition of the Facility

- As the condition of the facility improved, achievement scores improved.
- Stimulating environments promoted positive attitudes in students.
- Higher student achievement was associated with schools with better science laboratories. Furthermore, attitudes toward the science classroom predicted science achievement.
- Higher student achievement was associated with well-maintained schools.

2.6.3 Instructional Emerging Technology

A. Impact of Information and Communication Technology (ICT) in Classroom

ICT in schools, according to Gillian M. E. (2001); means the arrival of even one computer in the classroom can have a profound effect on the way students learn and the way the classroom operates. Teachers integrating computer use into the curriculum soon modify their classrooms to reflect the changes in student learning behaviour that inevitably emerge. Creating space in the classroom for computers and peripherals such as a printer, network connection and large monitor initiates a rethinking process by the teacher, leading to re-evaluating how classroom activities and learning experiences work best.

Gillian, (2001), in his research made a number of differing responses to ICT. Through grouping these responses, the following list of observed trends in the use of classroom spaces with ICT have been found (Gillian, 2001):

- Rearranging the classroom
- Creating new spaces from old configurations
- Providing centralised, shared facilities
- Creating dedicated, flexible classroom space
- Developing virtual classrooms and campuses
- District networks creating learning communities
- Web hosting by an external provider
- Classroom redesign for maximum flexibility
- Wireless technology offers new options
- Changes in traditional library areas

2.7 Communication in classroom

New applications of information and communications technologies, such as email, Internet, the World Wide Web and video-conferences, have created many new communication possibilities for schools, (Janet, 1999). In a classroom connected to the Internet, communication over distance is simpler than ever before. Communication outside the closed culture of a school can extend cultural understanding beyond the immediate social environment. Students in one country, for example, can exchange experiences with their counterparts in another using email or a video-conference. In one case, students linked up with an expedition on its way to the North Pole, demonstrating the dramatic possibilities for on-line interaction (Janet, 1999).

2.7.1 Smart Classroom and Tele-Education

According to Yuanchun et al, (2003) tele-education systems promise wider access to education and support for lifelong learning. These systems are either asynchronized or synchronized. Asynchronized systems are relatively simple. An organization can use the Internet to publish hyperlinked multimedia content and reach a wide audience. Yet, most current courseware is simply textbook material transferred to HTML; instead of reading the book, students read the screen. In most cases, live instruction catches students' attention and interest much more effectively than static materials. Real-time interactive virtual classrooms therefore play an indispensable role in distance learning. In this type of tele-education, multimedia communication systems let teachers and students in different locations participate in the class synchronously (Yuanchun, et al. 2003). A typical tele-education session is shown in **Figure 2.8.**

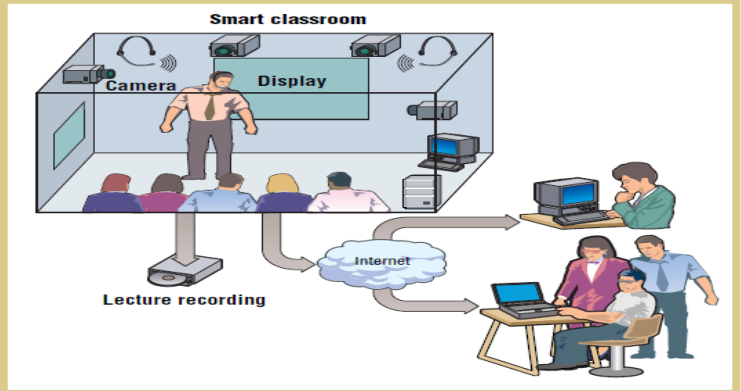


Figure 2.8 The smart classroom system. Integrated modules let teachers interact with remote students as though they were in the physical classroom.

2.7.2 Classroom Technical Services (CTS)

Classroom Technical Services (CTS) has extensive experience in the design and installation of highly customized presentation systems, which have distinctive functional requirements and subsequent unique design issues. Some of these specialized custom presentation systems are related to the focus of the particular college, school, or department, such as in the Moot Courtrooms for the Mondale Law School as shown in **Figure 2.9** (University of Minnesota, 2009).

Figure 2.9 Specialized Custom Presentation Systems in a Typical Classroom

There are also special function rooms such as Interactive Television (ITV) and Video Streaming Classrooms that are functionally applicable to any academic department pursuing these teaching styles. The following examples indicate the broad range of applications, which have had technology systems customized for their purposes (University of Minnesota, 2009). See **Figure 2.10 and 2.11**

Figure 2.10 Interactive Television (ITV) and Video Streaming Classrooms.

Figure 2.11 Interactive Television (ITV) and Video Streaming Conference Room.

In addition to Projection Capable Classrooms, CTS also has done technology design and installation of pilot Active Learning Classrooms (ALCs) that are designed as student-centered, integrated, flexible, active learning spaces. These are intended to stimulate interest in new and innovative classrooms, to demonstrate new flexible classroom construction techniques, and to allow faculty and student assessment of new classroom designs and pedagogy as shown in **Figure 2.12** (University of Minnesota, 2009).

Figure 2.12 Active Learning Classrooms (ALCs).

CHAPTER THREE

3 THE PHYSICAL AND ENVIRONMENTAL REQUIREMENTS OF A MODEL UNIVERSITY CLASSROOM

3.1 Physical Layout

3.1.1 Classroom size

Classroom size is largely dependent on classroom furniture and the number of students to be accommodated. The classroom size accommodating 20 to 30 students' capacity is considered for this study. In a collaborative classroom it is recommended to have a fewer number of students to avoid rowdiness. According to the study conducted by Kokkelenberg et al, 2005, average grade point declines as class size increases precipitously up to class sizes twenty and more gradually but monotonically through larger class sizes. Emory College Classroom Working Group (2008) recommends 8 to 25 seats in a collaborative classroom as it requires more space per person. According to (Emmons et al 2001), a computer classroom generally requires 30-40 square feet (approximately 3-4 square metres) per student. Even though classroom size is not of much concern in collaborative and interactive classroom sometimes, due to the fact that students do connect through tele-education or video conferencing and enjoy the same quality of learning with those physically attending the lecture session.

3.1.2 Instructor's Space

Due to the large quantity of facilities/equipment required to support interactivity in a collaborative classroom, expanded instructor space to use an interactive display is required. Apart from the instructor's seat, the instructor's space also accommodates the IT corner, which constitutes all the gadgets required to set-up interactivity, internet accessories, multimedia equipment, and other remote collaborative tools. The instructor's podium/lectern, printer, telephone and Sound Reinforcement System (SRS) are all situated in the instructor's space. In a collaborative classroom the instructor's area should be easily visible from all students' seats, and provides instructor seating, writing surfaces, and electronic controls to all audio/visual, pedagogical equipment, and lighting systems in the classroom.

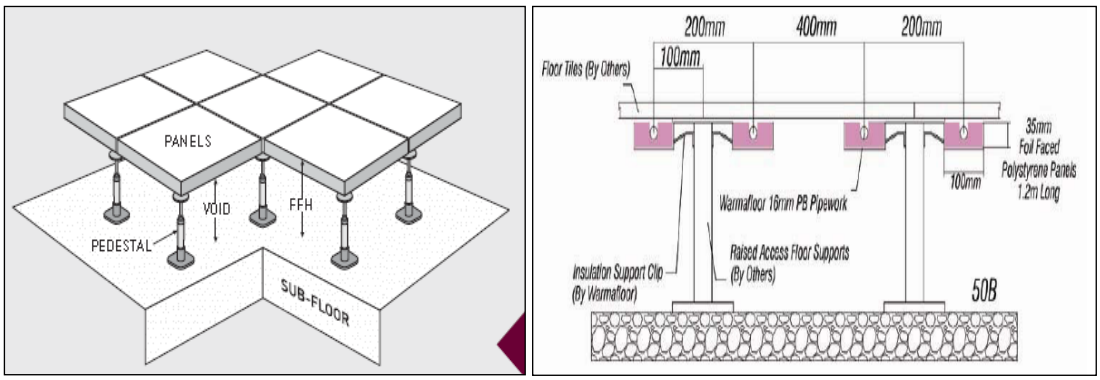
3.1.3 Raised Access Floor

The raised access floor in the classroom provides a void for cables, ducts and other under floor services. Each floor panel can be lifted with the correct lifting device, so that extra services can be easily installed, or existing ones re-routed AFC, (2010). Access floor systems provides mechanical and electrical accessibilities and flexibility in placing desks, and other classroom wiring systems that need not to be exposed and allow equipment movements and reconnection quickly. Typical access floor diagrams in 3D sections are illustrated in **Figure 3.1**(a) and (b), and **3.2**. Therefore, due to its advantages especially in a classroom where modular flexible furniture is used, the raised floor is to be used as a flooring system of the model university classroom. This will enable all the electrical and internet connection cables to be buried under the floor

and provide free floor surface for furniture reconfigurations. The following are some of the numerous advantages of a raised floor system (Kingspan Group, (2010). The advantages of an access raised floor in classroom include the following:

- Facilitates under floor cable management
- Maximises classroom space layout flexibility to meet occupants existing and future work space requirements, therefore extending the building's lifecycle
- Eliminates powered furniture costs
- Provides localised desk cable services
- Reduces power, voice and data cabling costs
- Permits rapid classroom and equipment layout change or upgrading
- Eliminates ceiling cable trays
- Removes cable ceiling to furniture pole systems and improves classroom environment.
- Faster on-site electrical/data/telecom installation
- Qualifies for 25% accelerated depreciation benefit
- Reduces operating costs
- Reduces facility and maintenance costs

In an access raised floor, the floor panels in the form of tiles are raised with a vertical reinforced steel member called a pedestal which is used to create a void between the sub-floors and finished floor of the building. This void will then be used as a space for running electrical and mechanical cables.



(a) (b)

Figure 3.1: (a)Typical 3D Illustration of Access Raised Floor (b) Typical Sectional Illustration of Access Raised Floor

{Source: (Eurodek, 2010) and (Warma Floor, 2010) respectively}

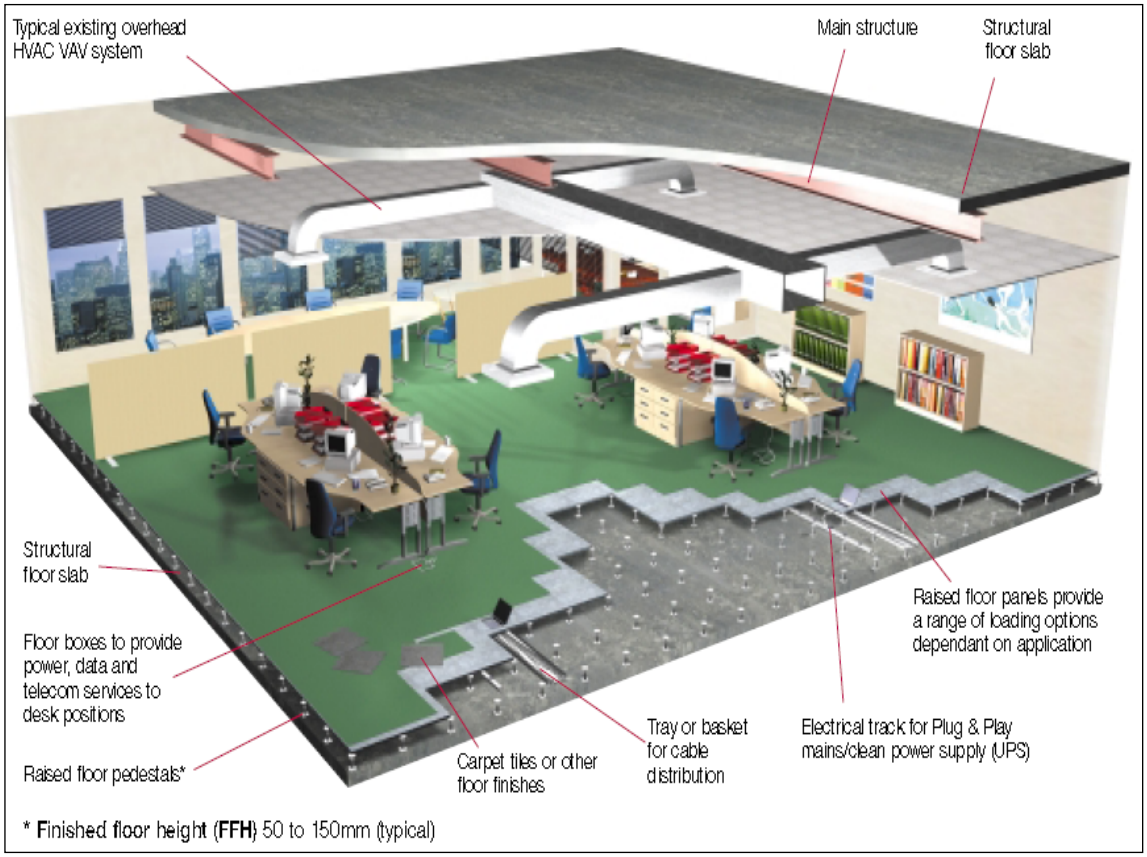


Figure 3.2 Typical 3D Showing Sectional Illustration of Access Raised Floor

{Source: (Kingspan Group, 2010)}

3.1.4 Classroom Furniture

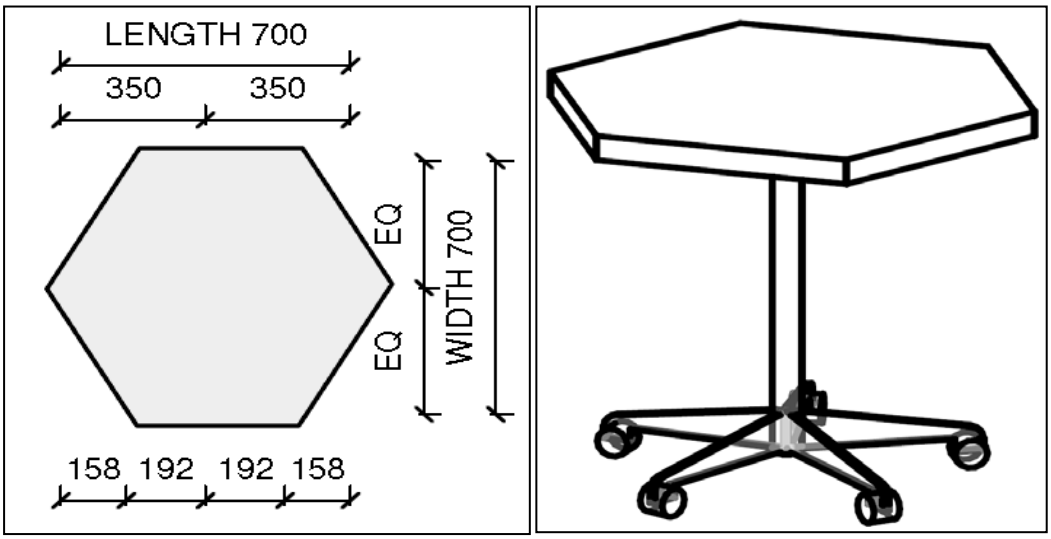
One of the most important factors of designing an adequate classroom is the good selection of furniture. Classroom furniture plays an important role in improving student comfortability in a university classroom. As different pedagogical techniques require different types of learning space, it is not cost effective to provide different classrooms for different pedagogical requirements. Therefore, flexible, adjustable and movable furniture has been adopted by the designer for the model university classroom. The mobility of the furniture provides a means for the student to manoeuvre the furniture to the requirement of the very pedagogical style operated in the classroom at any point in time. A survey has shown that almost half of the instructors prefer a movable seating arrangement (Niemeyer, 2003).

3.1.5 Flexible Student Desk

Classroom design cannot ignore the impact of appropriate furniture to support effective technology use. The adoption of flexible and adjustable tables in the model university classroom was informed by the aim of achieving a collaborative classroom that can accommodate several learning styles by reconfiguring the classroom desk arrangement. According to Emory College Classroom Working Group (2008), collaborative classroom seating should be easily reconfigured, and comfortable with movable chairs and tables. To achieve this purpose, the following classroom student desk configuration is recommended:

1. **Option "A"** Hexagonal Shape Desk

To achieve the required flexibility for adjustment and ability to manoeuvre to suit various learning styles employed in the model university classroom, a hexagonal shaped table configuration that can be easily reconfigured to any collaborative setting has been proposed. It has dimensions 700mm in length, 700mm in width and 800mm in height. This desk has swivel stands for easy movement on the classroom floor surface as shown in **Figure 3.3** (a) and (b).



(a) (b)

Figure 3.3 (a) Hexagonal Shape Student Desk, (b) 3D Hexagonal Shape Student Desk Showing Swivel Stand

Some of the possible arrangements of the hexagonal-shape desk together with the areas they consumed in square metres are illustrated in **Figure 3.4.** It is noticed that the higher the number of tables in a group, the less space it consumed.

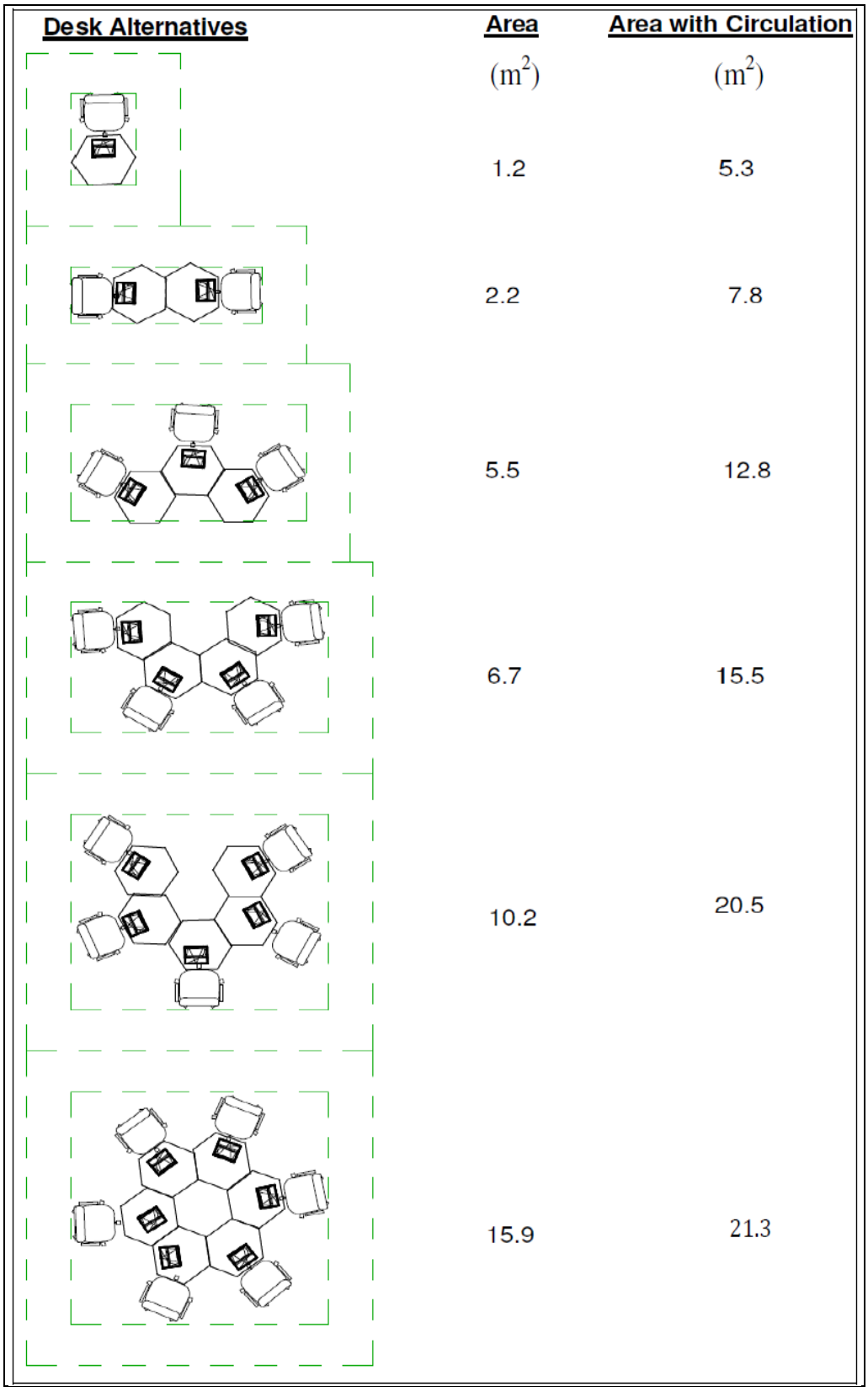
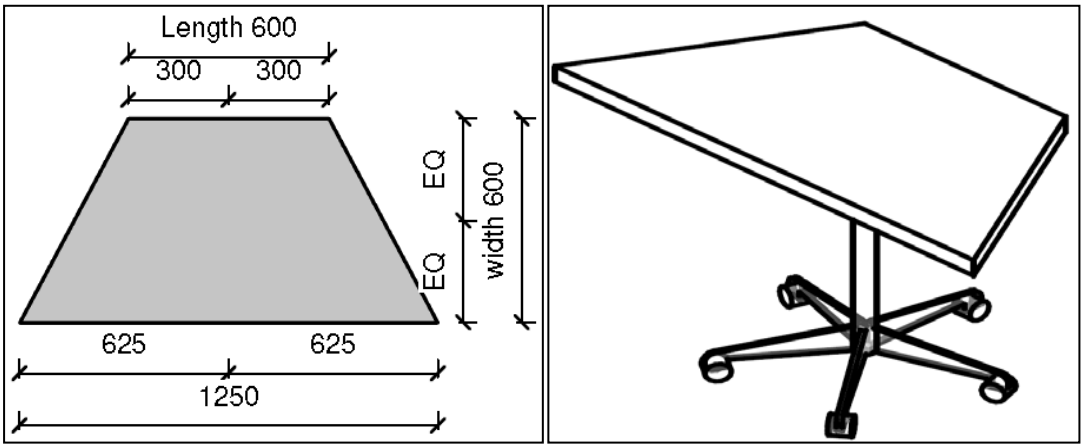


Figure 3.4 Possible Configurations of Hexagonal Shape Student Desk

2. **Option "B"** Trapezoidal Shape Desk

To achieve a maximum flexibility for alteration and ability to manoeuvre to match with various learning styles used in the model university classroom, a trapezoidal-shaped table configuration that can be easily reconfigured to any shape has been proposed as shown in **Figure 3.5** (a) and (b). The dimensions of the table include 1250mm and 600mm for major and minor length respectively, 600mm in width, and 800mm in height. These tables are wheel empowered, as layout reconfiguration and rearrangement will always be hard and time consuming with an un-wheeled table stand (Rogers, 2005).



(a) (b)

Figure 3.5: (a) Trapezoidal Shape Student Desk, (b) 3D Trapezoidal Shape Student Desk with Swivel Stands

The number of the possible arrangements of the trapezoidal shape desk, together with the areas they consumed in square metres is illustrated in **Figure 3.6.** It is noticed that the higher the number of tables in group, the less space it consumed. The hexagonal shape consumes less space compared to the trapezoidal space in the first three arrangement possibilities and vice versa when the table number combination is above three.

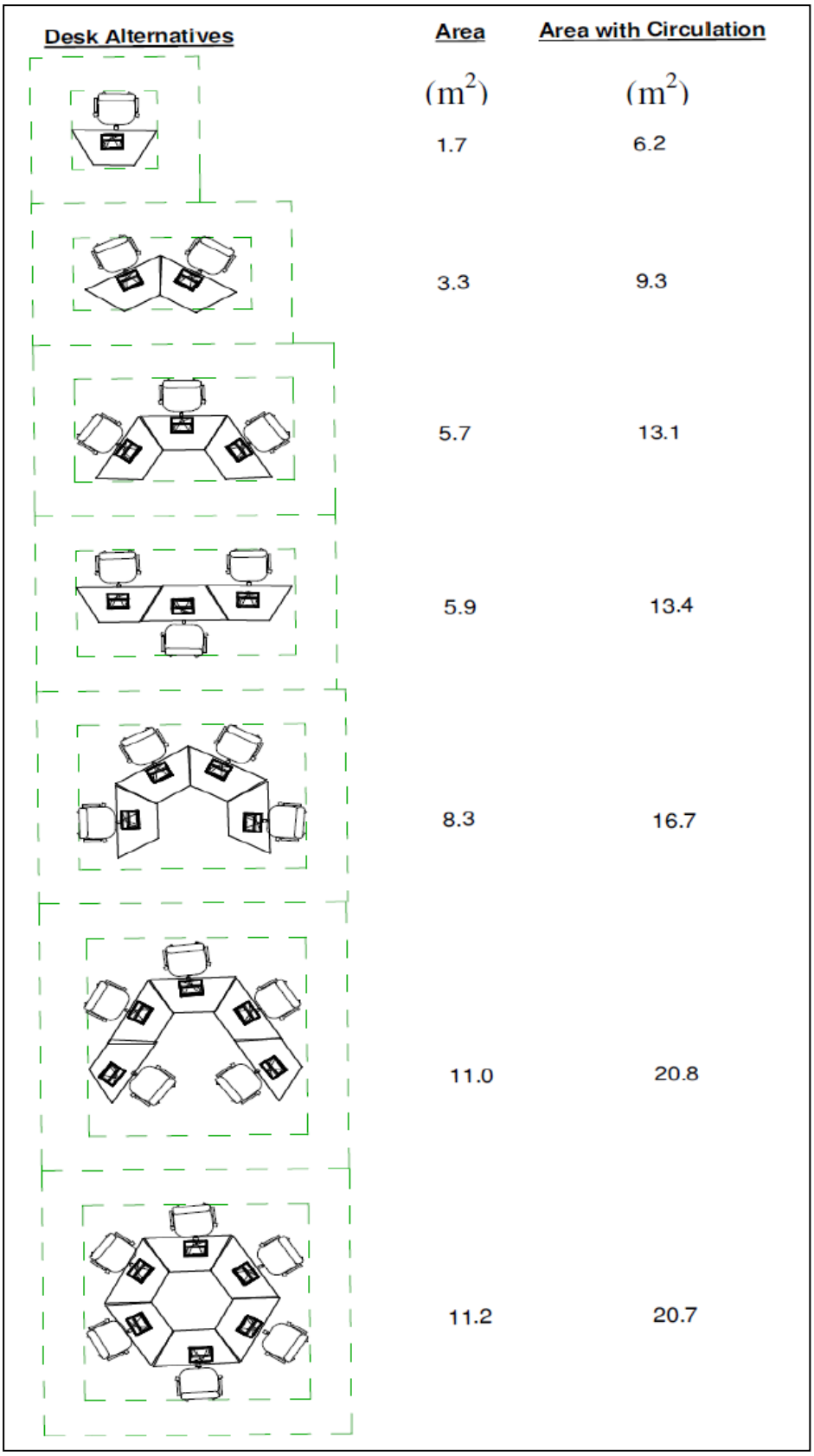
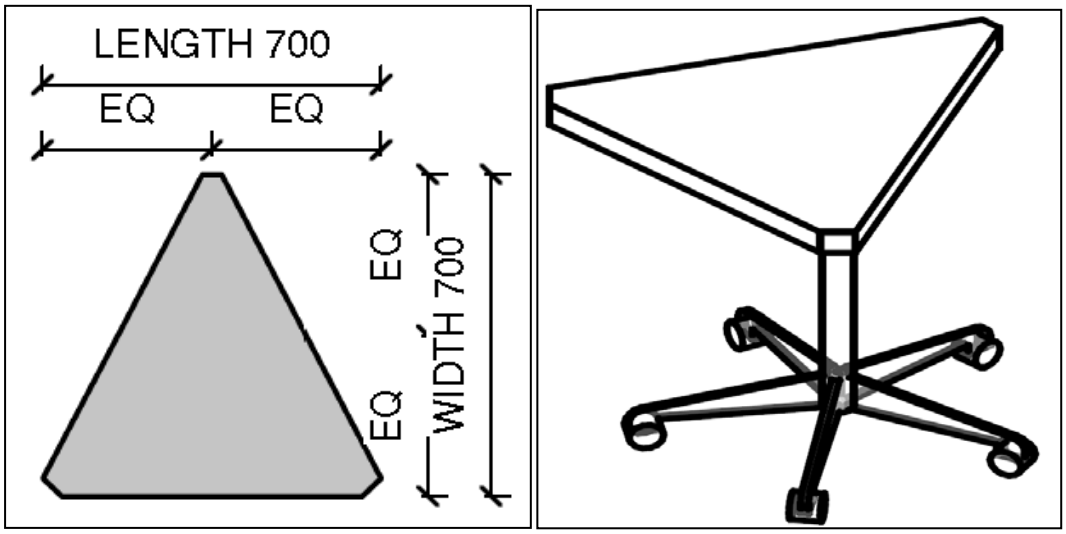


Figure 3.6 Possible Configurations of Trapezoidal Shape Student Desk

3. **Option "C"** Triangular Shape Desk

In order to achieve the required flexibility for adjustment and ability to manoeuvre to suit various learning styles employed in the model university classroom a triangular shaped table configuration that can be easily reconfigured to any collaborative setting has been proposed. It has dimensions of 700mm in length, 700mm in width and 800mm in height. This desk has swivel stands for easy movement on the classroom floor surface as shown in **Figure 3.7** (a) and (b).



(a) (b)

Figure 3.7: (a) possible configurations of Triangular Shape Student Desk, (b) 3D Triangular Shape Student Desk with Swivel Stands

Some of the possible arrangements of the triangular shape desk together with the areas they consumed in square metres are illustrated in **Figure 3.8.** It is noticed that the higher the number of tables in group, the less space it consumed. The triangular table consumes less space compared to the other two alternatives.

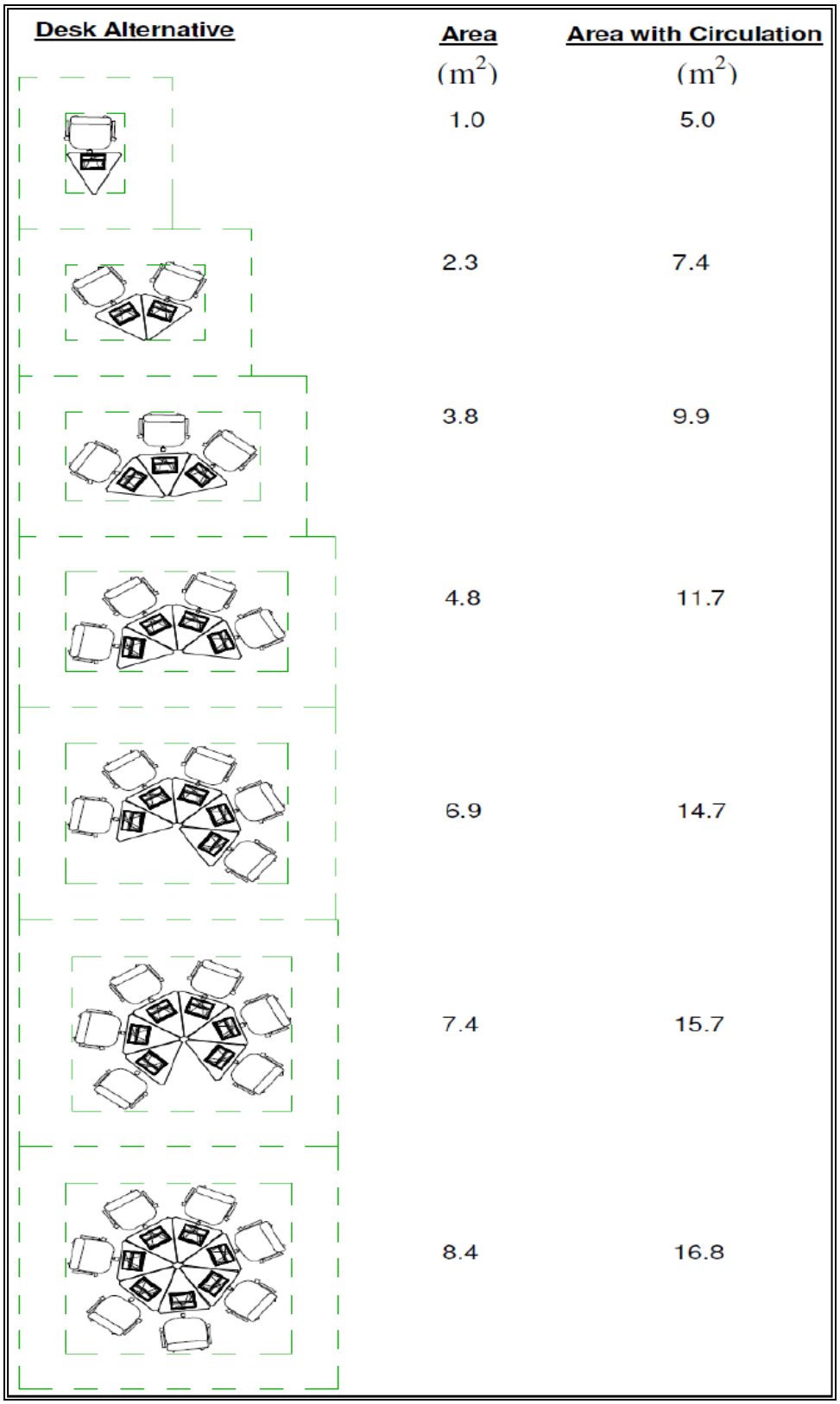


Figure 3.8 3D Possible Configurations of Triangular Shape Student Desk

3.1.6 Flexible Student's Chair

In order to maintain the tables flexibility it is also essential to extend the same features to the student's chairs to enable them turn and manoeuvre easily to respond to the learning styles used in the classroom. Ergonomically designed, padded, and adjustable chairs can accommodate individuals of varying sizes and provide comfort for a wide range of uses, which is particularly important as extended computer use increases (Butin, 2000). In the proposed model classroom all tables and chairs are proposed to have wheels and be adjustable, thereby increasing mobility and allowing the classrooms to be arranged differently from the usual rows of desks and chairs into small groups or islands. The typical classroom chair is shown in **Figure 3.9.** This flexibility increases the opportunity for colleagues to make lectures and tutorials much more interactive and increase collaboration amongst students (UWS, 2010).

Figure 3.9 Typical Classroom Chair

3.1.7 Teacher's desk

The teacher's desk should have ample, lockable storage space and allow for a computer and modem connection to provide the required instructional capability. In the proposed model university classroom, the teacher's desk is to be located in between the IT corner and the podium, to enable the instructor to use the two areas simultaneously.

3.1.8 Whiteboard

The issue of the whiteboard is critical and maintained as one of the most important means of knowledge transfer in the university classroom. But the major concern remains where to locate the whiteboard, as its integration with a slide projector screen in the front of the classroom, without distorting one another, remains in the forefront of research. The issue of whether to use a whiteboard or chalkboard has already been resolved in modern classrooms, as dust from a chalk board affects the electronics used in the classroom. This makes the chalkboard irrelevant in the proposed modern university classroom. The proposed whiteboard needs to have both vertical and horizontal sliding ability to enable the instructor to shift it in any direction necessary, in line with the learning and teaching styles employed in the classroom. Apart from the sliding ability, the proposed whiteboard also needs to be empowered with foldable technology for the benefit of the student in various angles of the classroom.

3.1.9 SmartBoard (Interactive Whiteboards)

A SmartBoard accommodates most mouse functions. To move to a new page, for example, the teacher needs only to touch an icon on the display. Teachers can use digital pens and erasers to write or remove directly (Yuanchun, et al 2003). An interactive whiteboard is a touch-sensitive screen that works in conjunction with a computer and a projector. Interactive White Boards (IWBs) are mainly being used as a data projector which can navigate to multiple screens, as a surface which can generate a dynamic rather than static form of display and to enhance presentation from the front of the class (DfES, 2007).

IWBs have enabled Information and Communication Technology (ICT) to be used for whole class and group teaching. This has possibly been the biggest development in educational ICT in the last 5 years. Previously, ICT had been a very individual teaching system. That is to say, each computer could be used to support the learning of 1 or 2 students at a time. To reach a whole class would entail the use of an ICT suite or require each student to have their own laptop or Personal Computer (PC). Now, there is always a place for ICT suites, but it would not be feasible to have one in every class or teaching area (it would also be very expensive). Each student having his/her own laptop is also very worthwhile but it would be very difficult for a teacher to monitor what each student accesses on his/her screen during a lesson or, indeed, to present the same material to each student at the same time (Wood, 2006)).

Therefore, it is a great opportunity to incorporate this verse technological enhancement to the model classroom. The SmartBoard and interactive whiteboard are placed in two corners of the classroom to enable different groups of collaborative learners to benefit

from them without shifting to the central one located in the front, as each group might embark on discussing on different subjects from each other. Hence, IWBs can enable technology to be used for both teaching classes and in groups empowered with Information Technology (IT). According to a study by SMART Technologies Inc. (2004), from the available body of research several themes and patterns are evident, including the positive effect interactive whiteboards have on student engagement, motivation, the ability to encompass a variety of learning styles (including special-needs students) and their ability to enhance student retention and review processes. In addition to student learning, observations also indicate that designing lessons around interactive whiteboards can help educators streamline their preparations and be more efficient in their ICT integration. The benefits of an interactive whiteboard system include support for differentiated instruction, because it accommodates different learning styles. Tactile learners benefit from touching and marking on the board, audio learners take advantage of videos and podcasts, and visual learners see what is taking place as it develops on the board (Wetzel, 2009). A typical smart interactive board is shown in **Figure 3.10.**

Figure 3.10 Smart Interactive Board

3.1.10 Storage Cabinets

The model university classroom needs to be furnished with wall mounted storage cabinets to enable students to keep their property. Students' property, if not kept properly, will be a source of disturbance for students and furniture movements and other activities in the classroom.

3.2 Classroom Geometry Arrangement

The classroom geometric arrangement remains the major important factor to be considered while incorporating or using different learning and teaching styles in the university classroom. The kind of communication as well as the amount of communication that occur in the classroom has long been thought to be partially a function of the seating arrangement of students. Due to the diversity of learning and teaching styles existing in the literature, depending on the type, nature and activities required for the course instruction, it is difficult to provide a separate classroom for these learning and teaching styles. As such, a flexible and easy to rearrange classroom furniture configuration has been adopted for the proposed model university classroom. These furniture layouts, as shown in **the Figure 3.11, 3.12, and 3.13,** are provided with swivel stands for easy manoeuvrability, and they are capable of holding laptop computers comfortably.

The physical surroundings of a class can encourage or inhibit the kind of interaction, and hence learning, which is required by students and instructors. Making distinct efforts to arrange the furniture of a classroom to promote a particular kind of

interaction also sends a strong message to participants, who are used to conventional layouts, that this class is something different (Atherton, 2009).

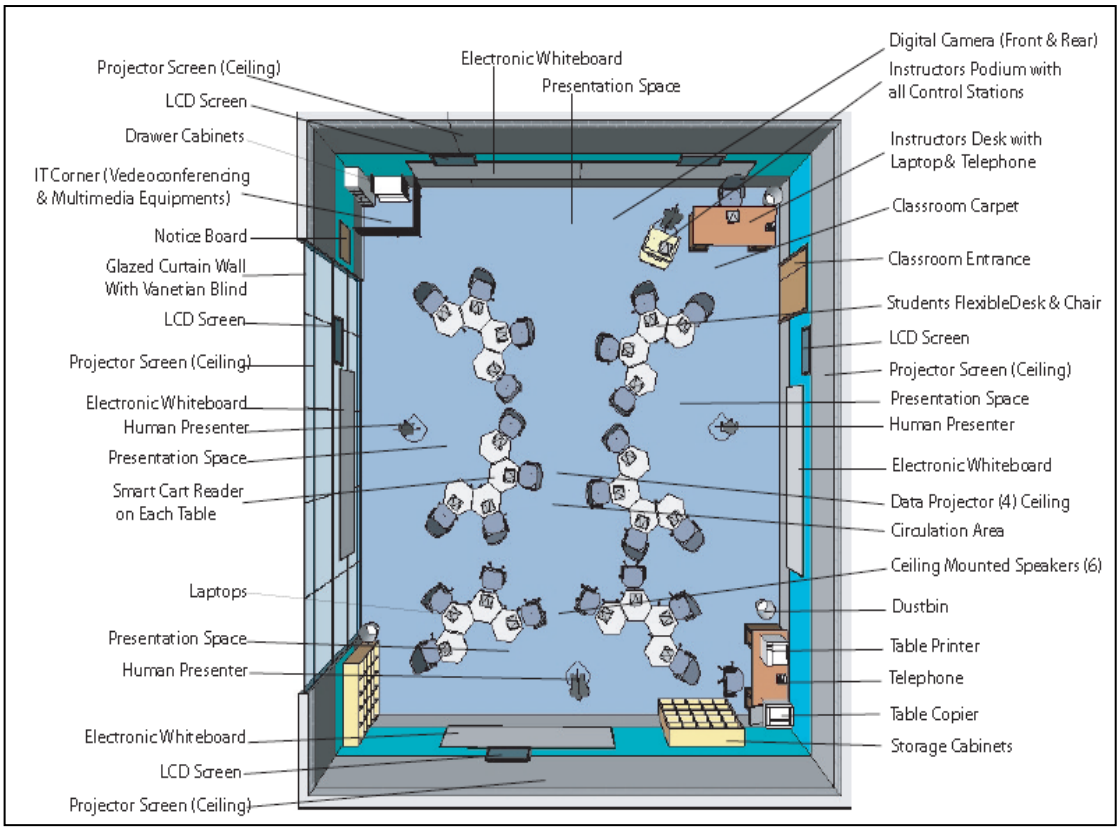


Figure 3.11 Collaborative Classroom Layout with Hexagonal Tables

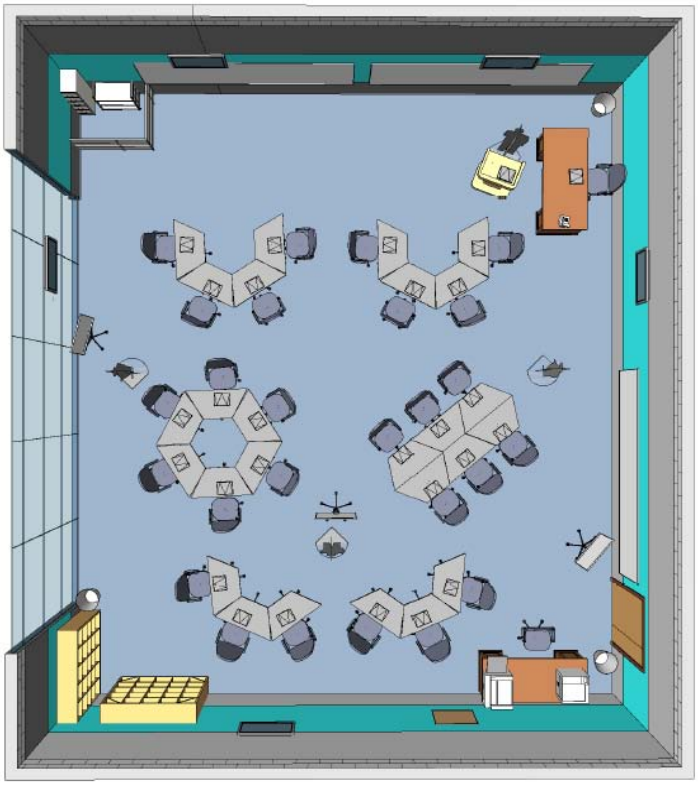


Figure 3.12 Collaborative Classroom Layout with Trapezoidal Tables

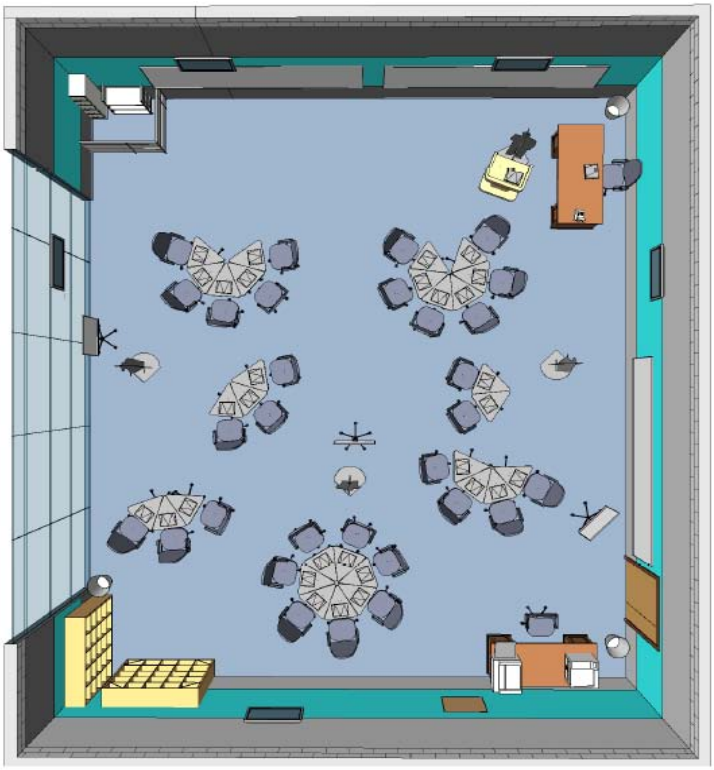


Figure 3.13 Collaborative Classroom Layout with Triangular Tables

3.2.1 Furniture Arrangement in a Hexagonal Classroom

Today, square and rectangular classrooms in our universities and other institutions of higher learning are the most commonly adopted shapes, due to the fact that the existing classrooms design usually follows the shape of the larger building in which it is situated. The adoption of these shapes is largely related to construction cost constraints and optimum utilization of space as polygonal shaped classrooms consume more space in design compared to rectangular and square shapes. But it is important to recognise that polygonal shaped classrooms will be more appropriate in fostering collaboration compared to square or rectangular shapes which are limited in their opportunities for re-arrangements of elements. The high number of interior faces in a polygonal classroom makes it very easy to group students and allocate a facade for each group for material presentation in the form of projector screens and white boards. Hence, there is a need to recognise the advantages and disadvantages of both square/rectangular and polygonal shapes while designing the university classroom. Polygonal classrooms are realizable while embarking on new school designs, while rectangular and square classrooms are the best option for existing schools. **Figure 3.14** illustrates a typical hexagonal shaped classroom with collaborative settings.

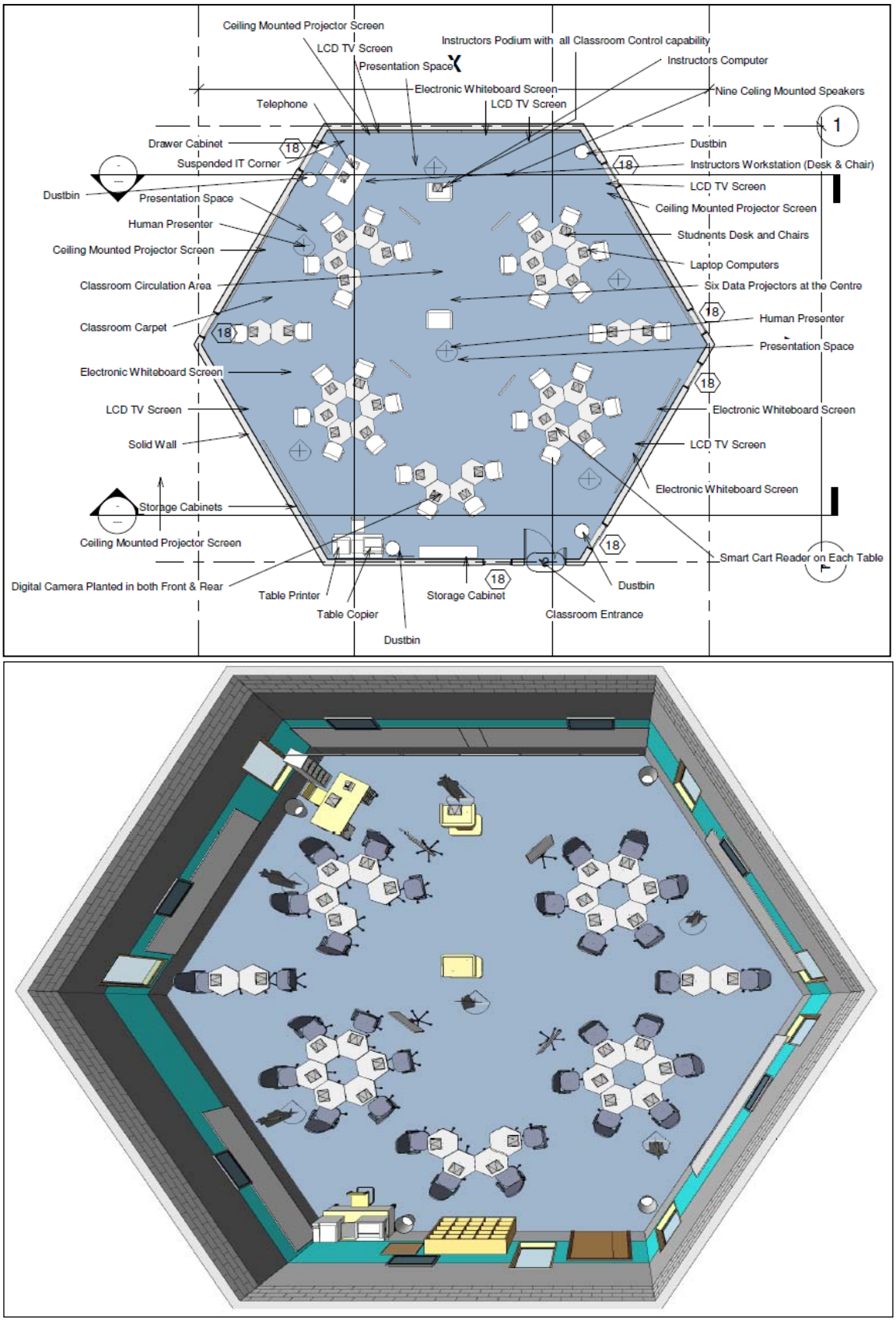


Figure 3.14 Plan and 3D View of Hexagonal Shape Classroom Layout

3.3 Instructional Equipment Technology

Due to the rapid changes in instructional equipment and technology, it makes it very difficult to fully satisfy the requirements of the university classroom. It requires a thorough investigation for immerging technologies and new sophisticated equipment that deliver the required instructional objectives. In recent times, classrooms have been provided with portable and flexible instructional equipment for easy delivery of instructions and a better active and engaging collaborative and interactive learning environment. A hardware and software installation allows for the automated capture of audio, video, slides, and handwritten annotations during a live lecture, with subsequent access by students (Winer and Cooperstock, 2002). The following equipment should be available to facilitate instruction in the model university classroom.

3.3.1 Classroom Instructional Equipment

A. Instructor's Podium/Lectern

The instructor's podium provides a contemporary reading desk for any classroom instruction. The proposed podium in the model university classroom is to be furnished with all the necessary technology required for easy instructional delivery and should have a control station that can control every aspect of the classroom's technology, including video displays, sound, lighting systems, whiteboards, and other electronic and communication equipment without any distraction.

The podium selection is of greater concern in university classroom due to the fact that it requires an ergonomic design that can suit the height of all the instructors using the

classroom. Based on the survey conducted by the Deanship of Academic Development (DAD, 2008), about 30% of course instructors were very satisfied with the podium, and 44% were satisfied , 14% said fair, while 8% and 3% said they were unsatisfied and very unsatisfied respectively. Therefore, there is a need to provide a very simple podium because most of the complainers say the height of the current podiums, especially in building 59 of KFUPM, is very high. The result of the survey is illustrated in **Figure 3.15.**

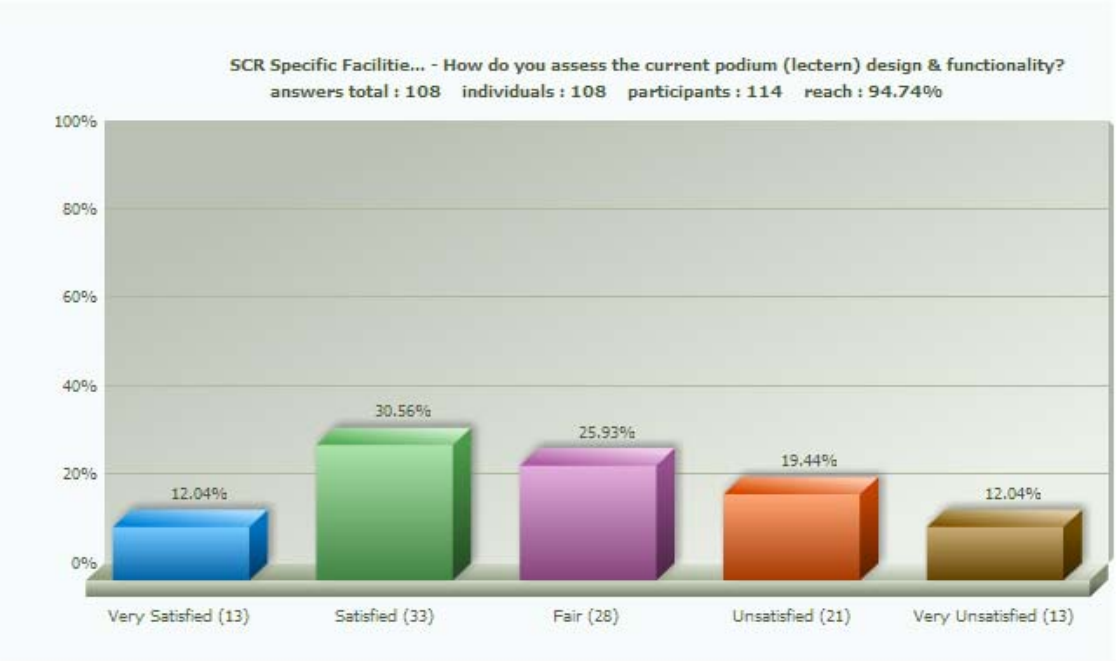


Figure 3.15: Suitability of Existing KFUPM Podium Design

The following set of equipment and technologies are essential to be accommodated in a typical instructor's podium of the model university classroom.

I. Control System

Typically consisting of a touch panel, a 'central controller', and other peripherals; this system of devices is used to simplify control when the facility has many technology

components. This will allow the instructor to control multiple pieces of equipment from one central location, which is the podium using a graphical interface (WVU, 2010).

II. Classroom Control Software

Classroom control software is the perfect teaching tool for networked classrooms and labs because it allows the user to simply and effectively control, manage, monitor, demonstrate, support and collaborate with students either individually, as a pre-defined group, or to the overall class. For example, Net-Support School classroom management software is capable of combining advanced classroom PC monitoring, real-time presentation and annotation tools with an innovative customised testing suite, internet and application control, real-time audio monitoring, automated Lesson Plans, Printer Management, Instant Messenger control, content monitoring and desktop security. The latest version of Net-Support School classroom management software rises to the challenge and requirements of today's modern classroom (Netsupport Schools, 2010).

III. Local Input Panel

Each classroom includes additional connectivity for portable equipment. By far, this component adds the greatest expandability for the least expenditure. The input panel should be located on the multimedia lectern, close to a flat area to place equipment and include a standard duplex power outlet (WVU, 2010).

IV. Telephone

The survey conducted for ERIC by (Lucas, 1994) indicated that telephone lines are used in classrooms in predominately two ways: voice communications and computer communications (telecommunications and tele-computing). A couple of respondents mentioned the use of phone lines for the exchange of FAX messages. Major uses and applications of telephone systems in the classroom in terms of voice communication include: making important school information available to the community, allowing connection to electronic grade book programs, ability to check on a student's progress (homework hotlines), obtaining test schedules via voice mail, and checking attendance records.

V. Portable amplifier Microphones (wireless)

Evidence is mounting that lightweight, wireless microphones worn by teachers and other educators increase student attentiveness and content retention, even as class size grows. At the same time, teachers benefit from lower stress associated with talking in a normal voice (Infocommiq, 2010). Classroom amplification systems produce a uniform speech level throughout the room and allow teachers to control, stabilize, and equalize the acoustical environment so that their voices are clearly audible above background noise at all locations within the room (Blazer, 2007).

B. Audio System

Typically consisting of an audio mixer, audio amplifier, and room speakers, this series of devices is used for sound reproduction from video sources and used in conjunction with microphones to create a voice amplification system (WVU, 2010).

C. Data / Video Projector

A data video projector is a display device that uses a high intensity light beam to project images onto a front or rear projection screen. Projectors are available in several sizes, ranging from small units appropriate for classrooms and labs to large units used in auditorium teaching facilities. Commonly referred to as LCD projectors, they use a variety of technologies to display images, most commonly LCD (liquid crystal display) and DLP (digital light processing) technology (WVU, 2010). In the model university classroom, both front and side projectors are proposed to be utilized for instructional delivery to provide the required flexibility for students to learn.

Based on the survey conducted by (DAD, 2008), more than 70% of the respondents to the interview are either satisfied or very satisfied with the level of educational needs satisfaction of the existing projectors in KFUPM classrooms as shown in **Figure 3.16**. And at the same time the data projector scored the highest points in the interview conducted when the respondents were asked to mention the three most suitable equipment or technology in the university classroom.

Figure 3.16: Projector satisfying educational needs

D. Electric Interactive Screens and Portable Screen

Electrical screens are the best choice because they are versatile, and easy to install and manipulate. Electric regulating systems allow users to lower the screen to the desired height and direction. It is recommended in the model university classroom due to the fact that it provides the users with enough opportunity to manipulate its height and position, making it easy to display for the required location in the classroom. The Electrical Interactive display screens allow the instructor to annotate areas and highlight points from anywhere in the room. Students can use wireless response devices, allowing them to quickly reply to questions posed by the instructor. Apart from the fixed screens, the need for portable screens located in various angles of the modern university classroom can never be over emphasized. As a collaborative classroom accommodates different sorts of discussion session at a time, every discussion group needs screens for the transmission of its session. Portable screens in the form of flipcharts are designed to be carried from one place to another with ease.

E. Network and Network Port

Even though the current trend is the use of wireless technology, there is a need for the provision of network ports in the classroom in case of wireless failure or breakdown as ports are more reliable than wireless networks. These ports can be either embedded in the floor or the walls. A raised floor has been adopted for the model university classroom to provide easy running of electric, internet and telephone cables without disruption to the classroom layout itself.

F. Information Technology (IT) Corner

The IT corner is located at the front angle of the classroom which accommodates all the information technology hardware and software used in the classroom such as email, Internet, the World Wide Web and video-conferences. The internet and wireless communication and multimedia accessories are all situated in the IT corner.

G. Digital Video Camera (Angle Controllable)

A digital video camera in the model university classroom is very important to facilitate interactivity in the form of video conferencing and Telecollaboration. It enables remotes students to join and see what is happening in the classroom by capturing images of the classroom session. The camera should be angle controllable that is able to capture all corners of the classroom to provide remote students with the ability to see every angle.

H. Laptops and Connection

For successful use of laptops in the classroom, users will have to be attentive to laptop features and construction, acquire any required adapters, and understand the graphics card's display settings and how to change them (Schoomer, 2009). Laptops also make possible the clustering and combining of enough units in each classroom to achieve critical mass - enough computers to do something worth doing. Because desktop computers tend to be large and heavy, they require special furniture and are rarely moved around to where they might do the most good or be used most frequently. Hence, they need to be replaced with more flexible laptops.

I. TV Screen (External Input Interface)

The TV screen is a widely used telecommunication medium for transmitting and receiving moving images in either monochromatic (“black and white”) or colour, usually accompanied by sound. Nowadays, with the adoption of collaborative and interactive tele-education in university classrooms, mobile communication between different classrooms has become necessary. A large flat High Definition (HD) TV screen has been adopted for the model university classroom for using DVD and videoconferencing, which is expected to provide learners with opportunity to see high-quality video in the classroom.

3.3.2 Classroom Instructional Technologies

A. Videoconferencing

Video conferencing is a process in which students can see and talk to others in distant places in real-time. This is achieved with the aid of mobile equipment which brings videoconference communication into the classroom, using electronic tools including: Camera and sound box, Projector and screen or TV monitor and Microphone and Internet connection (Bellingham Public Schools, 2010). In videoconferencing technology, two or more people at different locations can see and hear each other at the same time, sometimes even sharing computer applications for collaboration. Videoconferencing offers possibilities for schools, colleges, and libraries to use these systems for a variety of purposes, including formal instruction (courses, lessons, and tutoring), connection with guest speakers and experts, multi-school project collaboration, professional activities, and community events. Teaching professionals have observed that two-way videoconferences heighten students' motivation, and

improve communication and presentation skills. Additionally, a virtual field trip increases the depth of learning and provides a forum for a greater connection with the outside world (CSD, 2010).

A videoconference can improve students' memory retention by appealing to a variety of different learning styles by including diverse media such as video and audio clips, graphics, animation, and computer applications. Videoconferencing connects previously contained institutions in a way not possible using e-mail, the telephone, or online chat systems. The visual connection and interaction among participants enhances understanding and allows both the content providers and the students to feel connected to one another. That connection leaves a distinct impression on the students who have the opportunity to go on a virtual field trip.

B. Telecollaboration

Telecollaboration refers to a set of software technologies that enable the integration and extension of personal desktop collaboration into high definition videoconferencing solutions. Unlike pure high definition videoconferencing systems or tele-presence solutions, a Telecollaboration high definition videoconferencing environment is supplemented by spontaneously shared personal content thereby putting a remote meeting's emphasis not only on face to face communication but concurrently on collaboration (Wikipedia, 2010).

3.4 Indoor Environmental Quality of the Classroom Environment

3.4.1 Classroom Lighting Quality

Classroom lighting is one of the major determinants of student performance in the university classroom. The major challenge is to provide classroom lighting that increases teacher control, reduces glare, improves lighting and optimizes visual comfort while minimizing lighting power and energy use to their lowest possible levels." (Project FROG team, 2008). With input from representatives of the Collaborative for High Performance Schools (CHPS), Finelite Inc. used a combination of best practices and new technologies to develop and test an integrated classroom lighting system (ICLS) for K-12 classrooms. The basic system includes indirect luminaires with energy efficient Tubular-8/8 (T-8) lamps and electronic ballast, 96% reflective material within the fixture, a teacher control centre located at the front of the classroom, and plug-and-play components. It is recommended to provide modularity and options to deal with different classroom layouts, teaching and AV requirements, and daylighting conditions (PIER Lighting Research Program, 2005).

A. Luminaires

Luminaires are the total light delivery unit including lamps, lamp holders, reflectors, diffusers and control gear (BRANZ, 2007a). An Integrated Classroom Lighting System (ICLS) recommendation by PIER Lighting Research Program (2005) includes two rows of direct/indirect linear fluorescent pendants, mounted parallel to the windows and spaced about 15 ft. (4.572m) apart, with a wall washer illuminating the main teaching board. Each luminaire includes three high-performance (3100-lumen)

T8 lamps: two outboard lamps producing uplight and downlight, and a separately ballasted inboard lamp producing downlight. Both the inboard lamp and outboard lamps cannot be on at the same time, resulting in immediate energy savings. The employment of indirect luminaires to provide general classroom illumination, by lighting a 30 x 32-foot (approximately 9.2 x 9.8m) classroom with two (2) rows of a high-performance, indirect suspended luminaire with 3100 lumen T8 lamps and 1.2 BF T8 electronic ballasts. It is recommended to employ different T8 ballast factors for different size classrooms or for classrooms with extensive daylight.

Fluorescent lamps will be used instead of incandescent lamps in the model university classroom due to its numerous advantages including aesthetics, energy conservation, quality and comfort (NEEP, 2002).

B. Lighting Control and Sensors

Lighting control gives instructors the flexibility to set the lighting level to match the task being performed in the classroom (NEEP, 2002). It is essential to give the teacher control at the front of the classroom to change between General and Audio Visual (AV) modes of operation and to control other functions and options. As the model university classroom being a space used for customized collaborative and interactive pedagogical activities, the employment of lighting control and sensors is of greater importance. The instructors should be given an access to all the lighting control system in or close to the podium/lectern position to make sure they can manipulate the lighting system to the required level to support any learning style used in the classroom. Sensors, on the other hand are very important for energy conservation and safety as lighting system do off themselves automatically when there are no students,

the room is empty or there is enough daylight in the model university classroom. It is recommended to provide ways to control the electric light to reflect the amount of daylight in the classroom. Depending upon the nature of the daylight in the classroom, the consideration of manual control, stepped switching, or automatic dimming based on daylight levels are very important. This will provide the instructor the ability to keep the lights on during periods of quiet, time for tests or periods of individual study or work. The positioning of the occupancy sensors in the ceiling is of great importance as it minimizes obstruction by objects in the classroom if not properly positioned.

C. Classroom Lighting Mode of Operation

In the model university classroom, two mode of classroom lighting operation can be employed including a normal mode for conventional classroom activities and an AV mode in which a video projector and screen can be used without totally darkening the room. PIER Lighting Research Program, (2005) recommended to provide an AV-appropriate lighting mode in classrooms. During AV mode, it is recommended to decrease light on the front teaching wall while keeping an appropriate level of light on the students' desks for note-taking and class interaction.

D. Interconnections

It is recommended to use low voltage, plug-and-play between Torque Convertor Clutch (TCC) sensors and Control Pack and Row switches (high voltage) in all interconnections between lighting systems in the classroom. (PIER Lighting Research Program, 2005)

E. Sight Lines

One of the important factors affecting student line of sight in the university classroom is the angle of the sight line along which students are looking the instructor. Inability to see clearly may cause a student to adopt an uncomfortable posture and discomfort will result in loss of concentration (BRANZ, 2007). In the collaborative classroom, the instructor is mobile, going round the classroom, addressing the problems of various collaborative groups. Hence, the issue of line of sight is of less importance.

F. The Lighting Level

Illuminance is the luminous flux density at a surface expressed as lumens per square metre (lm/m^2) or lux. For classrooms, suitable illumination levels are between 300 to 500 lux at the working plane. The working plane is the level of the writing table in the classroom (BRANZ, 2007a). The typical classroom lighting plan is shown in **Figure 3.17.**

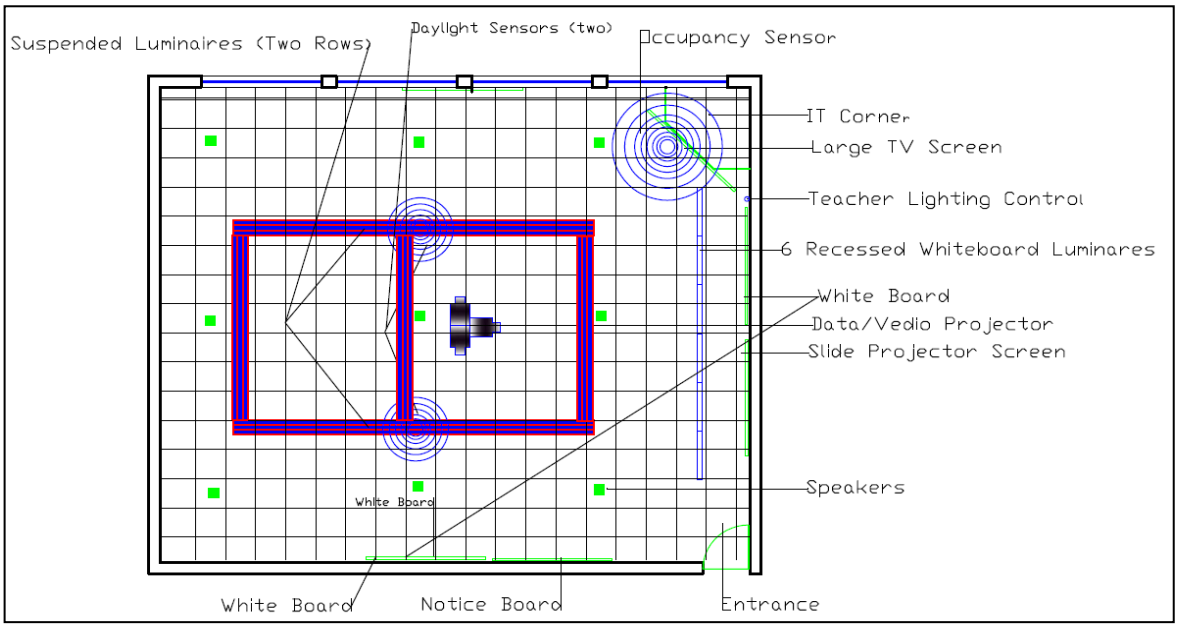


Figure 3.17: Model University Classroom Lighting Plan

G. Classroom Reflectance

Walls including tack boards and large cabinets or cupboards mounted on the wall should have non-specula surfaces with 40 to 60% reflectance. Blinds or drapes, like walls should be light coloured, with similar reflectance. Wall adjacent to windows should also have very high-non-specula reflectance to avoid excessive luminance ratios between the windows and the wall surface. The portion of the wall above the level of the luminaires should have a minimum reflectance of 80%. The ceiling should be even more highly reflective (white) and non-specula, because the ceiling is most important in reflecting light downward towards task on desktops when using direct-indirect or indirect luminaires. It is also necessary to avoid obvious brightness differences between the ceiling and the luminaires. Ideally, the ceiling should have a luminance greater than or equal to that of the side walls. It is desirable to have a luminance of the side walls at least one-half that of the upper walls and ceilings.

Floors provide the secondary background to desk-top tasks. Floors should, as with all other surfaces, be non-specula. The reflectance should be as high as practicable using readily available materials for floor coverings with the objective of having a reflectance approaching 25%. The floor reflectance is not as critical as other room surfaces, but it does contribute to the ambiance of the space and should not be overlooked as illustrated in **Figure 3.18**. The Figure is adopted from IESNA Lighting Handbook (Rea, 2000)

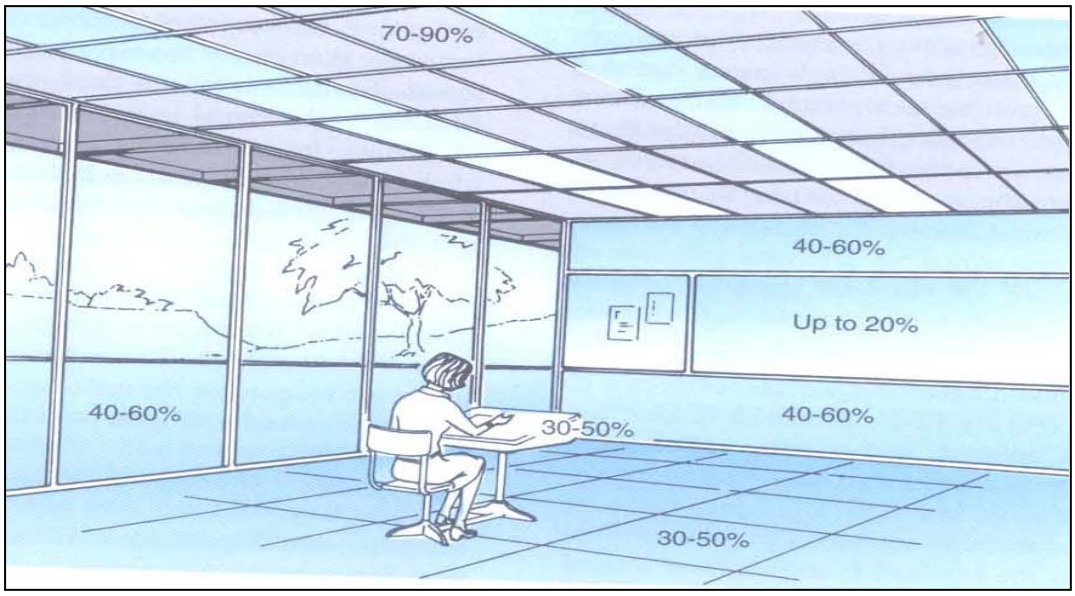


Figure 3.18: Recommended Reflectance for Surface and Furnishing in Classroom

3.4.2 Classroom Acoustical Quality

Classroom design and layouts with good acoustics help students understand what instructors are teaching and allows students to have a better understanding of the lessons with fewer distractions. Proper design and layout in a classroom environment includes adding acoustical wall panels or acoustical ceiling tiles to break up the hard wall and ceiling surfaces used in a typical classroom environment (Acoustical Solution Inc., 2010). The American National Standards Institute (ANSI) and the World Health Organization (WHO) suggest background noise in the classroom should be below 35 dB (Chiang and Lai, 2008). The American Speech-Language- Hearing Association (ASHA) recommends that the average unoccupied classroom should not exceed a 30-dB noise level (DiSarno et al. 2002). The following are the recommendations for the proposed model university classroom.

A. Reverberation

The model university classroom should have a Reverberation Time (RT) of 0.4-0.6 as recommended by (Seep et al, 2000, Zannin, and Zwirtes, 2009 and Chiang and Lai, 2008). To reduce the RT in the classroom fabric-faced glass fibre wall panels, carpet for floors and acoustical ceiling tiles with a Noise Reduction Coefficient (NRC) of 0.75 are to be used in the classroom as recommended in (Seep et al, 2000).

B. Walls

An acoustically sound wall system should be employed throughout the classroom construction. One of the major acoustical problems in classroom wall is the teachers' voice reflected by the rear wall which interferes with the teachers' speech in the form of an echo. To reduce this phenomenon, fabric faced glass fibre panels as a strong sound absorptive material will be used in the rear wall to prevent the teachers' voice from reflecting back (Seep, et al, 2000). Another major acoustical concern in classrooms is flutter echo which is usually more significant between the walls at the front where the teacher is speaking. Flutter echo between two parallel hard walls will be eliminated in the model university classroom through covering these walls with fabric faced glass fibre panels as a strong sound absorptive material. All walls should have acoustical panels to reduce background noise level in the classroom. Where adjacent activities exist, the common wall should achieve Noise Isolation Class (NIC) of 50, and the plenum should be carefully treated with high Ceiling Attenuation Class (CAC) tiles. Ceiling return air openings remote from common walls and R-19 fibreglass laid over an area which is at the common wall and 4 feet either side of it and proper design for a room where the spoken word is necessary to learning shall have a

preponderance of direct + early sound over reverberant sound, and a noise level of less than Noise Criteria (NC)-30 (Campanella, 2004).

C. Ceiling

The ceiling being one of the major sources of sound reflection in the classroom needs to be treated carefully to achieve an acoustically pleasant environment for comfortable instructional activities. Acoustical ceiling tiles of 0.75 NRC will be used to absorb both low and high frequency sound in the classroom as recommended by (Seep, et al, 2000). A gypsum board slope ceiling reflector suspended below the structural ceiling is recommended at the front of the classroom and ceiling with hard reflecting surfaces in the centre to help spread the instructor's voice to the entire classroom. Future classroom interiors should have a 25% area central ceiling reflector, acoustical tiles about the rest of the ceiling acoustical panels (Campanella, 2004), and sound absorbing surface ceilings around the perimeters of the classroom to reduce echo from reflected voice.

D. Floors

The floor surface in the university classroom has been one of the major contributors of noise mainly due to sliding furniture and movement of people. Even though simply adding carpeting to a classroom floor will not significantly reduce reverberation time, especially at low frequencies, it will reduce noise resulting from students sliding their chairs or desks on the floor (Seep, et al, 2000). But it is certain that carpet, being a soft material, can reduce sound reflection by absorption, thereby creating classrooms that are far more conducive to learning.

E. Ceiling Mounted Speakers

To achieve a constant spread of sound throughout the classroom, ceiling mounted speakers at different point has been adopted for the model university classroom. Loudspeakers with good and wide coverage pattern need to be used to avoid focussing of sound in one area. A coverage angle of 1400 is ideal.

The classroom acoustic recommendations by (Mir, and Abdou, 2005), as illustrated in **Table 3.1** are essential to be adopted in the model university classroom of the future. This is due to the fact that the model has treated the entire acoustical aspect of classroom in details. **Figure 3.19** illustrates the detailed graphical model of the classroom acoustic treatment shown in **Table 3.1.**

Table 3.1 Sound Absorbing Material Configuration for Good Acoustical Condition in a Classroom

Room Surface	Material type to be used	Approximate area & configuration	Percentage absorption (%)
Floor	Carpet	Whole floor	Light weight or higher thickness (40%)
Ceiling	Sound absorptive ceiling panels	40% of ceiling area around the periphery	40% to 60%
		60% of central area	Reflective material (10%)
Wall	Gypsum or other smooth plaster	Lower 25% of the wall area	Smooth finishing (10% to 20%)
	Sound absorptive panel or plaster	Middle 50% of the wall area	(20% to 30%)
	Sound absorptive panel	Upper 25% of the wall area	(40% to 50%)

Source: Mir and Abdou, (2005)

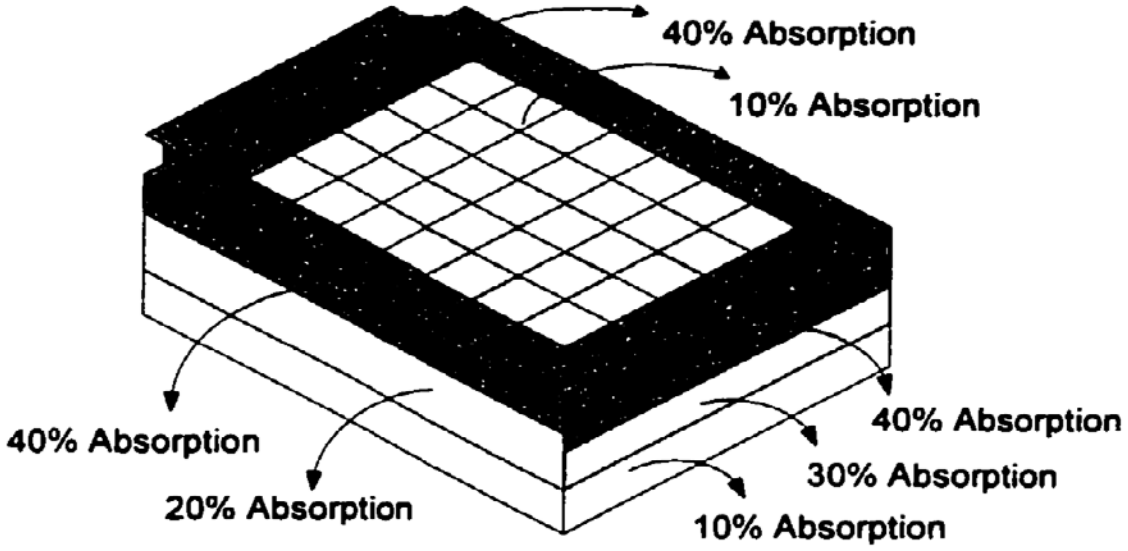


Figure 3.19 The developed smart classroom model showing the best overall sound absorbing material placement and absorption characteristics

{Source: Mir and Abdou, (2005)}

3.4.3 Classroom Indoor Air Quality and Thermal Comfort

A. Classroom Thermal Comfort

Indoor temperature in university classrooms is affected by heat from students' bodies, lights, computers and solar gain. Air temperature that feels comfortable will vary according to the time of day, the outdoor temperature and the activities of the students. Classrooms should be maintained at 18–20°C (BRANZ, 2007b).

B. Window Shades

To reduce direct sun glare and penetration of direct solar beams in the form of shortwave radiation to the interior part of the classroom through glazed openings, all the windows in the model university classroom need to be covered with window shades in the form of internal blinds.

C. Model University Classroom Indoor Air Quality Strategies

The indoor air quality standards and strategies are logically classified into the following categories:

1. HVAC System

The position of HVAC system in determining the level of indoor air quality in university classroom can never be over emphasized. HVAC should be well designed and maintained to deliver healthy and clean air to the conditioned space. The following strategies should be adhered to in respect of university classroom (EPA, 2010).

- When specifying a new classroom, the designer has to ensure that the Heating Ventilation and Air Conditioning (HVAC) system can provide a minimum of 450 cfm (based on 30 occupants at 15 cfm/occupant) of outside air and heat and cool this volume of outdoor air at design outdoor temperatures for the specific geographic location where each classroom is installed.
- Installation of an outdoor air intake must be specified as part of the exhaust system. Lack of an exhaust in the HVAC system with an outdoor air intake will result in inadequate removal of pollutants from the room.
- Outdoor air should be supplied continuously when a classroom is occupied.
- Demand-controlled HVAC package systems should operate only when the temperature of a space is different from the thermostat's set point. In order to provide a continuous outdoor air supply, it is important to ensure that the HVAC thermostat fan switch is set to the "on" or continuous mode when occupied.
- Air filters are needed for protection of HVAC components and reduction of airborne dust, pollens and microorganism from re-circulated and outdoor air streams. Air filters should have a dust-spot rating between 35% and 80% or a Minimum Efficiency Rating Value (MERV) of between 8 and 13.
- Ensure that at least one supply air outlet and return air inlet are located in each enclosed area.
- Ensure that building air intakes are located away from any exhaust outlet(s) or other contaminant sources.
- Locate HVAC and air handler units as far away as possible from teaching areas to reduce noise.

- If specifying duct board or internal duct lining for thermal and/or acoustical control, be sure to consider the potential for uncontrolled moisture to enter the duct over the life of the system.
- Ensure that HVAC ducts and plenums have easy access for inspection and cleaning.
- Specify that low Volatile Organic Compounds (VOC) emitting building materials be used in construction.
- Install filtration (50 to 70 percent dust spot efficiency) in areas or systems subject to moisture.
- The American Society of Heating, Refrigerating, and Air-Conditioning Engineers recommends (Innovative Design, 2009):
    - Relative Humidity - 30% to 60% (ASHRAE 55-1992)
    - Temperature - 68 degrees to 78 degrees (ASHRAE 55-1992)
    - Ventilation Rate - minimum of 15 cubic feet per minute per person (ASHRAE 62-1989)
    - Carbon Dioxide - maximum 1000 parts per million (ASHRAE 62-1989)

2. Interior Material Finishes

- If carpet is specified, use carpet that has been tested under the Carpet and Rug Institute's Indoor Air Quality Carpet Testing Program (EPA, 2010).
- Do not use carpet in entryways to classrooms with direct outdoor access. Supply waterproof mats over carpeted entryways and other areas used for drying clothing and umbrellas (EPA, 2010).

3. Construction Methods and operation

- To prevent or help resolve indoor air quality problems effectively and efficiently, schools must ensure that recommended temperature and relative humidity ranges be maintained in the indoor air and that the HVAC system is working properly. Generally, temperature and humidity should be maintained within the comfort zone of 68 to 78 degrees and 30% to 60% relative humidity, depending on the season (Pennsylvania Department of Health, 2002).

- Monitoring for carbon dioxide (CO2) routinely will be useful for indicating when outdoor air ventilation may be inadequate.

4. Building Materials

The indoor air quality control strategies in relation to building materials has been addressed based on low emission characterization of various material, and furnishings as follows (Godish, 2001):

- Flooring materials should not exceed the maximum acceptable emission rate of 0.6 mg/h/m^2
- Floor coatings materials have to be carefully selected and should not exceed the maximum acceptable emission rate of 0.6 mg/h/m^2
- Wall covering materials should not exceed the maximum acceptable emission rate of 0.4 mg/h/m^2
- Wall coating materials should not exceed the maximum acceptable emission rate of 0.4 mg/h/m^2
- All movable partitions should not exceed the maximum acceptable emission rate of 0.4 mg/h/m^2

- Office furniture should not exceed the maximum acceptable emission rate of 2.5 mg/h/workstation
- The US Environmental Protection Agency recommends Radon - maximum of four picocuries (pCi/L) per liter (Innovative Design, 2009)

5. Building Design

- Locate classroom away from locations where: (a) vehicles idle, (b) water accumulates after rains, or (c) there are other major sources of air pollution (EPA, 2010).
- Specify operable windows to provide user-controlled ventilation when needed.
- Consider covered entries with an exterior entry mat.
- Check that special-use classrooms (e.g., for chemistry, biology, fine arts, etc.) have local exhaust ventilation (e.g., hoods or window fans) and appropriate ventilation rates.
- It is recommended that for estimated occupancy, for 50 persons per 100 m^2/per floor area is 12.5 (L/s) per person and 2.5 (L/s) per person outdoor air requirements (Wadden, and Scheff, 1983).

6. Others

- Specify complete documentation of operation and maintenance requirements.
- Define a level of indoor air quality desired during occupied times; and place limitations on the use of materials, products, or systems that create biological, chemical, or physical IAQ problems and require monitoring equipment (Innovative Design, 2009).

CHAPTER FOUR

4 THE PHYSICAL AND ENVIRONMENTAL CHARACTERISTICS OF A MODEL UNIVERSITY CLASSROOM: A CASE STUDY OF KFUPM

4.1 Introduction

The importance of various attributes of the model university classroom on explaining its performance can never be over emphasized. These attributes include physical, technological, equipment and environmental constraints that facilitate in creating an enabling collaborative and interactive learning atmosphere for effective pedagogical delivery. As environment has greater impact on learning, students learn better in a well-designed classroom and can be distracted by a poorly designed space (Knirk, 1987; Gifford, 1976) cited in (Emmons and Wilkinson, 2001).

An interactive interview was conducted among some selected instructors and students in order to have their input on the suitability or otherwise of the various attributes suggested to be provided in the model university classroom. Some potential instructors with King Fahd University of Petroleum and Minerals (KFUPM) were selected based on certain criteria including faculty members recommended by the Deanship of Academic Development (DAD) based on related research work they conducted, Best Teaching Awards faculty members, English Language instructors, and others that were known as proponents of collaborative and interactive learning. At least senior level or graduate students were interviewed in every department at KFUPM. Due to the nature

of the research problem, it required responses from interested sectors of the academic community to avoid irrelevant responses.

Apart from the interview survey, another survey has been conducted by (DAD) on the performance of the smart classroom at KFUPM in 2008. The outcome of this has been received from (DAD) and some of the results that are related to this study will be used in the process of analysis.

4.2 Interactive Interview Survey Design

The interactive interview survey questions were developed to acquire an input from the university faculty members and students on the essential issues including classroom physical set up, seating arrangement, equipment technology and indoor environmental quality of the three developed options.

4.3 Content of the Interactive Interview

The sample of the interactive interview survey is shown in APPENDIX-A which is divided into two sections. The first section covers the general information about the respondent such as name, department, rank, address, and years of experience. The second section contains the general characteristics of the model university classroom and it is divided into six areas including; the respondents preference between the traditional and collaborative classroom, classroom physical set-up, seating arrangements, equipment/technology, lighting/acoustic and suggestions of any modification from the respondents to the proposed model classroom.

4.4 Data Collection Procedure

Due to the nature of the study that has to do with architectural drawings that require clear explanation for the respondents to understand the idea, the interview was conducted with all the respondents' faculty members and students individually in their offices and classrooms. This provided an opportunity for the respondents to ask questions about anything that needed clarification in the interview questionnaire. The first thing after meeting a potential respondent was the explanation of the entire idea which is presented in 2D and 3D attached to the interview questionnaire. Some respondents attended to the interview request right away while others asked to come back later for them to better comprehend the idea or because they had urgent things to perform at that time. The interview was conducted for a period of three weeks and ended with pursuing all the respondents that had pending survey forms for collection.

4.5 Result Analysis and Discussion

4.5.1 Respondent General Information

The first segment of the interactive survey questionnaire includes respondent's general information including name, rank and years of experience. The respondents are classified in terms of their years of experience in the classroom. Based on the results of the interview survey, the faculty respondents can be classified into three categories according to their number of years of experience in the academia: with less than 9 years of experience, with 10 to 19 years of experience, and with more than 20 years of experience as shown in **Figure 4.1.** It is obvious that more than 40% of the faculty

interviewed have classroom experience ranging from 10 to 19 years, while 36% have 1-9 years of classroom experience and 21% have classroom experience of above 20 years.

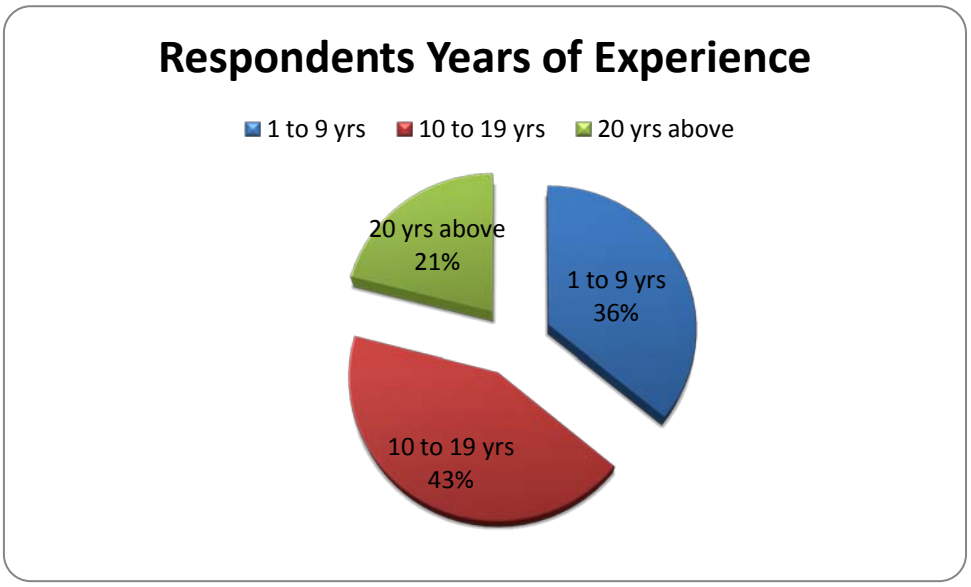


Figure 4.1: Respondents Years of Experience (course instructors)

The respondents among students were chosen among the final year undergraduate and graduate students cutting across all the colleges of King Fahd University of Petroleum and Minerals. This is due to the nature of the research which requires the inputs of experienced students that can make a difference in addressing the issues under consideration.

4.5.2 Justification of Sample Size and Quality

4.5.2.1 Sample Size

Sample size determination is often an important step in planning a statistical study and it is usually a difficult one. The most important aspect is the study sample must be of

adequate size, relative to the goals of the study. It has to be not too big or small, as an undersized study can be a waste of resources for not having the capability to produce useful results, while an oversized one uses more resources than are necessary. In an experiment involving human or animal subjects, sample size is a pivotal issue for ethical reasons. An undersized experiment exposes the subjects to potentially harmful treatments without advancing knowledge. In an oversized experiment, an unnecessary number of subjects are exposed to potentially harmful treatment, or are denied a potentially beneficial one (Russell, 2001).

Judgement sampling has been adopted in the study, as it provides all the necessary requirements to arrive at an acceptable and reliable outcome. Judgment sampling is a common non-probability method. The researcher selects the sample based on judgment of certain selected measures. This is usually an extension of convenience sampling. For example, a researcher may decide to draw the entire sample from one "representative" city, even though the population includes all cities. When using this method, the researcher must be confident that the chosen sample is truly representative of the entire population. (StatPac, 2010).

In the current study, the sample was selected based on departmental level, at least two course instructors and students have been selected from each department of the King Fahd University of Petroleum and Minerals (KFUPM) and some key actors in academic developments, such as Deanship of Academic Development, have been contacted for their input. Furthermore, course instructors that scored the best academic awards in all departments and some instructors that displayed interest in the area either by publishing an article, presenting related papers or implementing collaborative and interactive learning practically in their classrooms are also considered. The survey was

conducted in the form of an interview by meeting every instructor in his office for discussion. Then, the major and important points from the interview have been noted. Hence, the sampling strategy adopted has provided an opportunity to go round entire departments in the university to engage instructors and students in thorough discussion about the subject matter.

4.5.2.2 Sample Quality

The quality of samples to be surveyed in a study is one of the major factor that can ensure reliability if the study outcome. The quality of the samples selected for the interview in this study is through respondents past experience in collaborative and interactive pedagogical delivery. This is due to the fact that the nature of the research is so complex that one cannot respond to some questions without prior knowledge of the area. In terms of course instructors, the selection is based on past experience like publication, administrative duty and practical collaborative and interactive pedagogical delivery. While the selection of senior and graduate students was informed by the years they have spent in the classroom going through various instructional delivery methods compared to other sets of students in the junior level. Hence, senior and graduate students have at least acquired the required experience to respond to the questions in the interview.

4.5.3 Model University Classroom

A. Collaborative and Interactive Versus Traditional Classroom

“The term "collaborative learning" refers to a student centered instruction method in which students at various performance levels work together in small groups toward a

common goal, while interactivity is one in which students participate as equal partners in an ongoing discovery process within and beyond the level of the classroom. A traditional classroom, on the other hand, is a the teacher centered one in which the instructor has the total control of the classroom while students remain passive listeners.

When the course instructor respondents were requested to respond to their opinions to the interview question *"Is Collaborative and Interactive learning better than Traditional Learning"* out of 24 replies from interviewees, more than 91% of them said 'Yes', 0% of them answered 'No' and almost 9% are 'Unsure' as illustrated in **Figure 4.2**. In terms of students, the result of the interview confirms that out of 27 students interviewed about 89% of them have agreed with the statement *"Is Collaborative and Interactive learning better than Traditional learning"* while the remaining 11% were "Unsure" about the statement and there is no single disagreement with the statement, as illustrated in **Figure 4.2.**

Therefore, the researcher's assumption of the potential interviewees support for collaborative and interactive learning is true because of the high percentage of course instructors and students who preferred collaborative learning to traditional learning. While some course instructors that have an interest in both learner centered collaborative and teacher centered traditional learning style chose 'Unsure' based on the conversation they encountered with the researcher, they are proponents of both styles as they said both methods have their own strong points. This is due to the fact that some instructors used to feel happy to see their students passively listening to them while they remained the only active body in the classroom. But these types of

instructors at the same time like to collaborate and interact with students in some other academic activities, especially if students call or visit them in their offices.

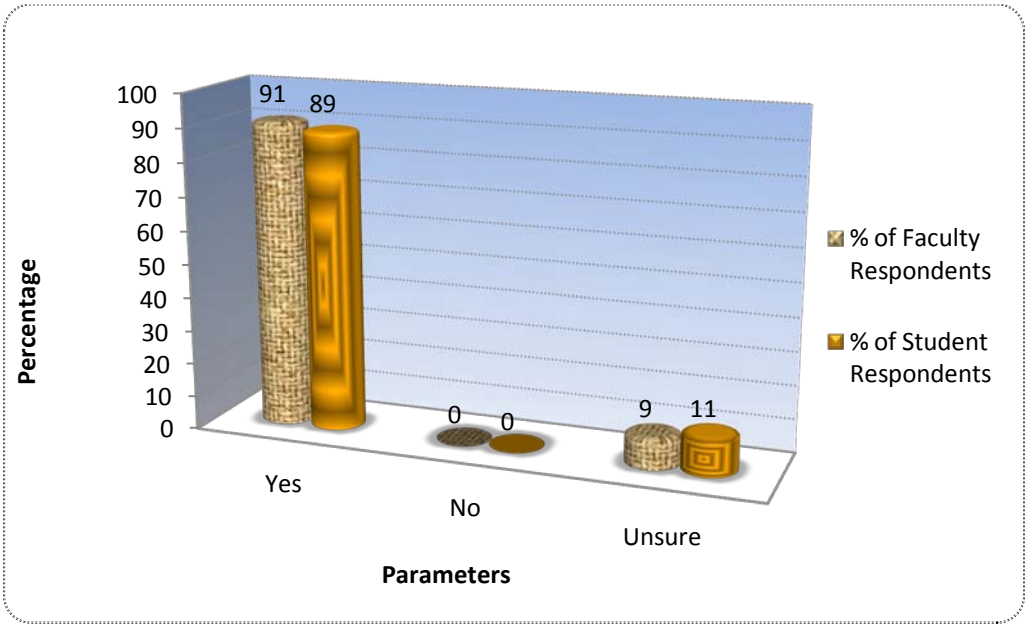


Figure 4.2 Response about Collaborative vs. Traditional Classroom

B. Classroom Physical Set-up and Shape

The physical set-up of the classroom includes the seating arrangement, positions and directions of electronic white/marker boards, dropdown display screen, podiums/lectern, IT corner, storage cabinets, position of entrance and general circulation in the classroom. While classroom shape referred to the geometrical form of the classroom including square, rectangle, or polygonal shapes. Class size is an important factor in school design and drives a host of costly facility-related issues that are part and parcel of the school building's planning, design, construction, cost, maintenance, and operation (Schneider M. 2002).

When a question was posed in the interview to the instructors respondents on the suitability of the proposed model university classroom physical set-up and shape; out

of 26 potential replies from interviewees, more than 61% of the respondents agreed with the classroom model presented in the interview survey and around 39% disagreed with some of the ideas presented in the model classroom as shown in **Figure 4.3.** Both instructors and student respondents have commented and proposed some suggestions to the model university classroom presented to them in the form of 2D and 3D drawings. These suggestions will be considered based on their frequency and equally importance in achieving a functional, conducive and cost effective collaborative and interactive learning environment. In terms of student respondents, 100% of those interviewed have totally agreed with the classroom physical set-up and shape presented in the interview survey as shown in **Figure 4.4.**

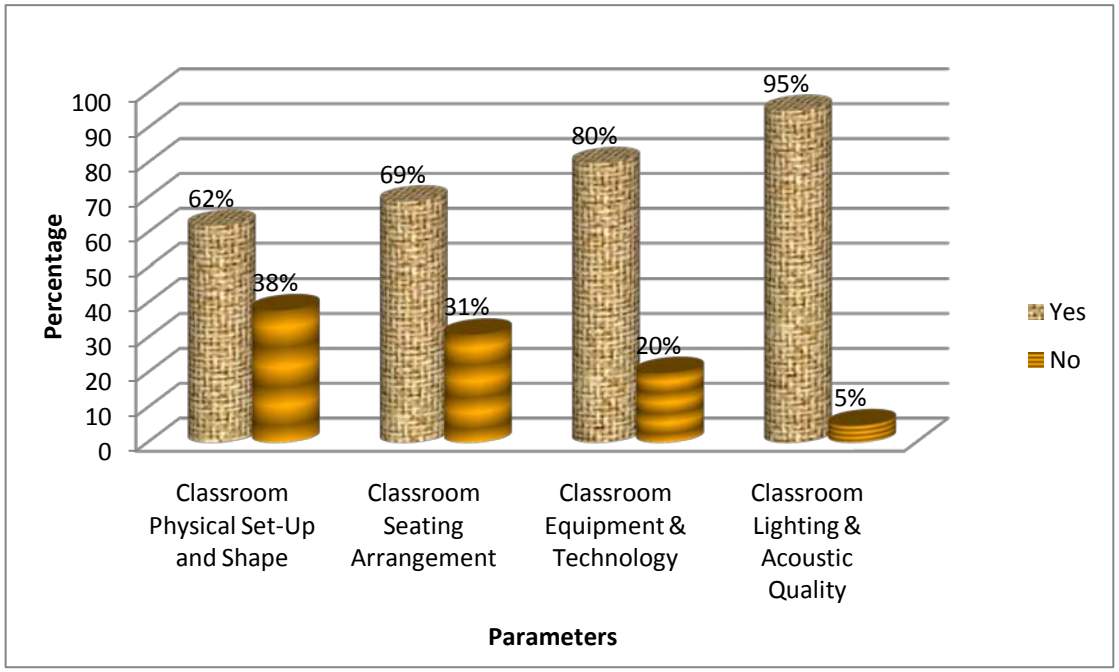


Figure 4.3 Instructors Responses about Factors Affecting Classroom Design

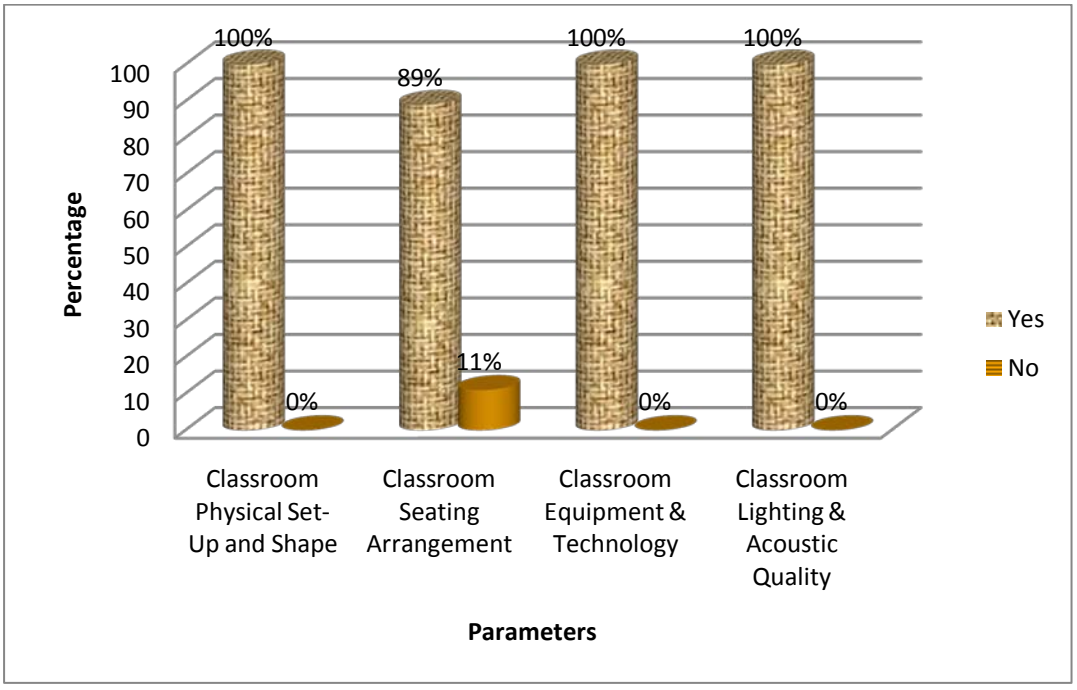


Figure 4.4 Students Responses about Factors Affecting Classroom Design

C. Classroom Seating Arrangements

The seating arrangements adopted in the model university classroom includes Hexagonal, Trapezoidal, and Triangular shapes with swivel stands to provide the required flexibility for easy reconfiguration to suit any type of collaborative and interactive learning style that will be employed. These tables are adjustable in height and equipped with electrical and internet plugging spaces for easy connection of laptops to the power and internet network ports. All the chairs in the classroom are also adjustable in height and flexible with swivel stands since effective communication in the classroom is essential to the success of both the student and the teacher (McCorskey, and McVetta, 1978).

When the course instructor respondents were asked about their views on the adopted seating arrangement, out of 26 replies from interviewees, almost 70% have accepted all three proposed table shapes and possible configuration alternatives, while around 31% responded that they have some reservations, especially on the arrangements as illustrated in **Figure 4.3.** Based on the researchers' interactions with the second set of respondents who expressed their disagreement with the seating arrangements, they have suggested some seating arrangements which will be discussed based on their frequency and importance. 89% of respondents among the students have replied positively when the question with respect to seating arrangement in the classrooms was posed to them, which indicates their agreement with the table proposals and arrangement systems presented. 12% were not in agreement with some of the proposals presented to them, such as the number of students per grouping and seating orientation, as illustrated in **Figure 4.4.**

D. Classroom Technologies and Equipment

The classroom technologies employed in the proposed model university classroom includes; videoconferencing and Telecollaboration technologies, internet connection, online collaboration tools (Wikis, Blogs, WebCT), smartcard reader technology to enable students to register their attendance in groups or classes, digital video cameras situated in the front and rear of the classroom for mobile students to track and see what is physically happening in the classroom, ceiling mounted loudspeakers, and overhead data projectors. New applications of information and communications technologies, such as email, Internet, the World Wide Web and video-conferences, have created many new communication possibilities for schools (Janet, 1999). In a classroom connected to the Internet, communication over distance is simpler than ever before. The types of equipment used in the proposed model university classroom includes; electronic whiteboards with capability of sliding to various direction of the classroom, LCD TV display screen for videoconferencing and Telecollaboration, ceiling mounted projector screen, table printers, copiers, telephone, and multimedia equipment.

When the 25 course instructors responded to a request on their view on the subject "Classroom Equipment/Technology", almost 80% accepted all the instructional equipment and technologies provided in the classroom, while 20% had some reservations, especially with suitability of some of the equipment and technologies provided in the classroom, as illustrated in **Figure 4.3.** Both groups of respondents have commented by suggesting some important equipment and technologies that will better facilitate the pedagogical delivery in a collaborative and interactive learning environment such as flipcharts, clickers, smart touch screen/interactive boards and online collaborative tools. These suggestions will be assessed in terms of their

suitability and considered based on their frequency and importance to the subject in question.

In terms of student respondents, 100% of those interviewed have responded positively to the classroom Equipment/Technology. Hence, they are in total agreement with the classroom equipment and proposed level of technologies presented in the interview survey as shown in **Figure 4.4.**

E. Input From Educational Technologies

The educational technologies department of KFUPM has provided results of previous studies showing faults/complaints related to smart classrooms within the university. A total of 67 faults/complaints were received from course instructors teaching in different academic buildings where smart classrooms are available. The faults/complaints were categorized into six types with their percentage of occurrence (DAD, 2008):

1. Computer related problem (55%)
2. Network problem (7%)
3. Peripheral not working (9%)
4. Projector problem (18%)
5. Screen not working (9%)
6. Software related problem (2%)

Figure 4.5 illustrates the percentage of count of different complaints received from the studies conducted by (DAD, 2008). It's clear from the figures that computer related problems were the highest (55%). The next most common problem reported was with the projector (18%).

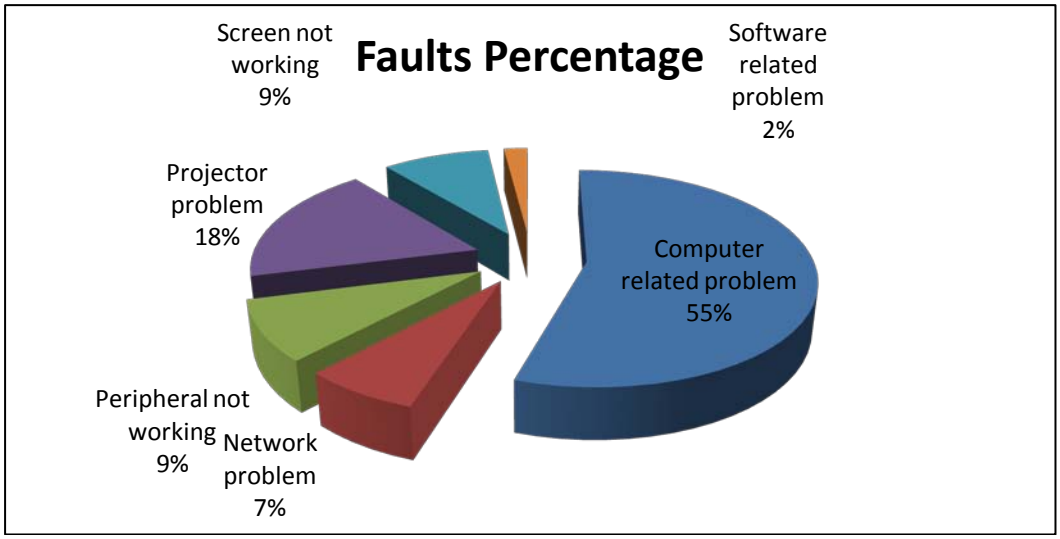


Figure 4.5 Count of Types of Fault/Complaints Percentage in KFUPM

Based on the above result, there is a need to provide the model university classroom with efficient, durable and superior computers and projector systems which are among the most important types of instructional equipment in the classroom according to the survey conducted as illustrated in **Figure 4.9**

F. Classroom Lighting and Acoustical Qualities

The lighting and acoustical issues of the model university classroom were considered based on adopting already existing standards in the literature. Lighting and acoustic qualities are the two major environmental factors that have a direct effect on the students' achievements in the university classroom. A major challenge is to provide classroom lighting that increases teacher control, reduces glare, improves lighting and optimizes visual comfort while minimizing lighting power and energy use to their lowest possible levels (Project FROG team, 2008). Many studies have shown the effect of lighting in a classroom on students' performance (Heschong Mahone Group, 2003), (New Building Institute, 2002)

The lighting standard adopted in the model university classroom is that of the PIER Lighting Research Program, (2005), and the Illuminating Engineering Society of North America (IESNA) due to the fact that apart from the provision of the required lighting level in the university classroom, the PIER research program lighting standard has also considered energy conservation issues and achieved the required illumination level with minimum amount of energy without compromising the students lighting comfort requirements as discussed in detail in the previous chapter.

Acoustical comfort is one of the essential factors for the development of class activities, especially those that require a high level of concentration (Kruger and Zannin 2004). The research linking acoustics to learning is consistent and convincing: good acoustics are fundamental to good academic performance (Schneider M. 2002).

The acoustical standard adopted in the model university classroom is that of the Acoustical Society of America by (Seep et al. 2000), which was validated by (Mir and Abdou, 2005) in their studies "Investigation of Sound-absorbing Material Configuration of a Smart Classroom Utilizing Computer Modelling." These standards were adopted in the model university classroom due to their research which was focussed and directed towards a detailed analysis of classroom acoustics compared to other existing standards, which either deal with schools in general or some aspect in the classroom only. The two acoustic standards have been discussed in detail in the previous chapter.

When the 20 respondents among the course instructors were asked on their views on the lighting and acoustical performance of the model university classroom, almost 95% accepted all the acoustical strategies of the adopted standards in the classroom,

while only 5% had some reservations, especially with the lighting system standards adopted in the classroom as illustrated in **Figure 4.3.** However, in terms of student respondents, 100% of those interviewed agreed with the lighting and acoustical quality standards adopted for the model university classroom as shown in **Figure 4.4.**

G. The Ranking of Students Desk Alternatives

Three types of students' desk were adopted in the proposed model university classroom of the future, including Hexagonal, Trapezoidal and Triangular shapes with swivel stands to achieve the highest level of flexibility required to manoeuvre and reconfigure the tables to suit any collaborative and interactive learning arrangement that will be adopted in the classroom.

The course instructors' respondents were requested to rank the three desk options in order of their suitability and flexibility; the evaluation terms used along with their corresponding weight were "1st position (best)" with 3 points, "2nd position" with 2 points, and "3rd position" with 1 point. The mean response for each of the performance elements was calculated in such a way that the number of responses for each evaluation term will be multiplied by the corresponding weight of that evaluation term and the results converted to a percentage. The result of the computation shows that option "B" (Trapezoidal shape) table scored the highest percentage of 50% and 46%, for faculty and students respectively followed by option "A" (Hexagonal shape) table, which scored 33% and 27% for faculty and students respectively, while option "C" (Triangular Shape) table score 17% and 27% for faculty and students respectively. The result of the ranking is shown in **Figure 4.6.**

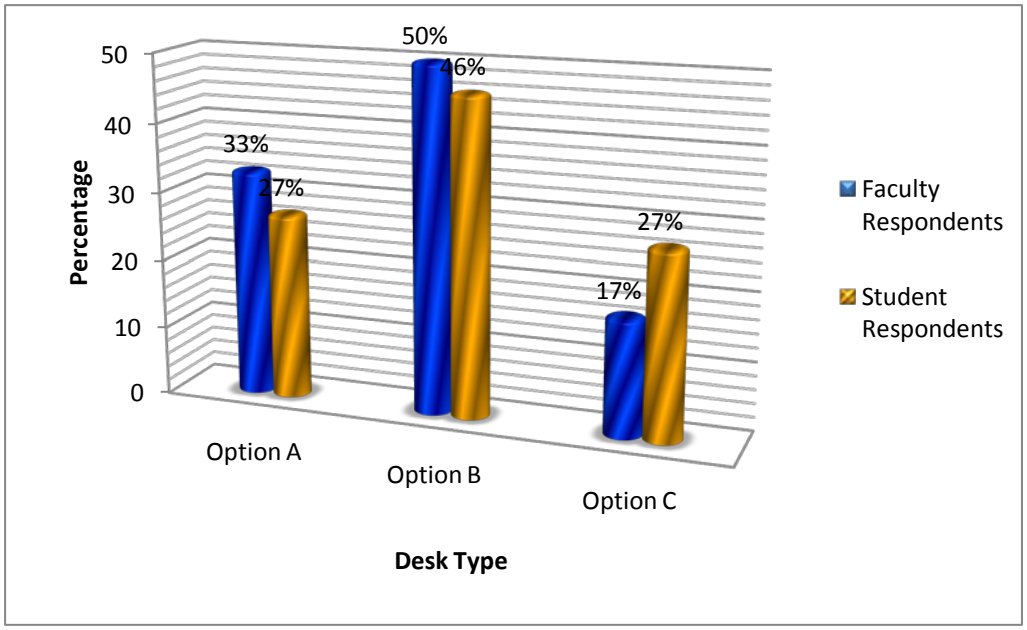


Figure 4.6 Responses about Classroom Desk Ranking

H. Analysis of Suggestions and Improvements

The reaction from the potential respondents has been analysed based on various classroom aspects in a logical manner. The star (*) signs in front of the major headings show the rate of importance and the amount of weight received by the parameter in the interview. The more the number of the stars, the more responses received for the parameter.

1. Classroom physical set-up and shape

a **Flip chart:** *** From the feedback received from course instructors, a strategic percentage of respondents have suggested the use of flip charts and subsequently to reduce the number of whiteboards and projectors. A Flip chart is a visual aid consisting of a large pad of paper mounted on an easel, used to present information. This will enable various groups in the classroom to write and record information and discuss in a collaborative session.

b **Location of projector screens:** ** The issue of integrating projector screens and the whiteboard position has been raised by a group of interviewees. The major issue is to position the two in such a way that they can be used simultaneously without any one covering the other. This problem has been solved in the front by the provision of a central projector screen and whiteboard in the model university classroom, but not addressed in the remaining screens and whiteboards locations. It will be solved by locating the projector screen tilted in the corner and the whiteboard covering the centre of the front wall.

c **Numbers of projector screens:** *** A strategic percentage of the respondents have commented on the number of projector screens and whiteboards in the model university classroom. The respondents suggested that considering the size of the classroom, the number of students to be accommodated, and cost effectiveness, the number of projector screens and whiteboards should be reduced to one or two.

d **Demonstration Tables in the Centre of the Classroom:** ** Owing to the fact that classroom furniture arrangement is largely dependent on the nature of course delivery and learning style to be adopted in the classrooms, some respondent, especially in engineering, have suggested the provision of demonstration tables in the centre of the classroom for demonstration purposes in science and engineering classes. Perhaps, this is the major reason why modular and flexible furniture has been proposed in the model university classroom. Hence, this problem has already been addressed in the physical set-up adopted in the classroom in which the flexible swivel table will equally be reconfigured to the required shape in the centre of the classroom to be used for the desired purpose.

e **Classroom Shape:** * In most universities and other institutions of higher learning, the shape of the classroom is largely dependent on the general shape of the academic building. Due to cost constraints related to the construction of polygonal shape classrooms like hexagonal and octagonal shapes, it is very difficult to realize hexagonal and octagonal classrooms in practice. Some of the respondents have suggested the use of a hexagonal or octagonal shaped classroom as it will be more appropriate in fostering collaboration compared to square or rectangular shapes which are limited in their opportunities for re-arrangements of elements. Hence, the main idea of modelling the university classroom for collaborative and interactive learning is not to remain as knowledge in theory, but to propose some sort of practical but futuristic idea that can make a difference in the collaborative and interactive pedagogical delivery in our universities.

2. Classroom Seating Arrangements

a Number Students/Chairs per Collaborative Group

It is a normal practice to divide the students in a classroom into different groups in a collaborative learning setting. These groups might be made of two, three, four, or more as the case may be and sometimes even the entire class will resolve as a single group to collaborate on certain issue that requires the entire classroom to participate. The idea of adopting a flexible modular supported with swivel stands is to create a sort of simplicity in the reconfiguration of the seating arrangement. Hence, the issue of number of students or seats per group has already been solved by the system adopted in the classroom.

3. Classroom Equipments and Technology

a **Clickers:** ** Current research describes the benefits of active learning approaches. Clickers, or student response systems, are a technology used to promote active learning. Most research on the benefits of using clickers in the classroom has shown that students become engaged and enjoy using them (Martyn, 2007). In case of voting on certain issues clickers will be very much appreciated in the classroom. Some respondents among the potential interviewees have suggested the incorporation of clickers with the various technologies used in the model university classroom. Due to its importance in facilitating collaborative pedagogical delivery, clickers will be adopted in the model university classroom. Some of the advantages of clickers in a collaborative and interactive classroom include; Clickers provide a mechanism for students to participate anonymously, decrease grading time by using clickers to collect student answers to quizzes and exams and helps integrate a "game approach" that may engage students more than traditional class discussion. With clickers, students have an input device that lets them express their views in complete anonymity, and the cumulative view of the class appears on a public screen. Each input device is numbered, however, so the instructor can download responses for recordkeeping after the class session ends.

b **Smart Touch Screen/Interactive Boards:** **** The SMART Board interactive whiteboard is a touch-sensitive display that connects to the computer and digital projector. Using a finger, instructors and students can control computer applications, write notes, pull up charts and images, search the Internet, play videos and save their work in the classroom. A strategic percentage of potential interviewees have suggested the provision of an interactive whiteboard in the model university

classroom. Due to the frequency of recommendations from the received feedback and importance of the interactive whiteboard technology in collaborative instructional delivery, it will be adopted in the model university classroom of the future.

c **Online Collaborative Tools:** ** The employment of online collaborative tools in the university classroom is of great importance for collaborative pedagogical delivery in the classroom. A group of respondents have suggested the incorporation of various online collaborative tools like Web-based Course Tools (WebCT), blogs, and Wikis to enhance the collaborative capability of the model university classroom.

WebCT is a course management tool used to deliver web-based courses and to support Web applications for classroom courses. WebCT integrates communication tools, including a bulletin board, chat room, private e-mail, and calendar on the WebCT site. In addition, graphics, video, and audio files can be incorporated into a WebCT site. Such features can facilitate interaction between faculty and students (Morss, 1999) as cited in (Burgess, 2003). These tools are available only to the students and instructor of the course, thus protecting the intellectual property of the instructor, the privacy of the student, and the course content from external parties.

WebCT also provides instructional tools to support course content such as a glossary, references, self-test, and quiz module. Students, too, can place assignments and other materials in WebCT for courses in which they are enrolled. WebCT also gives faculty course management tools for grading, tracking student interaction, and monitoring class progress. Students access their Web CT course materials using a Web browser from any computer connected to the campus Intranet or Internet (Morss, 1999).

Educators are recognizing that in addition to providing authentic and flexible learning environments, computer-based resources can be an ideal location for reflective and collaborative learning. Blogs are one example of this type of resource. Like other on-line environments that encourage reflective thinking, interactivity, and deep learning where students interpret information and apply their knowledge (Cashion and Palmieri, 2002, p.157), as cited in (Pinkman, 2005), blogs are being used to enhance and supplement classroom environments. Blogs, however, are innovative in that they require learners to interact with one another, not just the computer. For blog users, or bloggers, the computer is simply the medium for communication. By encouraging interaction with people, blogging takes on a more communicative and interactive role (Pinkman, 2005). As most blog sites allow group blogs. Hence, these can be used for collaborative groups to record their progress and compare notes, which is a wonderful way to encourage students to reflect on their group's process.

A Wiki is a web communication and collaboration tool that can be used to engage students in learning with others within a collaborative environment (Parker and Chao, 2007). A Wiki is also Web tool that allows a group of people to collaborate on web writing and/or projects. It can be either public or private and has various forms and capabilities depending on the host site. They function best as a common site for people separated by distance or time constraints to collaborate on a project (Steele, 2008). Collaborative learning becomes even more powerful when it takes place in the context of a community of practice. A community of practice consists of people engaged in collective learning in a shared domain. Thus, learning becomes a collaborative process of a group. Wikis can serve as a knowledge platform for a community of practice where members of the community can share their knowledge with the group, put up

interesting pieces of information, work together, discuss issues, etc. (Schaffert, Bischof, et al., 2006) as cited in (Parker and Chao, 2007).

I. Most Useful Equipment and Technology in a University Classroom

When the course instructors were asked in the interview survey to list the three most important kinds of equipment and technology in the classroom as follows; *"In light of your professional/teaching experience, please list the three most useful kinds of Equipment/ Technology in collaborative pedagogical delivery"*, out of the feedback from 20 respondents to this question, a data projector had the highest response, selected by 17 respondents as one of the important pieces of equipment in the classroom, followed by a whiteboard with 12 points, internet connection with 10 points, computer with 7 points, podia with 5 points, LCD and multimedia equipment with 3 points each, videoconferencing with 2 points and a documents camera with a single point as illustrated by percentage in **Figure 4.9.**

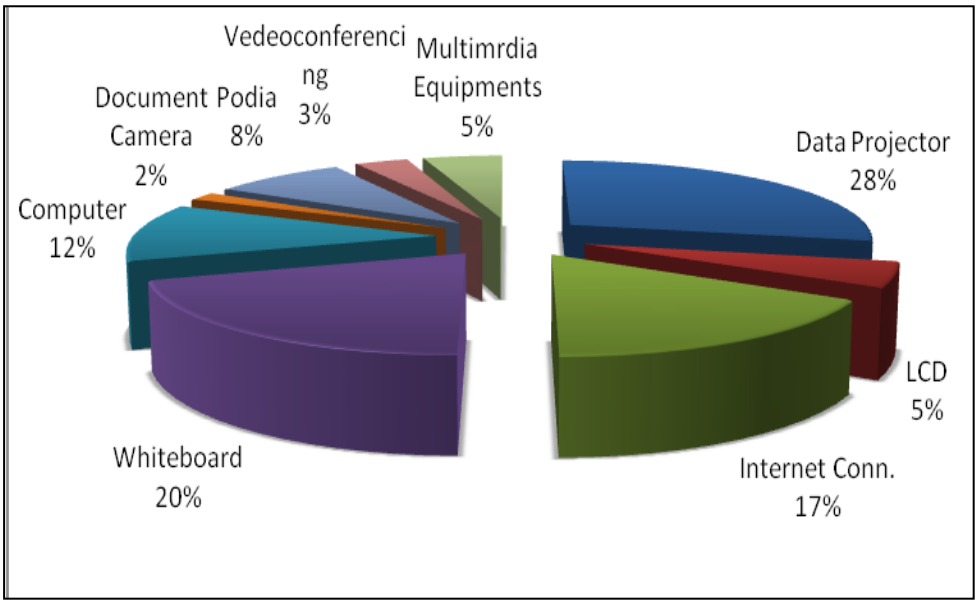


Figure 4.7 Responses with respect to most useful Equipment and Technologies in classroom

4.6 Methodology for Refining the Generic MUC

The following methodology will be implemented in refining the generic Model University Classroom to suit particular university learning environment, for either existing or new university classrooms. The flow diagram of the logical steps to be followed is illustrated in **Figure 4.8**

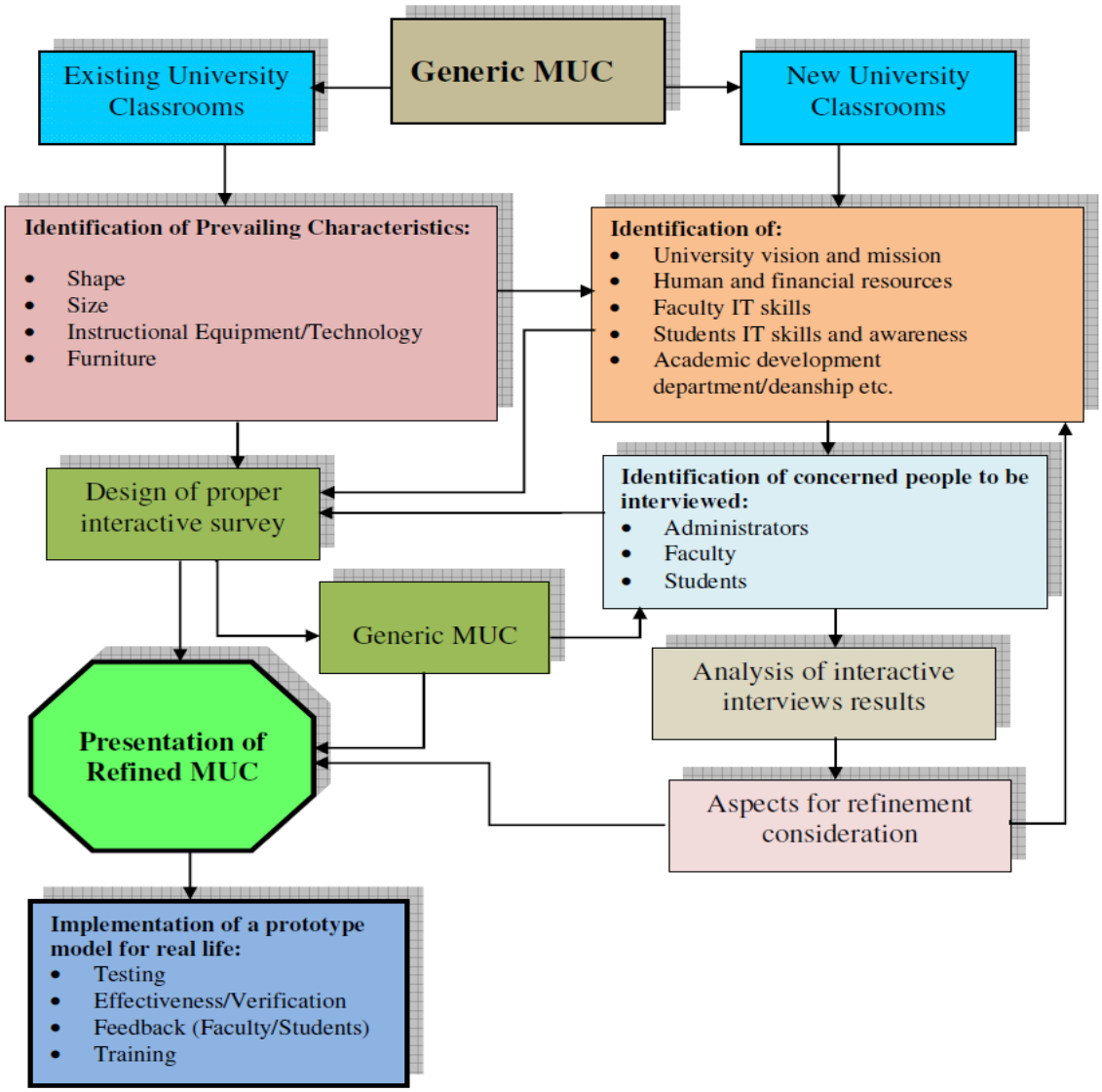


Figure 4.8 Methodology for Refining the Generic MUC to Suit Particular University Learning Environment

CHAPTER FIVE

5 THE MODEL UNIVERSITY CLASSROOM FOR COLLABORATIVE AND INTERACTIVE LEARNING

5.1 Introduction

This chapter deals with the architectural presentation of the model university classroom with all the modifications based on the interview feedback. The architectural designs are presented using a piece of software called Revit Architecture 2009. These designs include the floor plans, ceiling plan, sections and three dimensional views of the model university classroom.

5.2 Classroom Floor Plans

The proposed model university classroom floor plans presentation is aimed at illustrating the detailed physical set-up, furniture arrangements and pedagogical equipment to be used in the classroom. These plans will show the adoption of all the accepted comments and suggestions obtained from the interview feedback presented in chapter 4. Three floor plans of all the three students' desk options are presented in **Figures 4.1, to 4.13.** The three floor plans have the same physical set-up, equipment and instructional technology with different types of student's desks.

5.2.1 Option “A” (Hexagonal Desk) Configuration

The hexagonal desk configuration alternative consumes less space compared to the trapezoidal shape, with smaller group configurations and more space as the group increases to above four desks. It consumes more space compared to the triangular configuration. It has more opportunities to arrange in different directions due to its six sides. It was ranked as the second best in terms of flexibility and suitability to be used in the collaborative and interactive classroom by both faculty and students**. Figure 5.1** illustrates some of the typical configurations with four and five students per group and **Figure 5.2** shows the 3D view of the hexagonal desk configuration and various configurations achieved.

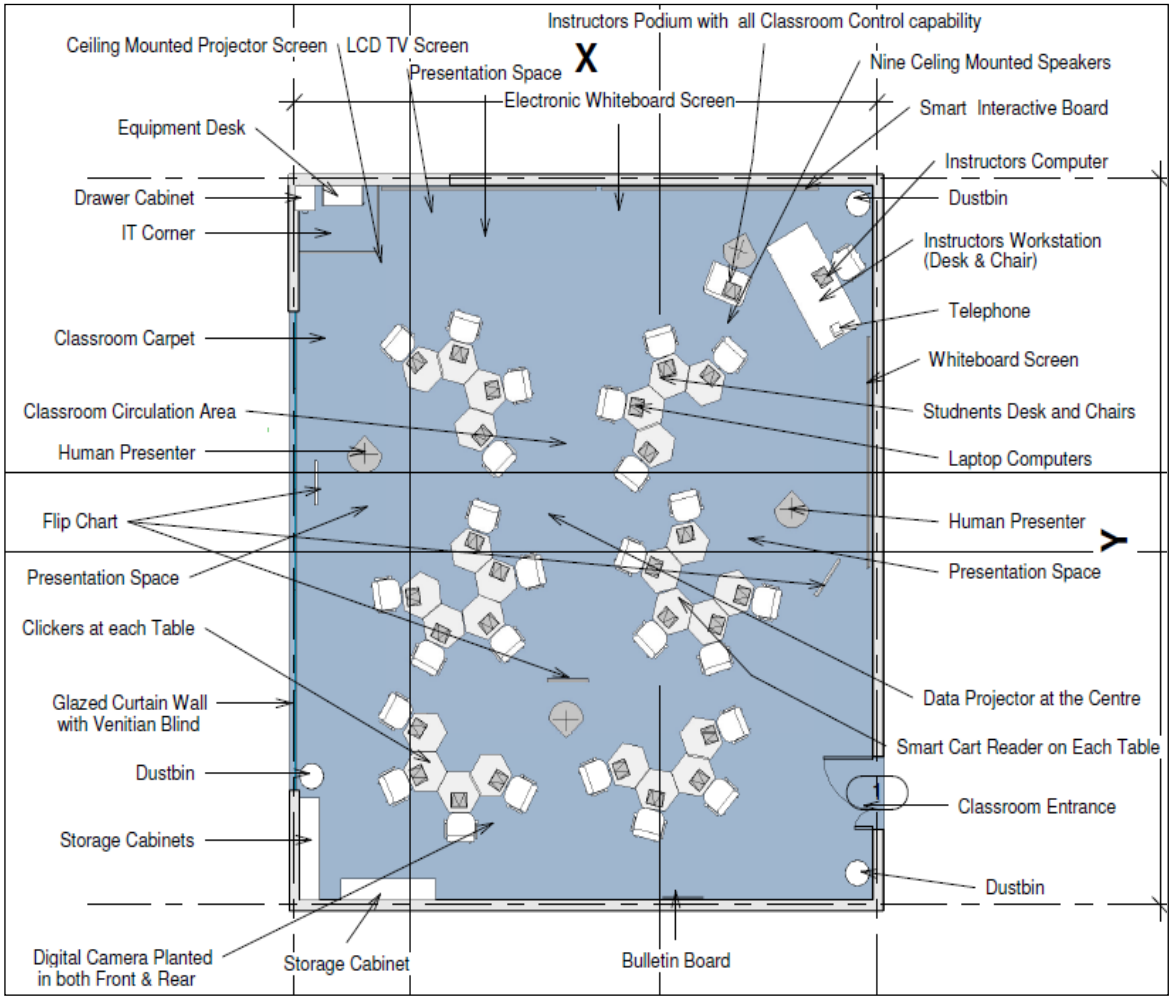
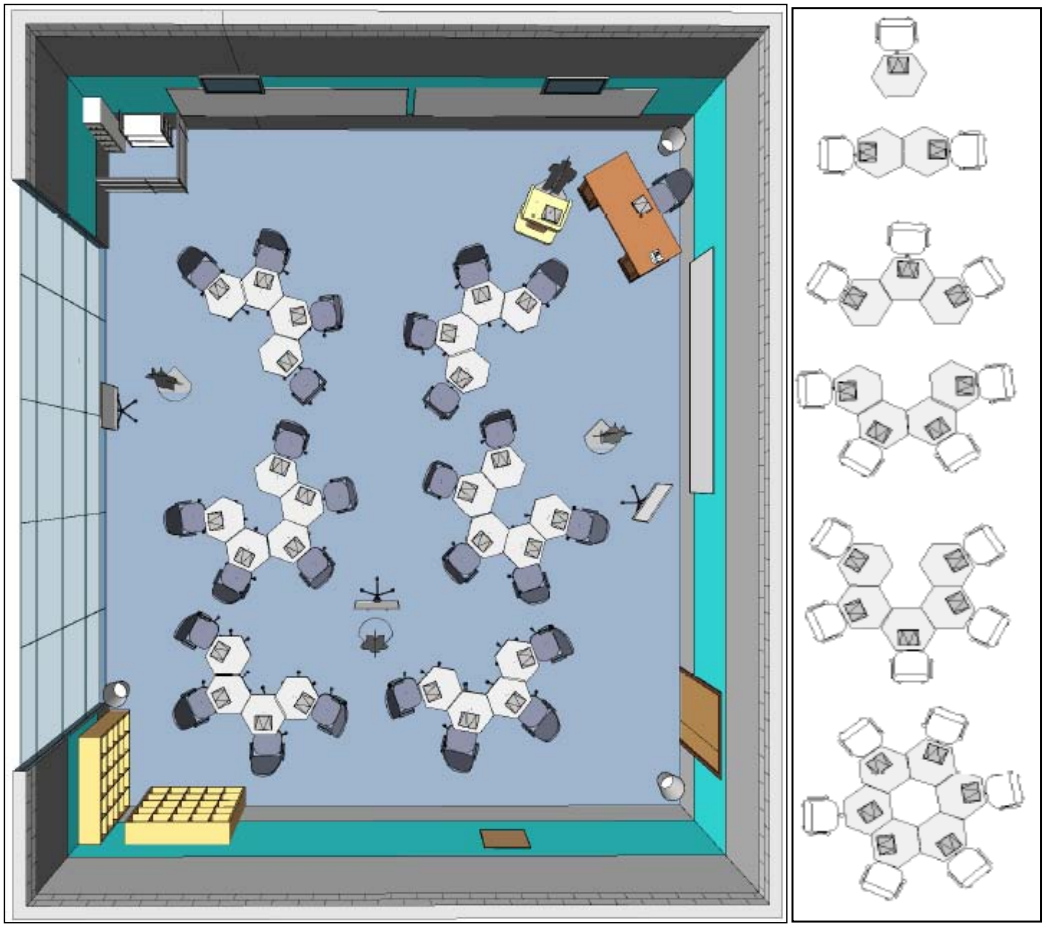


Figure 5.1 Typical Hexagonal Desk Configuration in Model Classroom

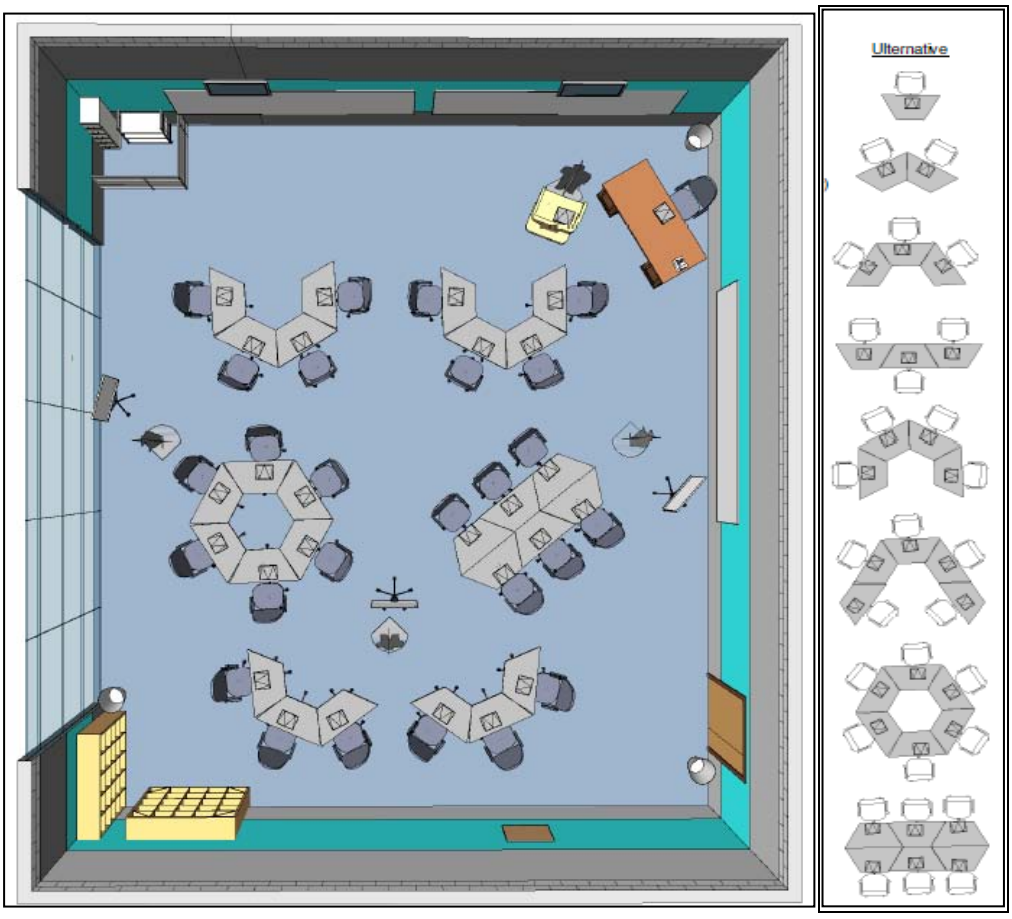


(a) (b)

Figure 5.2 (a) 3D View of the Hexagonal Desk Configuration in Classroom and (b) Various Configurations to be achieved with Hexagonal Desk

5.2.2 Option “B” (Trapezoidal Desk) Configuration

The Trapezoidal desk configuration alternative is one of the options developed to be used in the model university classroom, even though it consumes a larger space compared to triangular shape desk configurations. It was ranked as the best in terms of flexibility and suitability to be used in collaborative and interactive classroom by both instructors and students. It also has so many choices of arrangements to different configurations. **Figure 5.3** (a) and (b) illustrate some of the typical configurations and 3D view of the trapezoidal desk configuration and number of possible configurations achieved with the trapezoidal shape desk.

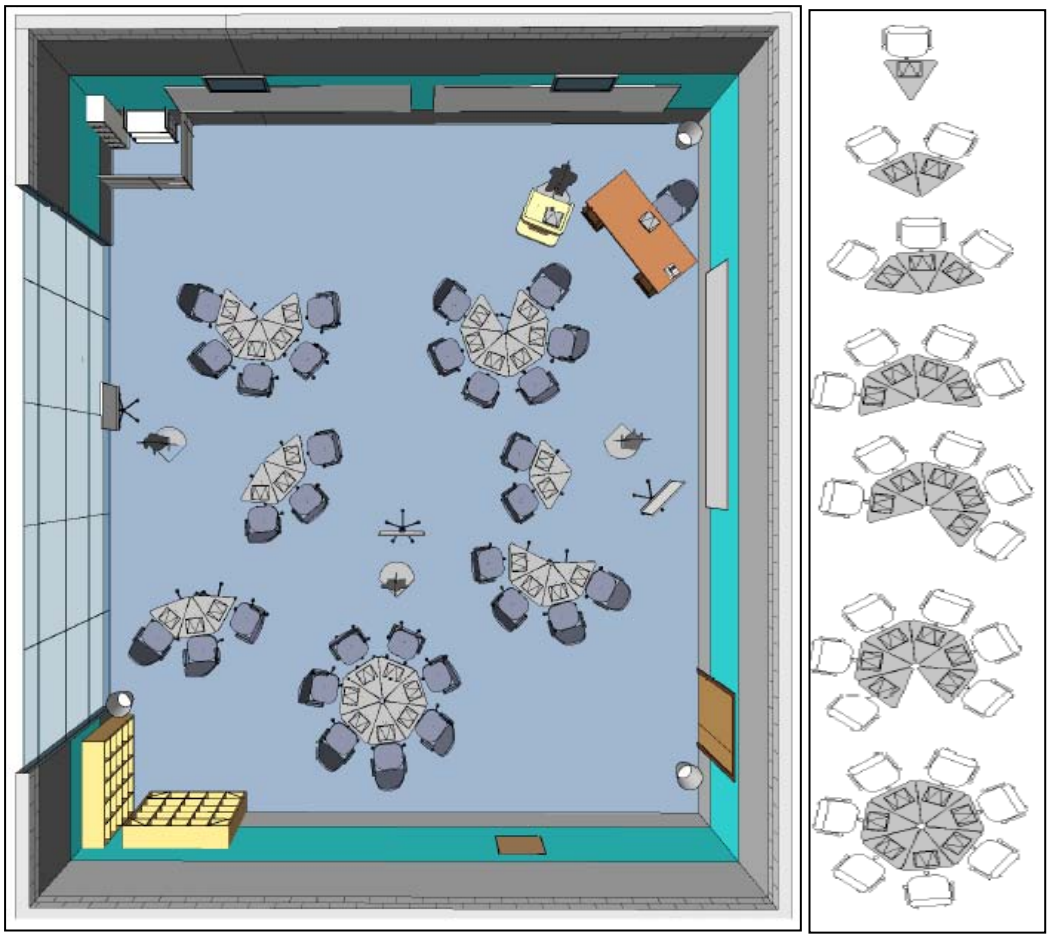


(a) (b)

Figure 5.3 (a) 3D View of the Trapezoidal Desk Configuration in Classroom and (b) Various Configurations to be achieved with Trapezoidal Desk

5.2.3 Option “C” (Triangular Desk) Configuration

The Triangular desk configuration alternative is one of the options developed to be employed in the model university classroom. It consumes the smallest space compared to hexagonal and trapezoidal shape desk configurations. It was ranked as the third best in terms of flexibility and suitability to be used in the collaborative and interactive classroom by instructors and second best by the students. It has fewer choices of arrangements to different configurations compared to hexagonal and trapezoidal configurations as it only has three sides. It also has the disadvantage of having the smallest working platform compared to the other two options. **Figure 5.5** illustrates some of the typical configurations achieved with triangular desk and **Figure 5.6** illustrates the 3D view of the triangular desk configuration and number of possible configurations achieved.



(a) (b)

Figure 5.4 (a) 3D View of the Triangular Desk Configuration in Classroom and (b) Various Configurations to be achieved with Triangular Desk

5.2.4 Model University Classroom Physical Set-up

The physical set of the model university classroom is characterised with state-of-the-art furniture and pedagogical equipment. The following is the furniture found in the classroom.

a **Students Desk:** Three different types of students' desk including hexagonal, trapezoidal and triangular configurations with swivel stands for easy movements and reconfigurations.

b **Students Chair:** A swinging students chair with swivel stands has been adopted in the model university classroom.

c **Electronic whiteboard:** An electronic whiteboard with the capability sliding horizontally is to be used in the classroom.

d **Instructors Podium:** Very light, easy to use and empowered with all the classroom lighting, sound and other equipment control system is to be used in the classroom.

e **Instructors Station:** The instructors' station includes the instructors chair, desk, telephone and computer for easy classroom management and instruction.

f **Flip Charts**: Three movable flip charts have been provided in the model university classroom to help the various collaborative groups in their discussions in the classroom.

g **IT Corner:** The IT Corner in the model university classroom is made up of all the video conferencing, internet and multimedia equipments and control systems.

h **Storage Cabinets:** The storage cabinets are to be used in the model university classroom to enable students keep their belongings while in the classroom to avoid disturbances and obstructions while reconfiguring classroom seating arrangements.

i **Dustbin:** Three dustbins have been provided in the classroom to avoid littering of refuse everywhere.

j **Bulletin Boards:** A notice board will be used in the classroom to serve as a sort of information delivery to the students.

k **LCD TV Screens:** LCD TV Screens are to be used in the model university to facilitate videoconferencing, Telecollaboration and other multimedia display activities in the classroom.

l **Interactive Smart Board:** The model university classroom has been equipped with a smart interactive whiteboard to provide the instructors with easy means of pedagogical delivery.

m **Printer and Copier**: The classroom is also equipped with a printer and copier for the utilization of the students and instructors.

n **Dropdown Projector Screens:** The model university classroom is equipped with two dropdown screens located in the front and the right side of the classroom.

5.2.5 Model University Classroom Equipment and Technologies

The model university classroom of the future is equipped with the modern state-of-the-are pedagogical equipment and technologies.

A. Classroom Instructional Equipments:

1. Basic (Minimum) Requirements

a. Audio System

b. Overhead Projector

c. Digital Video Camera (Angle Controllable)

d. Laptops

e. Ceiling Mounted Speakers

2. Additional Requirements

a. Smart card Readers

b. Lecture Recorder

c. Document Camera

d. Clickers

B. Classroom Instructional Technologies:

a Videoconferencing

b Telecollaboration

c Online Collaborative Tools Like WebCT, Blogs, and Wikis

5.2.6 Classroom Ceiling Plan

The ceiling plan of the model university classroom, apart from its architectural function of covering the unattractive part of the roofing system and creating a buffer zone between the envelope and the interior to reduce heat transfer, is also performing other functions like holding the sound speakers, dropdown screens, air condition diffusers, digital cameras, occupancy sensors, and daylight sensors as illustrated in **Figure 5.5**

The ceiling in the classroom is divided in two sections as shown in **Figure 5.5.** In the central part 10 % sound absorbing material or high sound reflective material is used to reflect a higher amount of sound in the classroom and in the peripheral area of the classroom 40% sound absorption material is used and these treatments have resulted in providing the required acoustic level in the university classroom (Mir and Abdou, 2005).

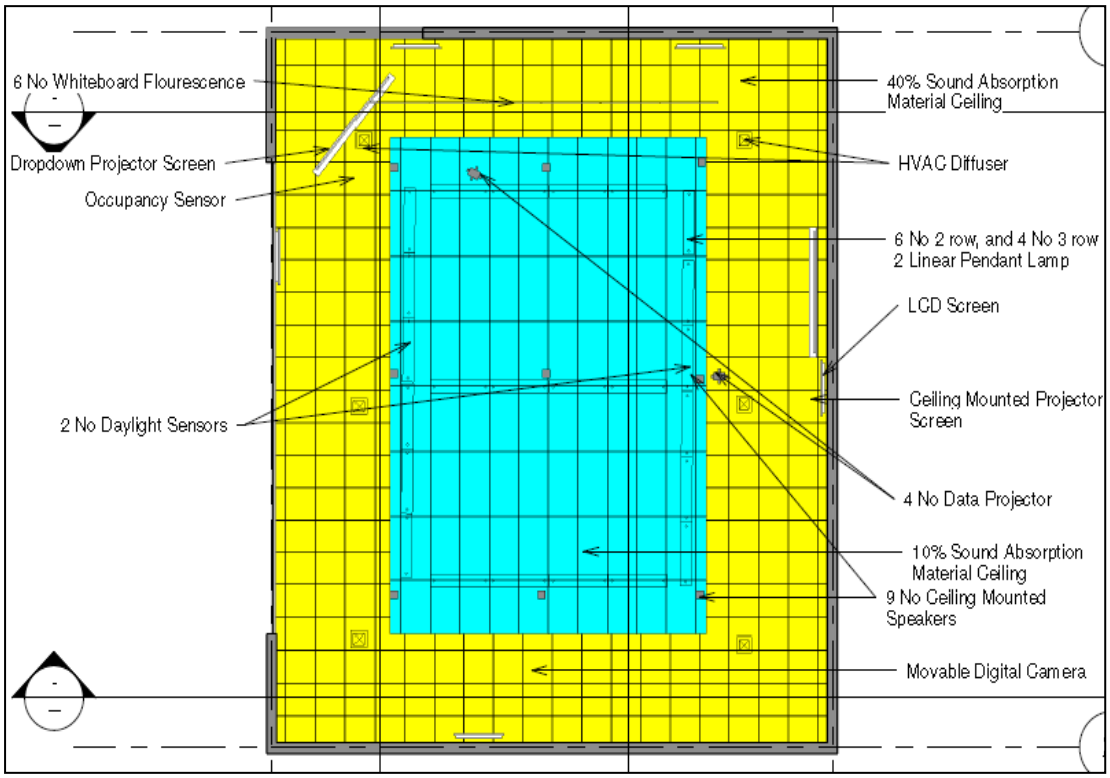


Figure 5.5 The Ceiling Plan of the Model Classroom

5.2.7 Classroom Sectional Views

The section views of the Model University Classroom were designed to illustrate the relationship between various furniture and equipment and the classroom itself. It more or less shows the actual appearance of intended parameters in relation to the model university classroom. The actual positions of whiteboards, smart interactive boards, student's chairs, desks, dropdown projectors, lighting systems, dustbins, flip charts, LCD's, walls, roofs and floor sections have been presented as illustrated in **Figures 5.6 and 5.7**.

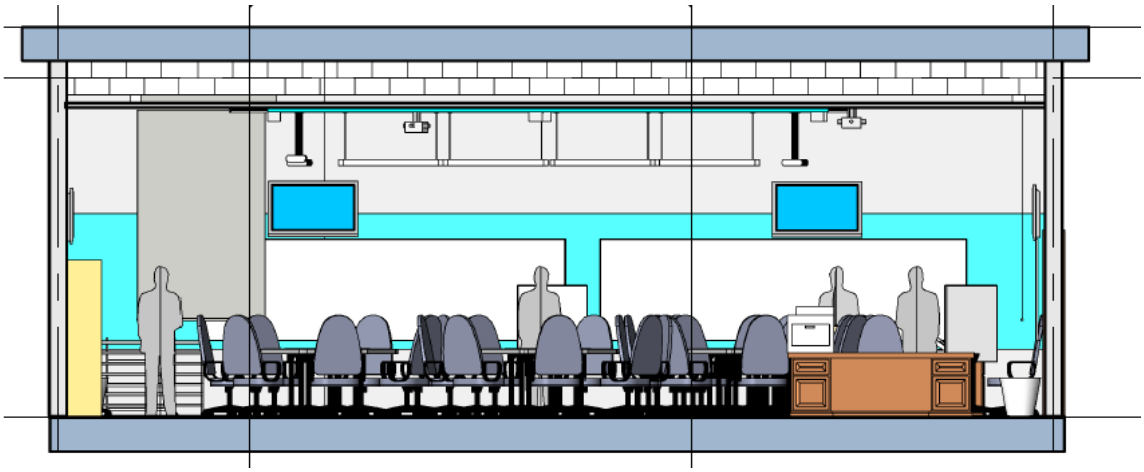


Figure 5.6 Cross Section of the Model University Classroom

The accessed or raised floor was used in the model university classroom of the future to enable the running of all the wiring cables beneath the floor system. These wiring cables, including electrical, mechanical and internet cables, and also the fixing and location of various sockets and outlets without disrupting the floor surface are included. Hence, the required flat surface to manoeuvre and reconfigure furniture in the classroom has been achieved.

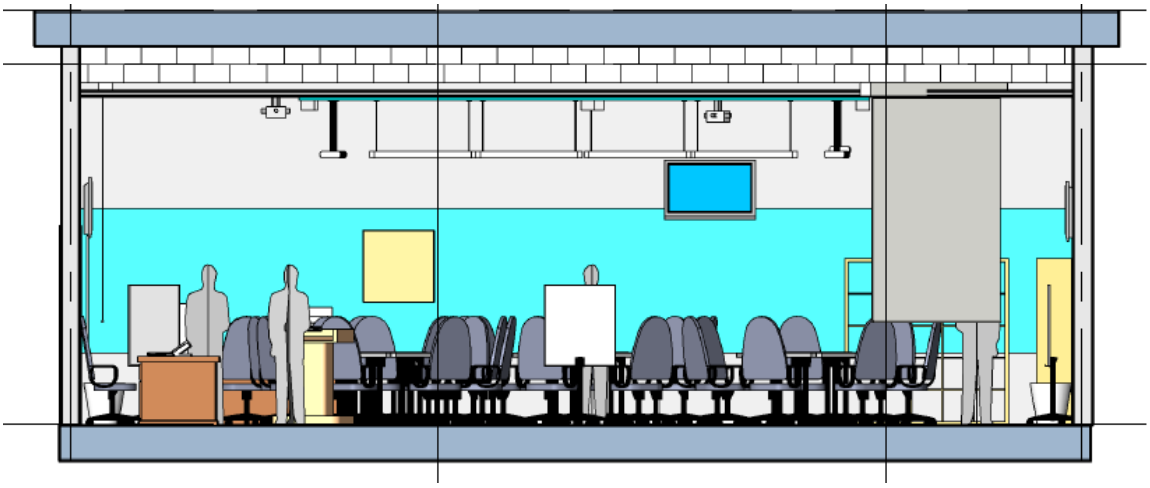


Figure 5.7 Longitudinal Section of the Model University Classroom

5.2.8 Classroom Three Dimensional View of the Interior

The three dimensional views of the model university classroom are presented with the intention of showing more or less the actual appearance of all the physical parameters from different angles as illustrated in **Figures 5.8 to 5.11.**

Figure 5.8 3D Interior view of the Model Classroom

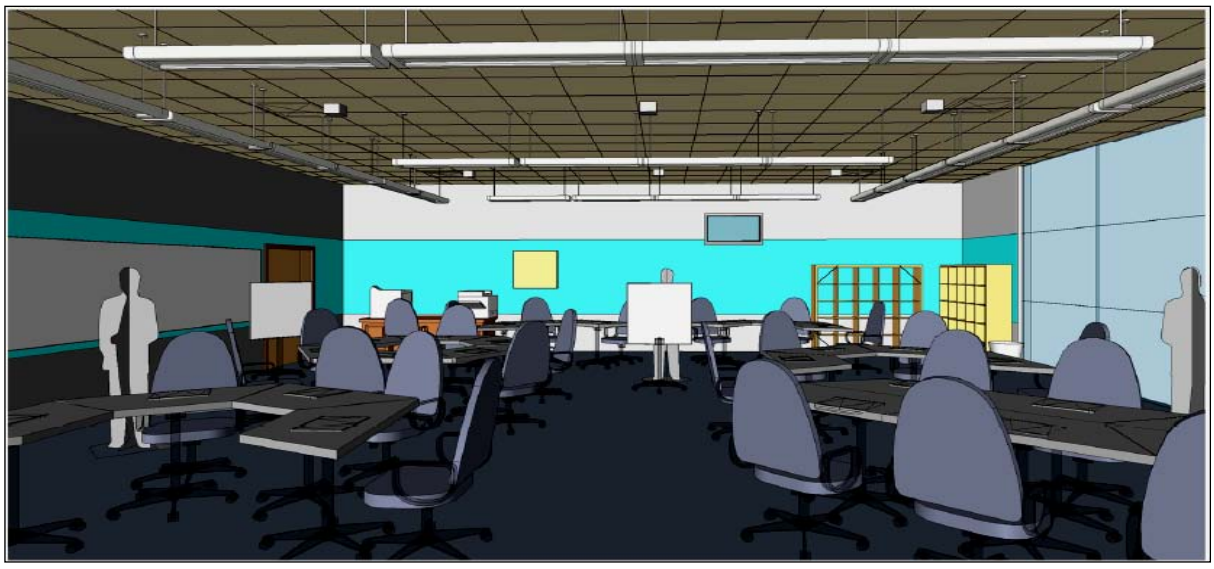


Figure 5.9 3D Interior Perspective View of Trapezoidal Desk Configuration in Classroom

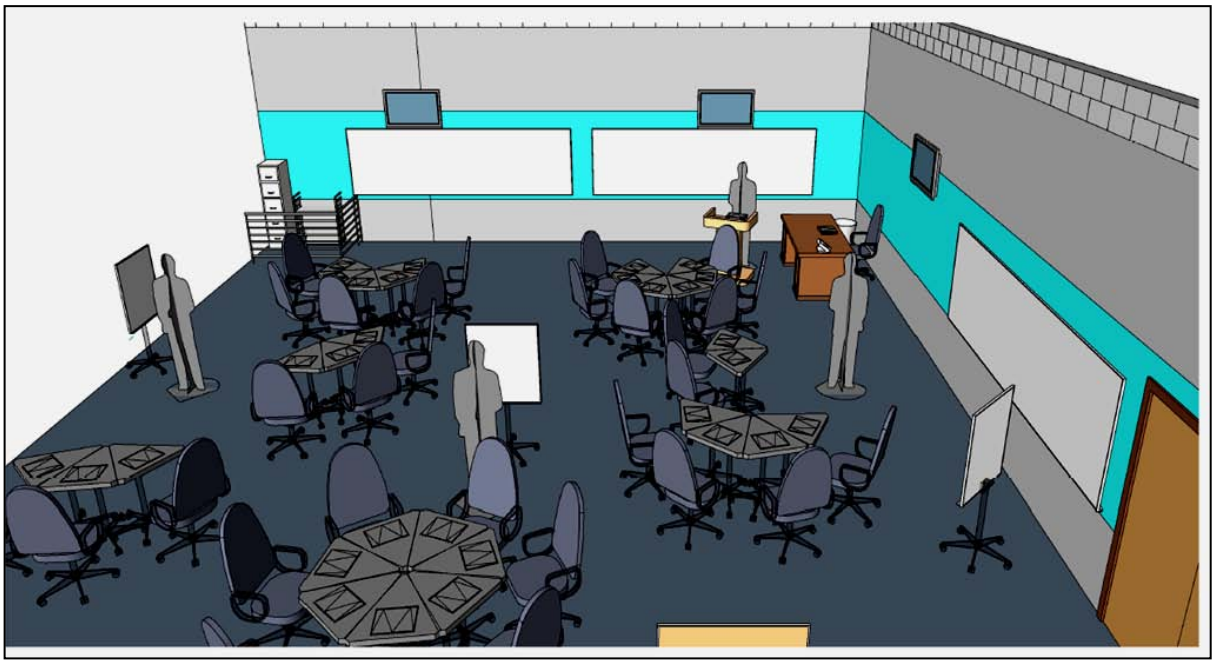


Figure 5.10 3D Interior Perspective View of Triangular Desk Configuration in Classroom

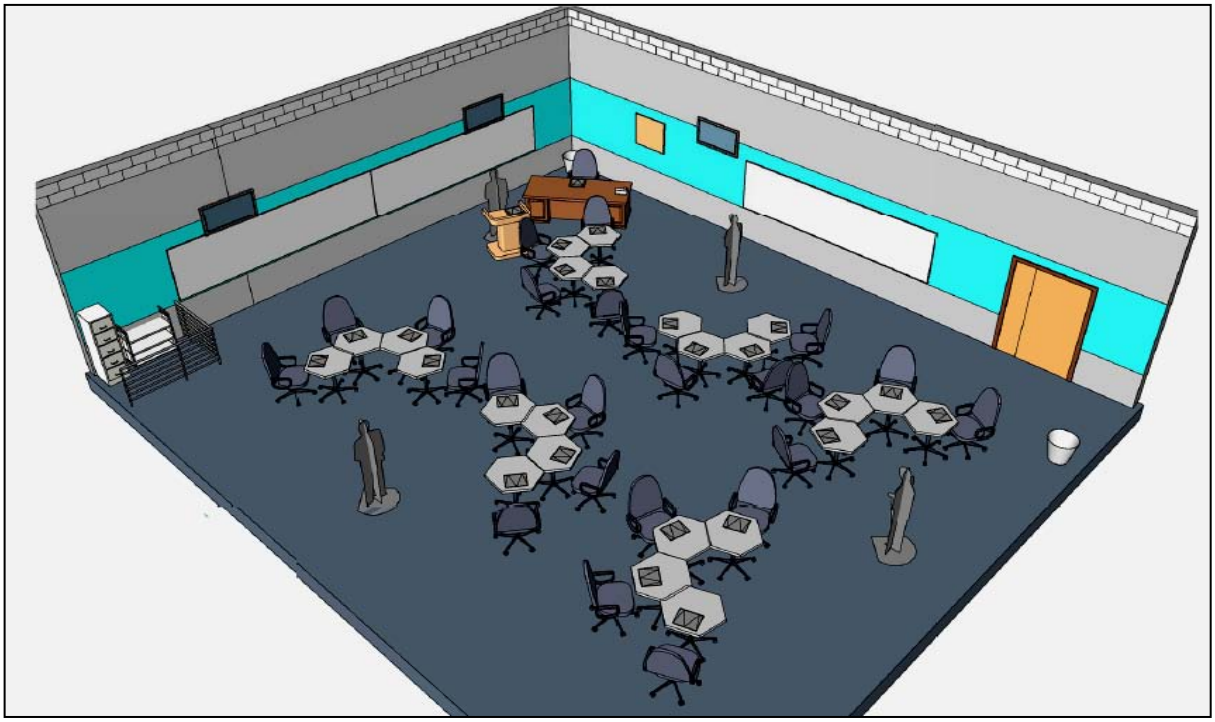


Figure 5.11 3D Perspective View of Hexagonal Desk Configuration in Classroom

The wall acoustical treatment in the model university classroom as adopted from (Mir and Abdou, 2005), has divided the wall into three different parts horizontally. In the lower part of the wall with 25% of the wall area, a smooth finish of 10 to 20 percent absorption material is to be used, while in the middle, which is about 50% of the wall area, 20% to 30% sound absorption material is to be applied and in the upper part of the wall which is 25% of the wall area, 50% to 60% absorption material is to be used, as illustrated in **Figure 5.12**.

The lighting system in the model university classroom was adopted from the PIER Lighting Research Program, (2005) and IESNA Lighting Handbook (2000) which has the advantage of considering energy conservation measures compared to the other standards. In order to solve the reflectance problem in the model university classroom, the floor material should have surface reflectance level of between 30 to 50%, glazed area 40 to 60%, ceiling 70 to 90 %, desk top 30 to 50%, and walls should be divided into three; upper, middle and lower with 40 to 60%, up to 20% and 40 to 60 % reflectance level respectively, as illustrated in **Figure 5.13.**

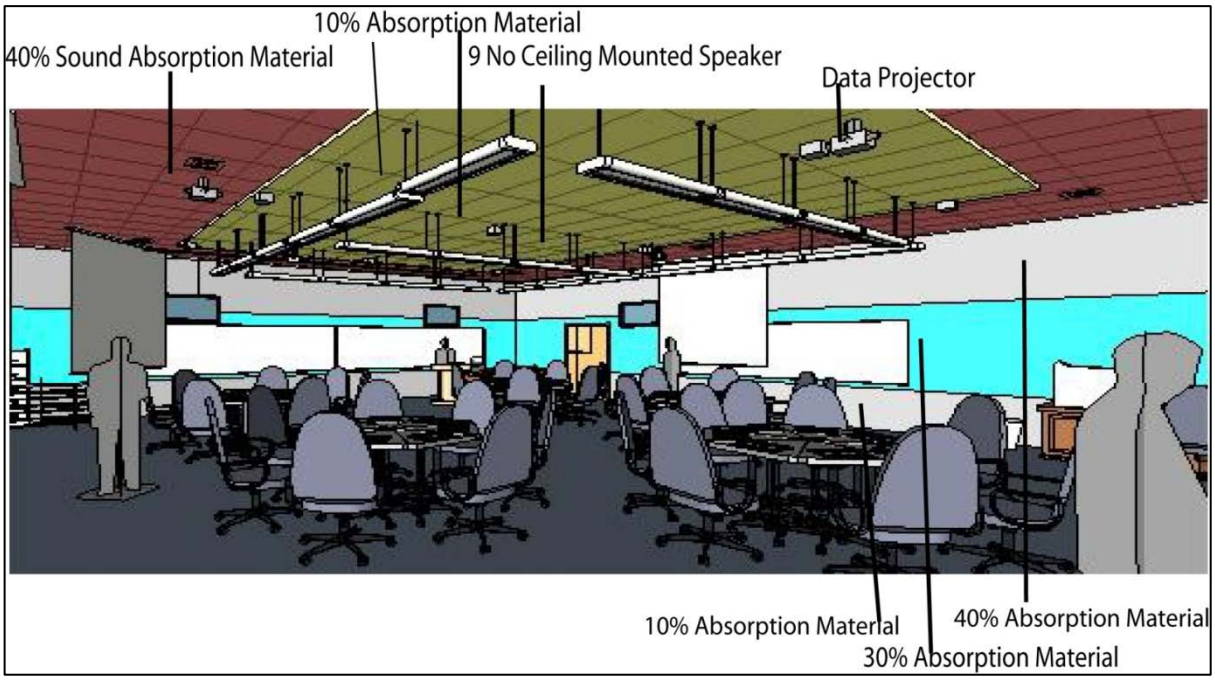


Figure 5.12 3D Interior view of the Model Classroom showing Acoustic Treatment

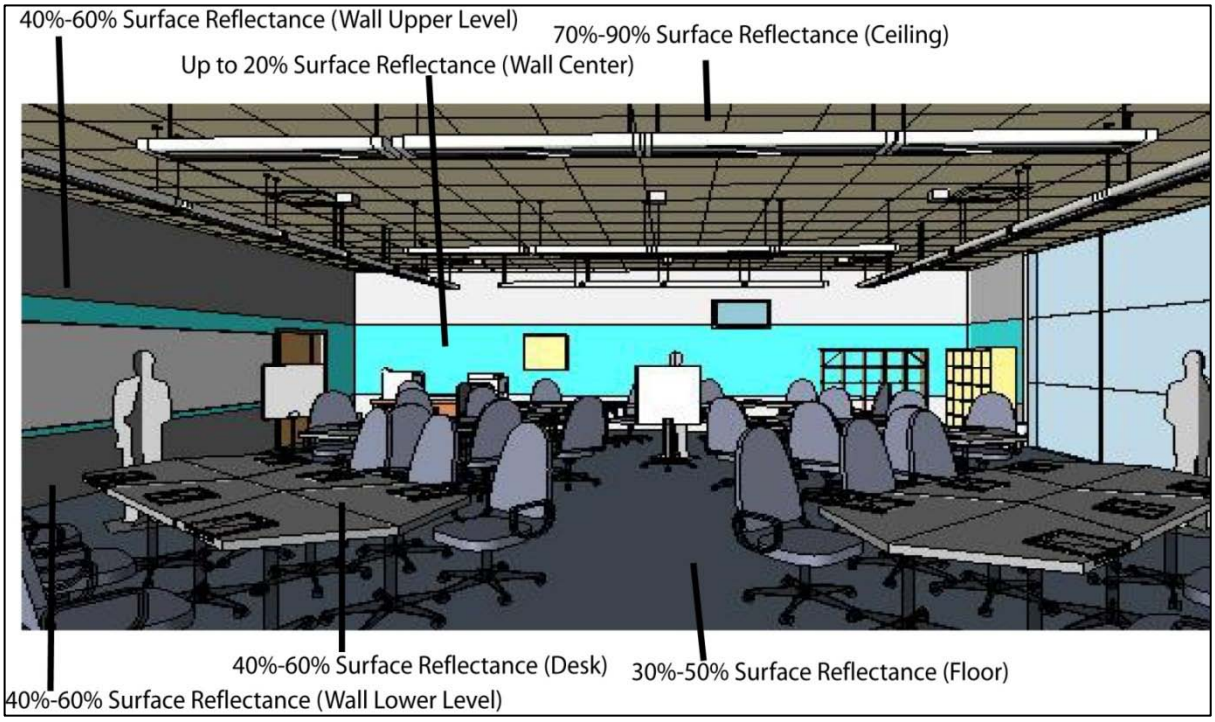


Figure 5.13 Interior view of the Model Classroom showing Lighting Reflectance Treatment

CHAPTER SIX

6 SUMMARY, CONCLUSION AND RECOMMENDATIONS

6.1 Summary

An enabling atmosphere where collaborative and interactive learning activities takes place without physical, equipment, technological and environmental problems and distractions has been an issue of concern for many decades. A comprehensive literature review has been conducted and it is confirmed that a well designed classroom physical environment, emerging instructional equipment and technologies, and proper indoor environmental quality are essential for suitable collaborative and interactive pedagogical delivery. Various parameters/factors impacting on the model university classroom have been identified and analyzed, and the model university classroom for collaborative and interactive learning has been developed and graphically presented. Three different students' desk shapes have been adopted including hexagonal, trapezoidal, and triangular with flexible swivel stands. In order to provide the required flexibility for the reconfiguration of furniture in the classroom, swivel stands are adopted for the student's chairs.

In addition, various equipment has been adopted to optimize the pedagogical delivery in the model university classroom including audio systems, data projectors, digital video camera, laptops, ceiling mounted speakers, smart readers, printers, copiers, LCD, flip charts, and IT equipment. The classroom is also empowered with the

capability of executing virtual instructional delivery technologies including videoconferencing, Telecollaboration and utilization of various online collaborative tools like Wikis, Blogs and WebCT. These technologies will help in fostering the required collaboration within and beyond the classroom space.

The importance of the relationship between indoor environmental ambience conditions to student's achievements and performance in the university classroom will never be over emphasized. Classroom lighting and acoustical comfort are the two major environmental conditions that have a direct effect and relationship with collaborative pedagogical delivery in the classroom, while thermal and indoor environmental qualities remain of great importance. Therefore, lighting standards prepared by PIER lighting research program (2005) of the California Energy Commission, and the Illumination Engineering Society of North America (IESNA) where mainly adopted in the classroom. This is due to the fact that the PIER proposal is very detailed, directly addressing classroom lighting and it considered energy conservation. IESNA presented a detailed model for solving reflectance problems in the classroom. A lighting control sensor has been used for the purpose of energy conservation, including daylight sensors and occupancy sensors. The classroom design incorporates audiovisual lighting modes of operation with a control system located in the instructors' podium for easy control if warranted. The PIER recommendation for classroom luminaires was adopted including two rows of direct or indirect linear florescent pendants parallel to windows about 4.5m apart. Each luminaire includes three high performance 3100 lumen T8 Lamps. The details are presented in Chapter Three. This standard was prepared for a 9.20m by 9.80m classroom. Therefore, to complement the larger size the of the model classroom of 10.0m by 12.0m and to

achieve equal distribution of lighting, another three cross sectional rows has been added, while the combined effect should not exceed 300 to 500 lux at the working plane. The instructor's space has been equipped with 6 recessed whiteboard luminaries that can be switch regulated when the need arises. To eliminate the reflectance problem in the model university classroom, the floor material should have surface reflectance level of between 30% to 50%, glazed area 40% to 60% ceiling 70% to 90 % desktop 30% to 50% and walls should be divided into three; upper, middle and lower part with 40 to 60%, up to 20% and 40 to 60 % reflectance level respectively.

It has been established from the literature that classroom acoustics has been one of the environmental factors that has a greater impact on student's achievements and performance. The acoustical standards proposed by the American Acoustic Association (ASA) and Mir and Abdou (2005) were adopted due to the fact that the two have conducted an in-depth and comprehensive analysis of classroom acoustics and smart classroom acoustics respectively, while others addressed acoustics at general school level. The model university classroom should have background noise of less than 35dB with a reverberation time of 0.4 - 0.6 (when occupied), be equipped with acoustical ceiling tiles and floor tiles/carpets of 0.75 NRC. The ceiling should be divided into two part with the central parts and peripheral part having materials of different absorption materials of 10% and 40% respectively. While the wall surface is divided into three parts horizontally at 25% upper part, 50% in the middle and 25% in the lower part, treated with 40%, 30% and 10% absorption level respectively. The detail of this model has been described in Chapter Three. The indoor air quality and thermal standards are divided based on their relation to HVAC systems, Interior

Materials Finishes, Construction Methods and Operation, Building Materials, Building Design and others. The details of indoor air quality standards have also been discussed in Chapter Three.

King Fahd University of Petroleum and Minerals' (KFUPM) Case study has been studied. An interactive interview survey has been carried out among the course instructors and students (KFUPM). The respondents were selected based on the previous records of interest in the study area. Apart from course instructors that are known for their support of collaborative and interactive learning, the names of instructors that have related publications, projects and workshops have been collected from the Deanship of Academic Development, and a list of best teaching award course instructors was collected from the General Services Department of KFUPM.

The study confirms that physical set up of the classroom, indoor environmental quality, instructional equipment technology and emerging teaching/learning pedagogies are the four major influential factors affecting student performance, learning and teaching styles in the classroom. Out of 26 course instructors and 27 students interviewed, 43% of the course instructors have classroom working experience of 10 to 19 years, 36% with 1 to 9 years and 21% with 20 years and above, while the student respondents were selected among the final year senior and graduate students. The result of the interview shows that 91% of the course instructors and 89% of the students prefer collaborative and interactive learning compared to traditional learning styles. The remaining 9% of the course instructors and 11% of the students were unsure about which among the styles is better.

The three options of the developed model university classroom have been presented to the potential respondents within the study area to seek their views and acquire their input with the aim of refining the model for KFUPM learning environment. Based on the developed generic model university classroom model and the results from the interview survey, a methodology for implementing the model in any university has been established. Since adoption of this model largely depends on individual university's vision, resources, faculty skills and students' awareness, academic development entities, and the nature of existing classroom space.

The potential interviewees were asked in light of their professional/teaching experience to list the three most useful instructional kinds of equipment and technology for a collaborative and interactive learning classroom. The response shows that a data projector, white board and internet connection, in order of importance respectively, are the most useful kinds of equipment and technology in a collaborative and interactive classroom. Lastly, a Model Classroom for Collaborative and Interactive Learning has been developed considering all the influential parameters including physical set-up, instructional equipment and technology and indoor environmental quality.

6.2 Conclusion

This study of developing a Model University Classroom for Collaborative and Interactive Learning was intended to carry out an analysis and a subsequent design of how a university classroom for collaborative an interactive learning will look like and to ascertain the major influential factors affecting student performance in the university classroom. The study is tailored towards addressing collaborative and interactive learning being learner-centered style, seeking to replace the widely used traditional teacher-centered learning style.

The study confirms that physical set up of the classroom; indoor environmental quality instructional equipment technology and emerging teaching/learning pedagogies are the four major influential factors affecting student performance, learning and teaching styles in the classroom. The research has also established a methodology for implementing the generic classroom model in any university, as adoption of the generic model depends on individual university's vision, resources, faculty skills and students' awareness, academic development entities, and the nature of existing classroom space.

The Generic Model University Classroom for Collaborative and Interactive learning for implementation in both new and existing universities was designed. Three different classroom desk alternatives have been developed including hexagonal, trapezoidal, and triangular. These alternatives are very flexible and can be reconfigured to any collaborative and interactive learning style. The classroom has been equipped with state-of-the-art instructional equipment and technologies. Various indoor environmental quality standards have been analysed and recommended

including lighting, acoustics, indoor air and thermal comfort for application in the model classroom.

A case study of King Fahd University of Petroleum and Minerals (KFUPM) has been studied by conducting an interview survey among course instructors and students. The three seating arrangement options have been presented to the potential respondents to seek their observations and acquire their input with the aim of improvement. The respondents have agreed with the proposed physical set-up, shape, seating arrangements, equipment/technologies, lighting and acoustical strategies of the model university classroom and contributed to its refinement.

The rectangular shape generic classroom was adopted for the KFUPM case study for easy implementation as almost all the existing classrooms in the university are rectangular in shape. The thesis outcome is thus a comprehensive Model University Classroom for Collaborative and Interactive Learning considering all the influential parameters including physical set-up, instructional equipment and technology and indoor environmental quality.

6.3 Recommendations

This research developed a state-of-the-art model university classroom for collaborative and interactive learning with proper physical set-up, integrated with efficient instructional technology and appropriate indoor environmental ambience conditions. However, it is very important to implement the classroom model presented practically and test its suitability for collaborative and interactive learning. This can be achieved by implementing the three options of the proposed model university classroom as it is described in this study in a few classrooms within an educational environment and allow a set of students and faculty members to utilize the classrooms using collaborative and interactive learning styles for a period of time. Then, both students and faculty members will be questioned to verify the suitability and effectiveness of these classrooms for collaborative and interactive learning. However, there is a need for further research on the collaborative and interactive learning environment for larger classrooms like lecture theatres, and auditoria.

Many actors should be involved and work together in the development of the Model University Classroom for Collaborative and Interactive Learning including; Architects, Interior Designers, Instructors, Audiovisual specialists, Academic Development Department/Deanship, University Project and Maintenance departments.

Educational awareness should be intensified among all actors, especially faculty and students, as success or failure depends on how the faculty and students adapt to the new environment. An awareness campaign in the form of workshops, seminars and symposiums should be conducted simultaneously with the Model Classroom implementation, as adaptation to the new learning environment is easier and quicker if

it is done practically within the new space. This is expected to positively impact on instructors and students belief in the concept of collaborative and interactive learning as critical to the success of the university learning mission.

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8 APPENDIX

8.1 Interactive Interview Survey Format

INTERVIEW

MODEL UNIVERSITY CLASSROOM FOR COLLABORATIVE AND INTERACTIVE LEARNING

[INSTRUCTORS AND STUDENTS]

Mr. ***Mohammed Alhaji Mohammed*** is a graduate student in the Architectural Engineering Department. He is currently collecting data for his Master Thesis titled ***"A Model University Classroom for Collaborative and Interactive Learning"***. He is required to conduct an interactive interview survey to seek opinions on the suitability of proposed model university classroom for collaborative and interactive learning based on the attached C**lassroom Layout** and **3D drawings**. The interview survey is conducted by interacting with the concerned persons including instructors, students and administrative officials.

Thank you in advance for providing any assistance required to make his research successful.

Your positive participation and active contribution are valued and very much appreciated.

What does Collaborative and Interactive Learning Mean?

"The term "collaborative learning" refers to a student centered instruction method in which students at various performance levels work together in small groups toward a common goal, while interactivity is one in which students participate as equal partners in an ongoing discovery process within and beyond the level of the classroom"

Section I: Respondent's General Information

Name :		***Rank:***	
Department/Section:			
		Experience:	
Mailing Address :		***E-mail :***	
Tel :		***Fax:***	

Section II: Model University Classroom

1. Is Collaborative and Interactive Learning Better than Traditional Learning?	*Yes* ☐	*No* ☐	*Unsure* ☐
2. Is the classrooms physical setup and shape suitable for collaborative and interactive learning?	☐ *Yes*		
	☐ *No*	**Suggestions**	
Physical Setup	1.		
Comments:	2.		
	3.		
	4.		
	5.		
	6.		
3. Is the adopted seating arrangement in the classrooms suitable for collaborative and interactive learning?	☐ *Yes*		
	☐ *No*	**Suggestions**	
Seating Arrangement	1.		
Comments:	2.		
	3.		
	4.		
	5.		
	6.		
4. Rank the three Classroom table alternatives Based on their suitability & Flexibility (Fill A, B, C, as appropriate)		**1**	
		2	
Comments (Why):		**3**	**Suggestions**
	1.		
	2.		
	3.		
5. Is the classroom Equipment/Technology suitable for collaborative and interactive learning?	☐ *Yes*		***See Attached List**
	☐ *No*		**Suggestions/Views**
Equipment/Technology	1.		
Comments:	2.		
	3.		
	4.		
	5.		
	6.		
6. Your Views about the classroom lighting/Acoustic System.			
			Suggestions/Views
Lighting/Acoustic system	1.		
Comments:	2.		
	3.		
	4.		

	5.
	6.

Do you suggest any **modification(s)** or **addition(**s) to the set of Equipment and/or Technology?	1.
	2.
	3.
	4.
In light of your professional/teaching experience, please list **three** most useful Equipment/ Technology in collaborative pedagogical delivery.	1.
	2.
	3.
	4.
What **element(s)** would you like to see added to the Model University Classroom that would help you utilize the classroom better in an effective way?	1.
	2.
	3.
	4.
General Comments (if any)	1.
	2.
	3.
	4.

Thank you for completing this survey

Classroom Layout Option (A)

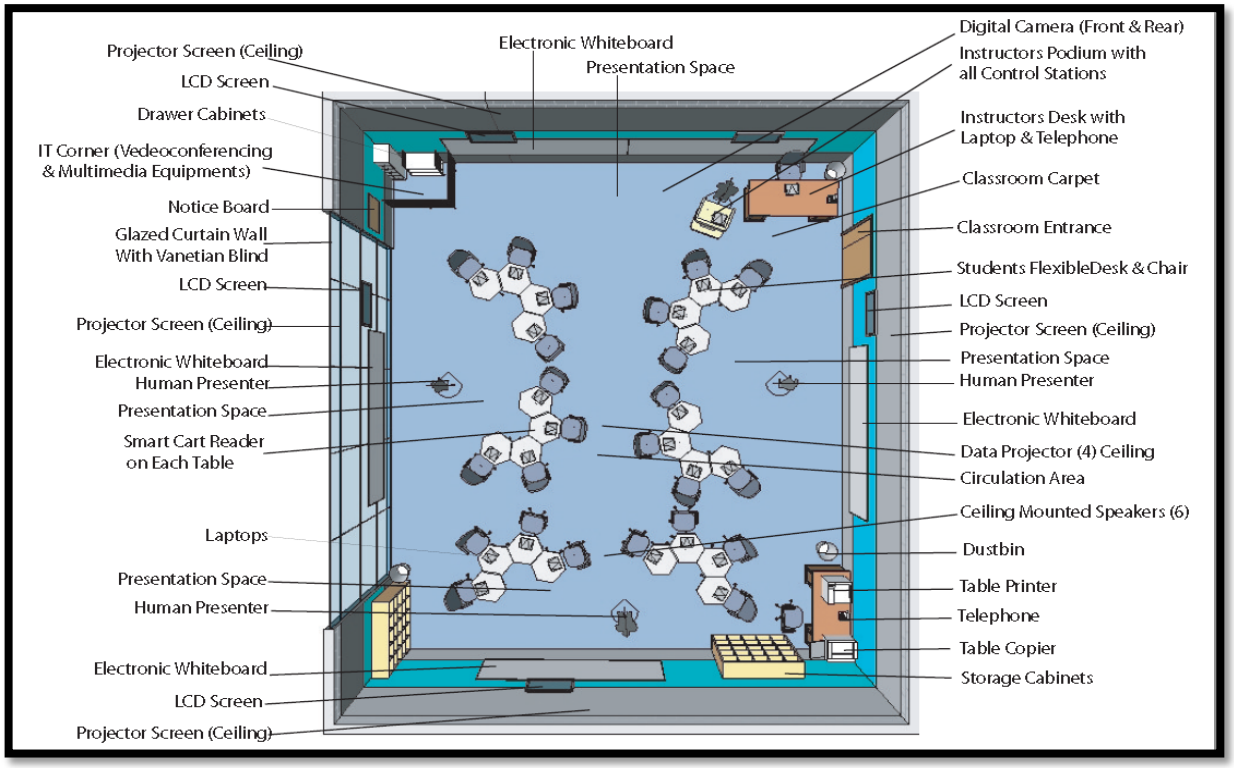

Figure 1: Typical 3D View of Classroom Option (A)

Figure 2: 3D Interior Perspective of Classroom Option (A)

Classroom Layout Option (B)

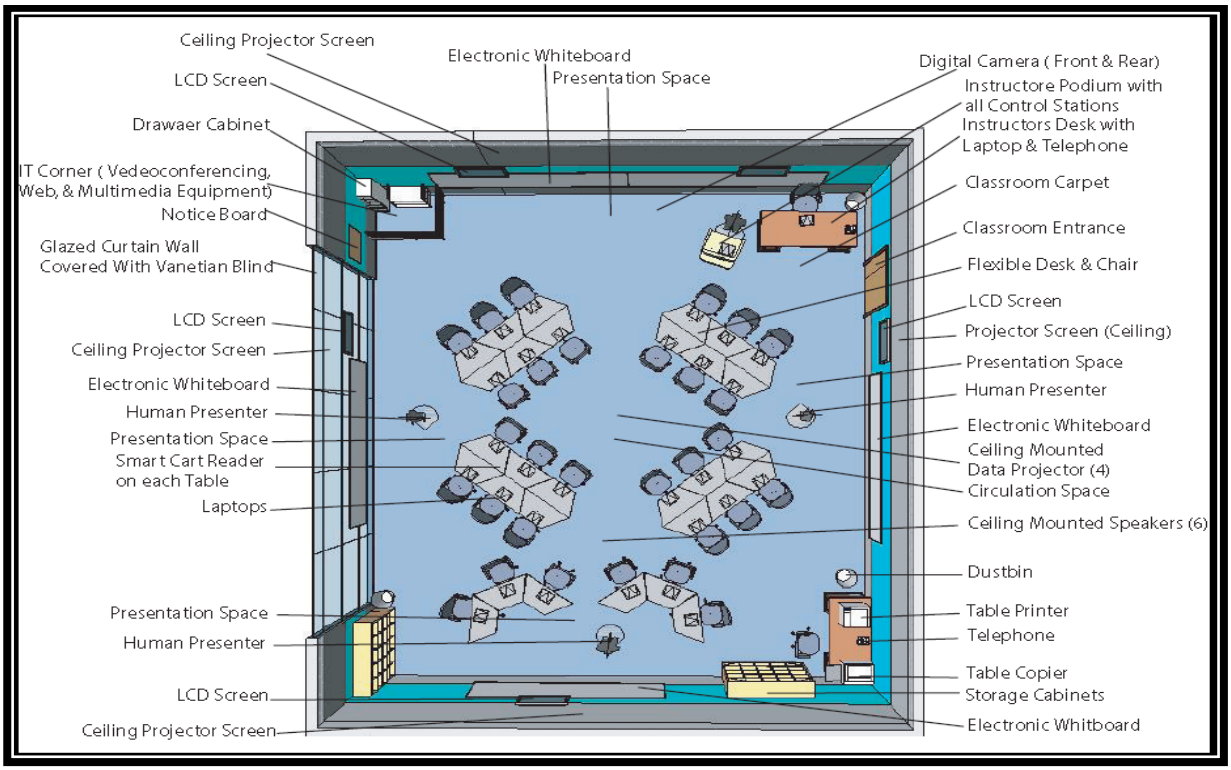

Figure 3: Typical 3D View of Classroom Option (B)

Figure 4: 3D Interior Perspective of Classroom Option (B)

CLASSROOM LAYOUT OPTION (C)

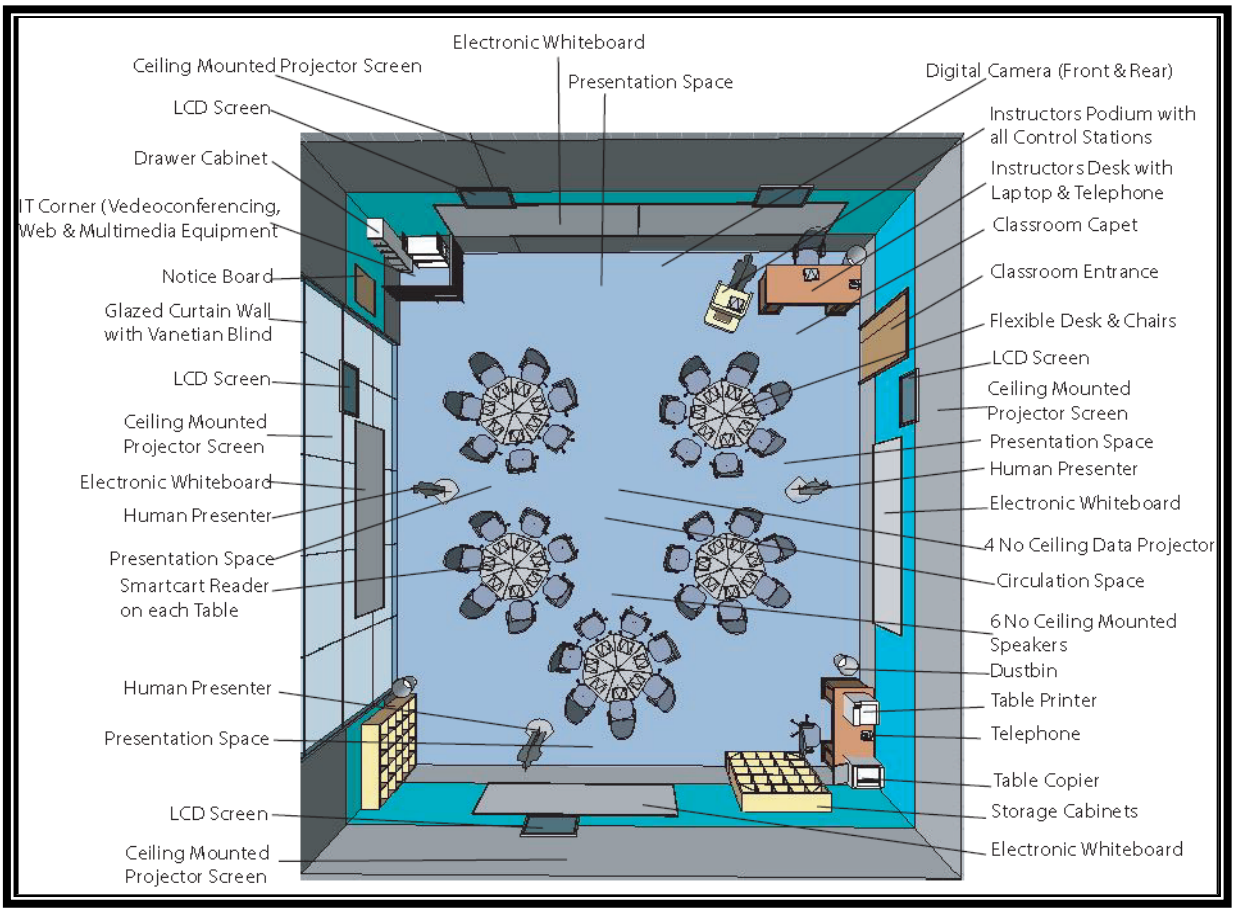

Figure 5: Typical 3D View of Classroom Option (C)

Figure 6: 3D Interior Perspective of Classroom Option (C)

CLASSROOM 3D VIEW & CEILING PLAN SHOWING LIGHTING/ACOUSTIC SOLUTIONS

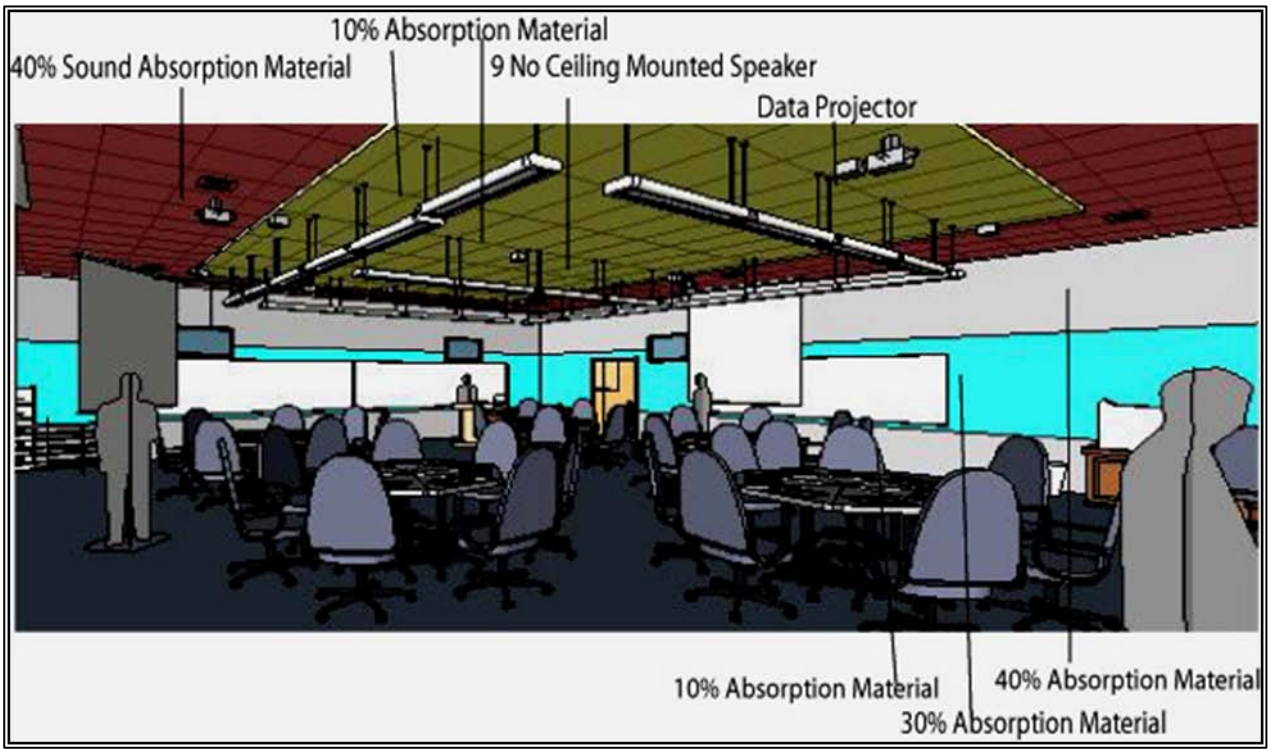

Figure 7: 3D View Showing Acoustic Treatment

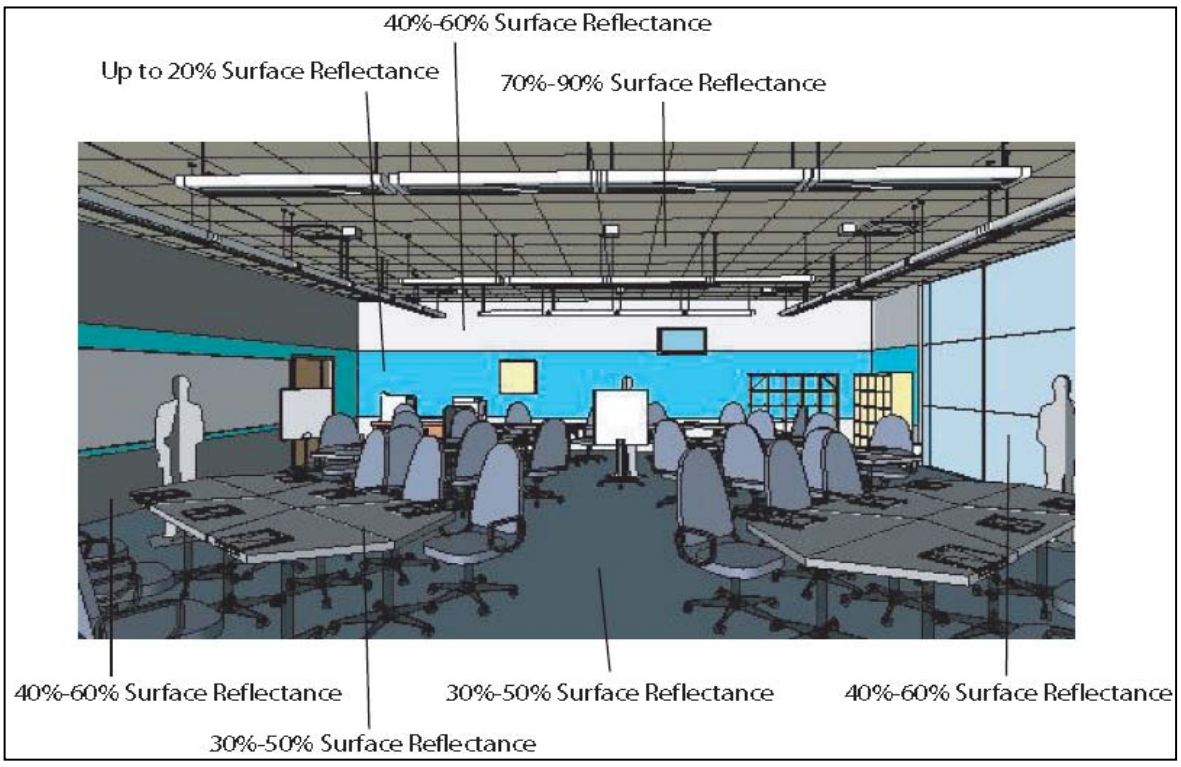

Figure 8: 3D View Showing Lighting Treatment

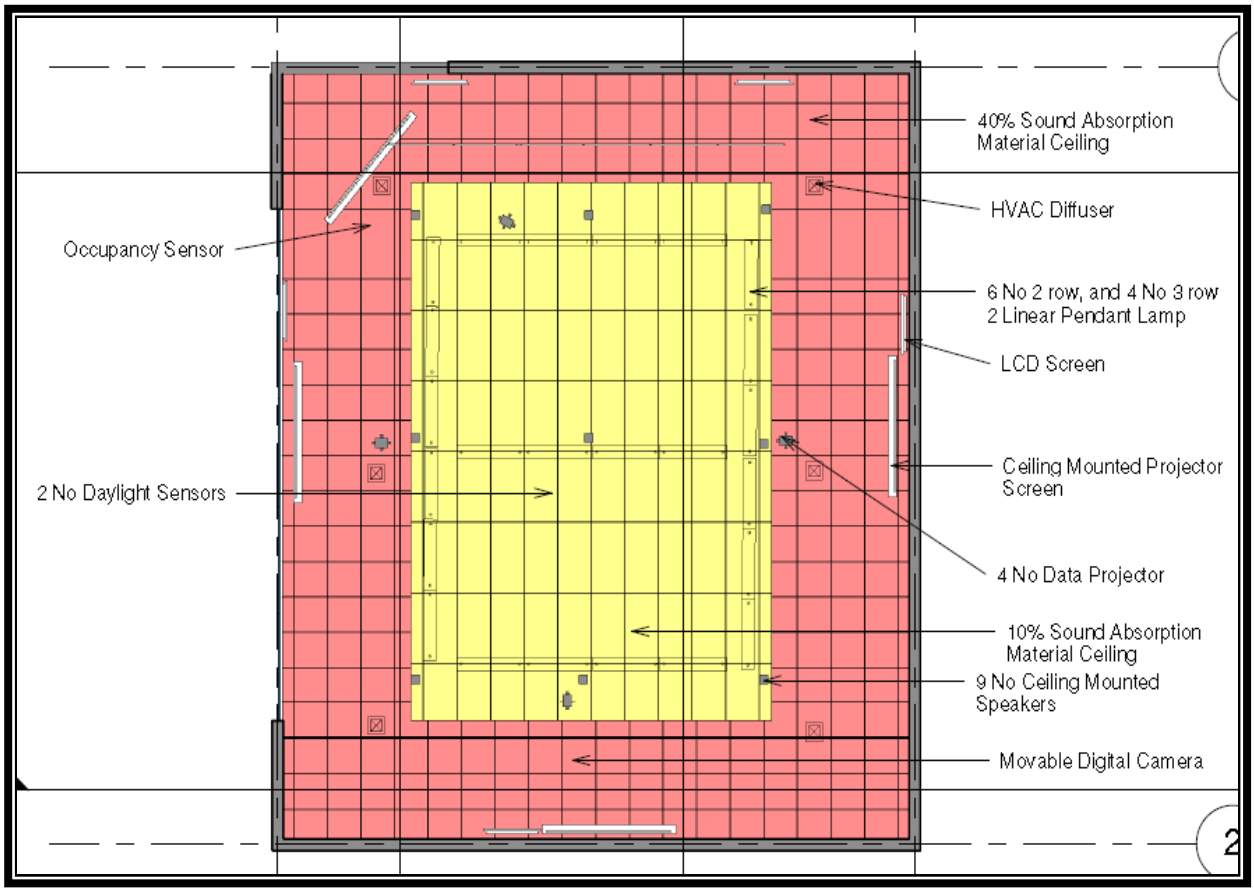

Figure 9: Ceiling Plan of the 3 Options

8.2 Equipment Lists

Are you satisfied With the Level of Equipment provided In the Classroom (Tick as Appropriate)?

S/No	Equipment/Technology	Required	Not Required
1.	Teachers Desk		
2.	Flexible Student Desk		
3.	Flexible Student Chairs		
4.	SmartBoard (Interactive Whiteboards)		
5.	Storage Cabinets		
6.	Slide projector		
7.	Overhead projector cart		
8.	Data / Video Projector		
9.	DVD/VCR		
10.	Portable projector screen		
11.	Electric Interactive Screens		
12.	Network and Network port		
13.	Speaker podium/Lectern		
14.	Portable amplifier with microphone		
15.	IT Corner		
16.	Document Camera Instructions		
17.	Control System		
18.	Classroom control software		
19.	Microphones (wireless)		
20.	Audio System		
21.	Local Input Panel		
22.	Laptops and connection		
23.	TV Screen (External Input Interface)		
24.	Telephone		
25.	Digital Camera		
26.	Flipchart		
27.	Storage Cabinet		
28.	LCD TV Screens		
29.	Ceiling Mounted Speakers		
30.	Waste Bins		
31.	Videoconferencing		
32.	Telecollaboration		
33.	WebCT, Blogs, and Wikis		
Please Suggest any Important Technology/ Equipment Not mentioned above			
34.			
35.			
36.			
37.			

8.3 Curriculum Vitae

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EDUCATIONAL HISTORY

- **King Fahd University of Petroleum & Minerals** - 2008-2010
  Address: Dhahran, Eastern Province, Saudi Arabia
  Major: Ms in Architectural Engineering

- **Abubakar Tafawa Balewa University Bauchi** - 2002-2006
  Address: Bauchi, Bauchi State, Nigeria
  Major: B-Tech. in Architecture

- **Ramat Polytechnic Maiduguri** - 1999-2001
  Address: Maiduguri, Borno State, Nigeria
  Major: National Diploma in Architecture

- **Government College Maiduguri** - 1992-1998
  Address: Maiduguri, Borno State, Nigeria
  Certificate: SSCE WAEC Certificate

- **Gajiganna Primary School** - 1986-1991
  Address: Magumeri L. G. Borno State, Nigeria
  Certificate: Primary School Certificate