University Model Classroom for Collaborative and Interactive Learning: Design Alternatives

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ABSTRACT
At the present time, collaborative and interactive learning is becoming more popular within the educational environment. This is not unconnected with the increased availability of equipment and technology that can support such learning pedagogy. Based on research findings, it is established that the quality of the indoor environment, instructional technology, and the physical set up of the classroom are related to student performance. This study presents a comprehensive and critical review of the available literature on the nature of the university classroom for collaborative and interactive learning, with the aim of providing an enabling environment of higher learning in universities. The paper considers the impact of both the physical and environmental factors on classroom comfort. The study has established the model university classroom for collaborative and interactive learning with three different classroom desk arrangements including hexagonal, trapezoidal, and triangular. These alternatives are very flexible and are easily reconfigured to any collaborative and interactive learning style. A higher percentage of both student and course instructor respondents prefer collaborative and interactive learning compared to traditional learning styles. A much higher percent than average of the respondents agreed with the suitability of the physical set-up, shape and the three seating arrangements of, the hexagonal, trapezoidal and triangular forms, the classroom equipment/technology, the lighting and the acoustics strategies of the model university classroom. Both instructors and students ranked the Trapezoidal shape arrangement, as the best alternative, the hexagonal and triangular forms as the second and third best respectively in classroom seating styles. A comprehensive classroom model has been developed considering all the influential parameters including the physical set-up, instructional equipment and technology and the indoor environmental quality.

Keywords: model university Classroom, collaborative and interactive learning, students, instructional technology, equipment, learning styles, physical set up, learning outcome, learning environment.

1. INTRODUCTION
The design of a model university classroom for collaborative and interactive learning was informed by the recent development in instructional technology and equipment, together with the desire for collaborative learning in our universities. The study will analyse the integration of influential factors responsible for the physical and environmental comfort in the university classroom. These factors have been identified from...
the literature as the classroom physical set-up/geometrical configuration, the instructional equipment technology, the indoor environmental quality and the emerging teaching and learning pedagogy. In most contemporary theories, learning is conceived of 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. Developments in technology that can be used to enhance and support learning have been more rapid. However, it would appear that the majority of the classrooms in today’s schools and universities do not match these developments (Mäkitalo-Siegl, et al 2010). The major difficulty is to provide a suitable collaborative learning environment that can easily accommodate the requirements of all the existing collaborative learning styles. This will be attained through reconfigurable furniture which offers the required flexibility suitable to any of the collaborative learning styles adopted in the classroom. The need for establishing suitable layouts for different types of collaborative 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 and are particularly well suited to certain types of teaching situation (Smawfield, 2007). Hence, to design a model university classroom for collaborative and interactive learning, with the appropriate physical set-up integrated with efficient educational/instructional technology and the indoor environmental ambience appropriate for the collaborative and interactive new teaching/learning pedagogical requirements, the input of the immediate users of the classroom i.e. students and instructors is necessary.

2. Approach for achieving physical and environmental comfort in classroom

The realization of both the physical and environmental comfort could be achieved through the optimization of various influential factors responsible. The physical factors consist of the classroom shape/size, furniture types and arrangement, and the emerging instructional equipment technology; in addition, the environmental factors include classroom lighting, the quality of the acoustics, indoor air quality and thermal comfort.

2.1 Physical Factors Responsible for Classroom Comfort

The size of classroom is one of the most important factors to consider in determining comfort in the collaborative classroom. Larger classrooms are inclined to be noisy when students are engaged in collaborative activities that have to do with discussions and arguments. 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. Out of the teachers surveyed by Public Agenda, 70% believed that a small class size is more important to student achievement than a smaller school size (Schneider M. 2002). According to the study conducted by Kokkelenberg, et al (2005), the average grade point declines dramatically as the class size increases up to 20 in size, and then more gradually but steadily through the larger class sizes.

Due to the large number of facilities and the amount of equipment required to support interactivity in the collaborative classroom, expanded instructor space for the use of interactive displays is required together with a raised floor to run electric and internet connection cables. As it enables all the electrical and internet connection cables to be buried under the floor and thus provide free floor surface for furniture reconfiguration, the raised floor has been used as the preferred flooring system of the model university classroom where modular flexible furniture is used.

The classroom furniture including desk, chairs, and flipchart, should be easily movable as reorganization is necessary when alternating between various collaborative learning styles in the classroom. Different pedagogical techniques require different types of learning space. However, it is not cost effective to provide different classrooms for different pedagogical requirements. The incorporation of the state-of-the-art equipment required for collaborative and interactive instruction delivery should also be considered while embarking on classroom design.

2.2 Environmental Factors Responsible for Classroom Comfort

Classroom lighting is one of the major determinants of student performance 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). The basic system includes indirect luminaries 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 (PIER Lighting Research Program, 2005).

Classroom design and layouts with efficient acoustics enable students understand what instructors are teaching and also allow them to have a better understanding of the lessons, with fewer distractions. The 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). American National Standards Institute (ANSI) and World Health Organization (WHO) suggest background noise in the classroom should be below 35 dB (Chiang, and Lai, 2008).

The indoor temperature in the university classroom is affected by heat from the 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, 2007). The position of the HVAC system in determining the level of indoor air quality in the university classroom can never be over emphasized. HVAC should be well designed and maintained to deliver healthy and clean air to the conditioned space. Low volatile organic compound emitting materials should be utilized for component construction and finishes in the university classroom. If carpet is specified, it should be tested under the Carpet and Rug Institute’s Indoor Air Quality Carpet Testing Program (EPA, 2010).

3. METHODOLOGY
In order to accomplish the study objectives, the following research methodology is implemented:

A comprehensive literature review has been conducted to address the main issues regarding the university classroom for collaborative and interactive learning. The literature has covered the areas of classroom physical set-up, seating arrangements, instructional equipment and technology, and indoor environmental qualities.

A multi method study approach has been applied to carry out the research in order to avoid bias. These methods include theoretical analyses of the literature, Architectural designs and interviews with course instructors and students. All these methods were utilized with the aim of obtaining reliable results and the summing of the views of the users on the outcomes of the study.

Comparison with existing standards in areas of indoor environmental qualities has been evaluated and considered based on data gathered from existing codes and standards. The compliance to adopted standards has been conducted based on the advantages of these standards over similar standards in the literature. Figure 1 illustrates the summary of methodology applied in conducting the study.
3.1 Characteristics of the Model University Classroom

The classroom characteristics related to collaborative and interactive learning are those that will enhance collaboration and allow remote students to joint in pedagogical sessions. Apart from the physical set-up, furniture, equipment and geometrical configuration requirements, a favourable indoor environmental quality which will provide a level of comfort which allows both students and instructors to perform their educational activities is also essential. Apart from providing an extended space for an instructor using a smart board and interactive displays, collaborative classrooms are characterized by having few seats, from 10 to 25, with larger seating than standard specifications, which, with the desks, must be easily reconfigured. To supply more space for person and to achieve the level of flexibility required, certain classroom student desk configurations are recommended.

To achieve the required flexibility for adjustment and manoeuvre, to accommodate the various learning styles employed in the model university classroom the hexagonal, trapezoidal and triangular shaped table configurations, that are capable of achieving easy reconfiguration to any collaborative setting, have been proposed. The hexagonal desk is 700 mm in length, 700 mm in width and 800 mm in height, while the trapezoidal desk has a major and minor length of 1250 mm and 600 mm respectively and a width of 600 mm, and a height of 800 mm height. The triangular desk is 700 mm in length, 700 mm in width and 800 mm in height. These desks have swivel stands for easy movement on the classroom floor surface, as layout reconfiguration and rearrangement will always be complicated and time consuming with unwheeled table stands (Rogers, 2005). The three desk options are shown in Figures 2. In order to maintain
the tables’ flexibility, it is also essential to extend the same features to the students’ chairs to enable them to turn and manoeuvre easily in response to the adopted learning styles 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 of particularly importance as extended computer use increases (Butin, 2000).

![Diagram](image)

**Figure 2.** Shapes of student desk for interactive learning. (a) Hexagonal Shape. (b) Trapezoidal. (c) Triangular Shape.

### 2.2 Collaborative and interactive learning environment

Collaborative learning can range from the one-time class discussion to long term multi-component projects. Learning in teams is preferable in knowledge-intensive societies; as organizations increasingly rely on teams to solve a variety of complex tasks and problems. In order to be effective and successful in solving problems, it is vital that knowledge is continuously shared and constructed in teams (Leinonen, 2007). Original empirical studies have shown that collaborative learning is often more effective than learning alone, and the effects of collaborative learning depending on the quality of interactions during collaboration (Dillenbourg, et al 2005). The collaborative learning medium provides students with opportunities to analyse, synthesize, and evaluate ideas cooperatively (Gokhale, 1995). Despite the fact that an interactive classroom is based on the different ways in which students interrelate, there is also a need for a simple way of arranging the classroom allowing student activities to flow easily
into whatever configuration is necessary without any disorder or loss of organization on the part of the instructor.

4. **The DESIGN OF THE MODEL UNIVERSITY CLASSROOM**

4.1 **Classroom Physical Set-up**

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 effectiveness 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. Due to the diversity of collaborative learning and teaching styles which exist in the literature depending on the type, nature and activities required for 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 Figure 3 are provided with swivel stands for easy manoeuvre, and which are capable of holding laptop computers comfortably. The physical surroundings of a classroom 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 in 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).

Today, the square and rectangular classroom in our universities and other institutions of higher learning, are the most commonly adopted shapes, because, classroom 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 constraint and the optimum utilization of space. Polygonal shaped classrooms consume more space in design compared to rectangular and square shapes, but it is important to recognize that polygonal shape classrooms will be more appropriate in fostering collaboration compared to square or rectangular shapes, which are limited in their opportunities for the re-arrangements of the elements. The high number of interior faces in the polygonal classroom makes it very easy to group students and to allocate a facade for each group allowing for material presentation in the form of projector screens and white boards. Hence, there is a need to recognize the advantages and disadvantages of both square/rectangular and polygonal shapes while designing the university classroom. Figure 4 depicts 3D views of the model classroom with hexagonal desk, trapezoidal desk and triangular desk configurations. Figure 5 illustrates a typical hexagonal shaped classroom with collaborative settings.
Figure 3. Collaborative classroom layout with hexagonal tables and its components

Figure 4. Alternative configurations of group tables. (a) Hexagonal desk configuration. (b) Trapezoidal desk configuration. (c) Triangular desk configuration
4.2 Instructional Equipment Technology
Recently, classrooms have been provided with portable and flexible instructional equipment for the easy delivery of instructions and a better and engaging collaborative and interactive learning environment. Some essential state-of-the-art equipment required for collaborative pedagogical delivery in the university classroom include audio system, overhead projector, digital camera, laptops, ceiling mounted speakers, smart card readers, lecture recorder, and document camera. Classroom technology includes videoconferencing, tele-collaboration and employment of online collaborative tools like Web-CT, blogs, and wikis.

4.3 Classroom Indoor Environmental Quality
The lighting system in the model university classroom was adopted from the PIER Lighting Research Program, (2005) and it has the advantage over other standards of considering energy conservation measures. In order to solve the reflectance problem of the interior surfaces in the model university classroom, the interior treatment presented in (Rea, 2000) has been adopted in which the floor material should have a surface reflectance level of between 30 to 50%, the glazed area 40 to 60%, the ceiling 70 to 90 %, and desk tops 30 to 50%. The wall 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 6.

The classroom acoustic recommendations by (Mir and Abdou, 2005), as illustrated in Table 1 are essential to the model university classroom, this is because the model has treated the entire acoustical aspect of classroom in detail. 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, which is 25% of the wall area, a smooth finish of 10 to 20 per cent 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

Figure 5. Hexagonal shape of collaborative classroom layout
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 7.

![Diagram of sound-absorbing material configuration](image)

**Figure 6. Interior view of the model classroom showing recommended lighting reflectance of interior surface treatment**

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

Source: Adapted from Mir and ABDOU, (2005) with permission
HVAC System

The position of HVAC system in determining the level of indoor air quality in the university classroom can never be over emphasized. HVAC should be well designed and maintained to deliver germ-free clean air to the conditioned space. The following strategies should be adhered to in respect of the 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 of the classroom environment.

The installation of an outdoor air intake must be specified as part of the exhaust system to avoid inadequate removal of pollutants from the room.

The outdoor air should be supplied continuously when a classroom is occupied.

Demand-controlled HVAC package systems should be operated 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 the 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.

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 aoustical control, the potential for uncontrolled moisture to enter the duct over the life of the system must be considered.

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.

Figure 7  3D interior view of the model classroom showing acoustics treatment

- Relative Humidity - 30% to 60% (ASHRAE 55-1992)
- Temperature - 68 degrees to 78 degrees (ASHRAE 55-1992)
- Ventilation Rate - minimum of 15 cfm per person (ASHRAE 62-1989)
- Carbon Dioxide - maximum 1000 parts per million (ASHRAE 62-1989)

**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. Waterproof mats should be supplied over carpeted entryways and other areas to be used for drying clothing and umbrellas (EPA, 2010).

**Construction Methods and Operation**

To prevent or help resolve indoor air quality problems effectively and efficiently, schools must ensure that the recommended temperature and relative humidity ranges be maintained in the indoor air and that the HVAC system is working properly. Generally, the temperature and humidity should be maintained within the comfort zone of 68 to 78 degrees Fahrenheit and 30% to 60% relative humidity, depending on the season (Pennsylvania Department of Health, 2002). Monitoring for carbon dioxide (CO2) routinely will be essential for indicating when outdoor air ventilation may be inadequate.

**Building Materials**

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

Table 2: Building Materials Indoor Air Quality Control Strategies

<table>
<thead>
<tr>
<th>S/N</th>
<th>Materials</th>
<th>Maximum Acceptable Emission Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Flooring Materials</td>
<td>0.6 mg/h/m²</td>
</tr>
<tr>
<td>2</td>
<td>Floor Coating Materials</td>
<td>0.6 mg/h/m²</td>
</tr>
<tr>
<td>3</td>
<td>Wall Covering Materials</td>
<td>0.4 mg/h/m²</td>
</tr>
<tr>
<td>4</td>
<td>Wall Coating Materials</td>
<td>0.4 mg/h/m²</td>
</tr>
<tr>
<td>5</td>
<td>All Movable Partitions</td>
<td>0.4 mg/h/m²</td>
</tr>
<tr>
<td>6</td>
<td>Office Furniture</td>
<td>2.5 mg/h/workstation</td>
</tr>
<tr>
<td>7</td>
<td>Radon</td>
<td>US Environmental Protection Agency recommends Maximum of 4 picocuries (pCi/L) per litre (Innovative Design, 2009)</td>
</tr>
</tbody>
</table>

**Building Design**

Locate classrooms 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 covering 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 the estimated occupancy of 50 persons per 100 m²/per floor area is 12.5 (L/s) per person and 2.5 (L/s) per person outdoor air requirements (Wadden, and Scheff, 1983).
Specify complete documentation of operation and maintenance requirements. 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 define the required monitoring equipment (Innovative Design, 2009).

5. RESULTS AND DISCUSSION
The importance of the various attributes of the model university classroom in explaining its performance can never be over emphasized. These attributes include the physical, technological and equipment and environmental constraints that facilitate in creating and enabling a collaborative and interactive learning atmosphere for effective pedagogical delivery in the classroom.
An interactive interview was conducted among selected instructors and students in order to have their input on the suitability or otherwise of the various attributes suggested in the model university classroom. Some potential instructors at KFUPM were selected based on certain criteria including instructors recommended by the Deanship of Academic Development (DAD) based on related research work they conducted, best teaching award instructors, English Language instructors, and other instructors that were known as proponents of collaborative and interactive learning. Students at a senior level and graduate students were interviewed in every department at KFUPM. Due to the nature of the research problem, it required responses from an interested sector of the academic community to avoid irrelevancies.
When the course instructor responded to the interview question “Is Collaborative and Interactive learning better than Traditional Learning” out of 24 reply from interviewees, more than 91% agreed and 9% were ‘Unsure’. In terms of students, out of 27 students interviewed about 89% agreed, while the remaining 11% were ‘Unsure’.
When a question was posed in the interview to the instructors on the suitability of the proposed model university classroom physical set-up and shape, out of 26 respondents, 61% of them agreed with the classroom model presented in the interview survey and 39% disagreed with some of the ideas presented in the model classroom as shown in Figure 8(a). All interviewed students agreed with the classroom physical set-up and shape presented in the interview survey as shown in Figure 8(b).
When the course instructors were asked about their view on the adopted seating arrangement, out of 26 respondents, 70% accepted all the three proposed table shapes and possible configuration alternatives, while 31% had some reservations, especially on the arrangements as illustrated in Figure 8(a). 89% of respondents from among the students replied positively when the question with respect to the seating arrangement in the classrooms was posed to them, which indicated their agreement with the table proposals and arrangement presented, 12% were not in agreement with some of the proposal presented to them, citing the number of students per grouping and seating orientation as illustrated in Figure 8(b).
Of the 25 course instructors who were questioned on their view of the subject “Classroom Equipment/Technology”, almost 80% of the respondents accepted all the instructional equipment and technology provided in the classroom, while 20% of them had some reservation, especially with the suitability of some of the equipment and technology provided in the classroom as illustrated in Figure 8(a). Both the groups of respondents suggested some additional equipment and technology that will better facilitate the pedagogical delivery in the collaborative and interactive learning environment, such as flipcharts, clickers, smart touch screen/interactive boards and online collaborative tools. 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 technology presented in the interview survey as shown in Figure 8(b).
Both instructor and student respondents commented on and proposed some suggestions to the model university classroom presented to them in the form of 2D and 3D drawings. These suggestions have been considered and subsequently incorporated in the final designs based on their frequency and, equally, importance in achieving a well functioning, conducive and cost effective collaborative and interactive learning environment.
Figure 9 illustrates the percentage of the different complaints received as seen in the studies conducted by (DAD, 2008). It is clear from the figure that computer related problems are the highest (55%). The next most common problem reported is with the projector (18%). Based on the above result, there is a need to provide a model university classroom with efficient, durable computers and projector systems. These two instructional pieces of equipment are among the most important according to the survey conducted, as illustrated in Figure 9. Three types of students’ desk were adopted in the proposed model university classroom, including hexagonal, trapezoidal and triangular shapes with swivel standards to achieve the highest level of flexibility required to manoeuvre and reconfigure the tables to suit any collaborative and interactive learning arrangement that can be adopted in the classroom. Both course instructor and student respondents were requested to rank the three desk options in order of their suitability and flexibility and the result is illustrated in Figure 10(a).

When the course instructors were asked in the interview survey to list the three most important pieces of equipment and technology in the classroom they were as follows; out of the feedback from 20 respondents to this question. A data projector, which has the highest point was selected by 17 respondents as one of the most important pieces of equipment in the classroom, followed by the 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 documents camera with a single point as illustrated by percentage in Figure 10(b).
6. CONCLUSION AND RECOMMENDATIONS
This study of developing a Model University Classroom for Collaborative and Interactive Learning was intended to carry out analysis and subsequently to design how the university classroom for collaborative and interactive learning will look and also to ascertain the major influential factors affecting student performance in the university classroom. The study is tailored towards addressing collaborative and
interactive learning, it being a learner-centred style seeking to replace the widely used traditional teacher-centred style. The model university classroom for collaborative and interactive learning was designed and 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 the state-of-the-art instructional equipment and technology. Various indoor environmental quality standards have been analysed and recommended including lighting, acoustics, indoor air and thermal comfort for application in the model classroom.

An interactive interview survey was carried out among course instructors and students within King Fahd University of Petroleum and Minerals (KFUPM). The study confirms that the physical set up of the classroom; the indoor environmental quality, the instructional equipment and technology and the emerging teaching/learning pedagogies are the four major influential factors affecting student performance, learning and teaching styles in the classroom. The result of the interview indicates that a higher percentage of the respondents from both students and course instructors prefer collaborative and interactive learning compared to traditional learning styles, while a smaller percentage of the respondents among the course instructors and the students is unsure on which of the two styles is better. More than half of the respondents agree with the suitability of the presented physical set-up, shape and the three seating arrangements (of hexagonal, trapezoidal and triangular shapes), the classroom equipment/technology, the lighting and the acoustic strategies of the model university classroom.

Finally, both instructors and students have ranked option “B”, which is the trapezoidal shape desk, as the best alternative. Instructors ranked option “A” (hexagonal shape) and students ranked both option “A” and “C” (hexagonal and triangular shapes respectively) as the second best, and the course instructors ranked option “C” (triangular shape) as the third best classroom seating styles. However, all three options have scored higher than the acceptable mean points of 1.5 out of 3. In relation to most important pedagogical equipment and technology the response shows that data projector, white board and internet connection respectively are the most useful equipment and components in the collaborative and interactive classroom. This research developed a state-of-the-art model university classroom for collaborative and interactive learning with an appropriate physical set-up, integrated with efficient instructional technology and suitable 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 several classrooms within an educational environment and allow a group of students and course instructors to utilize the classrooms for a period of time using collaborative and interactive learning styles. Then both students and course instructors 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 e.g. lecture theatres, and auditoria.

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