

**Lighting Impacts on Productivity and Performance  
of School Children  
An experiment in Elementary Schools**

تأثير الإضاءة على إنتاجية وأداء أطفال المدارس  
تجربة في المدارس الابتدائية

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Dissertation submitted in partial fulfilment of the requirements for the degree of MSc Sustainable Design of the Built Environment

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August-2013



## DISSERTATION RELEASE FORM

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Title
<p><b>Lighting Impacts on Productivity and Performance of School Children</b>  <b>An experiment in Elementary Schools</b></p> <p>تأثير الإضاءة على إنتاجية وأداء أطفال المدارس  تجربة في المدارس الابتدائية</p>

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## **ABSTRACT - ENGLISH**

Sustainability is an increasingly prevalent issue not only in terms of our environment and resources, but also our health and performance, especially within the indoor environment. One of the most important elements of the indoor environment is lighting, and natural lighting is the most sustainable form that should be introduced to all interior spaces. There is no clear strategy for the complementary artificial lighting that can enhance the illumination of the indoor environment. Economic, environmental and social aspects determine the selection of artificial lighting, and the social aspect is the subject of this study. A variety of sustainable lighting is offered in the market, and the major advantage among them is their impact on the users of interior space. Even though this is not the foremost strategy for choosing artificial light, this study highlights this characteristic.

In this study an experiment was conducted over an academic year in elementary schools to evaluate the performance of students and teachers under warm and cool lighting. A specially-designed teachers' questionnaire was answered and analysed along with the students' grades, which were collected and discussed under the experimental lighting: warm white. Planned methodology was by observation (walkthrough, photos, comments), site analysis, students' grades, and teachers' questionnaires. The analysis method selected was statistical analysis along with corresponding discussion. The two schools selected shared similarities (Grade 2 – two different sections in each, British curriculum), and differed in terms of their interiors (colourful and neutral), and lighting fixtures (open and covered).

The major findings conducted through the study showed the remarkable advantages of the suggested artificial lighting along with few disadvantages. This emphasises the usage of it in elementary schools in the United Arab Emirates (UAE) with time conditions.

## ABSTRACT - ARABIC

الاستدامة هي قضية سائدة ومهمة على نحو متزايد، ليس فقط من حيث البيئة والموارد، ولكن أيضا من حيث تأثيرها الجلي على صحتنا وأدائنا في نشاطات حياتنا اليومية المعتادة، ولا سيما عند تواجدها في البيئة الداخلية (المنزل والمكاتب والمدارس والجامعات... الخ). تعتبر الإضاءة من أهم عناصر البيئة الداخلية نظرا لتأثيرها الفعال والواضح على بقية عناصر البيئة الداخلية، والإضاءة الطبيعية هي الشكل الأكثر استدامة والتي ينبغي إدخالها إلى جميع المساحات الداخلية. ليس هناك استراتيجية واضحة لاختيار الإضاءة الاصطناعية التكميلية التي يمكن أن تعزز الإضاءة الطبيعية في البيئة الداخلية. تعد العوامل الاقتصادية والبيئية والاجتماعية هي الأساس في اختيار الإضاءة الاصطناعية، والجانب الاجتماعي هو موضوع هذه الدراسة. تتواجد مجموعة متنوعة من الإضاءة المستدامة في الأسواق، والميزة الرئيسية من بينها يجب أن تكون تأثيرها على مستخدمي المساحة الداخلية. حتى ولو لم تكن هذه هي الاستراتيجية الأساسية في الإضاءة الاصطناعية في وقتنا الحالي، فإن هذه الدراسة تسلط الضوء على هذه الخاصية.

في هذه الدراسة تم إجراء تجربة على مدى عام دراسي واحد في مدارس المرحلة الابتدائية في دولة الإمارات العربية المتحدة لتقييم أداء الطلاب والمدرسون تحت إضاءة دافئة (بيضاء مصفرة) وباردة (بيضاء مزرقة). تم تصميم استبيان خاص للمدرسين وتحليله جنبا إلى جنب مع درجات تحصيل الطلاب خلال العام الدراسي، والتي تم جمعها ونوقشت في إطار الإضاءة التجريبية المقترحة: الأبيض المصفر الدافئ. تعتمد المنهجية التي اتبعت من البداية على مراقبة ورصد بيئة التجربة عن طريق (التجول والملاحظة وأخذ الصور وتدوين التعليقات)، تحليل الموقع، نتائج استبيانات المدرسين ودرجات الطلاب. أما بالنسبة لأسلوب التحليل المختار فهو التحليل الإحصائي إلى جانب المناقشة التحليلية. تم اختيار الصف الثاني الابتدائي بمدرستين مختلفتين (صفيين في كل مدرسة) كما شاركت المدرستين بمنهاج الدراسة البريطاني. واختلفت المدرستين من حيث الديكورات الداخلية لكلتيهما (الملونة والمحايدة)، وأغطية الإضاءة الاصطناعية (المفتوحة والمغطاة).

أظهرت النتائج الرئيسية مزايا وتأثيرات إيجابية واضحة للإضاءة الاصطناعية المقترحة بصورة خاصة على أداء الطلاب، والقليل من العيوب كتأثيرات سلبية. هذه النتائج تشجع استخدام الإضاءة التجريبية في المدارس الابتدائية في دولة الإمارات العربية المتحدة استخداما مشروطا بالوقت الصحيح.

## DEDICATION

*I dedicate my dissertation work to my family and many friends. A special feeling of gratitude to my loving parents, Ghaleb and Mouyassar whose words of encouragement and push for tenacity ring in my ears. My husband Akram, my sisters Naela, Rana, Roba, and Huda and my brother Ahmad have never left my side and are very special. The dedication and thanks extends to my uncle Tayseer and my aunt Intesar.*

*This work is dedicated to my beautiful and ever curious son Jaber. Without him my world would not be nearly as colourful.*

*I also dedicate this dissertation to my many friends who have supported me throughout the process. I will always appreciate all they have done, especially Taghreed for helping me find the schools for the experiment.*

*I dedicate this work and give special thanks to my best friend Manar.*

## ACKNOWLEDGMENTS

*A special thanks to Prof. Bassam Abu-Hijleh, my supervisor for his countless hours of reflecting, reading, encouraging, and most of all patience throughout the entire process.*

*I wish to thank my co-supervisor Prof. Eman Gaad who was more than generous with her expertise and precious time.*

*I would like to acknowledge and thank the schools where the experiment was conducted.*

*Finally I would like to thank all the teachers and administrators in BUiD.*

## Table of Contents

<b>DISSERTATION RELEASE FORM</b>	<b>II</b>
<b>ABSTRACT - ENGLISH</b>	<b>III</b>
<b>ABSTRACT - ARABIC</b>	<b>IV</b>
<b>DEDICATION</b>	<b>V</b>
<b>ACKNOWLEDGMENTS</b>	<b>VI</b>
<b>1. INTRODUCTION</b>	<b>1</b>
<b>1.1 Background of the Study</b>	<b>1</b>
1.1.1 Interior Environment	1
1.1.2 Impact of Light	2
1.1.3 Lighting the Interior Environment	3
1.1.4 Lighting the Learning Environments	5
<b>1.2 Statement of the Problem</b>	<b>8</b>
1.2.1 Schoolchildren Performance and the Impact of the Classroom Lighting	8
1.2.2 Traditional Lighting Used in the United Arab Emirates	9
<b>1.3 Research Rationale</b>	<b>10</b>
<b>1.4 Significance of the Study</b>	<b>10</b>
<b>1.5 Thesis Outline</b>	<b>11</b>
<b>2. LITERATURE REVIEW</b>	<b>13</b>
<b>2.1 Power and the Importance of Light and Colour</b>	<b>13</b>
2.1.1 Visual Perception	13
2.1.2 Therapy	14
2.1.3 Health Hazards	15
<b>2.2 Performance and Light</b>	<b>16</b>
<b>2.3 Health Issues of Schoolchildren in the United Arab Emirates</b>	<b>20</b>
2.3.1 Sick Building Syndrome	24
2.3.2 Headache and Migraine	24
2.3.3 Asthma and Wheezing	25
2.3.4 Vitamin D and Calcium Metabolism	27
<b>2.4 Research Question</b>	<b>27</b>
<b>2.5 Hypothesis of the Study</b>	<b>28</b>
<b>3. METHODOLOGY</b>	<b>31</b>
<b>3.1 Different Methods for Similar Studies</b>	<b>31</b>

3.1.1	Theoretical Review	31
3.1.2	Social Survey	32
3.1.3	Simulation (Computer Aided Software)	34
3.1.4	Observational	36
3.1.5	Experimental	37
<b>3.2</b>	<b>Research Method of the Study</b>	<b>41</b>
<b>3.3</b>	<b>The Methodology Framework</b>	<b>43</b>
3.3.1	Duration of the Study	44
3.3.2	Location of the Study	44
3.3.3	Environment of the Study – the Classrooms	45
3.3.4	Lighting (Cause)	45
<b>3.4</b>	<b>Data Collection Methods (Effect)</b>	<b>46</b>
3.4.1	Observing the Environment	46
3.4.2	Students' Data and Grades	46
3.4.3	Teachers' Data and Opinions	47
3.4.4	Resource Requirements	47
<b>3.5</b>	<b>Data Analysis Procedures and Tools (Results)</b>	<b>48</b>
<b>3.6</b>	<b>Summary of the Conceptual Planned Experiment (Variables)</b>	<b>49</b>
<b>3.7</b>	<b>Research Boundaries of the Study</b>	<b>50</b>
<b>4.</b>	<b>THE EXPERIMENT</b>	<b>52</b>
<b>4.1</b>	<b>Designing the Experiment</b>	<b>52</b>
<b>4.2</b>	<b>Observing the Environment of the Experiment</b>	<b>53</b>
4.2.1	Location	53
4.2.2	Interior Environment	55
4.2.3	Users of Space	58
4.2.4	Lighting Study	60
<b>4.3</b>	<b>Details of the Experiment</b>	<b>69</b>
<b>4.4</b>	<b>Summary of the Experiment</b>	<b>71</b>
<b>5.</b>	<b>ANALYSIS AND DISCUSSION</b>	<b>74</b>
<b>5.1</b>	<b>Analysis of Teachers' Questionnaires</b>	<b>74</b>
<b>5.2</b>	<b>Analysis of Students' Results – Number of Classes</b>	<b>79</b>
5.2.1	Analysis: Students' Results - Time Reference	92
5.2.2	Analysis: Students' Results – School Reference	95
5.2.3	Analysis: Students' Results – Subject Reference	99
5.2.4	Analysis: Students' Results – Gender Reference	103
5.2.5	Summary of Number of Classes Analysis	107
<b>5.3</b>	<b>Discussion of the Study Results</b>	<b>108</b>
<b>5.4</b>	<b>Analysis: Students' Results – Students' Numbers</b>	<b>115</b>



<b>6.</b>	<b>CONCLUSION AND RECOMMENDATIONS</b>	<b>127</b>
6.1	Findings of the Study	127
6.2	Conclusion	128
6.3	Recommendations	130
<b>REFERENCES</b>		<b>132</b>
<b>BIBLIOGRAPHY</b>		<b>138</b>
<b>APPENDICES</b>		<b>142</b>
I.	<b>APPENDIX A: QUESTIONNAIRE</b>	<b>143</b>
II.	<b>APPENDIX B: CLIMATE STUDY IN SHARJAH</b>	<b>144</b>
III.	<b>APPENDIX C: THE RESULTS (RAW DATA)</b>	<b>157</b>
IV.	<b>APPENDIX D: DETAILED CHARTS FOR SCHOOL-A</b>	<b>174</b>
V.	<b>APPENDIX E: DETAILED CHARTS FOR SCHOOL-B</b>	<b>188</b>

## LIST OF FIGURES

FIGURE 1-1: LIGHTING QUALITY MODEL (VEITCH, 1998).	4
FIGURE 1-2: SUSTAINABILITY DESIGN POTENTIAL (TAYLOR AND ENGGASS, 2009).	7
FIGURE 2-1: CONCEPTUAL MODEL SHOWING RELATIONSHIPS BETWEEN LIGHTING CONDITIONS, INDIVIDUAL PROCESSES, AND INDIVIDUAL OUTCOMES (VEITCH, 2001).	18
FIGURE 2-2: PROPOSED LINKED MECHANISMS MAP (VEITCH ET AL, 2007).	19
FIGURE 2-3: FINAL LINKED MECHANISM MAP (VEITCH ET AL, 2007).	20
FIGURE 3-1: ELECTRIC LIGHTING CONCEPT (FIG. 2 BRUIN HORDJIK AND GROOT, 2007:8)	35
FIGURE 4-1: SCHOOL-A LOCATION MAP, SCHOOL ZONE NEAR SHARJAH UNIVERSITY (GOOGLE-MAPS).	54
FIGURE 4-2: SCHOOL-B LOCATION MAP, BEHIND SHARJAH TV STATION (GOOGLE-MAPS).	55
FIGURE 4-3: SCHOOL-A, CLASSROOM INTERIORS - COLOUR SCHEME (TAKEN BY THE AUTHOR).	56
FIGURE 4-4: SCHOOL-B, CLASSROOM INTERIORS - COLOUR SCHEME (TAKEN BY THE AUTHOR).	56
FIGURE 4-5: SCHOOL-A CLASSROOM FURNITURE PLAN-A1 (DRAWN BY THE AUTHOR).	57
FIGURE 4-6: SCHOOL-A CLASSROOM FURNITURE PLAN-A2 (DRAWN BY THE AUTHOR).	57
FIGURE 4-7: SCHOOL-B CLASSROOM FURNITURE PLAN-B1 AND B2 (DRAWN BY THE AUTHOR).	57
FIGURE 4-8: AC UNITS IN SCHOOL-A (TAKEN BY THE AUTHOR).	58
FIGURE 4-9: AC UNITS IN SCHOOL-B (TAKEN BY THE AUTHOR).	58
FIGURE 4-10: CLASSROOM A1 ALLOCATION OF DAYLIGHT ACCESSES (DRAWN BY THE AUTHOR).	61
FIGURE 4-11: CLASSROOM A2 ALLOCATION OF DAYLIGHT ACCESSES (DRAWN BY THE AUTHOR).	61
FIGURE 4-12: SCHOOL-A CLASSROOM-A1 SUN PATH STUDY (DONE BY THE AUTHOR).	62
FIGURE 4-13: SCHOOL-A CLASSROOM-A2 SUN PATH STUDY (DONE BY THE AUTHOR).	62
FIGURE 4-14: CLASSROOMS (A1 AND A2) GLASS DOOR (TAKEN BY THE AUTHOR).	63
FIGURE 4-15: CLASSROOMS (A1 AND A2) SHORT RAISED WINDOWS (TAKEN BY THE AUTHOR).	64
FIGURE 4-16: CLASSROOMS B1 AND B2 ALLOCATION OF DAYLIGHT ACCESS (DRAWN BY THE AUTHOR).	64

FIGURE 4-17: CLASSROOMS (B1 AND B2) ALLOCATION OF WINDOWS (TAKEN BY AUTHOR).	65
FIGURE 4-18: SCHOOL-B CLASSROOMS (B1 AND B2) SUN PATH STUDY (DONE BY THE AUTHOR).	65
FIGURE 4-19: COLOUR TEMPERATURE (KARLEN AND BENYA, 2004).	66
FIGURE 4-20: REAL LIGHT SOURCES (KARLEN AND BENYA, 2004).	66
FIGURE 4-21: FLUORESCENT TUBES USED IN THE EXPERIMENT (WWW.OSRAM.COM).	66
FIGURE 4-22: SCHOOL-A REFLECTED CEILING PLAN A1 (DRAWN BY THE AUTHOR).	67
FIGURE 4-23: SCHOOL-A REFLECTED CEILING PLAN A2 (DRAWN BY THE AUTHOR).	67
FIGURE 4-24: SCHOOL-B REFLECTED CEILING PLAN-B1ANDB2 (DRAWN BY THE AUTHOR).	68
FIGURE 4-25: SCHOOL-A COVERED LUMINARIES (TAKEN BY THE AUTHOR).	68
FIGURE 4-26: SCHOOL-B OPENED LUMINARIES (TAKEN BY THE AUTHOR).	68
FIGURE 4-27: FIRST SEMESTER EXPERIMENT DETAILING (DRAWN BY THE AUTHOR).	69
FIGURE 4-28: SECOND SEMESTER EXPERIMENT DETAILING (DRAWN BY THE AUTHOR).	70
FIGURE 5-1: SCHOOL-A TEACHERS' QUESTIONNAIRES YES/NO QUESTIONS (DONE BY THE AUTHOR).	74
FIGURE 5-2: SCHOOL-B TEACHERS' QUESTIONNAIRES YES/NO QUESTIONS (DONE BY THE AUTHOR).	74
FIGURE 5-3: SCHOOL-A TEACHERS' QUESTIONNAIRES BEHAVIOR DURING THE DAY (DONE BY THE AUTHOR).	75
FIGURE 5-4: SCHOOL-B TEACHERS' QUESTIONNAIRES BEHAVIOR DURING THE DAY (DONE BY THE AUTHOR).	75
FIGURE 5-5: SCHOOL-A TEACHERS' QUESTIONNAIRE - VENTILATION, IMPACT OF LIGHTING ON TEACHERS AND STUDENTS (DONE BY THE AUTHOR).	76
FIGURE 5-6: SCHOOL-B TEACHERS' QUESTIONNAIRE - VENTILATION, IMPACT OF LIGHTING ON TEACHERS AND STUDENTS (DONE BY THE AUTHOR).	77
FIGURE 5-7: SCHOOL-A TEACHERS' QUESTIONNAIRE - HEALTH ISSUES (DONE BY THE AUTHOR).	78
FIGURE 5-8: SCHOOL-B TEACHERS' QUESTIONNAIRE - HEALTH ISSUES (DONE BY THE AUTHOR).	78
FIGURE 5-9: CHANGES IN GRADES FOR CLASS A1 (DONE BY THE AUTHOR).	80
FIGURE 5-10: CHANGES IN GRADES FOR CLASS A1 / FEMALE STUDENTS (DONE BY THE AUTHOR).	81
FIGURE 5-11: CHANGES IN GRADES FOR CLASS A1 / MALE STUDENTS (DONE BY THE AUTHOR).	82

FIGURE 5-12: CHANGES IN GRADES FOR CLASS A2 (DONE BY THE AUTHOR).	84
FIGURE 5-13: CHANGES IN GRADES FOR CLASS A2 / FEMALE STUDENTS (DONE BY THE AUTHOR).	85
FIGURE 5-14: CHANGES IN GRADES FOR CLASS A2 / MALE STUDENTS (DONE BY THE AUTHOR).	86
FIGURE 5-15: CHANGES IN GRADES FOR CLASS B1 / FEMALE (DONE BY THE AUTHOR).	87
FIGURE 5-16: CHANGES IN GRADES FOR CLASS B2 / FEMALE (DONE BY THE AUTHOR).	88
FIGURE 5-17: CHANGES IN GRADES FOR CLASS B3 – SECOND SEMESTER / (MALE) REFERENCE 1 (DONE BY THE AUTHOR).	90
FIGURE 5-18: CHANGES IN GRADES FOR CLASS B4 – SECOND SEMESTER / (MALE) REFERENCE 2 (DONE BY THE AUTHOR).	91
FIGURE IV-1: CLASS A1 ISLAMIC STUDIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	174
FIGURE IV-2: CLASS A1 ARABIC RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	174
FIGURE IV-3: CLASS A1 SOCIAL STUDIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	175
FIGURE IV-5: CLASS A1 LITERACY RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	175
FIGURE IV-6: CLASS A1 MATH RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	175
FIGURE IV-7: CLASS A1 SCIENCE RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	176
FIGURE IV-8: CLASS A1 GEOGRAPHY RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	176
FIGURE IV-9: CLASS A1 FRENCH RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	176
FIGURE IV-10: CLASS A1 PE RESULTS COMPARISON CHART (DONE BY THE AUTHOR)	177
FIGURE IV-11: CLASS A1 ISLAMIC STUDIES / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	177
FIGURE IV-12: CLASS A1 ARABIC / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	177
FIGURE IV-13: CLASS A1 SOCIAL STUDIES / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	178
FIGURE IV-14: CLASS A1 LITERACY / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	178
FIGURE IV-15: CLASS A1 MATH / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	178
FIGURE IV-16: CLASS A1 SCIENCE / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	179

FIGURE IV-17: CLASS A1 GEOGRAPHY / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	179
FIGURE IV-18: CLASS A1 FRENCH / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	180
FIGURE IV-19: CLASS A1 PE / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	180
FIGURE IV-20: CLASS A2 ISLAMIC STUDIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	181
FIGURE IV-21: CLASS A2 ARABIC RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	181
FIGURE IV-22: CLASS A2 SOCIAL STUDIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	181
FIGURE IV-23: CLASS A2 LITERACY RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	182
FIGURE IV-24: CLASS A2 MATH RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	182
FIGURE IV-25: CLASS A2 SCIENCE RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	182
FIGURE IV-26: CLASS A2 GEOGRAPHY RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	183
FIGURE IV-27: CLASS A2 FRENCH RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	183
FIGURE IV-28: CLASS A2 PE RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	183
FIGURE IV-29: CLASS A2 ISLAMIC STUDIES / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	184
FIGURE IV-30: CLASS A2 ARABIC / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	184
FIGURE IV-31: CLASS A2 SOCIAL STUDIES / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	185
FIGURE IV-32: CLASS A2 LITERACY / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	185
FIGURE IV-33: CLASS A2 MATH / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	186
FIGURE IV-34: CLASS A2 SCIENCE / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	186
FIGURE IV-35: CLASS A2 GEOGRAPHY / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	186
FIGURE IV-36: CLASS A2 FRENCH / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	187
FIGURE IV-37: CLASS A2 PE / GENDER RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	187

FIGURE V-1: CLASS B1 ISLAMIC STUDIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	188
FIGURE V-2: CLASS B1 ARABIC RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	188
FIGURE V-3: CLASS B1 SOCIAL STUDIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	188
FIGURE V-4: CLASS B1 ENGLISH RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	189
FIGURE V-5: CLASS B1 MATH RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	189
FIGURE V-6: CLASS B1 SCIENCE RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	189
FIGURE V-7: CLASS B1 ACTIVITIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	190
FIGURE V-8: CLASS B1 HOLY QURAN RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	190
FIGURE V-9: CLASS B1 READING RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	190
FIGURE V-10: CLASS B1 LISTENING RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	191
FIGURE V-11: CLASS B1 CONVERSATION RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	191
FIGURE V-12: CLASS B2 ISLAMIC STUDIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	191
FIGURE V-13: CLASS B2 ARABIC RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	192
FIGURE V-14: CLASS B2 SOCIAL STUDIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	192
FIGURE V-15: CLASS B2 ENGLISH RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	193
FIGURE V-16: CLASS B2 MATH RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	193
FIGURE V-17: CLASS B2 SCIENCE RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	193
FIGURE V-18: CLASS B2 ACTIVITIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	194
FIGURE V-19: CLASS B2 HOLY QURAN RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	194
FIGURE V-20: CLASS B2 READING RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	194
FIGURE V-21: CLASS B2 LISTENING RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	195

FIGURE V-22: CLASS B2 CONVERSATION RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	195
FIGURE V-23: CLASSES B1 AND B2 ISLAMIC STUDIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	196
FIGURE V-24: CLASSES B1 AND B2 ARABIC RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	196
FIGURE V-25: CLASSES B1 AND B2 SOCIAL STUDIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	197
FIGURE V-26: CLASSES B1 AND B2 ENGLISH RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	197
FIGURE V-27: CLASSES B1 AND B2 MATH RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	198
FIGURE V-28: CLASSES B1 AND B2 SCIENCE RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	198
FIGURE V-29: CLASSES B1 AND B2 ACTIVITIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	199
FIGURE V-30: CLASSES B1 AND B2 HOLY QURAN RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	199
FIGURE V-31: CLASSES B1 AND B2 READING RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	200
FIGURE V-32: CLASSES B1 AND B2 LISTENING RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	200
FIGURE V-33: CLASSES B1 AND B2 CONVERSATION RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	201
FIGURE V-34: CLASS B3 ISLAMIC STUDIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	201
FIGURE V-35: CLASS B3 ARABIC RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	202
FIGURE V-36: CLASS B3 SOCIAL STUDIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	202
FIGURE V-37: CLASS B3 ENGLISH RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	202
FIGURE V-38: CLASS B3 ENGLISH RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	203
FIGURE V-39: CLASS B3 SCIENCE RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	203
FIGURE V-40: CLASS B3 ACTIVITIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	203
FIGURE V-41: CLASS B3 HOLY QURAN RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	204
FIGURE V-42: CLASS B3 READING RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	204

FIGURE V-43: CLASS B3 LISTENING RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	204
FIGURE V-44: CLASS B3 CONVERSATION RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	205
FIGURE V-45: CLASS B4 ISLAMIC STUDIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	205
FIGURE V-46: CLASS B4 ARABIC RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	206
FIGURE V-47: CLASS B4 SOCIAL STUDIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	206
FIGURE V-48: CLASS B4 ENGLISH RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	206
FIGURE V-49: CLASS B4 MATH RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	207
FIGURE V-50: CLASS B4 SCIENCE RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	207
FIGURE V-51: CLASS B4 ACTIVITIES RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	207
FIGURE V-52: CLASS B4 HOLY QURAN RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	208
FIGURE V-53: CLASS B4 READING RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	208
FIGURE V-54: CLASS B4 LISTENING RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	208
FIGURE V-55: CLASS B4 CONVERSATION RESULTS COMPARISON CHART (DONE BY THE AUTHOR).	209



## LIST OF TABLES

TABLE 1-1: SUGGESTED MODEL FOR SCHOOL DESIGN (TAYLOR AND ENGGASS, 2009).	6
TABLE 1-2: HOLISTIC GOALS OF EDUCATIONAL FACILITY DESIGN (TAYLOR AND ENGGASS, 2009).	7
TABLE 2-1: PATIENTS AT GOVERNMENT HOSPITALS	22
TABLE 2-2: PATIENTS AT MEDIAL PRIVATE SECTOR HOSPITALS	23
TABLE 2-3: STUDY RESULTS (BENER ET AL, 1998).	25
TABLE 3-1: SUMMERY OF PREVIOUS EXPERIMENTS (DONE BY AUTHOR).	41
TABLE 3-2: CONCEPTUAL SUMMARY OF VARIABLES (DONE BY THE AUTHOR).	49
TABLE 4-1: SUMMARY OF PARTICIPANTS (DONE BY THE AUTHOR).	59
TABLE 4-2: SUMMARY OF SIZE OF SAMPLE - QUESTIONNAIRES (DONE BY THE AUTHOR).	59
TABLE 4-3: SUMMARY OF SIZE OF SAMPLE - STUDENTS' RESULTS (DONE BY THE AUTHOR).	60
TABLE 4-4: SUMMARY OF EXPERIMENT (DONE BY THE AUTHOR).	71
TABLE 5-1: CHANGES IN GRADES FOR CLASS A1 (DONE BY THE AUTHOR).	79
TABLE 5-2: CHANGES IN GRADES FOR CLASS A1 / FEMALE STUDENTS (DONE BY THE AUTHOR)	81
TABLE 5-3: CHANGES IN GRADES FOR CLASS A1 / MALE STUDENTS (DONE BY THE AUTHOR)	82
TABLE 5-4: CHANGES IN GRADES FOR CLASS A2 (DONE BY THE AUTHOR).	83
TABLE 5-5: CHANGES IN GRADES FOR CLASS A2 / FEMALE STUDENTS (DONE BY THE AUTHOR).	84
TABLE 5-6: CHANGES IN GRADES FOR CLASS A2 (MALE STUDENTS).	85
TABLE 5-7: CHANGES IN GRADES FOR CLASS B1 / FEMALE (DONE BY THE AUTHOR).	87
TABLE 5-8: CHANGES IN GRADES FOR CLASS B2 / FEMALE (DONE BY THE AUTHOR).	88
TABLE 5-9: CHANGES IN GRADES FOR CLASS B3 – SECOND SEMESTER / (MALE) REFERENCE 1 (DONE BY THE AUTHOR).	89
TABLE 5-10: CHANGES IN GRADES FOR CLASS B4 – SECOND SEMESTER / (MALE) REFERENCE 2 (DONE BY THE AUTHOR).	90
TABLE 5-11: ANALYSIS - TIME REFERENCE – FIRST SEMESTER / IMPROVED (I) VS. RETRACTED (R) OR NEUTRAL (N) (DONE BY THE AUTHOR).	92
TABLE 5-12: ANALYSIS - TIME REFERENCE – SECOND SEMESTER / IMPROVED (I) VS. RETRACTED (R) OR NEUTRAL (N) (DONE BY THE AUTHOR).	93
TABLE 5-13: ANALYSIS - SCHOOL REFERENCE / SCHOOL-A / IMPROVED (I) VS. RETRACTED (R) OR NEUTRAL (N) (DONE BY THE AUTHOR).	95

TABLE 5-14: ANALYSIS - SCHOOL REFERENCE / SCHOOL-B / IMPROVED (I) VS. RETRACTED (R) OR NEUTRAL (N) (DONE BY THE AUTHOR).	97
TABLE 5-15: ANALYSIS – SUBJECT REFERENCE / IMPROVED (I) VS. RETRACTED (R) OR NEUTRAL (N) (DONE BY THE AUTHOR).	101
TABLE 5-16: ANALYSIS - GENDER REFERENCE / FEMALE RESULTS / IMPROVED (I) VS. RETRACTED (R) OR NEUTRAL (N) (DONE BY THE AUTHOR).	104
TABLE 5-17: ANALYSIS - GENDER REFERENCE / MALE RESULTS / IMPROVED (I) VS. RETRACTED (R) OR NEUTRAL (N) (DONE BY THE AUTHOR).	105
TABLE 5-18: ANALYSIS - SUMMARY OF ALL ANALYSES REFERENCES NUMBER OF CLASSES / IMPROVED (I) VS. RETRACTED (R) OR NEUTRAL (N) (DONE BY THE AUTHOR).	107
TABLE 5-19: ANALYSIS - ISLAMIC STUDIES PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	116
TABLE 5-20: ANALYSIS - ARABIC PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	116
TABLE 5-21: ANALYSIS - SOCIAL STUDIES PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	116
TABLE 5-22: ANALYSIS - LITERACY/ENGLISH PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	117
TABLE 5-23: ANALYSIS - MATHEMATICS PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	117
TABLE 5-24: ANALYSIS - SCIENCE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	117
TABLE 5-25: ANALYSIS - GEOGRAPHY PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	117
TABLE 5-26: ANALYSIS - FRENCH PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	118
TABLE 5-27: ANALYSIS -PE/ACTIVITIES PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	118
TABLE 5-28: ANALYSIS – HOLY QURAN PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	118
TABLE 5-29: ANALYSIS – READING PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	118
TABLE 5-30: ANALYSIS – LISTENING PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	119
TABLE 5-31: ANALYSIS – CONVERSATION PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	119
TABLE 5-32: ANALYSIS - ISLAMIC STUDIES FEMALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	119
TABLE 5-33: ANALYSIS - ARABIC FEMALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	119
TABLE 5-34: ANALYSIS - SOCIAL STUDIES FEMALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	120

TABLE 5-35: ANALYSIS - LITERACY/ENGLISH FEMALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	120
TABLE 5-36: ANALYSIS - MATH FEMALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	120
TABLE 5-37: ANALYSIS – SCIENCE FEMALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	120
TABLE 5-38: ANALYSIS - GEOGRAPHY FEMALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	121
TABLE 5-39: ANALYSIS - FRENCH FEMALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	121
TABLE 5-40: ANALYSIS -PE/ACTIVITIES FEMALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	121
TABLE 5-41: ANALYSIS - ISLAMIC STUDIES MALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	121
TABLE 5-42: ANALYSIS - ARABIC MALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	122
TABLE 5-43: ANALYSIS - SOCIAL STUDIES MALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	122
TABLE 5-44: ANALYSIS - LITERACY/ENGLISH MALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	122
TABLE 5-45: ANALYSIS - MATH MALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	122
TABLE 5-46: ANALYSIS – SCIENCE MALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	123
TABLE 5-47: ANALYSIS - GEOGRAPHY MALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	123
TABLE 5-48: ANALYSIS - FRENCH MALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	123
TABLE 5-49: ANALYSIS -PE/ACTIVITIES MALE PERCENTAGE OF IMPROVED (I), RETRACTED (R) AND NEUTRAL (N) RESULTS (DONE BY THE AUTHOR).	123
TABLE 5-50: ANALYSIS – PERCENTAGE OF STUDENTS' VS. NUMBER OF CLASSES RESULTS IN EXPERIMENTAL CLASSES (DONE BY THE AUTHOR).	125
TABLE II-1: : INTERPRETATION / KEY OF WEATHER TABLES ( <a href="http://www.tutiempo.net/en/climate/sharjah_international_airport">HTTP://WWW.TUTIEMPO.NET/EN/CLIMATE/SHARJAH_INTERNATIONAL_AIRPORT</a> )	144
TABLE II-2: SHARJAH WEATHER TABLE - SEPTEMBER 2009 ( <a href="http://www.tutiempo.net/en/climate/sharjah_international_airport">HTTP://WWW.TUTIEMPO.NET/EN/CLIMATE/SHARJAH_INTERNATIONAL_AIRPORT</a> )	145
TABLE II-3: SHARJAH WEATHER TABLE - OCTOBER 2009 ( <a href="http://www.tutiempo.net/en/climate/sharjah_international_airport">HTTP://WWW.TUTIEMPO.NET/EN/CLIMATE/SHARJAH_INTERNATIONAL_AIRPORT</a> )	146

TABLE II-4: SHARJAH WEATHER TABLE - NOVEMBER 2009 ( <a href="http://www.tutiempo.net/en/climate/sharjah_international_airport">HTTP://WWW.TUTIEMPO.NET/EN/CLIMATE/SHARJAH_INTERNATIONAL_AIRPORT</a> )	147
TABLE II-5: SHARJAH WEATHER TABLE - DECEMBER 2009 ( <a href="http://www.tutiempo.net/en/climate/sharjah_international_airport">HTTP://WWW.TUTIEMPO.NET/EN/CLIMATE/SHARJAH_INTERNATIONAL_AIRPORT</a> )	148
TABLE II-6: SHARJAH WEATHER TABLE - JANUARY 2010 ( <a href="http://www.tutiempo.net/en/climate/sharjah_international_airport">HTTP://WWW.TUTIEMPO.NET/EN/CLIMATE/SHARJAH_INTERNATIONAL_AIRPORT</a> )	149
TABLE II-7: SHARJAH WEATHER TABLE - FEBRUARY 2010 ( <a href="http://www.tutiempo.net/en/climate/sharjah_international_airport">HTTP://WWW.TUTIEMPO.NET/EN/CLIMATE/SHARJAH_INTERNATIONAL_AIRPORT</a> )	150
TABLE II-8: SHARJAH WEATHER TABLE - MARCH 2010 ( <a href="http://www.tutiempo.net/en/climate/sharjah_international_airport">HTTP://WWW.TUTIEMPO.NET/EN/CLIMATE/SHARJAH_INTERNATIONAL_AIRPORT</a> )	151
TABLE II-9: SHARJAH WEATHER TABLE - APRIL 2010 ( <a href="http://www.tutiempo.net/en/climate/sharjah_international_airport">HTTP://WWW.TUTIEMPO.NET/EN/CLIMATE/SHARJAH_INTERNATIONAL_AIRPORT</a> )	152
TABLE II-10: SHARJAH WEATHER TABLE - MAY 2010 ( <a href="http://www.tutiempo.net/en/climate/sharjah_international_airport">HTTP://WWW.TUTIEMPO.NET/EN/CLIMATE/SHARJAH_INTERNATIONAL_AIRPORT</a> )	153
TABLE II-11: SHARJAH WEATHER TABLE - JUNE 2010 ( <a href="http://www.tutiempo.net/en/climate/sharjah_international_airport">HTTP://WWW.TUTIEMPO.NET/EN/CLIMATE/SHARJAH_INTERNATIONAL_AIRPORT</a> )	154
TABLE II-12: SHARJAH WEATHER TABLE - JULY 2010 ( <a href="http://www.tutiempo.net/en/climate/sharjah_international_airport">HTTP://WWW.TUTIEMPO.NET/EN/CLIMATE/SHARJAH_INTERNATIONAL_AIRPORT</a> )	155
TABLE II-13: SHARJAH AVERAGE WEATHER TABLE IN FIRST AND SECOND SEMESTER - ACADEMIC YEAR 2009-2010 (DONE BY THE AUTHOR)	156
TABLE III-1: ANSWERS FOR QUESTION 1 (DONE BY THE AUTHOR).	157
TABLE III-2: ANSWERS FOR QUESTION 2 (DONE BY THE AUTHOR).	157
TABLE III-3: ANSWERS FOR QUESTION 3 (DONE BY THE AUTHOR).	158
TABLE III-4: ANSWERS FOR QUESTION 4 (DONE BY THE AUTHOR).	158
TABLE III-5: ANSWERS FOR QUESTION 5 (DONE BY THE AUTHOR).	159
TABLE III-6: ANSWERS FOR QUESTION 6 (DONE BY THE AUTHOR).	159
TABLE III-7: ANSWERS FOR QUESTION 7 (DONE BY THE AUTHOR).	160
TABLE III-8: ANSWERS FOR QUESTION 8 (DONE BY THE AUTHOR).	160
TABLE III-9: ANSWERS FOR QUESTION 9 (DONE BY THE AUTHOR).	161
TABLE III-10: CLASS A1 GRADE REPORT - FIRST SEMESTER	162
TABLE III-11: CLASS A1 GRADE REPORT - SECOND SEMESTER	163
TABLE III-12: CLASS A2 GRADE REPORT - FIRST SEMESTER	164
TABLE III-13: CLASS A2 GRADE REPORT - SECOND SEMESTER	165

TABLE III-14: CLASS B1 GRADE REPORT - FIRST SEMESTER	166
TABLE III-15: CLASS B1 GRADE REPORT - SECOND SEMESTER	167
TABLE III-16: CLASS B2 GRADE REPORT - FIRST SEMESTER	168
TABLE III-17: CLASS B2 GRADE REPORT - SECOND SEMESTER	169
TABLE III-18: CLASS B3 GRADE REPORT - FIRST SEMESTER (REFERENCE 1)	170
TABLE III-19: CLASS B3 GRADE REPORT - SECOND SEMESTER (REFERENCE 1)	171
TABLE III-20: CLASS B4 GRADE REPORT - FIRST SEMESTER (REFERENCE 2)	172
TABLE III-21: CLASS B4 GRADE REPORT - SECOND SEMESTER (REFERENCE 2)	173

# **1. INTRODUCTION**

## **1.1 Background of the Study**

### **1.1.1 Interior Environment**

Since the beginning of the 21<sup>st</sup> century, the buildings and construction revolution has expanded (Jones, 2008). Compound buildings started to be recognized in different societies and countries for their functionality in different climates, for time saving and many other situations (such as companies, factories, hotels, shopping malls, schools, universities, showrooms, office and residential towers, trade centers, compounds, villas). As a result of this revolution, people have more recently been spending over eighty percent of their lifetime indoors. Although this action helped the major functions it was designed for, some negative side effects started to be realized. Pollution in interior environments is recording higher levels than outdoors by a factor of two to five (LEED 2007). This pollution has numerous negative effects, principally causing health problems such as asthma, allergies, and general discomfort. This in turn affects our performance and contributes to millions of collective days of absence from school and work (Jones, 2008).

The dominant role of the interior environment in our lives (users and occupants) is believed to affect our mood, behavior and performance in different ways, both directly and indirectly. The interior environment, whether residential or commercial, features many elements that, individually or collectively, are powerful enough to have a remarkable impact on users and occupants, enhancing the overall effect casted

upon us. Although this is more complicated to control, a number of studies are focusing on individual elements as well as the relation between the elements taken as a whole. Occupants have varied reactions towards these elements, and major reactions are recorded in different studies.

Elements of the interior environment vary, from the space whose boundaries include walls, ceiling and floor, to any item or aspect that is added to enhance the function of the boundaries and the space within. Light, colour, furniture, texture, fixtures, finishes, ventilation, equipment, openings, and plenty of others can be considered elements of the interior environment. Each can have sub-categories as it possesses a number of varying characteristics, causing different impacts and interactions with other elements and characteristics too (Ching and Binggeli, 2004).

### **1.1.2 Impact of Light**

For a long time many researchers believed the major influence of lighting to be visual comfort or discomfort, until Kenz (1995) demonstrated that some lighting circumstances encourage negative influence and reduce performance, and vice-versa (Abramson et al, 2007). Since then, recommendations have been circulated to direct lighting research towards studying new concepts, in which lighting affects health, behaviour, mood, task performance and even circadian rhythms (Boyce, 2004). Recent studies started appearing in the lighting research field focusing on human performance in different areas (especially commercial areas such as offices, schools, universities) to provide evidence of lighting impact (Veitch, 2001a) regardless of the age of the users.

It is believed that results in every area may be conveyed to other areas, since the main study is human performance (Heschong et al, 2002). Further study is needed to expand the research parameters to include major light characteristics, psychological and biological processes. “It will certainly require a coordinated strategy using a combination of methodologies – laboratory experimentation, field work, and population studies –” (Heschong et al, 2002). There is no clear knowledge in this regard yet, except in that there is still much to learn and do (Veitch, 2005).

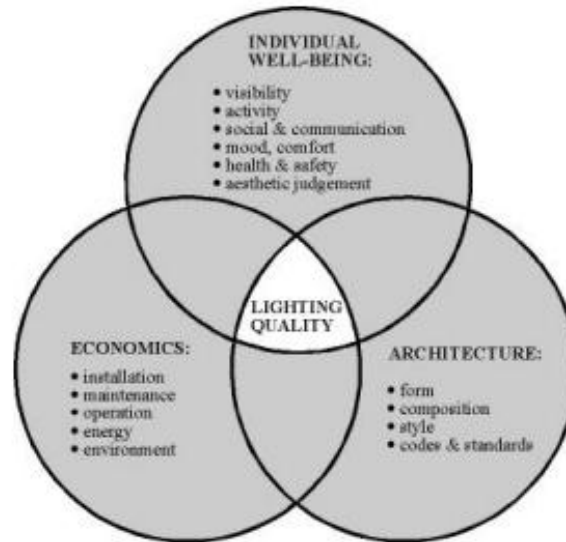
### **1.1.3 Lighting the Interior Environment**

Natural daylight is the best form of illumination for the interior environment, but in some cases cannot be the only source as the function, working hours, weather, location of the building and other factors require artificial light to complement them. The more efficient the daylight utilised in the interior environment, the fewer complications necessary to modify the accompanying artificial lighting. A lot of variables do play a substantial role in choosing the proper artificial light type in the interior environment to achieve the best illumination, and this will be illustrated through the experiment conducted in this study. Lighting colour, type, control, maintenance and operating schedules are important factors to be taken into consideration when comparing the best artificial light to be applied.

Veitch (1998) illustrates a lighting quality model in which three major factors should be applied when selecting the artificial light in the environment in order to attain quality lighting (Figure 1-1). If lighting achieves individual wellbeing,



and economic and architectural satisfaction, it will become the choice quality lighting within the interior environment.



**Figure 1-1: Lighting quality model (Veitch, 1998).**

As lighting and colour elements have great impact on other interior elements, they are also affected by all of them. This increases the variables that are influencing the performance of the artificial lighting, making it difficult to standardise lighting and colour type for different interior environments. Every interior environment with its design and elements should be unique and have a proper study for its illumination plan, with natural and artificial light complimenting each other for the best result.

To this day, studies have been carried out to explore and affirm the importance of other factors to be added to the quality lighting model, as well as the different elements affected positively or negatively, in order to achieve best performance.

#### **1.1.4 Lighting the Learning Environments**

Veitch (1998) states that architecture is one of the three principal elements of the lighting quality model. This asserts the responsibility placed upon architects and interior designers while designing the space. The major concern in designing the learning environment should be the daylight, according to Nair and Fielding (2009). After the form, openings that will allow the daylight, it is the artificial light and colour that should be designed in the correct manner to improve the performance of the users, along with the impact on them.

Taylor and Enggass (2009) contend, in their book “Linking Architecture and Education: Sustainable Design for Learning Environments”, that designing learning environments has always been a big challenge for designers, as the client (owner) in most cases is unaware of the users’ requirements. Such requirements accordingly do not make it into the design plan and program. Most of the designs rely on the standard vision of learning environments and do not upgrade the norm, to the detriment of the users. This keeps the issues and side-effects of the design affecting the users. Users of the space seek some understanding for their needs of fresh functional spaces to help them improve and promote their performance; as well as avoid the negativity they occasionally feel in such space. Recently this had become the concern of researchers, especially designers, to create a link and state a role to help the understanding from both sides. As the main customer interacting with the designers is the owner and not the user (as with most commercial buildings), this explains the conflict of needs. The following tables summarize the issue and the suggested model for school design:

This conflict misleads the designers and results in designs that neglect the major need and focus instead on minor needs. Hopefully this issue is now of concern to researchers from both sides: designers and academics (users). In this study the elementary schools lighting aspect will be studied along with its impacts on students. Children are the users most affected by their learning environment in different ways. Sustainable effective lighting will be suggested for the best impact on children in their learning environments.

**Table 1-1: Suggested Model for School Design (Taylor and Engass, 2009).**

<b>The Informed Learning Environment: Combining Architecture and Education to Create a Model for School Design</b>			
	<b>Natural</b>	<b>Built</b>	<b>Cultural</b>
<b>Architecture</b>	School playgrounds function as community parks, nature trails, fitness courses, gardens, zoos, habitats, weather stations, and places for experimentation.	Building systems teach through structural clarity, or "legibility" as described by Lynch (1993). The curriculum determines the design of the architecture.	Design ideas from cultural institutions are applied to school design: museums, galleries, plazas, health centers, local ethnicity and style, the workplace, families, and homes.
<b>Education</b>	Students perform site analysis as curriculum for understanding the life zone: climate, topography, plant and animal life, water, etc. Landscape architecture of the playground becomes a learning tool. Students collect data for the architect.	Behind every object is an idea or concept. Learners "read" physical objects and translate them into ideas. Thus, architecture is pedagogy. Physical elements or manifestations in the environment act as visual cues or prompts for learning.	The studio learning model, experiential learning, and design education are borrowed from architecture as teaching tools. The entire process of learning is visually and verbally documented. Performance is critiqued and assessed in more depth than testing alone can provide.
<b>Summary of Unifying Concept</b>	<b>The Learning Landscape</b>	<b>The Three-Dimensional Textbook</b>	<b>The Design Studio for Project-Based Learning</b>

**Table 1-2: Holistic Goals of Educational Facility Design (Taylor and Enggass, 2009).**

Holistic Goals of Educational Facility Design	
Goal of Education: Reaching the whole learner	Goal of Architecture (Vitruvius): Designing the whole building
Body (physical learning)	Firmness (structure)
Mind (cognitive learning)	Commodity (function)
Spirit (emotional learning)	Delight (beauty)

It is also useful to show the proposal guidance concluded in the book for designing a proper sustainable learning environment:

#### **Sustainability design potential**

Investigate siting, wind power, and solar orientation of school for maximum energy benefit.

- ▶ Provide systems for water harvesting and recycling.
- ▶ Design transitional spaces for learning, extensions to classroom areas, or links to the outdoors such as porches, patios, courtyards, decks, attached greenhouses, animal pens, shade structures, weather stations, planters, and water or sand areas.
- ▶ Design for agriculture and associated life skills.
- ▶ Create habitats for students to observe and maintain, such as a wetlands area on the playground, or preserve existing habitats.
- ▶ Design for student care and stewardship, not just janitor employment.
- ▶ Use local materials and vernacular building and landscaping (xeriscape) techniques.
- ▶ Follow LEED green design criteria to achieve certification.

**Figure 1-2: Sustainability Design Potential (Taylor and Enggass, 2009).**

## **1.2 Statement of the Problem**

### **1.2.1 Schoolchildren Performance and the Impact of the Classroom Lighting**

Dunn et al (1985) stated that the lighting does affect the performance and behaviour of the schoolchildren despite the difference of their preferences some prefer the bright light and other prefer the low. This finding was also proved in the literature review done by Martin (2006). Non-visual effects of the lighting on the schoolchildren were demonstrated in the study of Hathaway (1995) reflecting the importance of the lighting in the classrooms and its impacts on schoolchildren.

As children spend almost half of their day in the classroom (five to seven hours), it is important to apply the best lighting settings in this environment to minimise negative impacts on them as much as possible. In addition, the teachers using the classroom are affected with the lighting as well (Bruin-Hordijk and Groot, 2007). It is believed that for better performance of learning and teaching in the classroom, better lighting settings must be applied (Abramson et al, 2007).

This issue will be addressed in this study in the United Arab Emirates. Recently the UAE focused on sustainability and its different divisions. Huge organizations were founded to help in terms of exploring and applying sustainability, such as Estidama in 2007 and Masdar in 2006. One of the major concerns is the construction of future schools complete with improved environments for children that will attend them. This emphasises the concept of sustainability and helps to

introduce it to society. At the same time, it shows how important it is to address the issues in existing schools in order to investigate them and find the proper solution from all the major sides of sustainability, health, economic, and energy that will be reflected on the users. This study should encourage researchers to explore and determine their concerns in recent classroom design.

### **1.2.2 Traditional Lighting Used in the United Arab Emirates**

The standard artificial lighting that is used, in commercial interiors in the world generally and the UAE specifically, is predominantly fluorescent white lighting with blue wavelengths. Karcher et al (2009) describe how white light is the norm and how because people are used to it, they struggle to accept other lighting even if it is better for their health. The discomfort of changing cultural lighting makes it difficult to make people realise easily the negative direct or indirect effects of white lighting, as well as the perceived positive effects of other lighting colours. This in turn makes it harder on interior designers, especially lighting designers, to introduce and convince people of the best lighting for them.

White lighting applies both economic and architectural factors most of the time. The individual wellbeing factor is not statistically applied according to most of the studies, but is the standard lighting to be used for a long time. It is the lighting designer's responsibility to start introducing the suitable colour of light that will enhance the wellbeing factor. The health impact has to be studied in depth for the colour of the lighting to be used in the interior before it is applied. Fur-

ther study is required in this field and there is no standard colour that will match all the variables in different interiors (Karcher et al, 2009).

### **1.3 Research Rationale**

This research aims to explore different types of lighting settings in different classrooms and their effects on students' and teachers' performance. Such experiments will result in the desired objectives and conclusions about lighting settings leading to recommendations regarding the future usage of lighting in classrooms. This in turn will enhance related learning and teaching applications, as well as:

- Point out the importance of the interior environment and its elements, especially light and colour.
- Identify the impact of light and colour on health and performance.
- Highlight the health issues on school children in the UAE that can be related to misuse and/or interior pollution (especially from lighting).
- Start experimental studies in the UAE related to lighting's impact on health and performance.
- Analyse the findings hoping to establish a form of guidance for better lighting in elementary schools in the UAE.
- Recommend topics and issues that require further research.

### **1.4 Significance of the Study**

This study is important as it is the first to be conducted in the United Arab Emirates highlighting the impact of light on performance and health. Health issues are a huge problem affecting

schoolchildren, as will be explained in detail later in this paper, yet different factors are causes. It is believed that if the findings are as expected and demonstrate the relation between light and performance, it will promote further improvement of interior environments for schoolchildren along with the resultant health benefits.

Different interior elements were chosen for the experiment environment in order to focus on the results regardless of other interior elements. As the time frame is extensive, seasonal impact will also be studied.

## **1.5 Thesis Outline**

**Introduction:** The importance of the interior environment as in all its elements, especially light and colour, is presented, along with the impact of light. Lighting the interior environment is discussed with focus on the learning environment. The conclusion defines the traditional lighting in the United Arab Emirates.

**Literature Review:** The impact of lighting on human performance and health is discussed in detail in this chapter through the findings of previously published studies. As data is not available for the UAE, the common diseases of lighting misuse and interior/lighting pollution is addressed through published studies for schoolchildren in the UAE to focus on and highlight the importance of appropriate lighting design in elementary schools for better health and performance of children. The chapter is concluded with the thesis outline.

**Methodology:** Different methodologies were addressed in previous studies of light and performance and health impacts, along with their results. This led to selecting the method of this study, which will be discussed with the framework. The external parameter that



might affect the study and the model forms the conclusion of the chapter.

**The Experiment:** The full detailed explanation of the experiment that was conducted. Parameters, factors, set of locations, etc. will be explored in details.

**Analysis and Discussion:** The results of the experiment and analyzed statistically and discussed along with referencing to previous results from published studies and books for an enhanced understanding of the results.

**Conclusion and Recommendations:** Findings and final conclusions from the analysis, results and discussion will be stated. Further recommendations and needs will also be addressed.

## **2. LITERATURE REVIEW**

### **2.1 Power and the Importance of Light and Colour**

The most significant interior elements are lighting and colour as they have great impact on other elements and in creating the overall atmosphere in the space (Ching and Binggeli, 2004). Examples of principle advantages include visual perception and therapy, as well as disadvantages such as health hazards. The following provides a straightforward explanation of these points:

#### **2.1.1 Visual Perception**

Perception depends mainly upon the availability of two major factors: the human body and light. The human body factor mainly consists of the eyes that furnish colour and brightness sensation to brain, while the brain combines, orders and interprets sensations from the eyes. Light includes primary and secondary light sources. Daylight and artificial light which illuminate the environment and space are the primary light sources. On the other hand, any item that can amend the light wave is considered a secondary light source (weather, water vapor, dust, surrounding structures, louvers, interior environment elements, among others) (Egan, 1983). The aim of this study will be focusing on these two different light sources for a better understanding of their importance and impact.

Egan (1983) mentions how Johannes Purkinje in the nineteenth century perceived the difference of brightness between blue and red flowers as per the lighting. Red flowers

were brighter on sunny days, while blue flowers were brighter at dawn and dusk. This observation shows how the colour of the light does affect vision and how vision differs between day and night, summer and winter. This should be taken into consideration when applying artificial light in order to be a very well studied compliment to achieve a suitably illuminated interior environment for best results.

### **2.1.2 Therapy**

The power of colour was known and used by ancient civilizations in, for example, Egypt, Rome, Germany, China, and Greece. There is no doubt that when people used to spend most of their time outdoors in the natural light with the varied combinations of colours, they were healthier. This relationship between health and natural lighting and colour was very well understood and people started to use light and colour in therapy by any means available (light, landscaping, gems, flowers and plants, food) (Cumming, 2000). Each colour has its own psychology, meaning and power that affect physical health and mood in its own way, scientifically according to its colour temperature. Understanding these powerful effects guided the basics of the art of therapy and healing by colour and light (Amber, 1983). Numerous studies are conducted in order to explore and understand these therapies deeply and to discover their unique respective benefits. Colour therapy, also called Chromotherapy, uses both colour and light as tools, visuals, and suggestions to enhance physical and mental health (Meola, 2005). Light therapy (heliotherapy) focuses on natural or artificial light (different levels of laser, infrared, ultraviolet, red light, blue light, and so forth) on the body or specific areas or organs

through specialised devices. This latter type of therapy is effective in improving pain management, controlling hair growth and healing skin and wounds, as well as other diseases (Friedman et al, 2009). For example, blue light was proved to be advantageous in treating sleep disorders, jet lag, seasonal affective disorder, and premenstrual syndrome, when applied with special equipment (Holzman, 2010).

We are exposed daily to light and colour in the interior environment (commercial and residential), and with long periods of exposure we should take into consideration the powerful accumulative effects on our health, energy, mood and performance. Therefore, designers ought to be aware of how important it is to apply the correct light and colour into the interior environment to elicit the best health and performance of the users and occupants.

### **2.1.3 Health Hazards**

Studies prove that light pollution is one of the major and most serious hazards for human health. Lighting can be a chief cause of Volatile Organic Compounds (VOCs) in the interior environment as most of the lighting solutions applied interact with other elements in the atmosphere. If these solutions were to be applied without appropriate study of the interactions that might happen with the elements in the interior environment and atmosphere, this could lead to indoor pollution, with a harmful impact on health, performance and vision (Jones, 2008).

Lighting type and colour, if not applied properly, is a health hazard. Holzman (2010) describes how a study con-

ducted in 1958 showed the great power of blue light in affecting the circadian rhythms. This study unfortunately was not taken into consideration when blue light was introduced as the best artificial light for different interior environments, even residential, rather than trying to imitate the daylight, which is the best lighting for us. Blue light is very powerful, and can therefore become a health hazard if exposed to it for long periods of time without proper study.

It is believed that the misuse of interior lighting and exposure to its radiation does harm the skin as well as the visual and circadian systems. Light radiation (ultra-violet and infra-red) distresses tissues of the human body. Depending on the exposure length and strength, this effect might be healed or evolved into different kinds of cancer, breast cancer in particular. On the other hand, light disturbs the visual system, causing visual discomfort that can lead to eyestrain and migraine. When the circadian system is affected by light, the sleep/wake cycle is the major impact. This study and results demonstrated the strong relation between light and any disease relying on the visual or circadian systems or both, such as Seasonally Affective Disorder (SAD), Alzheimer's, multiple sclerosis, diabetes, vitamin D and calcium metabolism (affecting teeth and bones), tuberculosis, and many forms of cancer (Boyce, 2010).

## **2.2 Performance and Light**

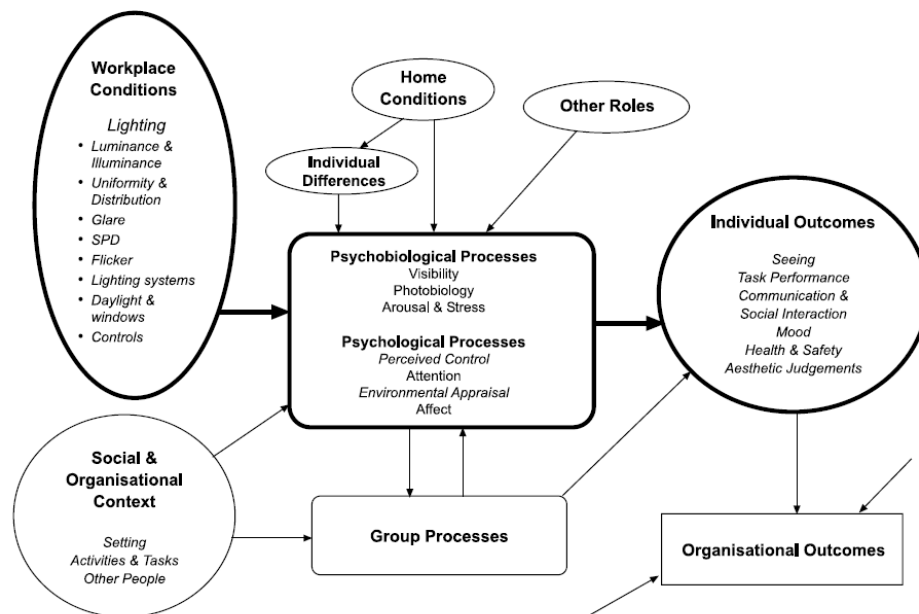
It is obvious to researchers now that the power of light does exceed vision. This power is reflected upon our mood, behavior, performance and health (Boyce, 2004).

Heschong et al (2002) found in their observations the need and importance of daylight in interior space via windows and skylights for better results for students in their exams and evaluations. Another study also reported the importance of daylight for workers to focus on their tasks and waste less time with chatting and phone calls compared to other workers, highlighting the beneficial impact of bright light in winter (Figueiro et al, 2002). Tonello (2004) was also successful in proving that mood and performance are affected by lighting through his experiment, underlining the negative impact of darkness on both mood and performance, although seasonal effects were not reported.

Giving the participant control over light led to rundown and slow performance compared to the performance of participants without control on inspiration tasks (Veitch and Gifford, 1996). Newsham et al (2004) also in their experiment concluded this improvement on performance when users were given control of their lighting, although this experiment was only for one day. Controlling the light aids concentration on the task and therefore better performance, but Boyce et al (2006) were not able to make further relation between mood and controllable lighting. With different based analysis done for the same experiment of Boyce et al (2006) by Veitch et al (2008), workers with high quality lighting were found to have better performance and health by the end of the experiment, and this stated that lighting quality does enhance users' performance and health (Veitch et al, 2008).

In Juslén and Tenner's (2007) experiment the importance of daylight in the factory was reflected on the better performance of the worker, although the controlled task light was needed to adjust the lack or excess of daylight.

In 2001 Veitch published an informative review of psychology and lighting. Accordingly, a conceptual diagram relating lighting with the individual process and outcomes was carried out. Light engineers and designers do rely on superficial control, notice and interest, environmental assessment, and influence for the psychological processes. In this model the psychological processes were stated along with the psychobiological processes, as the studies showed the importance of both in order to recommend further experiments and studies to be done to explore the psychological processes and effects. This was designed to reach a proper understanding of the responsible factors and to direct lighting engineers and designers to the correct path for better spaces for health and performance (Knez, 1995; Veitch and Gifford 1996; Veitch, 2001).

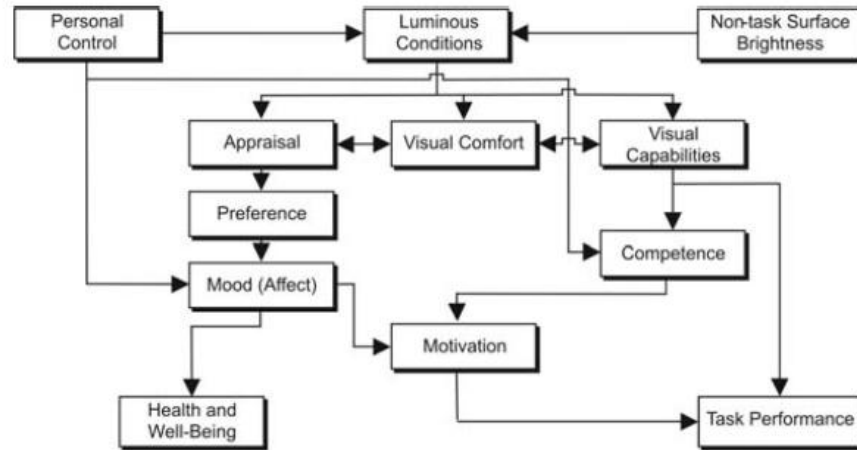


**Figure 2-1: Conceptual model showing relationships between lighting conditions, individual processes, and individual outcomes (Veitch, 2001).**

Veitch et al (2007) in an experimental study proposed a map of the effects and relations expected to link lighting with health, performance, mood, visual comfort and motivation (Figure 2-2). Two experiments were planned accordingly along with the tasks and

questions that the workers were asked to fulfill. Controlled and non-controlled lighting were designed in the space.

**Figure 2-2: Proposed Linked Mechanisms Map (Veitch et al, 2007).**



Analyzed results were finalized in the map (Figure 2-3). The clear and direct relation was in the order of Appraisal, Preference, Mood and Health, and Wellbeing, from both experiments' information. The types of tasks were normal typing and reading, and this might be why Visual Capabilities along with Task Performance did not confirm the same relation, although the typing task with little visual capabilities scored poor performance (Veitch et al, 2007).

Links between the two paths did not work as expected. Visual comfort and visual capabilities were unrelated here, likely because most people experienced high visual comfort. There was an unexpected negative relationship between preference and motivation that we cannot explain; however, motivation did positively predict several types of task performance. These relationships were mostly small to medium in size.

(Veitch et al, 2007).



These results were edited (Figure 2-2) to produce a final map (Figure 2-3).

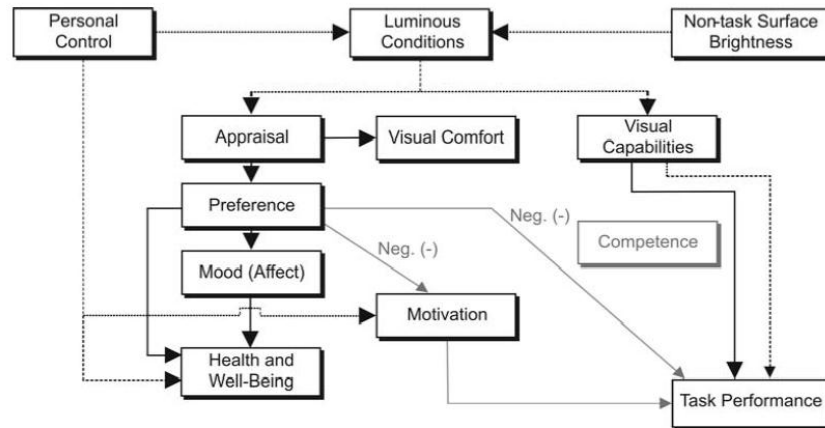


Figure 2-3: Final Linked Mechanism Map (Veitch et al, 2007).

### 2.3 Health Issues of Schoolchildren in the United Arab Emirates

Various studies were developed to prove that suitable lighting in the classroom plays a vital task in students' and teachers' performance (Erwine and Heschong, 2002). Some studies have supported the view that suitable lighting in the classroom (especially daylight) may have a positive impact on student performance and even health (Heschong et al, 2002). Other studies indicated that lighting developed encouraged better attendance, performance, and intensification on the part of the students (Hathaway, 1992). Heschong et al (2002) argue that there is no relation between lighting and student attendance.

Moving on with the topic, some researchers made remarkable steps and informative theoretical reviews to help expand further research topics and methodologies (Veitch, 2001a; 2001b; 2005). On the other hand, Bruin-Hordijk and Groot (2007) developed "The

electric lighting concept” for the classroom, which produces a lighting design model taking into consideration the different errands of both students and teachers for better learning and teaching. Despite all the research, questions regarding the indirect lighting impacts on students, the best lighting design guidance and other, have yet to be comprehensively answered. Most of the research recommends further research be carried out (Veitch et al, 2008), and lighting research is required in “areas where lighting operates on mood and behavior through the ‘message’ it sends and on health and task performance through the circadian system” (Boyce, 2004).

No data or studies found about lighting and performance in the United Arab Emirates, or classroom lighting and performance or health of students and/or teachers (through the search on *Google Scholar* directly or cited on any other studies) has been encountered. Therefore, the common health issues to be related to the misuse of lighting and performance and attendance of school children in UAE have instead been selected. Some of these studies were conducted in one emirate, with others covering more than one, and occasionally all seven emirates.

Statistical information of diseases in Dubai city in the UAE was ready for the use in this study. Unfortunately they were not detailed as per age or school clinics, but show the indications of ratios of the diseases.

Successive studies have been carried out regarding health issues of schoolchildren in the UAE to focus on this great issue in order to enhance their health and performance, but more need to be done. Unfortunately, some important studies were done focusing on major health issues, but none for a better understanding of

the topic. Some studies focus on the factors in an attempt to recommend powerful and immediate solutions. Others show the importance and need for looking into these issues and the urge to resolve them. It is interesting that the factors that were discussed to be the reasons varied between genetic, weather, outdoor pollution, and more. However, indoor pollution was related to domestic environments, not classrooms, in most studies (Yeatts et al, 2012).

**Table 2-1: Patients at Government Hospitals**

( [http://dsc.gov.ae/Publication/SYB\\_2010.pdf](http://dsc.gov.ae/Publication/SYB_2010.pdf) )

مرضى المستشفيات الحكومية (خارجي/ داخلي) حسب التخصص - إمارة دبي  
Patients at Government Hospitals (Out/ In) by Specialty - Emirate of Dubai  
(2010)

جدول (06-07) Table

Specialty	مرضى القسم الداخلي Inpatients		المرقدون على العيادات المتخصصة* Attendants to Specialty Clinics*		التخصص
	المحلي Local	الاتحادي Federal	المحلي Local	الاتحادي Federal	
Internal Medicine**	3,635	852	37,366	8,324	أمراض باطنية**
Heart Diseases and Cardiac Surgery	3,861	351	16,363	3,655	أمراض القلب وجراحة القلب
Chest Diseases	1,025	1	3,420	133	أمراض صدرية
Gastroenterology	796	-	5,791	-	أمراض الجهاز الهضمي
Infectious Diseases	433	-	1,925	-	أمراض معدية
Neurology and Neurosurgery	1,809	-	14,672	1,406	الأعصاب وجراحة الأعصاب
Psychology	661	330	7,965	10,748	أمراض نفسية
Haematology	1,907	-	1,574	-	أمراض الدم
Urology Diseases	656	211	4,480	2,956	أمراض المسالك البولية
Nephrology	940	-	9,326	-	أمراض الكلى
Orthopaedic Diseases	425	387	9,710	7,140	أمراض العظام
Fractures and Injuries	4,132	-	12,690	-	الكسور والإصابات
Ophthalmology Diseases	1,041	50	19,150	3,656	أمراض العيون
Ear, Nose and Throat	810	347	11,606	3,922	أنف وأذن وحنجرة
Gynae and Obstetric Diseases	17,945	2,611	65,355	8,969	أمراض نساء وولادة
Paediatrics Diseases	7,656	958	12,134	4,359	أمراض الأطفال وجراحة الأطفال
Dermatology Diseases	68	-	11,096	1,740	أمراض جلدية وناسالية
Neonatology	82	19	1,152	-	حديثي الولادة
Oncology	2,756	-	3,908	-	الأورام
Dental	628	117	33,673	4,799	أسنان
Burns and Plastic Surgery	197	-	2,543	-	الحروق وجراحة التجميل
Vascular Diseases	104	-	2,366	-	جراحة الأوعية الدموية
General Surgery	3,997	1,212	7,856	3,553	جراحة عامة
Chest Surgery	138	-	238	-	جراحة الصدر
Other	17,300	206	172,230	9,719	أخرى
<b>Total</b>	<b>73,002</b>	<b>7,652</b>	<b>468,589</b>	<b>75,079</b>	<b>المجموع</b>

\* Excluding attendants to emergency and health centers

\* لا يشمل المرقدون على الطوارئ والمراكز الصحية

**Table 2-2: Patients at Medial Private Sector Hospitals**  
( [http://dsc.gov.ae/Publication/SYB\\_2010.pdf](http://dsc.gov.ae/Publication/SYB_2010.pdf) )

مرضى مستشفيات القطاع الطبي الخاص (خارجي/ داخلي) حسب التصنيف الدولي للأمراض - إمارة دبي  
Patients at Medial Private Sector Hospitals (Out/ In) by International Classification of Diseases - Emirate of Dubai  
(2009-2010)

جدول (06-08) Table

International Classification of Diseases	مرضى القسم الداخلي Inpatients		المترددون على العيادات التخصصية* Attendants to Specialty Clinics*		التصنيف الدولي للأمراض
	2010	2009	2010	2009	
Infectious and Parasitic Diseases	6,565	2,519	42,555	46,962	الأمراض المعدية والطفيلية
Neoplasm	2,090	2,195	8,523	10,011	الأورام الخبيثة
Diseases of the Blood and Blood Forming Organs	303	314	4,054	3,689	أمراض الدم وأعضاء تكوين الدم
Endocrine, Nutritional and Metabolic Diseases	1,290	2,214	54,249	44,606	أمراض الغدد الصماء والتغذية والتمثيل الغذائي
Mental and Behavioral Disorders	698	217	22,764	18,575	الاضطرابات العقلية
Diseases of the Nervous System	1,119	973	27,045	23,726	أمراض الجهاز العصبي
Diseases of the Eye and Adnexa	1,546	1,763	47,587	48,989	أمراض العيون وملحقاتها
Diseases of Ear and Mastoid Process	795	1,092	48,953	43,983	أمراض الأذن وبنوة خلف الأذن
Diseases of the Circulatory System	7,363	5,867	58,494	55,387	أمراض الجهاز الدوري
Diseases of the Respiratory System	12,041	8,100	286,930	302,247	أمراض الجهاز التنفسي
Diseases of the Digestive System	8,624	12,162	120,420	117,249	أمراض الجهاز الهضمي
Diseases of the Skin and Subcutaneous Tissue System	1,599	1,560	81,079	73,810	أمراض الجلد ونسيج تحت الجلد
Diseases of the Musculoskeletal System	1,125	3,430	139,676	131,592	أمراض الجهاز الهيكلي والعظمي
Diseases of the Genitourinary System	5,788	7,105	100,066	97,619	أمراض الجهاز التناسلي
Pregnancies, Childbirth and the Puerperium	21,453	12,714	12,096	7,666	الحمل والولادة والتفاس
Perinatal Period	5,449	1,321	3,855	1,329	حالات معينة تنشأ في الفترة حول الولادة
Congenital Malformations, Deformities and Chromosomal Abnormalities	198	253	5,040	1,728	التشوهات الخلقية
Symptoms and Signs Unclassified	5,263	4,172	180,878	136,483	العلامات والأعراض والحالات غير المحددة
Injury, Poisoning and External Causes of Morbidity and Mortality	5,367	3,736	103,449	103,231	الإصابات والتسمم والأسباب الخارجية للأمراض والوفيات
Other Factors Influencing Health Status	9,249	12,729	249,864	184,794	العوامل الأخرى المؤثرة على الحالة الصحية
<b>Total</b>	<b>97,925</b>	<b>84,436</b>	<b>1,597,577</b>	<b>1,453,676</b>	<b>المجموع</b>

dsc.gov.ae

Most of the above diseases and symptoms can be related to different factors, but can be strongly related to the misuse of lighting (Hathaway 1994). Although McColl and Veitch (2001) didn't improve the positive relation in their study. The focus on these findings is to emphasize the need and importance of this study and to recommend further studies to be done in a bid to reduce and potentially eradicate such health issues for schoolchildren in the UAE.

### **2.3.1 Sick Building Syndrome**

Gibson et al (2013) state that indoor air quality is the second most prolific cause of diseases that lead to death in the United Arab Emirates. The study was conducted among residential and commercial interiors. This assures the importance of the research and analysis of the preliminary schools in the UAE and the impact on health and performance of the children there. Al Sallal (2010) recommends a better design for elementary schools in the UAE for improved visual performance after his findings of the misuse of daylight in his analysis of the elementary schools lead to discomfort and affected the children's performance. On the other hand, the study conducted by Behzadi and Fadeyi (2012) in four different elementary schools in Dubai city concluded that:

The majority of the environmental parameters exceed recommended threshold limits provided by cognizance authorities. This study is important because it shows the need for monitoring (a practice which is non-existing) IAQ conditions seriously in UAE elementary schools.

(Behzadi and Fadeyi, 2012).

### **2.3.2 Headache and Migraine**

It was difficult to find data about headaches and migraines in schoolchildren in the UAE. This field consists of only one study which was conducted in the academic year 1995-1996 and published in 1998 (Bener et al, 1998). The

results can be summarized in the following two tables as the findings and possible factors:

**Table 2-3: Study Results (Bener et al, 1998).**

City	Headache %	Migraine %
Al-Ain	37.8	3.6
Dubai	38.4	4.1
Sharjah	34.5	3.7

**TABLE 2.** *Comparison variables between children with headache and those without headache.*

Variable	Children with headache N=428	Children without headache N=731	P-value
Family problems	78 (18.2%)	78 (10.7%)	0.0003
School problems	97 (22.7%)	103 (14.1%)	0.0002
Parent(s) often complaining of headaches	196 (46.2%)	479 (68.9%)	0.0001

This study was cited in other different studies made in Riyadh (Saudi Arabia), Doha (Qatar) and Shizan (Iran). Unfortunately, no study was made in the UAE apart from a follow-up from Bener et al (2000) exploring a huge increases up to 13.7% in migraines in children, while headaches stayed in the range of 36.9%. No clear vision of the reasons that were related to environmental, genetic, psychological and social factors has been mentioned (Bener et al, 2000).

### 2.3.3 Asthma and Wheezing

In 1994 Bener et al found that asthma is a long-lasting disease among primary school children in the UAE (Al Ain City). In the survey that took place in the academic year 1991-1992 in 30 different primary schools (15 boys and 15 girls), 8.1% of boys and 5.4% of girls were reported asthmatic, causing the absence of 4.9% of students for a mini-

mum of a day in the academic year (62% of the asthmatic boys and 72% asthmatic girls). Absences varied between gender and season, with boys' absence 42% in spring and 26% in autumn, and girls 45% in spring and 22% in autumn.

A study investigating the genetic asthma and allergies in primary school children from October 1992 to May 1993 was conducted by Abdulrazzaq et al (1994), which strongly concluded the relation between asthmatic children and their asthmatic parents (mother, father, or both) with a higher ratio coming from the mother's side. An expanded study amongst schoolchildren of primary schools throughout the UAE by Al Maskari et al (2000) focused on asthma and respiratory indicators. Using the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaires, the results stated the hazard of asthma on schoolchildren is huge in all seven emirates and increasing, pointing out that parental asthma is not the principal cause. Results of the children were: asthma 13%, wheezing 15.6%, coughing 21%, eczema 11% and hay fever 14.9%.

The uncontrolled increase of asthma percentages among UAE residents is the issue of concern in Mahboub's (2012) research, recommending further studies be conducted in order to find the factors and work on reducing these percentages for better health. Further study was conducted emphasising the impact of asthma on academic performance of children, especially with lack of proper care. Revel and Baynouna (2012) similarly recommends further studies and better care in order to achieve better academic performance.

### **2.3.4 Vitamin D and Calcium Metabolism**

The importance of vitamin D and calcium for human health is a worldwide issue, especially in children. This importance affects their bones, teeth and brain growth. The lack of vitamin D was found very common in school children in Al Ain city, especially in girls (Muhairi et al, 2013). Rajah et al (2012) found 37% of 183 children facing the lack of vitamin D in the UAE. These facts should be highlighted less to resolve the issue in the children rather than describe the supplement as the cure.

## **2.4 Research Question**

Exploring the impact of different types of lighting in the classroom on teachers' and students' performance is the aim of the developed research plan in this study. In order to establish "which type of lighting might be helpful for improving the learning and teaching environment in the classroom?" a study can be carried out to compare the varied impacts of changeable lighting types in different classrooms, with clear consideration for the other variables that will affect the results.

The study is predicted to feature different variables such as lighting, users of the space and their tasks, and interior environment elements among others. The appropriate techniques and methodology will be used with a view to creating further questions to be studied in future research, ultimately establishing a concrete answer for the research question.



As such, the research question can be more detailed, focused and specific, with the objective of examining the relationship between lighting in elementary schools in the United Arab Emirates and the performance and health of the children (the users of the space). As the experiment will be conducted for a whole academic year, results are expected to be reasonable as sufficient time will have passed to have had some noticeable impact on the children. Previous similar experiments discussed earlier were day-long experiments which crucially did not allow sufficient time to show a significant impact. No huge changes will be made throughout in order to keep the children in a consistent and healthier environment. If any complaints are reported the experiment will be stopped and the results taken for the period of time in which it was conducted (for the safety of the children).

Therefore, this experiment is designed in order to test the impact of different colour of lightings on the users' performance, in order to show lighting impacts on work performance, hoping to conclude a lighting scheme to be advised for less pollution and better users' performance in addition to be environmentally friendly. And by that to have proper answer to the research question, along with raising more topics for further research questions, studies, and experiments.

## **2.5 Hypothesis of the Study**

The health impacts of environmentally-friendly or energy saving varieties are not studied in depth in the applied artificial lighting. It is believed that light does have both physical and psychological impacts, so this experiment is designed to test the impact of different types of lighting (cool and warm) with a view to establishing an

advisable lighting scheme for less pollution and better user performance, in addition to being environmentally friendly.

In order to monitor the research field, an observation and experiment will be developed, with different classes of grade two in two different schools (at least) selected. The interior environment elements vary from one school to the other and will be kept the same. The lighting setting will be kept in some classes as the existing used lighting (cool white) then changed to the suggested type (warm light) and vice versa, along with the controlled daylight. Lighting to be used are the existing cool white and the full spectrum lighting (matching the daylight most closely - warm white). Lighting covered and uncovered luminaries will stay the same for an improved understanding and observation of dust assembling. With these different lighting settings, the students and teachers will spend the whole day through the whole academic year doing their normal tasks. By the end of the academic year, teachers will fill out a questionnaire about the experiment and lighting types. In addition, the students' grade reports will be collected and analyzed by the end of the academic year. These will be the collected evidence, to go along with other observational data.

This approach will help collect the evidence from the natural source, giving it more reliability, although controlling the variables in the actual field is difficult and will affect the results of the repetition of any part, giving different results. With such topics, the field monitoring approach would help collect more valuable and trustworthy evidence.

This study is a step towards the awareness that has been called for by the responsible people in charge of classroom design, especially in elementary schools in the United Arab Emirates. It is

not only aiming to further understanding of what is the best, most environmentally friendly lighting to go along with the daylight in the UAE in summer and winter, but also to show how important it is to make sure of the tiny elements of lighting design (Gestalt Theory) as per the changes that happen caused by the variables and elements of both indoor and outdoor space throughout the whole year.

## **3. METHODOLOGY**

### **3.1 Different Methods for Similar Studies**

Researchers started to expand their perspective of lighting impacts to involve biology, health and behavior since the mid-1990s. With this rapid movement in lighting research, this is a review of the basic issues and aspects that are required and the way that might be transferred into application (Veitch, 2005).

Different research methods that were conducted in different studies and research papers will be discussed to show how useful they are for the topic, along with the range of settings and conclusions.

#### **3.1.1 Theoretical Review**

Recently, a lot of researchers are adopting the new direction in lighting research, exploring the impacts of lighting on behavior, satisfaction, mood and performance (Boyce, 2004). Numerous scientific reviews were adopted on the biological and psychological processes to enhance the understanding of these concepts in lighting research. Boyce (2004) explains in his review the detailed process to relate it with the lighting psychological and biological impacts is believed to help in more advanced studies in this field. Such review help in demonstrating the relation between light and bio-psychological process, theoretically hoping it will be applied in superior research in the near future (Veitch, 2001b).

Some reviews demonstrate and emphasise important aspects for researchers to explore. It is a great help to have such reviews and avoids repetition in research topics which waste money and time. Such reviews are very informative, clear and enlighten the way for further research (Veitch, 2005). There is a lot to be explored in the zones where lighting affects the mood, behavior, health and task performance (Boyce, 2004).

Concluding the best lighting design for the biopsychological processes will be hard without a clear understanding of such processes. Therefore, informative and comprehensive review is needed to provide a clear vision for the type of hypothesis required for further lighting research. Recommendations were given to enlarge the research effort into the lighting impact on health and wellbeing from biologists, psychologists and lighting experts. With the urgent need for these advanced studies, to reach a level of understanding equal to the understanding of visibility, such review is a great help for researchers to choose the method of research that will deal with any of the evidently explained topics (Veitch, 2001b). This, if used in the correct manner, will enrich the research and save valuable time and money (Veitch, 2005).

### **3.1.2 Social Survey**

Tonello (2004) developed a study for the influences of the lighting (natural and artificial) and interior decoration on one hand, and the workers' mood and productivity on the other. A questionnaire was designed and given to over 200 people working in open plan offices, closed offices and a fac-

tory plant. The artificial lighting varied between Fluorescent Lighting (in the offices) and Sodium Lighting (in the factory plant) in addition to very limited natural lighting in some spaces. The survey was taken five different times throughout one year in order to obtain the seasonal effects, though the study did not improve such effects of the seasonal variations in outdoor lighting on workers' mood. However, the emotional results showed the important effects of the interior environment (lighting and decoration) on the workers' mood, especially in the darker seasons (Tonello, 2004).

The method demonstrated the impact of the interior environment and lighting on workers' mood, especially from the psychological view, rather than the effect of seasonal timing. It also explored a slight connection between lighting and mood. It is worthwhile to note that good lighting will improve the emotional mood of a person (Tonello, 2004).

The Social Survey Method, which was applied in this paper, is supposed to allow the researcher to control the parameters of the study, as most of them were set in the questionnaire in a way that will prove the hypothesis. Theoretically, this will build a large informative database of answers (Tonello, 2004).

However, there are a number of issues that could be problematic. The main issue is misunderstanding the questions, which leads to useless and incorrect answers. Also, the questionnaire was seven to eight pages long, potentially making it difficult to check if people are responding honestly or if they were concentrating chiefly on the last pages. Moreover, the questionnaire was set with some closed ques-

tions and this may constrain the data, and the open questions will drop some of the results during the analysis process and eliminate a richer range of responses.

In spite of these issues, the results garnered from the study are helpful to continue the research in the same direction to explore and advanced findings in this topic, maybe by applying different research methods.

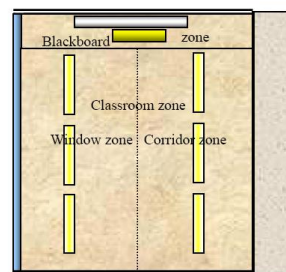
### **3.1.3 Simulation (Computer Aided Software)**

Simulation is one of the more recent approaches that save money and time through creating a virtual study aiming to propose a model to be followed. It is hoped such simulated solutions will be utilised in some studies to examine the light impact in real interiors applying the suggested model.

One of the more tasking areas to apply good lighting to is the classroom, and this is the main issue for this study. To start with, the luminances and illuminances were evaluated in some built schools and developed into nine different lighting design modules for classrooms. Using the light simulation program, Desktop Radiance, comparisons were developed between the nine different modules according to the light act, taking the tasks of students and teachers in classrooms into consideration. In a new concept for classroom lighting (electronic lighting), good lighting can be realized by mixing good daylight and good artificial light in a studied way (simulating the results) that guarantees comfort and improved performance for both students and teachers in the classroom (Bruin-Hordijk and Groot, 2007).

For the electric lighting concept the classroom zone is preferably divided in two rows of three luminaries parallel to the window (Fig.2). They all have a daylight responsive control system which provides for the general lighting. The blackboard zone has its own blackboard luminary. The blackboard luminary must be switchable independent of the general lighting. For user's ease the blackboard switch should be placed in the neighborhood of the blackboard.

(Bruin-Hordijk and Groot, 2007: 8)



**Figure 3-1: Electric Lighting concept (Fig. 2 Bruin Hordijk and Groot, 2007:8)**

In a new direction of research, the light impact was fixed and a solution to achieve it was studied. The new concept that is introduced in this paper takes into consideration the variable tasks of both students and teachers in the classroom, as the classroom was divided into zones. This concept is a good starting point for applying computer simulation into the lighting impacts. The light applied through this concept is believed to be a good lighting that will improve the task performance for both users of the classroom, students and teachers, and this will happen through simulating good daylight and good artificial light in the classroom (Bruin-Hordijk and Groot, 2007). Further application of computer simulation is needed for improving the research of the light impact on human performance.



### 3.1.4 Observational

Some studies observe existing interiors and lighting (daylight and artificial) and explore the impact of the lighting on the users' mood and performance. One study investigated whether there is any clear connection between daylight and human performance. Three school sectors were chosen for this study, with different programs, managerial and teaching styles, building designs, and very different weather. Variables were set for all sectors, including the age of school, size of classroom, windows and skylights, population of school and classroom, and classroom type. The collected data was analyzed for the importance and influence of these variables simultaneously. This statistical analysis led to the strong connection between daylight and students' performance: a result that is believed to be carried and applied in other areas such as offices and workplaces (Heschong et al, 2002).

This observational study and the statistical analysis that was used for the collected data (test scores) recognized important consequences on human behavior of natural light. Although the study did not conclusively offer any explanations for such effects, it strongly related the importance of the presence of windows and skylights in buildings in order to supply daylight, to these positive effects on human performance (Heschong et al, 2002). Such observational studies can explore new findings that can provide details for use in further research.

Another study took place in the winter of 2001 for nine weeks, comparing the types of behavior of workers who were assigned to interior or windowed offices in order to conclude a relation between productivity and lack of daylight (winter timing). The study showed that workers in windowed offices were concentrating more on work tasks, with less time wasted on telephone calls or chatting with co-workers compared to the workers in interior offices. The reason for these findings is not explored, but the results are clear and proved “that bright light during the day improves productivity during winter months” (Figueiro et al, 2002).

This observational study was designed to experience the relation between winter and productivity of workers in two different types of offices (windowed or interior). The results proved this relation as the workers in windowed offices were concentrating on the tasks more than workers in the interior offices. Although the study was not for circadian and performance, the results concluded that daylight might influence productivity in offices during the winter. Recommendations of further studies for such relations were offered in the conclusion to look more into the impact of daylight (bright light) and productivity (Figueiro et al, 2002).

### **3.1.5 Experimental**

Conducting an experiment is a highly effective method in research, although this requires time and money, but results can be easily performed in real life or rejected. Some experiments recommend further studies or can set applied solutions to enhance performance.

A one day laboratory experiment with one-hundred-and-eighteen contributors worked under one of four lighting designs. No control of the light was provided until the latter half of the afternoon, when all contributors were given individual lighting control (dimming). The contributors' participated in some virtual tasks in addition to completing questionnaires on varied topics such as mood, contentment and distress. Questionnaire results recorded positive influences after applying the lighting control on the mood, performance, productivity, environmental and vision. Contributors who applied a lot of control on the lights recorded the biggest enhancement in their outcomes. On the other hand, those who only slightly controlled their lights recorded no enhancement in their outcomes. Therefore, it might be the application of the controlled lighting rather than giving the control itself which affected the performance. These results were not very clear in the task performance side and, as such, further study is recommended (Newsham et al, 2004).

The experiment successfully encountered a relation between providing controlled lighting for individuals and their task performance. The tasks were virtual and this variable would affect the results, but the questionnaire added some reality to the tasks. The time duration (one day) was meant to be extended were there any kind of positive results, and developed into a more detailed experiment (Newsham et al, 2004).

Two field simulation experiments were arranged in order to study the illumination effect on workers' performance and health. The first experiment was carried out with four types of lighting: (1) direct lighting, (2) (direct and indirect)

lighting, in addition to individual control over (3) the desk lamp and (4) workstation light. The second experiment only included two types of lightings, both without any controlling feature: (1) direct lighting and (2) (direct and indirect) lighting. The study did not conclude a strong impact of such types of lightings and performance of the workers, although it did conclude that the controllable lighting facility increases motivation and performance (Boyce et al, 2006).

Boyce et al (2006) report the results statistically between lighting adjustments and human performance, mood and health. The study accordingly did not prove a strong impact. Veitch et al (2008) report further analysis testing the connected instruments by which lighting influences health, mood and task-performance in these two experiments. This concluded that workers identifying high quality office lighting in their spaces displayed signs of better mood and health at the end of the day. Workers preferred the control of direct and indirect lighting, and a noticeable finding was that the lighting circumstances that enhanced visibility also enhanced task performance (Veitch et al, 2008).

Newsham et al (2008) set another laboratory experiment for one-day to study the individual control on electrical lighting in a day-lit office. Forty participants engaged the office laboratory which was glare-free and day-lit, and every thirty minutes they were allowed to adjust the electrical lighting to their preferences. Before and after each adjustment, the lighting readings were reported and an advanced and professional digital camera was used to create luminance maps. The experiment concluded a strong variation between the existing illuminance of the desktop and the participant

adjustments of lighting. This states that from the participants' view, natural lighting is needed and might replace artificial lighting (Newsham et al, 2008).

As previous studies recommended new methodologies and aspects to be explored (Boyce 2004), Newsham et al (2008) in this study investigate new techniques to obtain new findings in the lighting research field. As the experiment, despite the time limitations, proved most of its hypothesis, this has to be motivating for other researchers to make more advanced studies on the proved hypothesis. The experiment contested that automatic lighting controls do not successfully satisfy the needs of workers, and the energy output was reduced by 25% according to the adjustment done by the participants (Newsham et al, 2008).

Another experiment was designed to study the different lighting conditions in one area (skylight, daylight and dimmable task lighting). The selected location was a luminary factory in France with a skylight in the hall, in which dimmable task lighting was set up at six working places and available for the workers to use anytime. The reported readings were taken between winter 2004 and spring 2005, with users completing a questionnaire form after the experiment was done. It was concluded that the task lighting was used when changes occur on the amount of daylight is (more or less), and task performance. The users reported that the task lighting improved their performance and wanted to keep the task lighting in the space (Juslén and Tenner, 2007).

This study proved that in a day-lit work area the task lighting was not used very frequently (except for during

changes in the daylight intensity). On the other hand, it concluded that the task controls the time and option of lighting, as almost all of the workers used the task lighting and many felt it helped them perform better. These findings encourage the use of skylights in workspaces (Juslén and Tenner, 2007).

### 3.2 Research Method of the Study

The topic to be studied is evaluation and measuring of human performance under different types of light (warm and cool). As human perform experiments anyway many variables are there to be explored and studied. Among the different research methods presented earlier, the experimental research method is believed to be the best method for this topic, as the other methods lack the necessary control over the situation. In the experiments the cause and effect can be better established, as well as the objectivity and accuracy measurement of the dependent variables. On the other hand, in the field experiments, the sampling bias is avoided and the demand characteristics minimized (Colorado State University, 2008). Previous experiments are summarized to provide a form of guidelines in this study:

**Table 3-1: Summary of Previous Experiments (Done by Author).**

Type	Duration	Variables	Effect	Results
Laboratory	One Day	- Control lighting - Different work task	Health, mood and performance of users of space	Recorded positive influences after applying the lighting control on the mood, performance, productivity, environmental and vision

Type	Duration	Variables	Effect	Results
Laboratory	One Day	<ul style="list-style-type: none"> <li>- Day-lit office</li> <li>- Controlling lighting</li> </ul>	Individual control on electrical lighting in day-lit office	Concluded a strong variation between the existing luminance of the desktop and the participant adjustments of lighting
Simulated Office Space	Not specified	<ul style="list-style-type: none"> <li>-Non-task surface luminance</li> <li>- Lighting manipulations</li> <li>- Photometric conditions</li> <li>- Participant Characteristic</li> <li>- Dependent Measures and Procedure</li> <li>- Measurement of perceptions and feelings</li> </ul>	Individual control over artificial lighting with or without the present of daylight	The study did not conclude a strong impact of such types of lighting and performance of the workers, though it did conclude that the controllable lighting facility comparatively increases motivation and performance of the workers
Field (Factory)	Between winter 2004 and spring 2005	<ul style="list-style-type: none"> <li>- Lighting (skylight and dimmed task lighting)</li> <li>- Questionnaire</li> </ul>	Task performance, mood and health	Encourage the use of skylight –Daylight- in offices

The basic draft for the experiment plan that is determined from these experiments is that the method ought to be field a year-long observation in primary/elementary schools in the UAE, gauging changes in task, performance, mood and health that could be the result of changes in lighting. The variables are expected to include artificial lighting (cool and warm, covered and uncovered luminaries), students' results, questionnaires, interior design of classrooms.

### **3.3 The Methodology Framework**

Exploring the impact of different types of lighting settings in the classroom on teachers' and students' performance is the aim of this study. In order to acquire the knowledge of what type of lighting might be helpful for improving the learning and teaching environment in the classroom, an experiment will be conducted to compare the varied impacts of changeable lighting settings in different classrooms, with a clear consideration for the other variables that will be affecting the results.

The extensive list of predetermined variables in the experiment includes: the lighting itself, both natural daylight through windows and skylights, and artificial (cool and warm, along with covered and un-covered luminaries); users of the space (teachers and students); important work areas (blackboard, teachers' desks, students' desks, activity areas); interior environment elements (furniture, colour, materials, finishes); teachers' tasks (writing on black/white board, reading from black/white board, talking to the students, following up students' work, preparing teaching material, presentations); and students' tasks (writing on black/white board, reading from black/white board, class work (writing, reading, drawing, paying attention to the teacher).



The study of these variables through usage of the appropriate techniques and methodology is expected to create more questions to be studied in further research for their benefit and the research question of this thesis: what type of lighting might be helpful for improving the learning and teaching environment in the classroom?

### **3.3.1 Duration of the Study**

One academic year: it is believed that the longer the exposure time, the clearer the results will be. Some experiments proved the relation between performance and lighting in one day, others garnered better results after a period of several months.

### **3.3.2 Location of the Study**

Elementary Schools in the United Arab Emirates have been selected as the ideal locations for the study. The Cycle One year group specifically has been chosen, as forty percent of the total number of students in Dubai schools are in cycle one ([http://dsc.gov.ae/Publication/SYB\\_2010.pdf](http://dsc.gov.ae/Publication/SYB_2010.pdf)). Other reasons for this decision include: the variety of the nature of the users of the space (classroom), the teachers and children; the interactive work frequently conducted between teachers and students; long working days, typically of six to nine hours, allow plenty of time for observation; student evaluation is considered a normal process; numerous schools in Dubai means that it is a straightforward process to find similar environment used by different users for comparison purposes; various light impacts mentioned in other stud-

ies are found in this cycle; previous evaluations would be available if needed for comparison purposes; and the type of work itself, in that leave must be reported as is not the norm during term time.

### **3.3.3 Environment of the Study – the Classrooms**

Different classrooms are required with the same curriculum (British), grouped in two for comparison. The interior is to be varied to assure that the results, if expected to be better under certain lights, are not affected by the interior design and colour scheme. Slight changes may prove necessary after analysis. The students will be seated in certain places where they should remain for the duration of the experiment for consistency purposes (as this will be recorded and interfere in the results). Rotation time is done for each pair of classrooms by semester (occasional rotation might be required). Ventilation means have to be unique for all classrooms, or at least for similar classrooms in the same school (when needed extras should be requested). Health issue reports for both the students and their teachers from the school clinic will be requested (if permission is granted).

### **3.3.4 Lighting (Cause)**

The illumination in all classes should be noted down whenever a rotation is placed in the classrooms. Lighting specifications, direct or indirect (fixtures design, type, or any required) will be recorded in the correct manner. Natural lighting will be the main source of lighting which will be shared in all classes in all rotations, while the artificial lighting

will be the changeable parameter and variable in every rotation (if possible).

### **3.4 Data Collection Methods (Effect)**

Means and methods of evaluation: Observation (walkthrough, photos, comments, etc.), site analysis, interviews (with teachers, students, principals, supervisors, etc.), student grade and behavioural reports, illumination measurements, and questionnaires.

#### **3.4.1 Observing the Environment**

Direct questionnaires regarding the environment and its impact from teachers will be handed out, and reporting and recording of any comments is intended. Additionally, lighting reports (maintenance, life time, problems recorded, technical) will be monitored.

#### **3.4.2 Students' Data and Grades**

Students in elementary schools in the UAE (Cycle One: grade two or three). Children are affected in their health and performance (attendance). Therefore, it is important to focus on them to try to improve their interior environment. As they are known to be very sensitive to their surroundings, changes in the environment can easily be reflected in their grade reports, especially in the subjects that need real focus, as well as their attendance and health. Yearly detailed results (oral, written, class work, etc.) in all subjects, especially Science, Mathematics, Arabic or English (focusing on different educational goals) will be requested and monitored. Also

to be requested are: absence reports with official medical excuses (if permitted); detailed behavioural reports (if permitted); health records (if any issues are reported); parents' monthly questionnaire about health, behaviour, mood of their children (if permitted); and psychological questionnaires at the beginning and end of the experiment (if permitted).

### **3.4.3 Teachers' Data and Opinions**

These will be gathered by means of the collection of health records (if any issues are reported) and the occasional questionnaire to be filled in by the teacher in the classroom at end of class.

### **3.4.4 Resource Requirements**

The main required resources are: appropriate schools to act as the field of the study; teachers and students (human resources) to observe their performance as the sample of study; equipment and workers (human resources) to apply the different lighting settings in the classrooms; time for the experiment and the analysis; human resources, as detailed above, in addition to the experts in statistical and psychological analysis (if possible and not affected by time and/or money constraints); financial capital for lighting and other expenses; and devices for recording, reporting, analysing, and generally conducting the experiment and analysis. Furthermore, extra resources might be needed according to some developments in the plan, methodology, or other thus far unforeseen circumstances.

### 3.5 Data Analysis Procedures and Tools

- The main analysis method will be used is statistical. Though psychological analysis (handwriting analysis, mood analysis, tension, etc.) is also desirable, the need for extra money, time, and experts to do it makes it impractical. A comparison between the performance of students and teachers under the different lighting settings will be included in the analysis to help provide the reader with a better understanding of the results. It is important here to point out that what is expected from the analysis methods is not an answer to the question. Instead it will be helpful if the analysis provides a direction towards new questions that will in turn lead to further study and a more detailed conclusion regarding suitable lighting settings in the classroom to help learning and teaching performance, as well as reduce health issues.
- Statistical analysis will be done and illustrated in tables and charts for better understanding for both results of the teachers' questionnaires and the standard evaluations of the students.
- The results of the teachers' questionnaires will be analysed to show the health issues, behaviours during the day, impact of lighting, and ventilation in the classrooms reported by the teachers in each school and will be compared among the two experimental schools along with the opinions of the teachers. All these analysed information will be discussed.
- The results of the standard evaluations of the students will be analysed and illustrated in tables and charts to show the changes of the grades under the different lighting used in the experiment (experimental and existing). Detailed analysis with reference to the four major variables of the experiment: time, school, subject, and gender to show the effect of lighting on their results (improved, retracted, or neutral) under these different variables is illustrated and discussed to show the effect of the lighting in use.

All the results (of experimental and reference classes) will be summarized in one table for better reading, easier comparison, and thorough discussion. For better reading of the results percentages of the achievements will be addressed in tables for each subject in all experimental classes.

- Psychological (if permitted and specialists available).

### 3.6 Summary of the Conceptual Planned Experiment (Variables)

Table 3-2: Conceptual Summary of Variables (Done by the Author).

SN	Variable	Setting of the variable
1	Lighting	Cause
1.a	School # 1	Cool white alternatively with warm white in 2 classrooms of grade 2
1.b	School # 2	Cool white alternatively with warm white in 2 classrooms of grade 2
1.c	School # 1 and 2	Natural lighting
2	User of Space	The sample will be set as the following:
2.a	Teacher	Same teachers in each school
2.b	Students	Students in four different classes of grade two will be facing the assigned artificial lighting per semester
3	Work Areas	Lighting will be assigned according to the layout applied in each classroom (blackboard, teachers' desks, students' desks, activity areas)

SN	Variable	Setting of the variable
4	Interior Environment Elements	Will be fixed – no changes will be applied, but varied in every school (Furniture, colour, materials, finishes, etc.)
5	Performance of users	Effect (teachers and students)
5.a	Tasks of Teachers	Collected evidence, questionnaire
5.b	Tasks of Students	Collected evidence, results in all subjects
6	Duration of Experiment	In one year the performance evidence will be collected twice (in December and June), in each month the evidence will be collected daily for all the different subjects in the four different classes.
7	Extra	Medical absence reports per year will be collected, progress in the teaching plan, and any other related evidence for the best evaluation of the lighting impacts

### 3.7 Research Boundaries of the Study

One academic-year-long experiment to be conducted in the United Arab Emirates elementary schools in order to evaluate the performance of students and opinions of teachers under different artificial lighting settings (cool and warm, and covered and uncovered), to devise suggestions for good light models to be implemented in schools.

As the teachers and students are performing, the evidence collected in the actual field will be more valuable and realistic than

by other approaches. Since the human response can be difficult to measure, the methodology has to be clearly applied to draw inferences trying to offer an answer to the research question or perhaps lead to further research questions. The collected evidence in this approach will be statistically analyzed to clarify and conclude the best lighting for best performance of both teachers and students. A comparison between the performances under the different types of lighting at different times of the year will be drawn to allow more realistic inferences. Psychoanalysis will be very helpful to draw another line of inferences, but this will require more money, time and specialist psychologists (extra resources).

It is believed that the inferences drawn by these methodologies will lead to better lighting settings in classrooms that will in turn help better performance in teaching and learning, or will open the door to new questions for further detailed studies.



## **4. THE EXPERIMENT**

### **4.1 Designing the Experiment**

The design of this experiment was devised from the literature review explained earlier in chapter two and the methodology in chapter three. Experiments with a similar goal of linking light to performance were the major key, and evaluating the impact of lighting colour and type on the performance of schoolchildren in the United Arab Emirates is the goal of this experiment. Therefore, the experiment is designed for classrooms in elementary schools in the UAE.

Earlier experiments varied in their duration, with some lasting one day (Newsham et al, 2004; 2008), and being more detailed and taking longer to complete. For example, Juslèn and Tenner (2007) spent around six months on their experiment. As the results of the long-term experiments were more clear and reliable, this experiment was designed for a whole academic year, aiming for better reading of the results and rich discussion, especially with regard to the seasonal effects aspect, as the schoolchildren and teachers will be exposed to the lighting for enough time to be affected and reflect this in their performance. Also, the results will be ready for collection by the end of the academic year to be analyzed, reflecting the exposure of the different types of lighting.

The classroom environments are expected to have different interiors in every school. One school will feature colourful interiors, while the other will have neutral interiors. Different desks distribution is expected in both schools. The interiors will be kept the same without any changes, except for the lighting. This will reduce the

impact of the interior environment and emphasize the impact of the lighting in the analysis (Ching and Binggeli, 2004; Jones, 2008).

As other experiments focused on the systematic lighting (controlled, task, dimmable) this study will focus on the colour of the lighting. The existing lighting that is used in most of the commercial areas in the UAE, and especially in schools, is the fluorescent cool white. Believing that daylight and its components does have the better effects on humans in general, and children specifically, the fluorescent warm white (imitating daylight) will be the suggested lighting in the classrooms (Boyce, 2010; Holzman, 2010).

At the end of the experiment results will be collected in the form of the students' grade reports along with questionnaires that will be designed and answered by the teachers. The nature of the schoolchildren's tasks and their grade reports by the end of every semester is helpful as the evaluation is certified and reliable for this study, and the schoolchildren will perform naturally. The questionnaire (Appendix A) is designed to focus on health issues, impact of lighting, ventilation, issues in the classroom, and request the comments and opinions of teachers. It is a 'yes or no' along with scaled 'one to five' answered questions, along with additional space for comments and opinions.

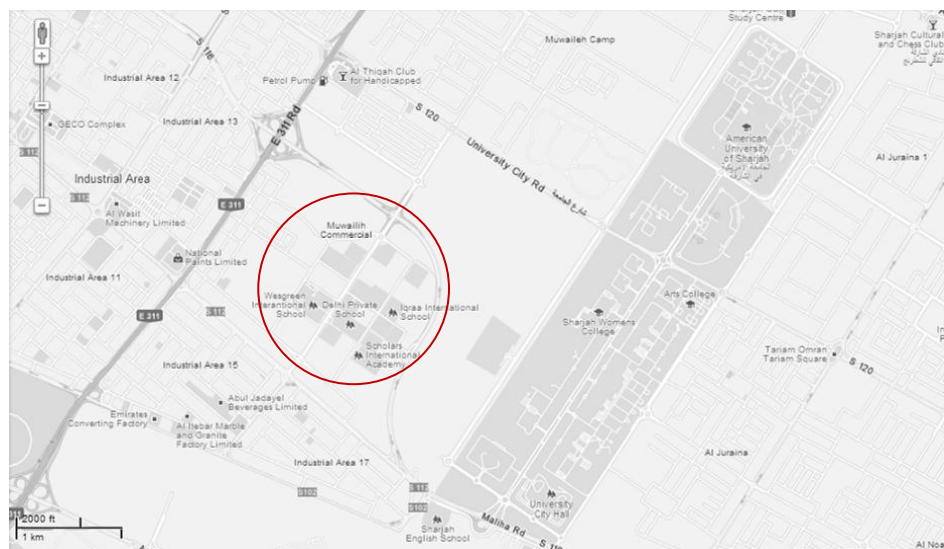
## **4.2 Observing the Environment of the Experiment**

### **4.2.1 Location**

Two different elementary schools in the emirate of Sharjah permitted the experiment in their classrooms and will be addressed as school-A and school-B in this paper, as one of the schools asked not to be identified. School-A is located

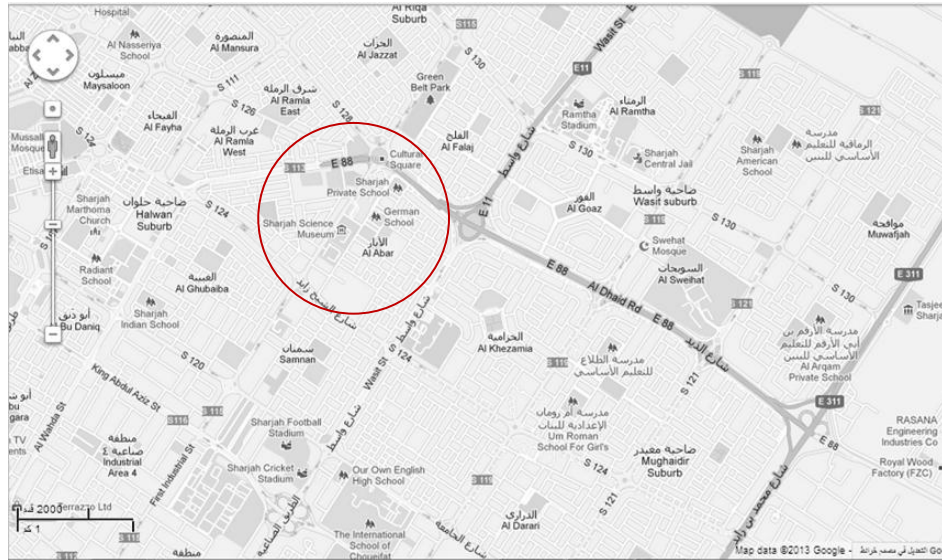
in the School Zone near Sharjah University, while school-B is located behind Sharjah TV Station. The experiment took place in the academic year 2009-2010 in cycle one (grade two). Both schools follow the British curriculum.

A detailed climate study is attached (Appendix B) for the emirate of Sharjah in the UAE for the academic year 2009/2010.



**Figure 4-1: School-A Location Map, School Zone near Sharjah University (Google-Maps).**

([https://maps.google.com/maps?f=q&source=s\\_q&hl=en&geocode=andabauth=5171d68bdRdfu1fiTAT01BNWaxfr-xWWD38andauthuser=0andq=American+University+of+Sharjah++Sharjah++United+Arab+Emiratesandaq=4anddq=Sharjah+Universityandvps=5andjsv=452candsll=25.345577,55.374527andsspn=0.111389,0.181618andvpsrc=0andnum=10andvector=1](https://maps.google.com/maps?f=q&source=s_q&hl=en&geocode=andabauth=5171d68bdRdfu1fiTAT01BNWaxfr-xWWD38andauthuser=0andq=American+University+of+Sharjah++Sharjah++United+Arab+Emiratesandaq=4anddq=Sharjah+Universityandvps=5andjsv=452candsll=25.345577,55.374527andsspn=0.111389,0.181618andvpsrc=0andnum=10andvector=1))



**Figure 4-2: School-B Location Map, Behind Sharjah TV Station (Google-Maps).**

(<https://maps.google.com/maps?q=25.352268,+55.426605&num=1&ll=25.371929,55.410622&spn=0.322831,0.512238&hl=ar&ie=UTF8&ll=25.353315,55.427227&spn=0.013651,0.01929&t=h&z=16&iwloc=near>)

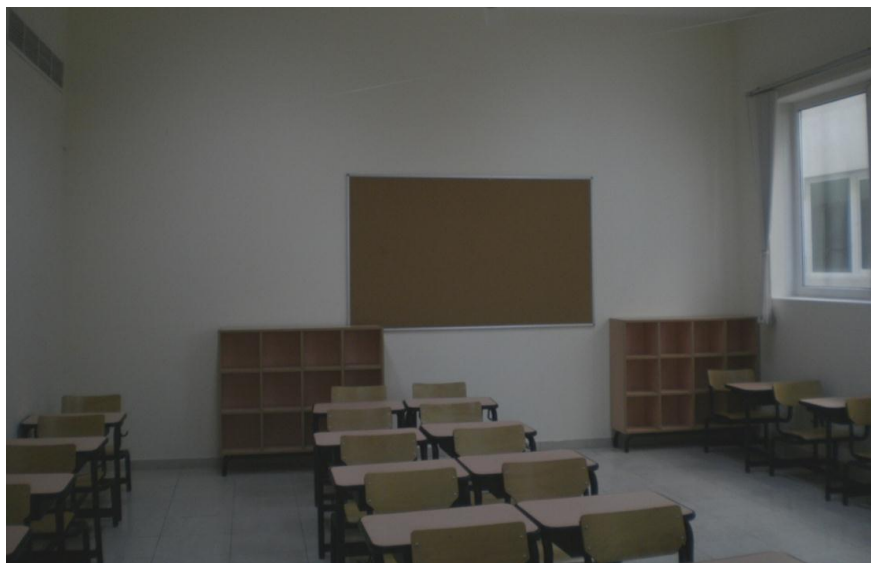
## 4.2.2 Interior Environment

The interior environment in school-A is colourful and the desk distribution is clustered grouped. In school-B the interior features a muted neutral colour scheme (beiges and browns), with standard desk distribution facing the whiteboard. In school-A the furniture plans of the classrooms A1 and A2 are different, as shown below. Conversely, in school-B the furniture plan is standardized for all classrooms, with both classrooms B1 and B2 sharing the same plan.

Air Conditioning (AC) units are also different in both schools. In school-A the AC units are split units, while in school-B the central system is employed.



**Figure 4-3: School-A, Classroom Interiors - Colour Scheme (Taken by the author).**



**Figure 4-4: School-B, Classroom Interiors - Colour Scheme (Taken by the Author).**

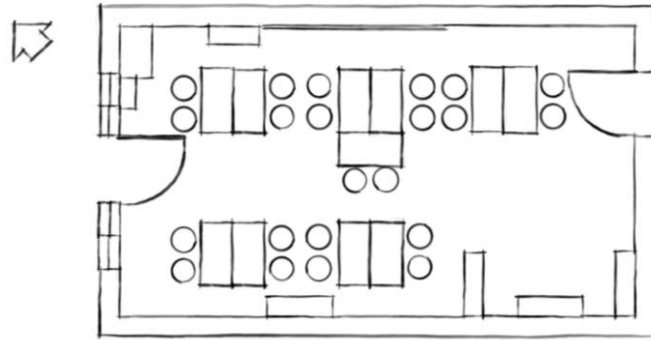


Figure 4-5: School-A classroom Furniture Plan-A1 (Drawn by the Author).

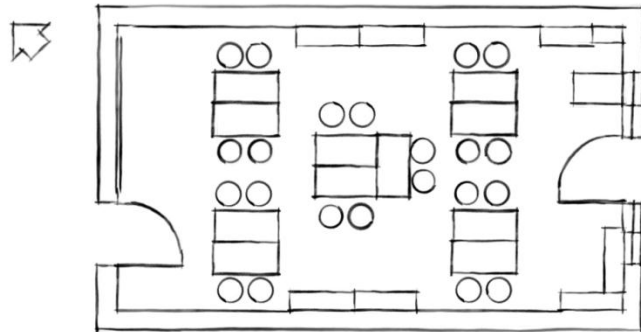


Figure 4-6: School-A classroom Furniture Plan-A2 (Drawn by the Author).

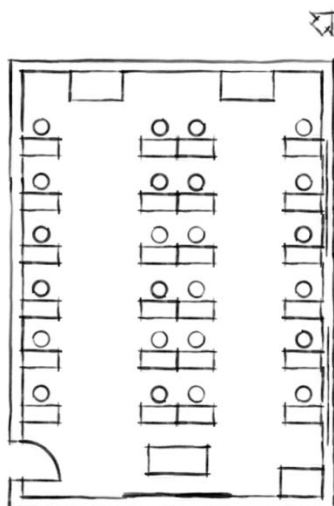
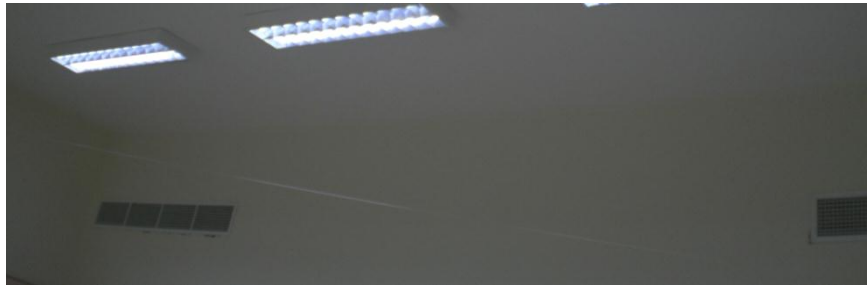


Figure 4-7: School-B classroom Furniture Plan-B1 and B2 (Drawn by the Author).



**Figure 4-8: AC Units in School-A (Taken by the author).**



**Figure 4-9: AC Units in School-B (Taken by the author).**

Both schools maintained their respective interior environment throughout the experiment. These variations amplify the impact of the lighting in the results and analysis, yet minimize the impact of other factors in the interior.

### **4.2.3 Users of Space**

In school-A every subject is taught by an individual teacher. Some teachers are common for the two classes A1 and A2, making a total of ten different teachers. As for the students, they are mixed boys and girls in the same classroom. Each classroom has twenty students, making the total of students in school-A forty. The nine different subjects that are graded are Literacy, Mathematics, Science, Geography, Arabic, Islamic Studies (for Muslim students only), Social Studies, Physical Education, and French.

In school-B the total of teachers for both classes B1 and B2 is ten. Classrooms B1 and B2 are girls only. Classroom B1 has 18 girls, while classroom B2 has 20 girls. This makes the total of the students thirty-eight. There are eight graded subjects and they are: Islamic Education (for Muslim students only), Arabic, Social Studies, English, Mathematics, Science, Activities, and Holy Quran. Further grades are given as reading, conversation and listening. This will help in the analysis of the results. In addition, there are two other classrooms in the school which are boys only. These classes are not included in the experiment but their grades will be shown for reference. The classrooms are the same as B1 and B2 and the total of thirty-eight extra students' results of the boys (nineteen students in each classroom) will be addressed for reference.

**Table 4-1: Summary of Participants (Done by the author).**

		Total	A1	A2	B1	B2	Reference	
							B3	B4
<b>Students</b>	Male	21 38	12	9	0	0	19	19
	Female	57	8	11	18	20	0	0
<b>Teachers</b>	Male	0	0	0	0	0	0	0
	Female	20	10		10			
<b>Total</b>	<b>136</b>	<b>88</b> <b>48</b>	<b>20</b>	<b>30</b>	<b>18</b>	<b>20</b>	<b>19</b>	<b>29</b>

**Table 4-2: Summary of size of sample - questionnaires (Done by the author).**

		Total	School-A	School-B
<b>Teachers</b>	Male	0	0	0
	Female	20	10	10
<b>1 Questionnaire for each</b>				
<b>Total</b>		<b>20</b>	<b>10</b>	<b>10</b>



**Table 4-3: Summary of size of sample - students' results (Done by the author).**

	Total	A1 M	A1 F	A2 M	A2 F	B1 F	B2 F	Reference	
								B3 M	B4 M
<b>Students</b>	<b>78</b>	12	8	9	11	18	20	-	-
<b>Reference</b>	<b>38</b>	-	-	-	-	-	-	19	19
<b>Subjects</b>		9				11			
<b>Experiment</b>	<b>778</b>	108	72	81	99	198	220		
<b>Reference</b>	<b>418</b>							209	209
<b>Total in one Semester</b>	<b>1,196</b>	360				418		418	
<b>Total</b>	<b>2,392</b>	<b>720</b>				<b>836</b>		<b>836</b>	
		<b>1,556</b>							

#### 4.2.4 Lighting Study

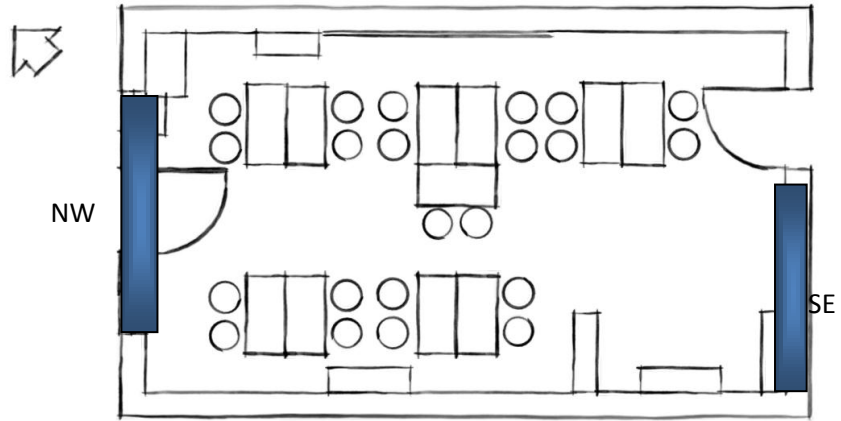
Existing lighting in both schools A and B consists of both natural and artificial lighting. Natural lighting is kept as it is in both schools, but the artificial lighting will be changed alternatively from existing to the experimental lighting or vice versa, as will be explained later.

##### Natural Lighting – Daylight Design

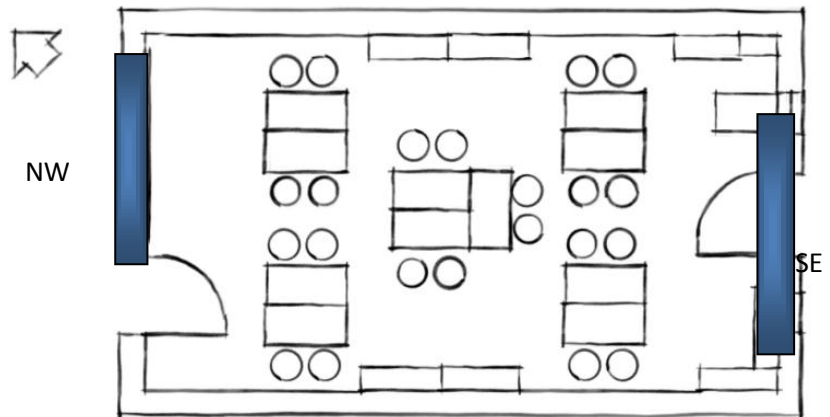
In school-A the classrooms are designed to allow in daylight from two different sides facing each other, as shown in figures 4-10 and 4-11. The classrooms are lit from the north-west (NW) and south-east (SE) all year round.

A Sun Path Study for each classroom in school-A is done for a better overall understanding of daylight positioning during the academic year. Classroom A1's sun path

study is shown in Figure 4-12, and Figure 4-13 shows the sun path study for classroom A2.



**Figure 4-10: Classroom A1 Allocation of Daylight Accesses (Drawn by the author).**



**Figure 4-11: Classroom A2 Allocation of Daylight Accesses (Drawn by the author).**

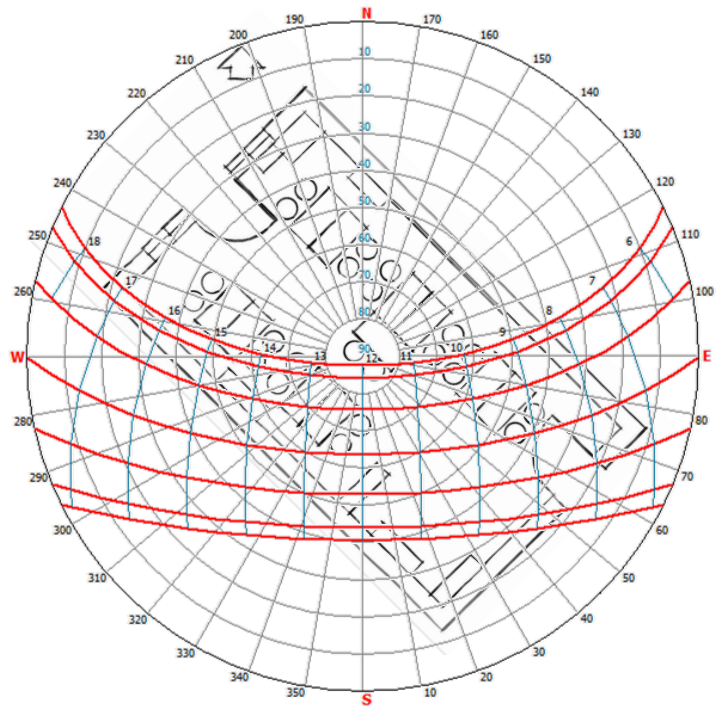


Figure 4-12: School-A Classroom-A1 Sun Path Study (Done by the author).

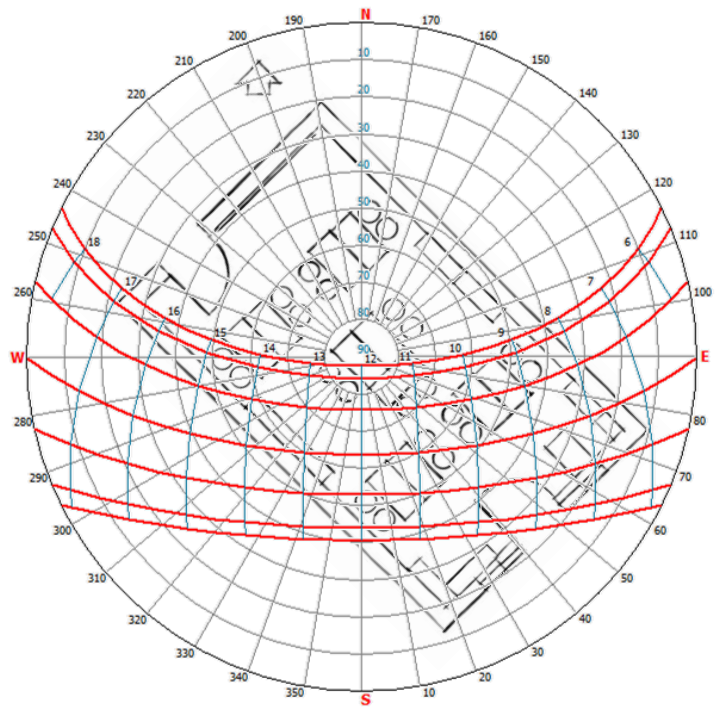


Figure 4-13: School-A Classroom-A2 Sun Path Study (Done by the author).

A glass door that leads to the school garden is located in the classrooms as a way to link the interior with the exterior (Figure 4-14). In both classrooms the daylight through the glass doors can be controlled by light fabric blinds. In classroom A1 the glass door is located on the NW side (Figure 4-10), while it is located on the SE side in classroom A2 (Figure 4-11).

On the other side facing the glass door, and to allow more daylight into the classrooms, short raised windows can be located (Figure 4-15). In classroom A1 the windows are located on the SE side (Figure 4-10), while in classroom A2 they are on the NW side (Figure 4-11).

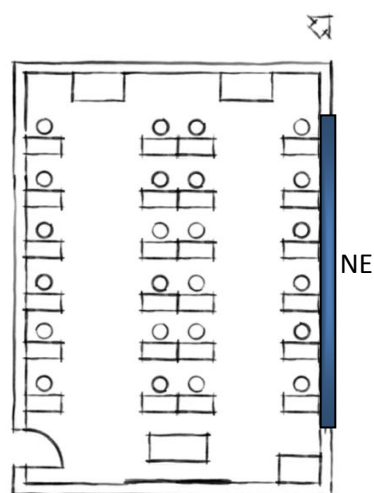


**Figure 4-14: Classrooms (A1 and A2) Glass Door (Taken by the author).**



**Figure 4-15: Classrooms (A1 and A2) Short Raised Windows (Taken by the author).**

In school-B the classrooms are lit by natural light from the NE all year round (Figure 4-16). Each classroom has two large windows that allow the daylight from one side only, facing another building (Figure 4-17). Thick fabric blinds are available to control the daylight in both classrooms (Figure 4-17).

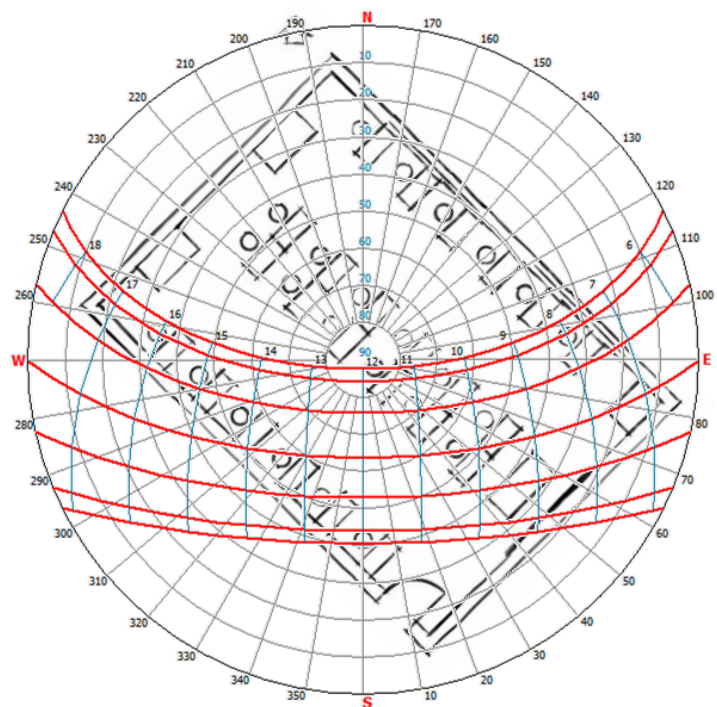


**Figure 4-16: Classrooms B1 and B2 Allocation of Daylight Access (Drawn by the author).**



**Figure 4-17: Classrooms (B1 and B2) Allocation of Windows (Taken by author).**

The Sun Path Study for the classrooms in school-B is done for a better overall understanding of the daylight during the academic year. Both classrooms B1 and B2 share the same sun path study, which is shown in Figure 4-18.



**Figure 4-18: School-B Classrooms (B1 and B2) Sun Path Study (Done by the author).**

## Artificial Lighting Design

In both schools (A and B) the same type of lighting is used: fluorescent tubes of cool white. They both also have white ceilings with ceiling fans in the classrooms. The only control over the artificial lighting is the on/off switch. Figure 4-19 shows the colour temperature for the general lighting and how different the cool lighting is from the warm in colour, while Figure 4-20 shows how the modern fluorescent (warm white fluorescent) is the closest colour to the natural light summer noon where all colours are almost in the same range (Karlen and Benya, 2004).

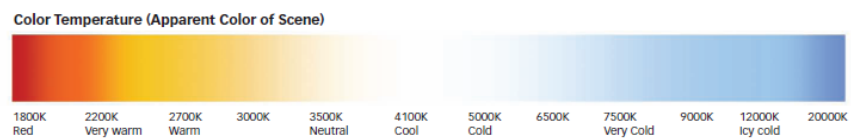


Figure 4-19: Colour Temperature (Karlen and Benya, 2004).

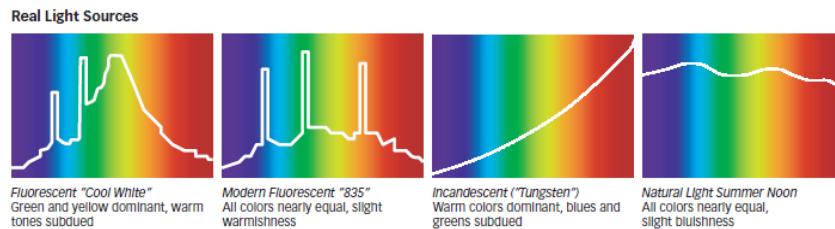
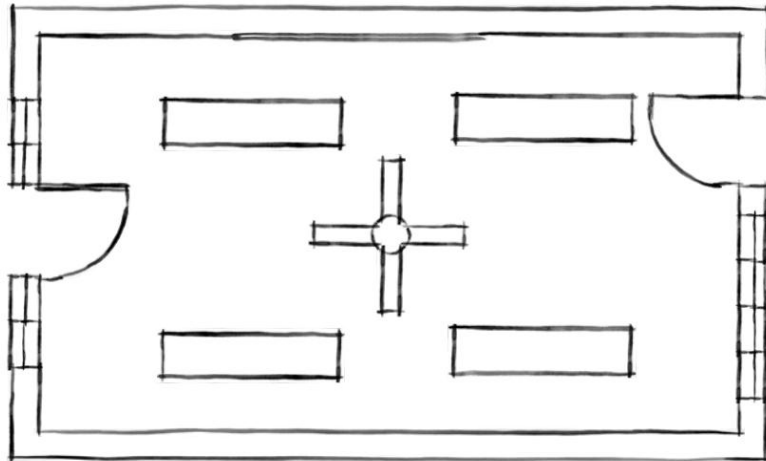


Figure 4-20: Real Light Sources (Karlen and Benya, 2004).

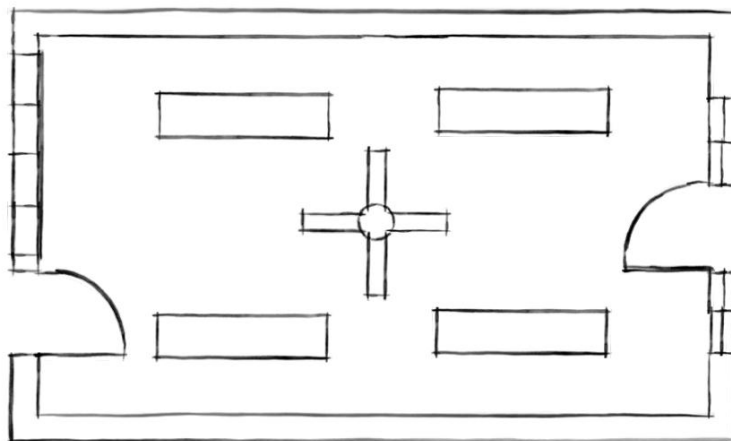


Figure 4-21: Fluorescent Tubes Used in the Experiment (www.osram.com).

The distribution of lighting in both schools (A and B) is symmetrical, as shown in the reflected ceiling plans below (Figures 4-22, 4-23 and 4-24):



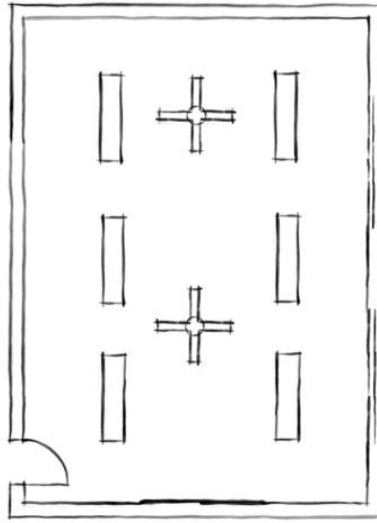
**Figure 4-22: School-A Reflected Ceiling Plan A1 (Drawn by the author).**



**Figure 4-23: School-A Reflected Ceiling Plan A2 (Drawn by the author).**



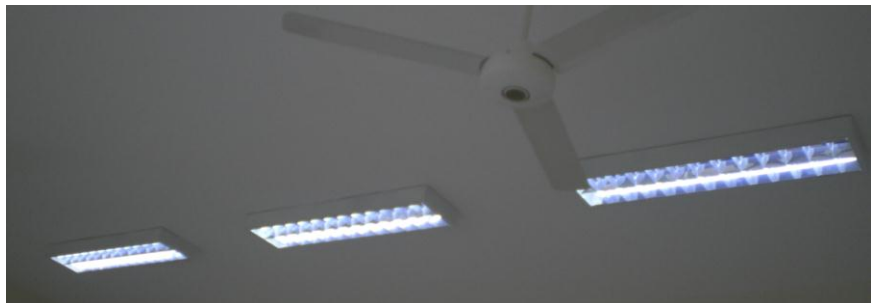
**Figure 4-24: School-B Reflected Ceiling Plan-B1andB2 (Drawn by the author).**



In school-A the luminaries are covered (Figure 4-25), while in school-B the luminaries are opened (Figure 4-26).



**Figure 4-25: School-A Covered Luminaries (Taken by the author).**



**Figure 4-26: School-B Opened Luminaries (Taken by the author).**

### 4.3 Details of the Experiment

The academic year in most schools in the UAE, including school-A and school-B, consists of two semesters. The academic year 2009/2010 commenced on 15 September and ended 13 June. The vacation in between semesters was in February.

By the end of every semester evaluations take place and grade reports are submitted to students. During each semester some evaluations are made as well, but this experiment will depend upon and collect only the major two evaluations at the end of each respective semester. Therefore, the rotation pattern in our experiment will focus on the first and second semesters. The experimental classes were set with appropriate lighting before the beginning of each semester.

On 1 September all fluorescent tubes in classrooms A1, A2, B1, and B2 were replaced with brand new tubes for both the cool white and warm white, in order to make sure that all the types of lighting are uniform. The covered luminaries were opened and cleaned thoroughly to compare the dust collection through the experiment between the cool and warm white, to look for differences.

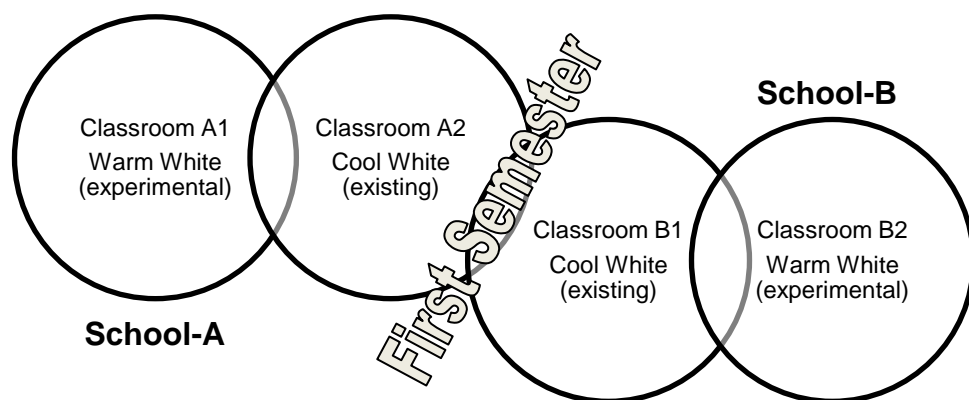
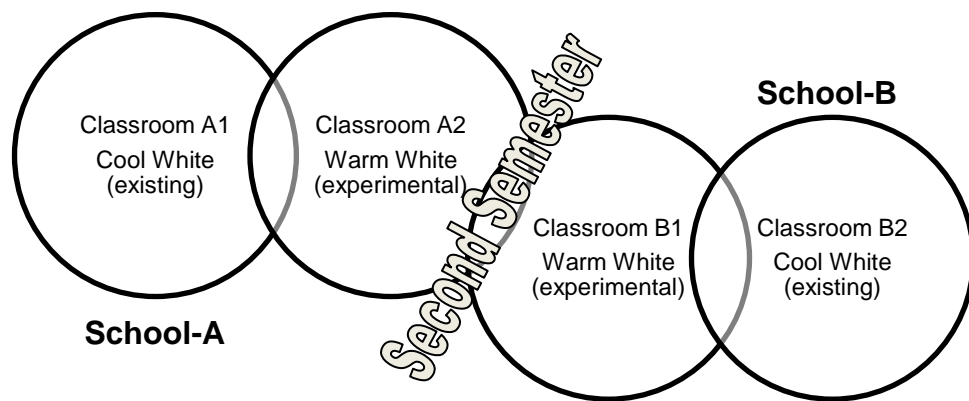


Figure 4-27: First Semester Experiment Detailing (Drawn by the author).



**Figure 4-28: Second Semester Experiment Detailing (Drawn by the author).**

In the first semester classes A1 and B2 had the experimental lighting: warm white fluorescent tubes, while classes A2 and B1 were left with their existing lighting: cool white. Alternatively on 20 February, classes A1 and B2 had the cool white fluorescent tubes and classes A2 and B1 had the warm white fluorescent tubes.

One week after the school term and the experiment began, school-B reported that they will stop the experiment. Most of the teachers teaching class B2 asked for changing the lighting, describing it as “annoying”. They complained that the classroom looks “very yellow” in the morning, but in the afternoon it is bearable. The next day after this issue was reported I went to check on the situation. The department director, the nurse and I had meetings with the teachers and the children. The experiment was explained briefly for the teachers. It turned out that no health issues were reported and that it was only discomfort from the colour and the lack of the brightness that the teachers were feeling in the morning. The nurse checked the children and nothing extraordinary or negative was discerned to stop the experiment. The director and the nurse suggested keeping the experiment running for one more week and stop it immediately if any complaint was received. After one week, none was reported, and the teachers did not mind completing the exper-

iment as they gradually became used to the experimental lighting. Accordingly, the experiment was completed in school-B. School-A was contacted to establish whether there were any complaints. Their response was that it was a “strange feeling” at the beginning, but they got used to it and did not mind carrying on with the experiment.

School-A reported that the covered luminaries with the experimental lighting were cleaned twice per semester, while the covered luminaries with the existing lighting were cleaned four times over the same period. This may not be an accurate means of measuring the dust collected from both lighting types, but nevertheless deserves to be mentioned and might be a topic of further research.

Throughout the duration of the experiment no flicking was reported except for one tube on 16 May in school-B. The tube was replaced immediately.

The results were fully reported by 15 July from both schools in the form of the questionnaires from the teachers along with the grade reports of the students.

#### 4.4 Summary of the Experiment

Table 4-4: Summary of Experiment (Done by the author).

Parameters	School-A	School-B
Location	Sharjah: School Zone, near Sharjah University	Sharjah: Behind Sharjah TV Station
Curriculum	British	British

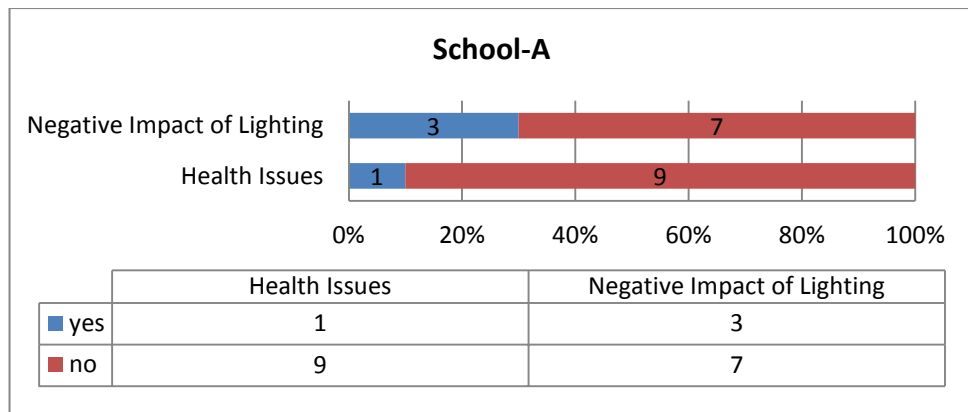
<b>Parameters</b>	<b>School-A</b>	<b>School-B</b>
<b>Circle</b>	One	One
<b>Grade</b>	Two	Two
<b>Gender</b>	Mixed Boys with girls	Separated Girls only Boys (reference)
<b>Duration</b>	One academic year 2009/2010	One academic year 2009/2010
<b>Interior Environment</b>		
<b>Color Scheme</b>	Colourful Red, yellow and blue	Neutral Beiges and browns
<b>Desk Distribution</b>	Clustered Groups	Aligned facing the white board
<b>Air Conditioning</b>	Split Units	Central System
<b>Users of Space</b>		
<b>Teachers</b>	10	10
<b>Students</b>	40	38 Plus 38 as reference
<b>Total Number of Participants</b>	98 Plus 38 as reference	
<b>Teachers</b>	20	
<b>Students</b>	78 Plus 38 as reference	
<b>Subjects</b>	9	11

<b>Parameters</b>	<b>School-A</b>	<b>School-B</b>
<b>Assessment</b>	Twice a year	Twice a year
<b>Size of Sample</b>	20 Questionnaires 1,556 individual results Plus 836 individual reference results	
<b>Questionnaires</b>	10	10
<b>Total Students Results</b>	720	836 Plus 836 reference
<b>Existing Lighting</b>		
<b>Natural</b>	Glass door with blinds Raised windows NW and SE	2 large windows with blinds NE
<b>Artificial</b>	Covered Luminaries On/off control Cool white	Open Luminaries On/off control Cool white
<b>Rotation Pattern</b>	Every Semester Twice a year	Every Semester Twice a year
<b>Rotation Detail</b>	Existing Lighting: Cool White Experimental Lighting: Warm White	
<b>First Semester</b>	A1: Experimental A2: Existing	B1: Existing B2: Experimental
<b>Second Semester</b>	A1: Existing A2: Experimental	B1: Experimental B2: Existing
<b>Comments in Week One</b>	Strange feeling	Annoying Very yellow
<b>Reported Tube Issues</b>	None	Flicking tube (16 May), replaced
<b>Results Submission</b>	15 July	15 July

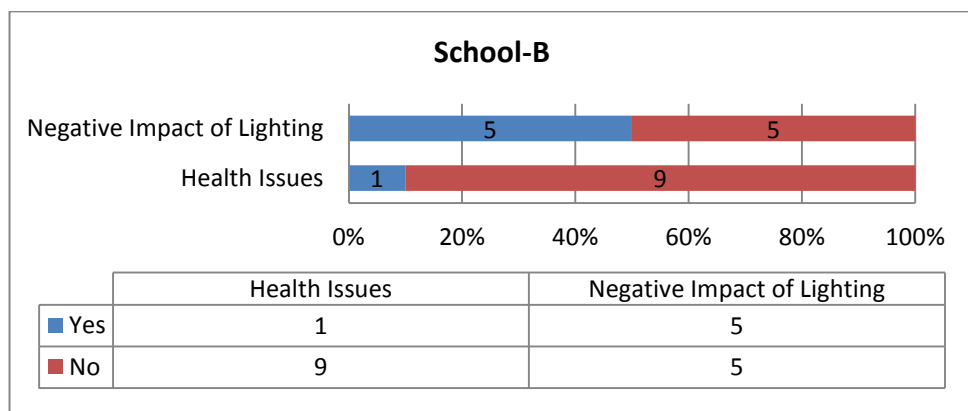
## 5. ANALYSIS AND DISCUSSION

### 5.1 Analysis of Teachers' Questionnaires

One teacher in school-A reported suffering a migraine, and one teacher in school-B reported hypothyroidism. Thirty percent of the teachers in school-A believed that lighting does affect them and their students negatively with migraines (Figure 5-1), while in school-B fifty percent thought that the negative impact of lighting on them is through discomfort and eyestrain (Figure 5-2).

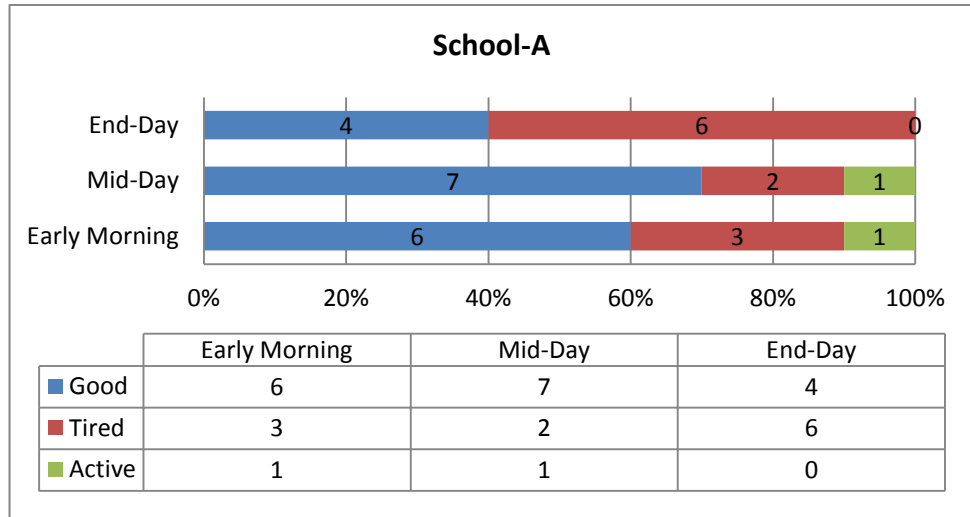


**Figure 5-1: School-A Teachers' Questionnaires Yes/No Questions (Done by the author).**

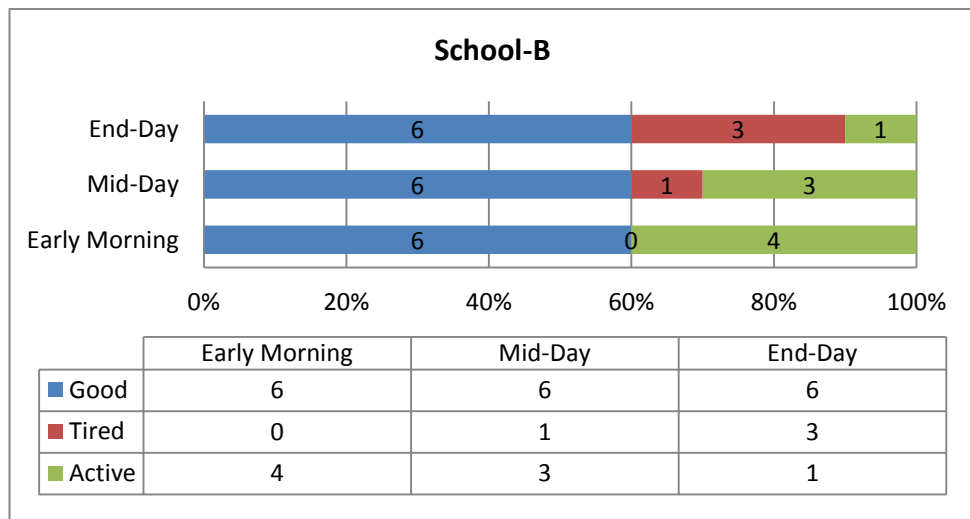


**Figure 5-2: School-B Teachers' Questionnaires Yes/No Questions (Done by the author).**

The teachers' behaviors during the day varied between good, tired, and active in both schools – A and B as shown in Figures 5-3 and 5-4.



**Figure 5-3: School-A Teachers' Questionnaires Behavior During the Day (Done by the author).**

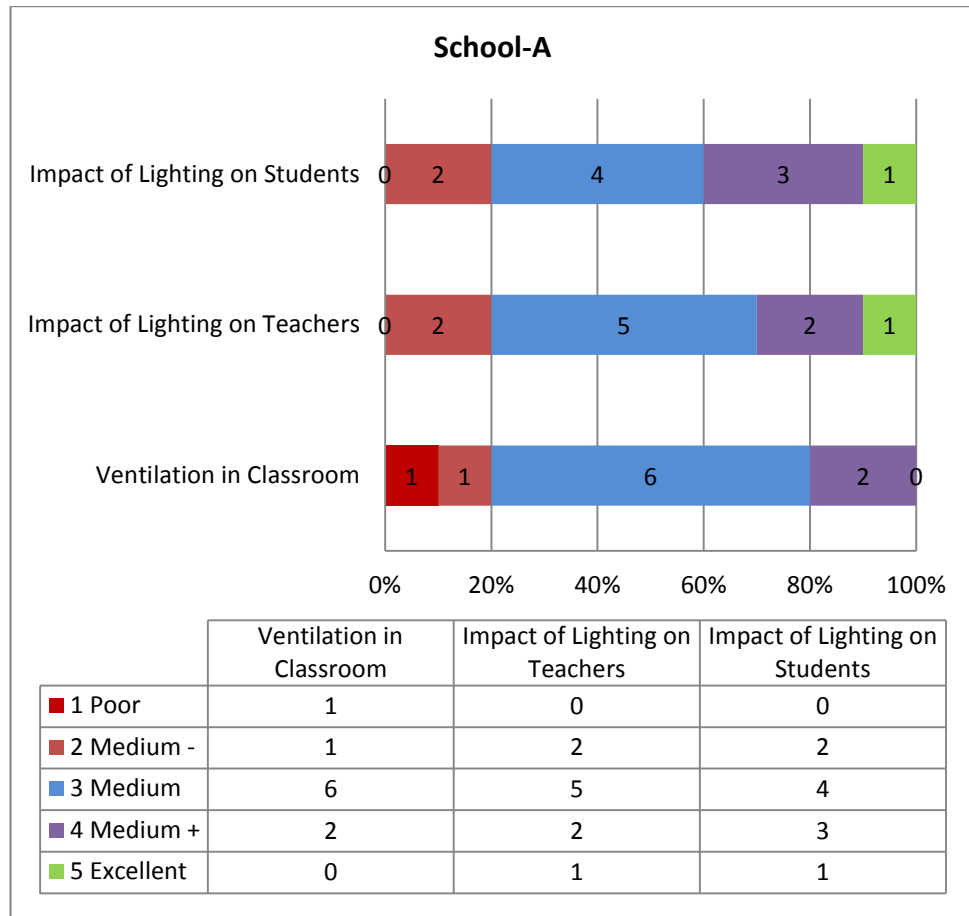


**Figure 5-4: School-B Teachers' Questionnaires Behavior During the Day (Done by the author).**

The ventilation in school-A, where the luminaries are covered and the AC Systems are split units, was rated medium by six

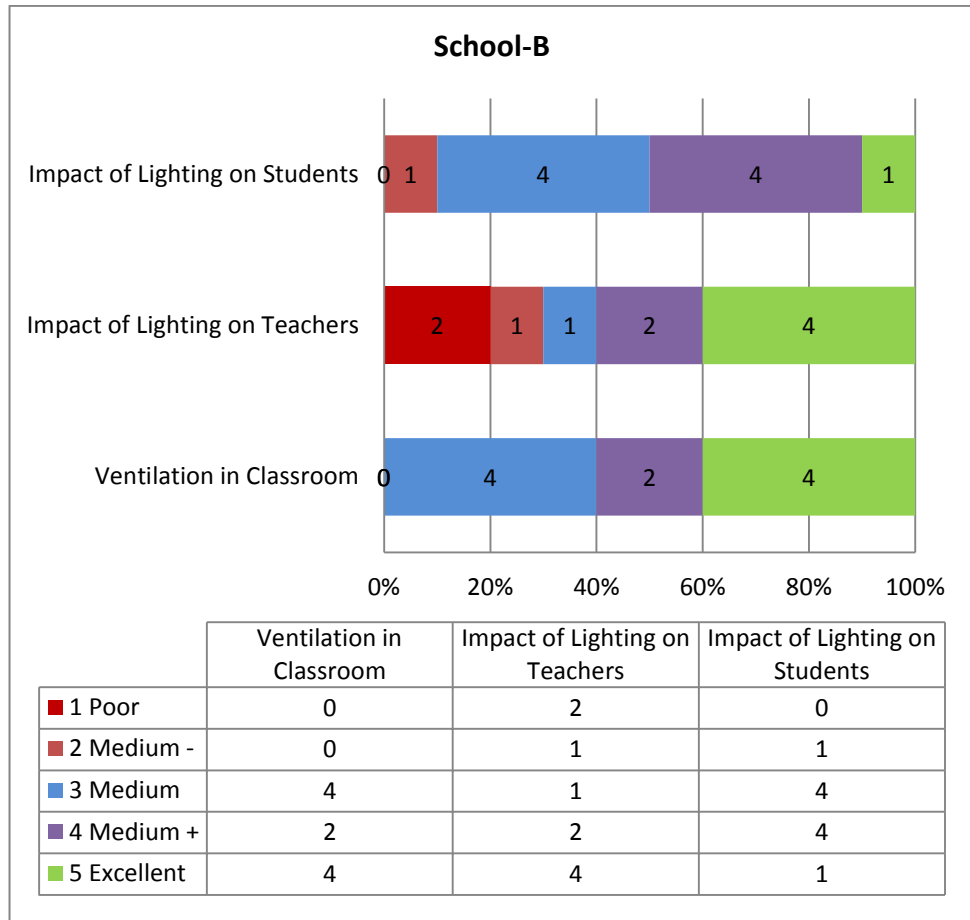


teachers. Half of the teachers considered the impact of lighting on them to be medium, while the impact of lighting on students was more valuable and reliable in their points of view, as four gave it medium importance and another three gave it medium plus (Figure 5-5).



**Figure 5-5: School-A Teachers' Questionnaire - Ventilation, Impact of Lighting on Teachers and Students (Done by the author).**

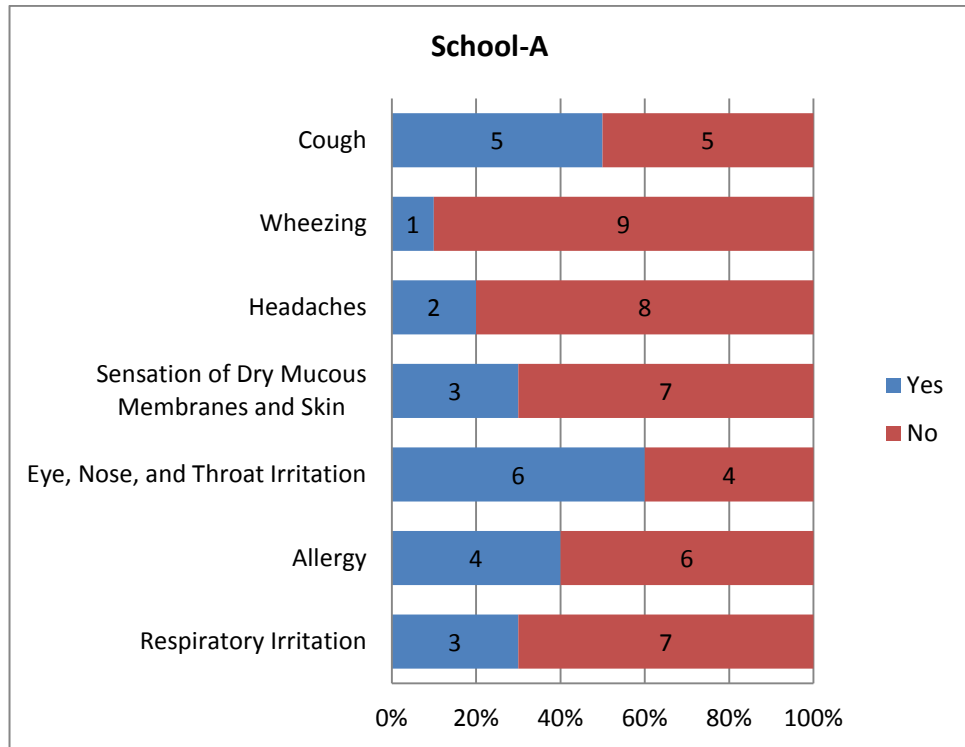
The teachers in school-B were more satisfied with the ventilation as four of them saw it as medium and another four excellent. The opinion of the impact of lighting on teachers varied along all the scale, with four votes for the top impact, while the lighting impact on students scored four for medium and another four for medium plus (Figure 5-6).



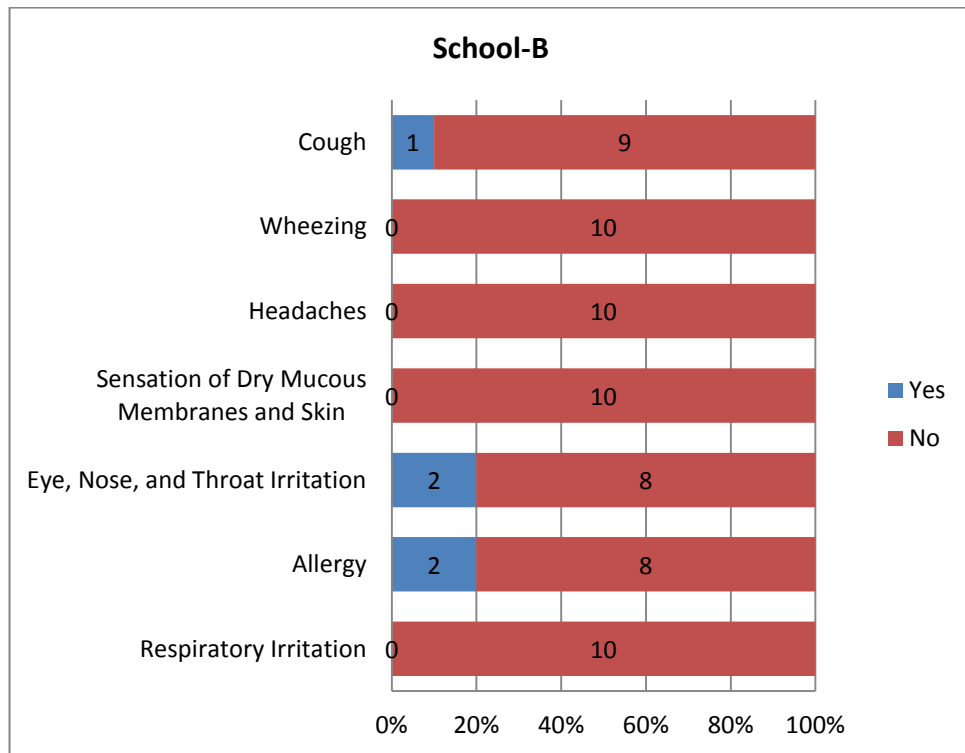
**Figure 5-6: School-B Teachers' Questionnaire - Ventilation, Impact of Lighting on Teachers and Students (Done by the author).**

Teachers' issues in classrooms A1 and A2 were the storage areas and the AC noise and smell that affected the circulated air, while the issues in classrooms B1 and B2 consisted of the ventilation and the lack of control over the AC.

The highest score of the health issues in the users of the classroom was for "eye, nose, and throat irritation", then cough and allergy, while respiratory irritation and "sensation of dry mucous membranes and skin" both had the same thirty percent score. Headache and wheezing scored the least in the school-A questionnaire (Figure 5-7).



**Figure 5-7: School-A Teachers' Questionnaire - Health Issues (Done by the author).**



**Figure 5-8: School-B Teachers' Questionnaire - Health Issues (Done by the author).**

School-B reported only five votes: two for the “eye, nose, and throat irritation”, another two for allergy, and one vote for cough (Figure 5-8).

## 5.2 Analysis of Students’ Results – Number of Classes

In order to analyze the results of the students in both schools, the difference between the grades was calculated with reference to the grade under the experimental lighting. These results were recorded in tables then shown in charts that will be illustrated in this chapter as the general analysis for the students’ results. In the charts the analyses of the grades are shown in three different divisions: blue for improved (change > 0), red for retracted (change < 0), and green for neutral (1- change = 0, and 2- Non Muslim Students in Islamic Studies and this was used for school-A only). The number of students will be indicated at the top of each bar. Each class will be rated as per the majority of the subjects’ scores.

Detailed analysis will be shown depending on these results with a variation of references: time, school, subject, and gender, in order to clarify the results for more thorough findings and better discussion.

**Table 5-1: Changes in Grades for Class A1 (Done by the Author).**

School-A Class A1 Changes in Grades										
Serial No.	Gender	Islamic Studies	Arabic	Social Studies	Literacy	Maths	Science	Geography	French	PE
1	F	NM	-6	-5	-4	3	0	-2	-1	-1
2	M	2	-6	3	4	1	-5	0	2	2

School-A Class A1 Changes in Grades										
Serial No.	Gender	Islamic Studies	Arabic	Social Studies	Literacy	Maths	Science	Geography	French	PE
3	M	-5	2	-4	4	1	-12	-4	0	0
4	F	5	3	-1	-2	4	-5	-1	-2	0
5	M	2	-5	3	-3	-2	3	3	-8	2
6	F	NM	-3	-5	3	3	4	-6	3	-3
7	M	NM	2	-1	2	-8	-8	-5	-3	1
8	F	-2	-4	2	3	-3	-1	2	-3	-2
9	M	NM	-5	-3	-5	-1	-8	-7	-1	5
10	M	NM	4	-2	7	2	6	2	0	2
11	M	-3	-3	-5	2	-4	-5	-5	-1	3
12	M	4	-3	3	-2	0	14	3	-6	0
13	F	NM	1	-10	2	4	7	-6	-5	-4
14	M	2	-2	1	-3	3	-8	-3	-6	-1
15	M	-3	6	-11	2	5	-3	-14	2	-1
16	F	NM	1	-7	-2	-1	-1	-5	2	-4
17	M	7	-3	2	1	-1	-3	1	2	2
18	F	-3	-8	0	1	-3	-2	-5	2	-3
19	M	4	6	-9	-5	5	-3	-4	-1	2
20	F	-5	0	-1	2	-2	-5	-3	-6	1

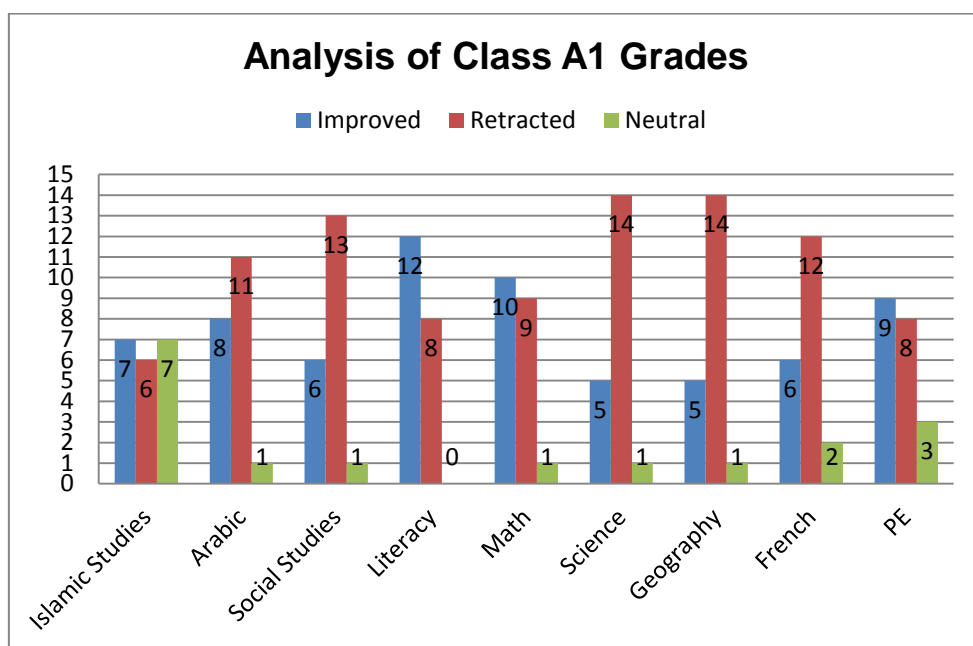


Figure 5-9: Changes in Grades for Class A1 (Done by the Author).

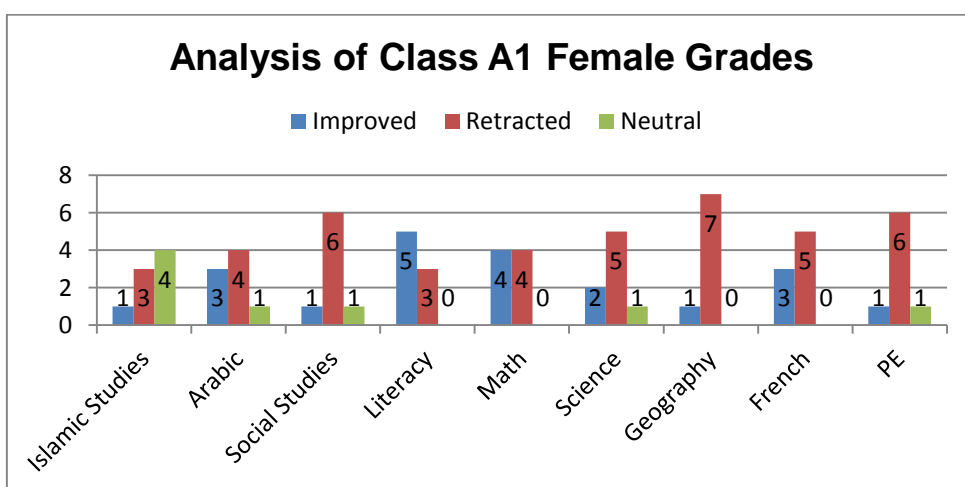
The overall score of class A1 is retracted, as five out of nine subjects scored retracted results. Four subjects had improved re-

sults (as Islamic Studies' neutral results were for Non-Muslim students as in table 5-1) and one subject had equal neutral with improved scores (Figure 5-9).

As school-A is has mixed students in each of its classes A1 and A2, separated tables for females and males, along with the details charts, were conducted for enhanced analysis. While the classes in school-B are separated there is no need for further tables and charts to be conducted.

**Table 5-2: Changes in Grades for Class A1 / Female Students (Done by the Author)**

School-A Class A1 Changes in Female Grades										
Serial No.	Gender	Islamic Studies	Arabic	Social Studies	Literacy	Maths	Science	Geography	French	PE
1	F	NM	-6	-5	-4	3	0	-2	-1	-1
4	F	5	3	-1	-2	4	-5	-1	-2	0
6	F	NM	-3	-5	3	3	4	-6	3	-3
8	F	-2	-4	2	3	-3	-1	2	-3	-2
13	F	NM	1	-10	2	4	7	-6	-5	-4
16	F	NM	1	-7	-2	-1	-1	-5	2	-4
18	F	-3	-8	0	1	-3	-2	-5	2	-3
20	F	-5	0	-1	2	-2	-5	-3	-6	1

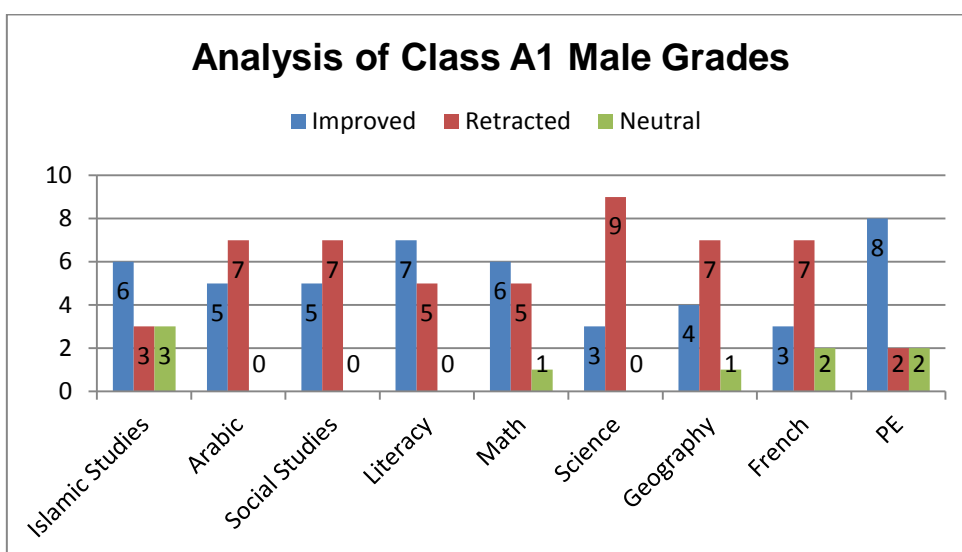


**Figure 5-10: Changes in Grades for Class A1 / Female Students (Done by the Author).**

Literacy is the only subject that improved in class A1 female students, and it is one of the three improved subjects in class A1. Seven subjects were reported with retracted results, making the female results of class A1 retracted. Mathematics scored equal results between improved and retracted (Figure 5-10).

**Table 5-3: Changes in Grades for Class A1 / Male Students (Done by the Author)**

School-A Class A1 Changes in Male Grades										
Serial No.	Gender	Islamic Studies	Arabic	Social Studies	Literacy	Maths	Science	Geography	French	PE
2	M	2	-6	3	4	1	-5	0	2	2
3	M	-5	2	-4	4	1	-12	-4	0	0
5	M	2	-5	3	-3	-2	3	3	-8	2
7	M	NM	2	-1	2	-8	-8	-5	-3	1
9	M	NM	-5	-3	-5	-1	-8	-7	-1	5
10	M	NM	4	-2	7	2	6	2	0	2
11	M	-3	-3	-5	2	-4	-5	-5	-1	3
12	M	4	-3	3	-2	0	14	3	-6	0
14	M	2	-2	1	-3	3	-8	-3	-6	-1
15	M	-3	6	-11	2	5	-3	-14	2	-1
17	M	7	-3	2	1	-1	-3	1	2	2
19	M	4	6	-9	-5	5	-3	-4	-1	2



**Figure 5-11: Changes in Grades for Class A1 / Male Students (Done by the Author).**

The results of the male students in class A1 are the same as the results of class A1. Four improved and five retracted subjects are the reported results of male students in class A1 (Figure 5-11).

**Table 5-4: Changes in Grades for Class A2 (Done by the Author).**

School-A Class A2 Changes in Grades										
Serial No.	Gender	Islamic Studies	Arabic	Social Studies	Literacy	Maths	Science	Geography	French	PE
1	F	NM	-5	3	-1	2	-1	3	1	-2
2	M	-4	2	-1	-4	0	-1	-1	-1	1
3	F	NM	2	-2	2	5	5	2	0	3
4	M	1	-1	-3	-1	5	-1	-1	-2	0
5	M	NM	5	4	0	0	-4	5	9	-1
6	F	4	-9	0	5	2	-6	1	-4	1
7	F	NM	-3	1	0	-1	1	1	1	2
8	M	7	-2	5	4	0	1	5	2	-3
9	M	NM	-5	11	5	-5	1	8	-2	2
10	M	-4	2	10	9	10	-2	10	2	1
11	F	NM	2	-4	0	-2	1	0	-7	0
12	M	8	3	7	0	-2	4	5	0	3
13	F	NM	-5	1	-2	0	4	5	-2	0
14	F	-2	-4	3	0	1	1	3	3	1
15	F	5	-2	-5	1	2	-6	1	3	0
16	M	-1	0	-2	-3	7	6	-2	-3	2
17	F	5	-1	2	5	5	-1	1	-6	-6
18	F	4	-9	-6	4	5	-1	0	0	0
19	F	NM	1	10	0	-4	4	4	3	-8
20	M	2	4	-2	2	-5	-2	2	0	-1

Class A2, in contrast to class A1, had improved results in six subjects (Islamic Studies (as neutral results were for NM students), Social Studies, Literacy, Mathematics, Geography, and PE). Two subjects had equal scores of improved with retracted: Science and French. Arabic is the only subject that was retracted (Table 5-4 and Figure 5-12).



Class A2 was analyzed in detail along with class A1 to show the female and male students' differences in progress (Tables 5-5 and 5-6, Figures 5-13 and 5-14).

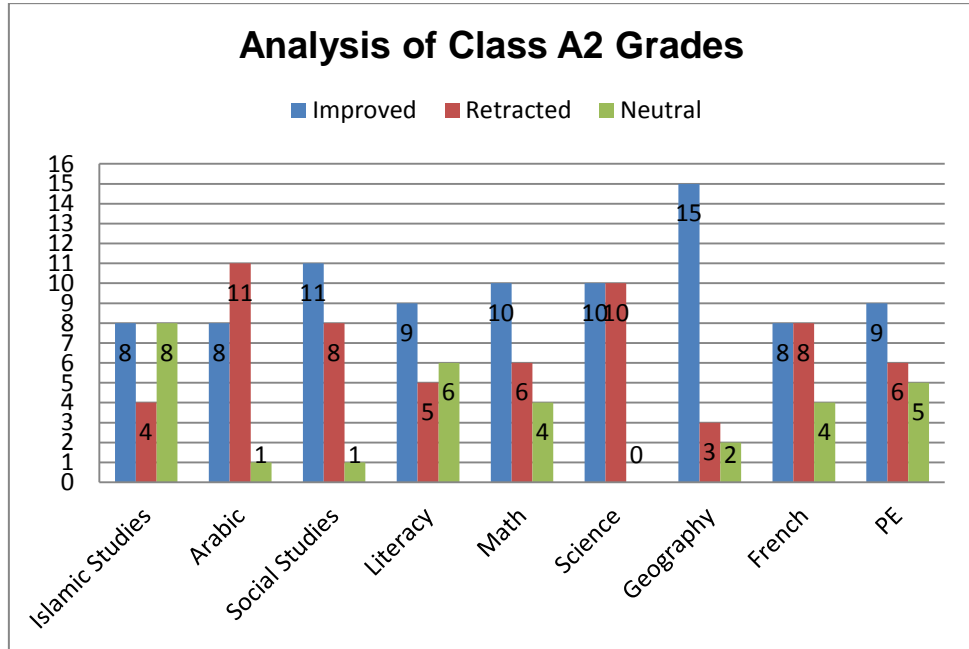
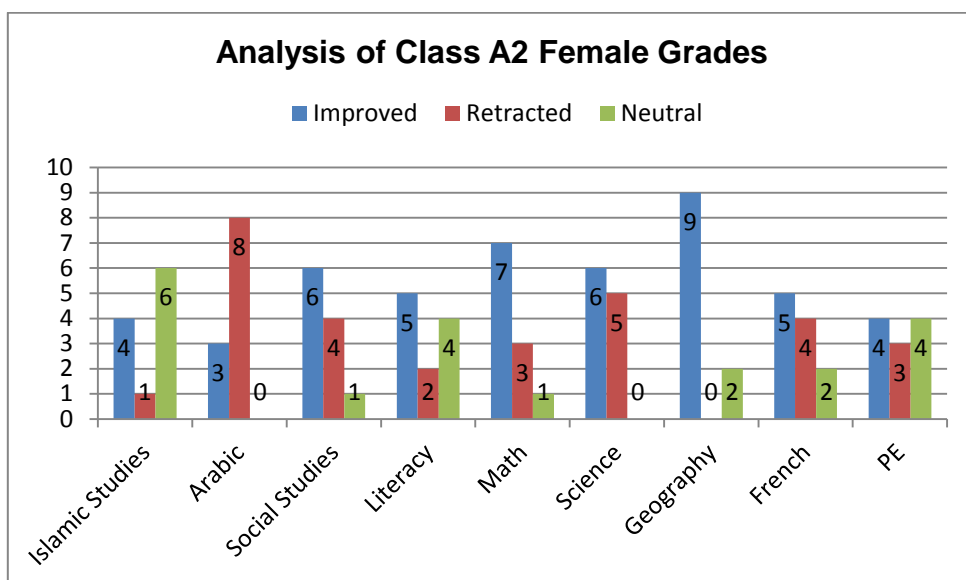


Figure 5-12: Changes in Grades for Class A2 (Done by the Author).

Table 5-5: Changes in Grades for Class A2 / Female Students (Done by the Author).

School-A Class A2 Changes in Female Grades										
Serial No.	Gender	Islamic Studies	Arabic	Social Studies	Literacy	Maths	Science	Geography	French	PE
1	F	NM	-5	3	-1	2	-1	3	1	-2
3	F	NM	2	-2	2	5	5	2	0	3
6	F	4	-9	0	5	2	-6	1	-4	1
7	F	NM	-3	1	0	-1	1	1	1	2
11	F	NM	2	-4	0	-2	1	0	-7	0
13	F	NM	-5	1	-2	0	4	5	-2	0
14	F	-2	-4	3	0	1	1	3	3	1
15	F	5	-2	-5	1	2	-6	1	3	0
17	F	5	-1	2	5	5	-1	1	-6	-6
18	F	4	-9	-6	4	5	-1	0	0	0
19	F	NM	1	10	0	-4	4	4	3	-8

Female students in class A2 scored eight improved results and one retracted in Arabic (Figure 5-13), which is concluded from Table 5-5 and is better than the class A2 results.



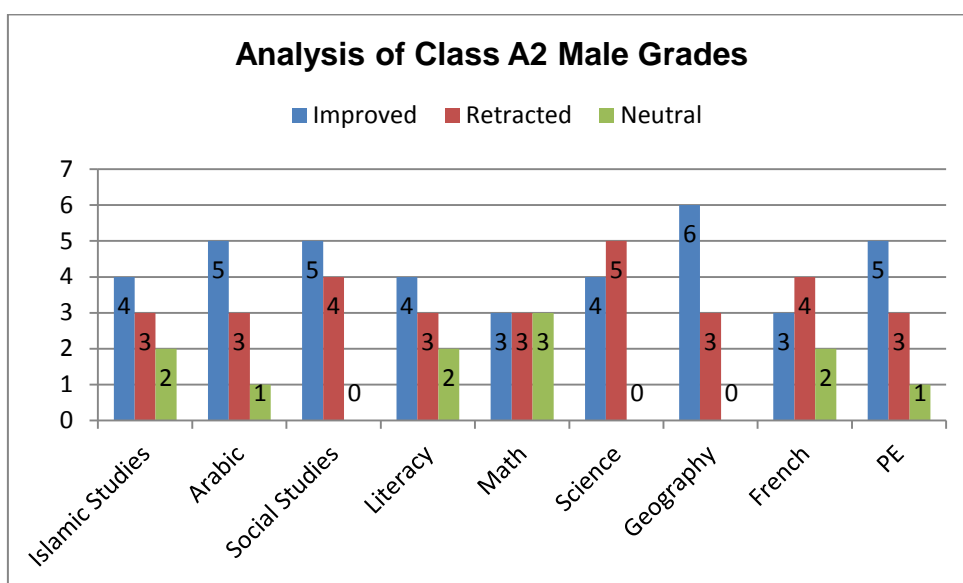
**Figure 5-13: Changes in Grades for Class A2 / Female Students (Done by the Author).**

Male students in class A2 scored six improvements in Islamic Studies, Arabic, Social Studies, Literacy, Geography, and PE. Mathematics scored equal improved, retracted and neutral results, while Science and French were retracted. These results are illustrated in Table 5-6 and Figure 5-14. Further detailed charts for school-A are added in Appendix C.

**Table 5-6: Changes in Grades for Class A2 (Male Students).**

School-A Class A2 Changes in Male Grades										
Serial No.	Gender	Islamic Studies	Arabic	Social Studies	Literacy	Maths	Science	Geography	French	PE
2	M	-4	2	-1	-4	0	-1	-1	-1	1
4	M	1	-1	-3	-1	5	-1	-1	-2	0
5	M	NM	5	4	0	0	-4	5	9	-1
8	M	7	-2	5	4	0	1	5	2	-3

School-A Class A2 Changes in Male Grades										
Serial No.	Gender	Islamic Studies	Arabic	Social Studies	Literacy	Math	Science	Geography	French	PE
9	M	NM	-5	11	5	-5	1	8	-2	2
10	M	-4	2	10	9	10	-2	10	2	1
12	M	8	3	7	0	-2	4	5	0	3
16	M	-1	0	-2	-3	7	6	-2	-3	2
20	M	2	4	-2	2	-5	-2	2	0	-1



**Figure 5-14: Changes in Grades for Class A2 / Male Students (Done by the Author).**

In school-B the female classes B1 and B2 were involved in the experiment while the male classes' results were given as a plus B3 and B4 for reference.

Class B1 improved in the results of Arabic, Social Studies, Science, Holy Quran, Reading, Listening, and Conversation. Islamic Studies was neutral in the changes. The retracted subjects were English, Mathematics, and Activities.

Table 5-7: Changes in Grades for Class B1 / Female (Done by the Author).

School-B Class B1 Changes in Grades											
Serial No.	Islamic Studies	Arabic	Social Studies	English	Maths	Science	Activities	Holy Quran	Reading	Listening	Conver-sation
1	0	0	1	2	-1	1	0	1	0	2	0
2	0	1	3	3	0	2	-4	0	0	2	0
3	0	3	0	0	-6	1	-6	2	7	7	5
4	-1	3	2	0	-1	-1	0	1	5	2	5
5	0	3	3	-3	-5	1	-3	1	5	5	5
6	0	2	1	-2	-4	0	-2	1	3	5	5
7	1	2	3	-1	-1	1	-5	1	2	7	7
8	0	1	1	0	-1	-2	-1	0	0	2	2
9	0	3	1	8	0	3	-3	1	5	3	7
10	0	3	0	-3	-5	0	-2	1	7	13	7
11	0	1	0	-5	-2	-2	-3	0	3	2	2
12	0	1	2	0	0	1	0	0	2	2	2
13	0	1	1	-1	-4	-3	-3	3	4	2	0
14	2	1	2	-2	-4	6	-5	2	2	5	2
15	1	2	4	2	0	1	-3	6	3	5	3
16	1	2	-1	-2	-8	-4	-5	-4	5	5	5
17	1	1	0	-4	-5	-6	-6	3	3	5	5
18	0	3	1	0	-1	-1	0	0	7	7	12

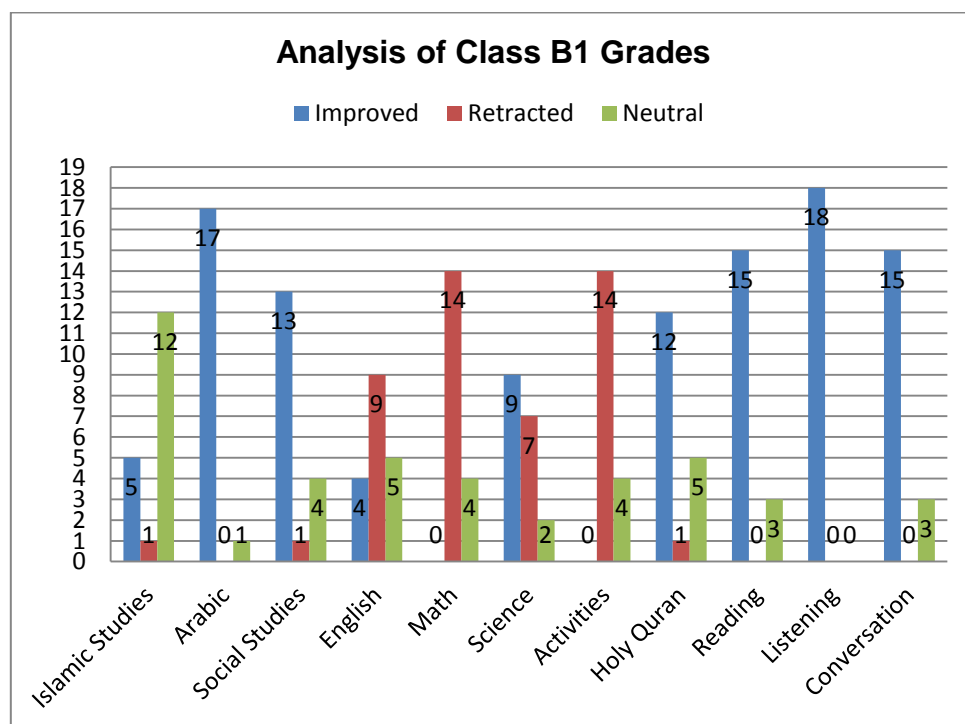


Figure 5-15: Changes in Grades for Class B1 / Female (Done by the Author).

Table 5-8: Changes in Grades for Class B2 / Female (Done by the Author).

School-B Class B2 Changes in Grades											
Serial No.	Islamic Studies	Arabic	Social Studies	English	Maths	Science	Activities	Holy Quran	Reading	Listening	Conver- sation
1	-1	-1	0	-6	-2	-3	2	-1	2	-5	-2
2	0	-1	-2	-5	1	-5	2	1	-2	-2	0
3	0	-1	2	2	5	-5	4	-1	0	-5	-3
4	-2	-3	-1	-8	-4	-11	5	2	-1	-7	-7
5	-1	-1	0	0	1	-1	1	3	0	-5	0
6	-1	-2	-4	-3	5	-2	2	-2	-4	-5	-7
7	-1	-2	-4	-5	3	-5	1	2	-4	-2	-2
8	-1	-1	0	-6	5	-7	9	-1	-2	-3	-2
9	0	-1	0	-7	1	-5	3	0	0	-2	-3
10	-2	-1	0	-2	-2	-1	0	2	-5	-3	2
11	-1	-1	0	-4	0	-1	0	-2	-2	-2	-2
12	0	-3	-1	-5	0	-8	1	0	-10	-10	-2
13	0	0	0	1	0	0	0	1	0	-2	0
14	-1	-2	1	-8	-1	-4	1	-2	-7	-5	0
15	0	0	0	-1	5	-1	1	2	0	2	-3
16	-1	-1	-1	-1	12	-6	5	-3	-2	-2	0
17	-1	-1	0	-1	3	-3	4	-2	-3	-5	-3
18	-1	0	0	-1	4	-2	1	1	0	3	3
19	0	-1	0	-4	1	-2	0	-1	-2	-2	-2
20	0	-3	1	1	0	-1	1	1	-5	-3	-7

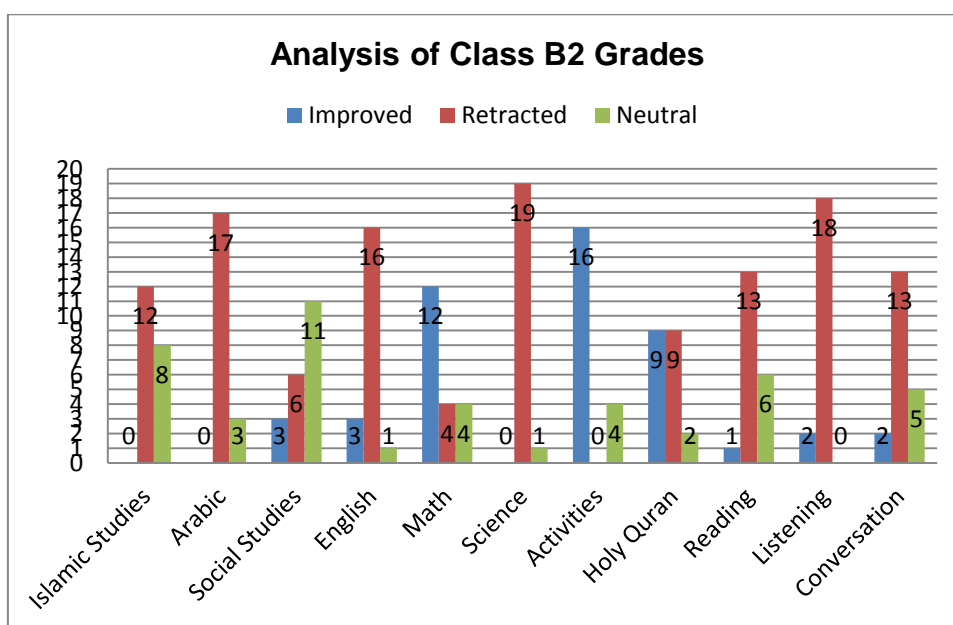


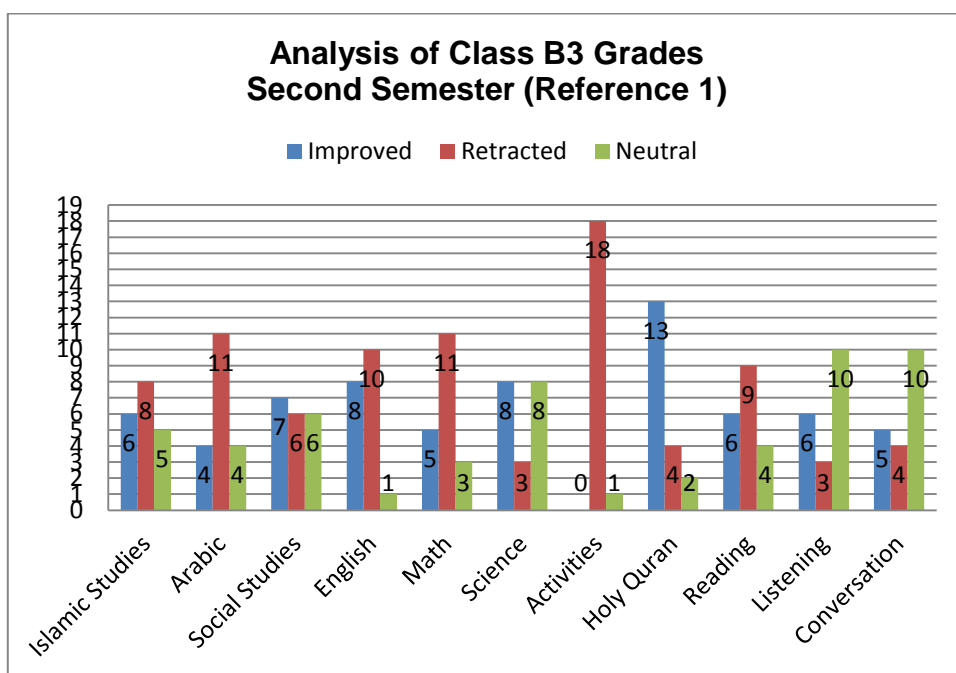
Figure 5-16: Changes in Grades for Class B2 / Female (Done by the Author).

Class B2 had Islamic Studies, Arabic, English, Science, Reading, Listening, and Conversation retracted. Mathematics and Activities recorded improved results. Holy Quran had equal improved with retracted results, but Social Studies had neutral results (Table 5-8 and Figure 5-16).

**Table 5-9: Changes in Grades for Class B3 – Second Semester / (Male) Reference 1 (Done by the Author).**

School-B Class B3 Changes in Grades Second Semester (Reference 1)											
Serial No.	Islamic Studies	Arabic	Social Studies	English	Maths	Science	Activities	Holy Quran	Reading	Listening	Conversation
1	1	-2	1	1	-4	1	-3	3	-10	-3	5
2	1	-2	-1	-4	0	0	-10	4	3	0	7
3	-16	-18	1	-3	-34	0	-6	-2	-6	-10	0
4	1	0	-1	-1	24	3	-4	1	0	0	0
5	-5	-12	1	-7	-31	0	-10	1	0	0	0
6	0	0	0	0	0	0	-1	-2	-8	0	2
7	18	30	1	-2	11	1	-1	9	5	-8	-3
8	-8	-15	2	-16	-12	5	-9	0	0	2	0
9	-8	-14	-5	13	0	0	-4	-6	2	0	2
10	-1	-1	0	-1	-14	0	-7	1	0	0	0
11	0	0	0	1	-4	6	-5	0	-1	2	-5
12	0	1	1	1	-7	2	-1	4	-5	0	0
13	3	9	-1	1	6	-1	0	5	2	5	0
14	0	-1	0	12	-10	7	-4	1	-1	0	-5
15	-3	-6	-1	-8	-9	0	-10	-5	1	2	0
16	0	0	2	10	1	13	-2	3	-3	0	0
17	-4	-7	0	-9	-19	-13	-6	2	1	10	17
18	-1	-3	0	-4	-1	0	-1	1	-1	2	-5
19	25	25	-1	1	26	-2	-2	7	-5	0	0

The first reference class, B3, recorded six retracted results: Islamic Studies, Arabic, English, Mathematics, Activities, and Reading. Social Studies and Holy Quran reported improved results. Science scored equal improved with neutral results. Listening and Conversation had neutral changes in the results. These results are displayed in Table 5-9 and Figure 5-17.



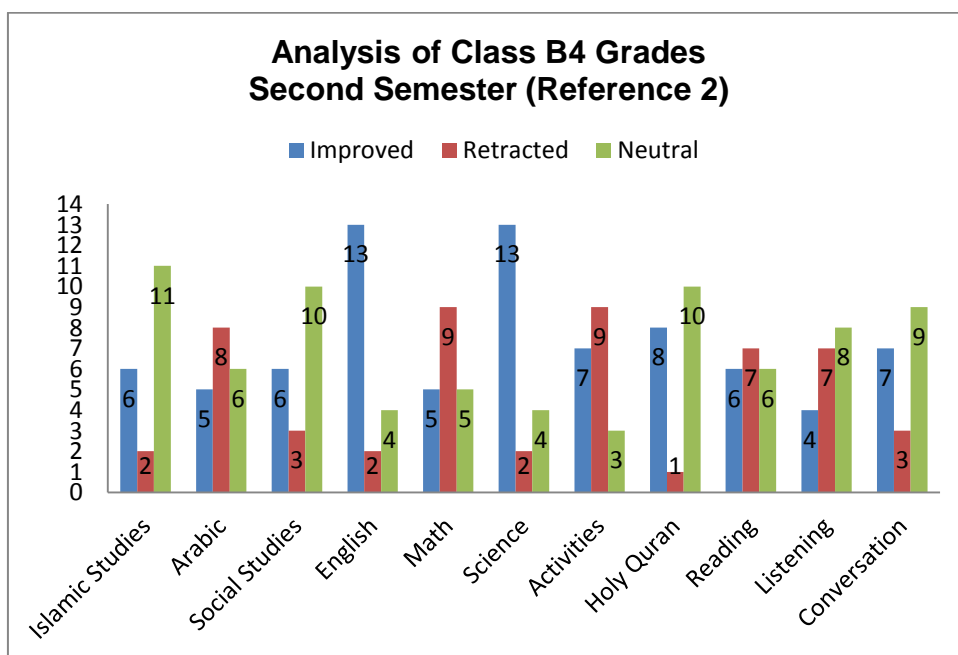
**Figure 5-17: Changes in Grades for Class B3 – Second Semester / (Male) Reference 1 (Done by the Author).**

The second reference class, B4, recorded five neutral changes in results: Islamic Studies, Social Studies, Holy Quran, Listening and Conversation. Four retracted results were scored in class B4 in Arabic, Mathematics, Activities, and Reading. Only two subjects were improved: English and Science (Table 5-10 and Figure 5-18). Further detailed charts for school-B are added in Appendix D.

**Table 5-10: Changes in Grades for Class B4 – Second Semester / (Male) Reference 2 (Done by the Author).**

<b>School-B Class B4 Changes in Grades Second Semester (Reference 2)</b>											
Serial No.	Islamic Studies	Arabic	Social Studies	English	Maths	Science	Activities	Holy Quran	Reading	Listening	Conversation
1	0	0	0	0	-1	0	3	0	0	0	0
2	0	2	1	0	0	-1	4	1	5	5	3
3	0	0	0	6	-2	5	0	2	0	0	0
4	0	0	0	1	2	1	2	0	0	0	0
5	2	2	0	0	0	0	-1	0	5	5	2

School-B Class B4 Changes in Grades Second Semester (Reference 2)											
Serial No.	Islamic Studies	Arabic	Social Studies	English	Maths	Science	Activities	Holy Quran	Reading	Listening	Conver- sation
6	-1	-2	0	4	2	5	2	0	11	0	0
7	0	-1	1	3	-3	3	8	0	5	0	-3
8	0	0	0	8	0	3	5	1	-5	3	0
9	-3	-2	-2	1	-11	8	-6	1	-12	-10	5
10	0	0	0	0	0	0	1	0	0	0	0
11	0	0	0	4	-3	2	-1	1	-15	0	-8
12	0	1	0	4	-3	1	-1	1	-19	3	2
13	0	-2	1	13	-4	11	-6	2	-10	-3	2
14	5	-5	-1	5	0	3	-2	1	0	-25	7
15	1	-8	3	-1	-10	2	0	0	0	0	0
16	0	6	-1	5	1	8	-3	0	2	-3	-3
17	4	-1	2	4	5	7	-7	0	7	-15	0
18	28	-2	0	-2	-20	-1	-2	0	-10	-3	2
19	9	6	1	2	20	0	0	-1	-7	-5	0



**Figure 5-18: Changes in Grades for Class B4 – Second Semester / (Male)  
Reference 2 (Done by the Author).**



### 5.2.1 Analysis: Students' Results - Time Reference

The time reference analysis depended on the subjects' results of experimental classes as per the rotation pattern. Two semesters, first and second, and the experimental lighting were alternatively placed in the classes.

In the first semester the experimental lighting was applied to classrooms A1 and B2. The results of both classrooms were improvements in Mathematics and Activities (PE). Additional improvements in class A1 were recorded in Islamic Studies and Literacy (Table 5-1 and Figure 5-9). On the other hand, class B2 did not record any other improvements, except in Holy Quran, where the improvement was equal to the retraction (Table 5-8 and Figure 5-16).

Illustrated below in Table 5-11 is the analysis concluded from Tables 5-1 and 5-8, along with Figures 5-9 and 5-16 to show the results of both classrooms A1 and B2.

**Table 5-11: Analysis - Time Reference – First Semester / Improved (I) vs. Retracted (R) or Neutral (N) (Done by the author).**

Analysis - Time Reference / First Semester														
Improved (I) vs. Retracted (R) or Neutral (N)														
Semester	Class	Islamic Studies	Arabic	Social Studies	Literacy/ English	Maths	Science	Geography	French	Activities/ PE	Holy Quran	Reading	Listening	Conversation
First	A1	N	R	R	I	I	R	R	R	I	/	/	/	/
	B2	R	R	N	R	I	R	/	/	I	R	R	R	R

In the second semester the experimental lighting was applied to classrooms A2 and B1. Only Social Studies recorded improvement in both classrooms in the second semester. All subjects in class A2 were improved apart from Arabic. The results of class A2 of Science and French were improved and retracted with the same percentage (Table 5-4 and Figure 5-12), while in class B1 all subjects were improved except English, Mathematics and PE (Table 5-7 and Figure 5-15).

The reference classes B3 and B4 did not record huge improvements. Class B3 improved in three subjects (Social Studies, Holy Quran, and Science – with equal neutral results), while English and Science were the subjects that were improved in class B4. This shows how the experimental classes had more improvement in the results (Table 5-12).

**Table 5-12: Analysis - Time Reference – Second Semester / Improved (I) vs. Retracted (R) or Neutral (N) (Done by the author).**

Analysis - Time Reference / Second Semester														
Improved (I) vs. Retracted (R) or Neutral (N)														
Semester	Class	Islamic Studies	Arabic	Social Studies	Literacy/ English	Maths	Science	Geography	French	Activities/ PE	Holy Quran	Reading	Listening	Conversation
Second	A2	N I	R	I	I	I	I R	I	I R	I	/	/	/	/
	B1	N	I	I	R	R	I	/	/	R	I	I	I	I
Reference	B3	R	R	I	R	R	I N	/	/	R	I	R	N	N
	B4	N	R	N	I	R	I	/	/	R	N	R	N	N

Illustrated in Table 5-12 is the analysis concluded from Tables 5-4, 5-7, 5-9 and 5-10, along with Figures 5-12, 5-15, 5-17 and 5-18.

The major findings in the first semester analysis concluded from Table 5-11 demonstrate that: an improvement is not recognized in most of the subjects; Mathematics and Activities are the improved subjects in both experimental classes; in class A1 Literacy is improved along with Islamic Studies, as neutral results are for Non-Muslim students; in class B2 only Holy Quran scored improvement as much as neutral; Social Studies in class B2 recorded neutral results; and the rest of the subjects in both experimental classes, a total of twelve, have retracted results.

In comparison, the major findings in the second semester analysis concluded from Table 5-12 demonstrate that: the improvement in the results is clearer than the first semester in both classes A2 and B1; the reference classes B3 and B4 experienced less improvement than the experimental classes; Social Studies improved in both experimental classes; one subject has retracted results in class A2, Arabic, while three different subjects have retracted results in class B1, English, Mathematics and Activities; Science and French scored equal improved and retracted results; Islamic Studies has equal neutral and improved results in class A2, while it has the majority of neutral results in class B1; the rest of the subjects, with the total of ten in both experimental classes, A2 and B1, are improved; class B3 improved in Social Studies, Holy Quran, and Science (with equal neutral results); Class B4 improved in English and Science and scored neutral in Islamic Studies, Social Studies and Holy Quran;

Listening and Conversation, scored neutral changes in results in both experimental classes B3 and B4; reference class B3 recorded retracted results in Islamic Studies, Arabic, English, Mathematics, Activities, and Reading; Arabic, Mathematics, Activities and Reading had retracted scores in class B4. Overall, the subjects that had the best results among the four classes B1 and B2 (experimental) and B3 and B4 (reference), were Social Studies and Science.

**5.2.2 Analysis: Students’ Results – School Reference**

School-A had only two mixed classes for grade two A1 and A2, and both were involved in the experiment. The experimental lighting was applied alternatively in both classrooms (A1: First Semester, A2: Second Semester). The results of both classrooms were improved under the experimental lighting in Islamic Studies (as the N here refers to the NM students as show in Tables 5-1 and 5-4), Literacy, Mathematics and PE. Arabic noticeably retracted in both classes.

**Table 5-13: Analysis - School Reference / School-A / Improved (I) vs. Retracted (R) or Neutral (N) (Done by the author).**

Analysis - School Reference / School-A												
Improved (I) vs. Retracted (R) or Neutral (N)												
School-A	Class	Islamic Studies	Arabic	Social Studies	Literacy	Maths	Science	Geography	French	PE	Experimental Semester	
	A1	N = I	R	R	I	I	R	R	R	I	First	
	A2	N = I	R	I	I	I	I = R	I	I = R	I	Second	

In class A1 the four subjects (Social Studies, Science, Geography and French) recorded retracted changes in the students' results. On the other hand, class A2 had further clear documented improvements in Social Studies and Geography. Other improvements were realized, but with equal retracted results for each of Science and French in class A2.

Illustrated in Table 5-13 is the analysis concluded from Table 5-1 and Figure 5-9, along with Table 5-4 and Figure 5-12, to display the results of both classrooms A1 and A2.

Moving on to school-B in which four classes for grade two were available: B1 and B2 for girls only, and B3 and B4 for boys only. Classes B1 and B2 were involved in the experiment, while classes B3 and B4 were set as reference. The experimental lighting was placed in class B1 in the second semester and in the first semester in class B2.

Under the experimental lighting, class B1 shows better improvements than class B2. Seven subjects were improved in class B1 (Arabic, Social Studies, Science, Holy Quran, Reading, Listening, and Conversation), three retracted (English, Mathematics and Activities) and one with neutral results (Islamic Studies). Class B2 recorded three improvements (Mathematics, Activities, and Holy Quran that had equal results of retracted), seven retracted (Islamic Studies, Arabic, English, Science, Reading, Listening, and Conversation), and one neutral (Social Studies). Holy Quran is the only subject that recorded improvement in both classes over the same period (although the improvement in class B2 was

equal to the retracted). English is the subject that was retracted in both classes.

**Table 5-14: Analysis - School Reference / School-B / Improved (I) vs. Retracted (R) or Neutral (N) (Done by the author).**

Analysis – School Reference / School-B													
Improved (I) vs. Retracted (R) or Neutral (N)													
School-B	Class	Islamic Studies	Arabic	Social Studies	English	Maths	Science	Activities	Holy Quran	Reading	Listening	Conversation	Experimental Semester
	B1	N	I	I	R	R	I	R	I	I	I	I	Second
	B2	R	R	N	R	I	R	I	I R	R	R	R	First
	B3	R	R	I	R	R	I N	R	I	R	N	N	Refer- ence 1
	B4	N	R	N	I	R	I	R	N	R	N	N	Refer- ence 2

The reference classes B3 and B4 in the same school which are boys only, the opposite of classes B1 and B2, displayed a similar outcome to class B2 with more retracted and neutral results, as opposed to class B1 which recorded more improved results. Both reference classes shared the same results in seven subjects (one improved, two neutral, and four retracted). Science is the improved subject, although in class B3 the improved results were equal to the neutral results. Listening and Conversation were the subjects that were not scoring changes in most grades, and the retracted subjects were Arabic, Mathematics, Activities and Reading.

Illustrated in Table 5-14 is the analysis concluded from Tables 5-7, 5-8, 5-9 and 5-10, along with Figures 5-15, 5-16, 5-17 and 5-18.

The major findings in school-A's (classes A1 and A2) analysis concluded from Table 5-13 that: class A2 recorded more improvements than class A1; four subjects are improved in both classes (Islamic Studies, Literacy, Mathematics and PE); Arabic is retracted in both classes; In class A1 four subjects are retracted (Social Studies, Science, Geography and French); and in class A2 Social Studies and Geography are improved, while Science and French are additionally improved along with equal retracted results.

The major findings in school-B's (classes B1, B2, B3, and B4) analysis concluded from Table 5-14 show that: class B1 recorded more improvements than class B2; both the experimental classes B1 and B2 have improved in Holy Quran (although improved and retracted results in class B2 are equal) and are retracted in English; class B1 is improved in Arabic, Social Studies, Science, Reading, Listening and Conversation; Mathematics and Activities are retracted in class B1, while Islamic Studies gathered neutral results; class B2 is improved in Mathematics and Activities; the retracted subjects in class B2 are (Arabic, Science, Reading, Listening, and Conservation) the opposite of class B1's results, along with Islamic Studies; Social Studies recorded neutral results; reference classes do not show greater improvement than experimental classes; reference classes both improved in Science (although in class B3 improved equal neutral); class B3 is improved in Social Studies and Holy Quran; English is improved in class B4; class B3 has

more retracted results than class B4; Islamic Studies, Arabic, English, Mathematics, Activities, and Reading have retracted results in class B3; Arabic, Mathematics, Activities, and Reading are retracted in class B4; Listening and Conversation are neutral in class B3; Islamic Studies, Social Studies, Holy Quran, Listening and Conversation have neutral changes in the results; and none of the subjects scored four full improved or retracted among the four classes, although some scored three out of four, and this will be discussed in detail later in analysis by subject.

### **5.2.3 Analysis: Students' Results – Subject Reference**

In this analysis, the subjects' results had been evaluated among the four different experimental classes in both schools A and B, with each subject scoring a final result of improved, retracted or neutral and, in some cases, two equal different scores.

Table 5-15 summarizes all the subjects' results in a more comprehensible manner for the analysis. Results of experimental classes: class A1 (Table 5-1 and Figure 5-9), class A2 (Table 5-4 and Figure 5-12), class B1 (Table 5-7 and Figure 5-15), and class B2 (Table 5-8 and Figure 5-16). Reference classes: class B3 (Table 5-9 and Figure 5-17), class B4 (Table 5-10 and Figure 5-18).

Both schools had seven subjects in common (Islamic Studies, Arabic, Social Studies, Literacy/English, Mathematics, Science, and Activities/PE). Four of these subjects scored improved results. Mathematics and Activities/PE scored improved results in three experimental classes and



retracted results in one experimental class, while the two reference classes had retracted results. On the other hand, Islamic Studies and Social Studies recoded two improved results in two experimental classes, one retracted and one neutral result in the other two experimental classes. One reference class was improved in Social Studies while the other had neutral results, and for Islamic Studies one was retracted and the other neutral.

Arabic was retracted in all the classes, experimental and reference, except one experimental class that garnered improved results. Science also scored retracted results, but the reference classes had better results and improved equal neutral. The results of Literacy/English were equally improved and retracted in both experimental and reference classes.

School-A taught two extra subjects, Geography and French, with no reference scores to be compared, only two experimental classes. One experimental class had improved results while the other had retracted results for Geography. On the other hand, French scored retracted results in one class, and equal retracted and improved results in the other class.

School-B had Holy Quran, Reading, Listening, and Conversation as additional subjects. The results of these subjects are reported for two experimental classes along with two reference classes.

**Table 5-15: Analysis – Subject Reference / Improved (I) vs. Retracted (R) or Neutral (N) (Done by the author).**

Analysis – Subject Reference										
Improved (I) vs. Retracted (R) or Neutral (N)										
Subject	School-A		School-B		Total Scores			Final Result	Reference	
	A1	A2	B1	B2	(I)	(R)	(N)		B3	B4
Islamic Studies	I= N	I= N	N	R	2	1	1	I	R	N
Arabic	R	R	I	R	1	3	0	R	R	R
Social Studies	R	I	I	N	2	1	1	I	I	N
Literacy/ English	I	I	R	R	2	2	0	I= R	R	I
Mathematics	I	I	R	I	3	1	0	I	R	R
Science	R	I= R	I	R	1.5	2.5	0	R	I= N	I
Activities/ PE	I	I	R	I	3	1	0	I	R	R
Geography	R	I			1	1	0	I= R		
French	R	I= R			0.5	1.5	0	R		
Holy Quran			I	I= R	1.5	0.5	0	I	I	N
Reading			I	R	1	1	0	I= R	R	R
Listening			I	R	1	1	0	I= R	N	N
Conversation			I	R	1	1	0	I= R	N	N

Holy Quran was improved in the experimental classes, but had improved result in one reference class and neutral in the other. Reading scored improved results in one experimental class and retracted in the other, while both refer-

ence classes were retracted. Both Listening and Conversation shared the same results, the experimental classes had one improved result and the other retracted, while reference classes garnered neutral results.

The major findings as per analysis with subject reference concluded from Table 5-15 are: four common subjects show improvement in results (Islamic Studies, Social Studies, Mathematics, and Activities/PE), one subject (Literacy/English) has equal improved with retracted results, and two subjects (Arabic and Science) are retracted; Mathematics and Activities/PE record the most significant improvement in the experimental classes (three out of four), while reference classes were retracted; Mathematics and Activities/PE gained the same scores in both experimental and reference classes; Islamic Studies has two improvements in experimental classes and one retracted and one neutral in the other two experimental classes, reference classes also have one retracted and one neutral; Social Studies also has two improvements in the experimental classes with one neutral and another retracted for the other two experimental classes, while reference classes has one improved and one neutral results; Literacy/English has two improved and two retracted results in the experimental classes, while the reference classes have one retracted and one improved result; Science is retracted in the experimental classes, but shows better results in reference classes: one improved and one improved equal with neutral results; Arabic is retracted among all classes except one experimental class in which it is improved; extra subjects are Geography and French in school-A, the results of two experimental classes only; Geography has one improved result and one retracted; French is retracted in one

class and has equal retracted with improved results in the other; Holy Quran, Reading, Listening, and Conversation are extra subjects in school-B, the results of two experimental classes and two reference classes; Holy Quran is improved in experimental classes and has one improved and one neutral result in the reference classes; Reading has one improved and one retracted result in the experimental classes, while both reference classes are retracted; and Listening and Conversation each have one improved and one retracted result in experimental classes along with neutral results in all reference classes.

#### **5.2.4 Analysis: Students' Results – Gender Reference**

Mixed classes A1 and A2 were divided here for the analysis as A1-F (Table 5-2 and Figure 5-10), A1-M (Table 5-3 and Figure 5-11), A2-F (Table 5-5 and Figure 5-13), and A2-M (Table 5-6 and Figure 5-14). This information, along with that of the female classes B1 and B2 and the reference male classes B3 and B4 (Table 5-14), is concluded in the Tables 5-16 and 5-17 in order to compare the female and male results for better understanding and more detailed analysis.

The female results were all in experimental classes. Classes A1-F and B2-F featured the experimental lighting in the first semester, with classes A2-F and B1-F adopting it in the second semester, and the male results had two experimental classes: A1-M with experimental lighting in the first semester and A2-M with the in the second semester, along with reference classes B3 and B4.

**Table 5-16: Analysis - Gender Reference / Female Results / Improved (I) vs. Retracted (R) or Neutral (N) (Done by the author).**

Analysis – Gender Reference / Female Results														
Improved (I) vs. Retracted (R) or Neutral (N)														
Class / Gender	Islamic Studies	Arabic	Social Studies	Literacy/ English	Maths	Science	Geography	French	Activities/ PE	Holy Quran	Reading	Listening	Conversation	Semester
A1-F	R	R	R	I	I R	R	R	R	R	/	/	/	/	First
A2-F	I	R	I	I	I	I	I	I	I N	/	/	/	/	Second
B1-F	N	I	I	R	R	I	/	/	R	I	I	I	I	Second
B2-F	R	R	N	R	I	R	/	/	I	I R	R	R	R	First

In Table 5-16 no subject was found scoring full improvement or retraction among all four classes. The scores were varied among the same subject and no pattern was discerned. The basic results seen in the analysis were that in each school one class was improved and the other was retracted, as reference to the time. The classes with experimental lighting in the second semester were improved in contrast with first semester in which results were retracted.

The two experimental male classes A1-M and A2-M reported improved results in Islamic Studies, Literacy, and PE. Mathematics was improved in class A1-M, with equally improved, retracted and neutral results in class A2-M. The remaining five subjects (Arabic, Social Studies, Science, Geography, and French) in class A1-M had retracted results.

A2-M also improved in Arabic, Social Studies, and Geography, and retracted in Science and French (Table 5-17).

**Table 5-17: Analysis - Gender Reference / Male Results / Improved (I) vs. Retracted (R) or Neutral (N) (Done by the author).**

Analysis – Gender Reference / Male Results														
Improved (I) vs. Retracted (R) or Neutral (N)														
Class / Gender	Islamic Studies	Arabic	Social Studies	Literacy/ English	Maths	Science	Geography	French	Activities/ PE	Holy Quran	Reading	Listening	Conversation	Semester
A1-M	I	R	R	I	I	R	R	R	I	/	/	/	/	First
A2-M	I	I	I	I	I=R =N	R	I	R	I	/	/	/	/	Second
B3-M	R	R	I	R	R	I=N N	/	/	R	I	R	N	N	Reference
B4-M	N	R	N	I	R	I	/	/	R	N	R	N	N	

The reference male classes B3-M and B4-M did not show the same improvement as the experimental male classes A1-M and A2-M. Six subjects had retracted results in class B3-M, four in common with class B4-M (Arabic, Mathematics, Activities and Reading), and the extra two were Islamic Studies and English.

Class B3-M recorded two neutral results (Listening and Conversation) and two improved results (Social Studies and Holy Quran), while Science had equal improved and neutral results. Class B4-M had two improvements (English and Science) and five neutral results were scored for Islamic

Studies, Social Studies, Holy Quran, Listening and Conversation (Table 5-17).

The major findings in the female classes' (A1-F, A2-F, B1-F, and B2-F) analysis concluded from Table 5-16 show that: class A2-F recorded the most improvements of the female classes followed by class B1-F; no single subject is improved or retracted among all classes; no pattern was found as the scores for the same subject differ among the three evaluations: improved (I), retracted (R) or neutral (N); and analysis based on gender for female classes is better understood when combining the analysis based on time reference and school at the same time. In the second semester classes with experimental lighting are improved in each school, while classes with experimental lighting in first semester are retracted.

The major findings in male classes (experimental classes A1-M and A2-M, along with reference classes B3-M and B4-M) analysis concluded from Table 5-17 demonstrate that: the experimental male classes A1-M and A2-M show more improvement than reference male classes B3-M and B4-M; class A2-M had the most improvements in the male classes followed by class A1-M; experimental classes both improved in Islamic Studies, Literacy and PE; Mathematics is improved in class A1-M, but in class A2-M its result is equally improved, retracted and neutral; Arabic, Social Studies, Science, Geography, and French results in class A1-M are retracted; class A2-M is improved in Arabic, Social Studies, and Geography while Science and French retracted; reference classes B3-M and B4-M report retracted results in Ara-

bic, Mathematics, Activities and Reading; Islamic Studies and English are retracted in class B3-M and Social Studies and Holy Quran are improved, but Science has equal improved and neutral results; English and Science are improved in class B4-M; two neutral results in class B3-M: Listening and Conversation; and five neutral results are scored in class B4-M for Islamic Studies, Social Studies, Holy Quran, Listening and Conversation.

### 5.2.5 Summary of Number of Classes Analysis

Table 5-18 summarises all four analyses references for a thorough reading of the results of the experiment and enhanced discussion. Time as the first and the second semester is the first analysis reference. The second analysis reference is the school as school-A and school-B. Subject is the third analysis reference, listing all seven common subjects along with the extra two in school-A and four s in school-B. The fourth and final analysis reference is Gender.

**Table 5-18: Analysis - Summary of All Analyses References Number of Classes / Improved (I) vs. Retracted (R) or Neutral (N) (Done by the author).**

Analysis – Summary of All Analyses References Number of Classes (Time, School, Subjects, and Gender) Improved (I) vs. Retracted (R) or Neutral (N)										
School	School-A					School-B				
Class	A1	A1	A1	A2	A2	A2	B1	B2	B3	B4
Gender	Mix	F	M	Mix	F	M	F	F	M	M
Subject										
Islamic Studies	I	R	I	I	I	I	N	R	R	N
Arabic	R	R	R	R	R	I	I	R	R	R
Social Studies	R	R	R	I	I	I	I	N	I	N
Literacy/ English	I	I	I	I	I	I	R	R	R	I



Analysis – Summary of All Analyses References Number of Classes (Time, School, Subjects, and Gender) Improved (I) vs. Retracted (R) or Neutral (N)										
School	School-A					School-B				
Class	A1	A1	A1	A2	A2	A2	B1	B2	B3	B4
Gender	Mix	F	M	Mix	F	M	F	F	M	M
Subject										
Mathematics	I	I=R R	I	I	I	I=R R=N	R	I	R	R
Science	R	R	R	I=R R	I	R	I	R	I=R N	I
Geography	R	R	R	I	I	I				
French	R	R	R	I=R R	I	R				
Activities/ PE	I	R	I	I	I=R N	I	R	I	R	R
Holy Quran							I	I=R R	I	N
Reading							I	R	R	R
Listening							I	R	N	N
Conversation							I	R	N	N
Experimental Semester	First			Second			Second	First	Reference	

### 5.3 Discussion of the Study Results

The analysis of the teachers' questionnaires offers some interesting points for discussion. Two health issues were reported: migraines, which can be related to the lighting, which if not the major cause certainly does exacerbate the symptoms (Bener et al, 1998); and hypothyroidism, which was not related to lighting in any of the literature encountered thus far (Figures 5-1 and 5-2).

Eight teachers in both schools A and B considered the migraines, discomfort, and eyestrain that they suffered were caused by the lighting and affected their performance, correlating with what Al Sallal (2010) and Gibson et al (2013) assert in their studies. The remaining twelve teachers did not complain of any health issues and did not consider the lighting to have any negative impacts on their health or performance (Figures 5-1 and 5-2).

The majority of teachers in both schools reported feeling good and active early in the morning and at midday, while three teachers in school-A reported feeling tired early in the morning and three teachers in both schools felt tired at midday. At the end of the day ten teachers reported feeling good, one active, and nine tired. The rise in the number of tired teachers by the end of the day is expected and does not show any direct relation with lighting. Instead, it can be related to the normal fatigue after spending the whole day dealing with and teaching children, which is a naturally tiring duty (Figures 5-3 and 5-4).

School-A did not report any complaints regarding ventilation in classrooms, though one teacher declared it poor, and another medium (Figure 5-5). Nevertheless, the health issues that were reported in the classrooms reveal a problem with the ventilation, with numerous mentions of health conditions by both teachers and students (eye, nose and throat irritation 6/10; cough 5/10; and allergy 4/10). Other health issues scored fewer points (respiratory irritation 3/10; sensation of dry mucous membranes and skin 3/10; headaches 2/10; and wheezing 1/10 (Figure 5-7)). The small area which is fully occupied in the classrooms of school-A (Figures 4-3, 4-5, and 4-6) along with the lack of proper windows for more daylight does affect the ventilation (Figure 4-15), although the lighting lumi-

naries are covered (Figure 4-25) and there is glass door for daylight (Figure 4-14). However, the daylight does not enter the classroom in a sufficiently large quantity or the proper way for ventilation, as shown in the sun path studies for class A1 (Figure 4-12) and class A2 (Figure 4-13). In class A1 the glass door is located in the North West (Figure 4-10), allowing less daylight to enter the class than A2, in which the glass door is in the South East facing more daylight (Figure 4-11) (Heschong et al, 2002; Behzadi and Fadeyi, 2012).

No complaints whatsoever were received from School-B in terms of the ventilation as all teachers reported medium, medium+, and excellent ventilation in the classrooms, and the health issues reported emphasise this satisfaction (eye, nose and throat irritation 2/10; Allergy 2/10; and cough 1/10). It is notable that the windows in school-B's classrooms are larger than those in school-A and take up an entire wall (Figure 4-17) in the NE (Figure 4-16), allowing most of the daylight into the classrooms, as shown in the sun path study (Figure 4-18). Also, the spacious classroom does help better ventilation (Figures 4-4 and 4-7).

In terms of the students' results, different analyses were carried out with different references (time, school, subject, and gender) for an enhanced reading and illustration of the results in order to enrich the discussion. All the results from the various analyses were brought together into one table (Table 5-18) and illustrated for a thorough reading.

The general analysis showed conflicting results in each school. In both schools, one experimental class had the majority of retracted results and the other had the majority of improved results (Tables 5-13 and 5-14). On the other hand, the reference classes

in school-B, which are male classes, did not demonstrate clear improvements as each had only two improved subjects out of eleven (Table 5-14). This could be related to gender base, but in class A1 male students showed added improvements in their results (Figure 5-11) than female students (Figure 5-10), while in class A2 both males and females showed clear improvements (Figures 5-13 and 5-14). Accordingly, the reference results will be used and discussed in this study.

The analyses of results with time reference showed the improvement in the experimental classes in the second semester (Table 5-12), while those in first semester, and the reference classes, showed more retracted and neutral results (Tables 5-11 and 5-12). This emphasises the seasonal effect and role in choosing the colour of artificial lighting in the interiors for its clear impact on performance. The second semester featured more mean temperature and wind speed and less humidity and rain than the first semester (Appendix-B). This shows that the warm white light would work better if the temperature were high with low to medium humidity, along with good to high wind speed. Therefore, the use of the experimental lighting (warm white) is advised in the second semester, from March to June, rather than the first semester, from September to January (Figueiro et al, 2002).

When the school was the reference in the conducted analyses, the major finding was that neither school recorded better results than the other. In each, one experimental class was improved and the other was retracted (Tables 5-13 and 5-14). This highlights the impact of the lighting itself and reduces the impact of other interior elements that were completely opposite in both schools, as expected and explained when designing the experiment (Ching and Binggeli, 2004; Jones, 2008). On the other hand, reference classes

in school-B were not improving more than the experimental classes; they reported retracted and neutral results. Colour scheme could be one of the reasons for this result, and Gaines and Curry (2011) emphasise the influence of colour on schoolchildren's mood, behaviour, and performance. Using colour in the classroom should be very well studied in balance, as excessive colour schemes can be risky and damaging to schoolchildren as well of pale colour schemes. This knowledge should be introduced to designers, teachers and all personnel responsible for classroom design.

Another means of conducted analysis was with subject reference (Table 5-15). Mathematics and Activities/Physical Education were the most improved subjects. They were improved in three of the experimental classes, and retracted in the two reference classes, scoring the same results in all experimental and reference classes. This relation between Mathematics and Activities/PE and their progressive improvement under the experimental lighting is a remarkable finding. Knight and Rizzuto (1993) encountered a similar relation as Reading and Mathematics scores increase when Balance Skills scores increase. Although Reading in this study was retracted in reference classes, it was improved in one experimental class and retracted in the other. This might be considered a slight improvement that is emphasised with the retracted results in reference classes.

Holy Quran depends mainly on reading skills, and it was improved in one experimental class and improved by the same percentage with retracted in the other experimental class. This can also be added to the improvements of reading under experimental lighting. Caterino and Polak (1999) relate the improvement in Physical Education with significant improvements in children's concentration levels. This shows that the direct impact of the experi-

mental lighting improved physical skills and health of the children, along with their scores that led to the improvement in Mathematics and Reading. Listening and Conversation were improved in one experimental class and retracted in the other, while reference classes recorded neutral results. This could be included with the slight improvements under the experimental lighting as well.

Literacy/English was improved in experimental classes of school-A and one reference class only, while the other classes had retracted results. Although Dexter (1999) discovered a poor but positive relationship among academic skills and performance in Mathematics and English with sport performance, this wasn't achieved in English in this study, as the improvement was related to school-A and did not match the improvement in Mathematics and Activities/PE. Islamic Studies also was improved in the experimental classes in school-A, while school-B's classes (experimental and reference) recorded no improvement. Kennedy (2005) states that colour inspiration in the educational environment enhances attention and motor processes, leading to a positive impact on performance, especially academic. Gaines and Curry's (2011) study was more detailed and focused on the powerful impact of colour on schoolchildren and offer six different suggestions to be followed when applying colour to the classroom in order to get the best of the colour power impact on schoolchildren's mood, behaviour, and performance. It is clear in this study that the colour scheme in school-A emphasised the scores in Literacy/English and Islamic Studies more than the neutral colour scheme in school-B.

Literacy/English and Islamic Studies showed their clear improvement under the experimental lighting in school-A, with the colourful interior and less daylight, among both female and male students (except A1F which scored retracted results) in both semes-

ters (Table 5-18). This discovery is recommended as a subject for further study.

On the other hand, French and Geography are subjects exclusive to school-A. French did not record any improvement under the experimental lighting. Shephard (1997) found that when Physical Education score is increased, Languages report poor scores, although this finding was not emphasised in other studies and requires more research. Geography was improved in one class and retracted in the other, showing no clear impact of the experimental lighting.

Experimental lighting showed slight or no clear impact on some subjects. Social Studies was improved in two experimental classes, along with one reference class, showing no obvious impact of experimental lighting. Arabic, on the other hand, was retracted in three experimental classes as well as the reference classes. This shows no impact of the experimental lighting, as five classes out of six, experimental and reference, were retracted in both schools.

Science was the only subject that recorded retracted results under experimental lighting, while the reference classes had improved results. This is the only negative finding for the experimental lighting with subject reference, although research showed that Science education is facing a number of challenges, especially in elementary schools (Ward et al, 2011) as many studies are conducted continuously to improve the learning and teaching tools for better performance (Duit and Treagust, 2003). However, this does not seem to be the cause of the Science results in this case, as the reference classes improved. The experimental lighting did not work properly for Science as the existing brighter cool lighting recorded improved results. Therefore, controlled task lighting could be an op-

tion to be used in Science classes whenever needed, as the control lighting does improve the performance and boosts the concentration of users (Newsham et al, 2004; Juslén and Tenner, 2007).

Gender was the final reference used for analysis. In the mixed class A1 the female students had more retracted results than males, but in class A2 female students reported more improved results than male students. This shows no gender performances (Tables 5-16 and 5-17). In school-B the experimental female classes also displayed the same observation, as one class had most of the grades retracted and the other reported grades improved for most of the subjects.

Female results in experimental classes did not have any subject with the same result. On the other hand, male students in the two experimental classes showed improvements in Islamic Studies, Literacy and Physical Education. Thus, the gender of students did not demonstrate significant impact on the results under the experimental lighting, although male students showed some common improvements. This could be due to having two classes to compare rather than four classes, in the case of females. Even in terms of health impacts there were only minor differences found between females and males, showing that both were affected in a similar way, not showing any more sensitivity for any of them more than the other (Bener, 1994).

#### **5.4 Analysis: Students' Results – Students' Numbers**

It was realized from the analyses by the number of classes with different references that some results needed to be more accurate. For a more thorough reading of the results, the students' numbers were taken to conclude the percentage of improved, re-



tracted, and neutral results for each subject. Regardless of the schools and classes, the focus at this stage is the accurate results of the total number of students under the experimental lighting in every single subject. In this way the results would be finalised for the overall impact of the lighting over the students' results. The following analysis was conducted using Figures 5-9, 5-10, 5-11, 5-12, 5-13, 5-14, 5-15, and 5-16:

**Table 5-19: Analysis - Islamic Studies Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Islamic Studies	A1	7	6	7 NM
	A2	8	4	8 NM
	B1	5	1	12
	B2	0	12	8
<b>Total Students</b>	63	20	23	20
<b>Percentage</b>	1.0075200%	32%	37%	31.752%

**Table 5-20: Analysis - Arabic Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Arabic	A1	8	11	1
	A2	8	11	1
	B1	17	0	1
	B2	0	17	3
<b>Total Students</b>	78	33	39	6
<b>Percentage</b>	1.003100%	42.31%	50%	8%

**Table 5-21: Analysis - Social Studies Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Social Studies	A1	6	13	1
	A2	11	8	1
	B1	13	1	4
	B2	3	6	11
<b>Total Students</b>	78	33	28	17
<b>Percentage</b>	100%	42%	36%	22%

**Table 5-22: Analysis - Literacy/English Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Literacy/English	A1	12	8	0
	A2	9	5	6
	B1	4	9	5
	B2	3	16	1
<b>Total Students</b>	78	28	38	12
<b>Percentage</b>	100%	36%	49%	15%

**Table 5-23: Analysis - Mathematics Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Mathematics	A1	10	9	1
	A2	10	6	4
	B1	0	14	4
	B2	12	4	4
<b>Total Students</b>	78	32	33	13
<b>Percentage</b>	100%	41%	42%	17%

**Table 5-24: Analysis - Science Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Science	A1	5	14	1
	A2	10	10	0
	B1	9	7	2
	B2	0	19	1
<b>Total Students</b>	78	24	50	4
<b>Percentage</b>	100%	31%	64%	5%

**Table 5-25: Analysis - Geography Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Geography	A1	5	14	1
	A2	15	3	2
	B1	---	---	---
	B2	---	---	---
<b>Total Students</b>	40	20	17	3
<b>Percentage</b>	100%	50%	43%	8%

**Table 5-26: Analysis - French Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
French	A1	6	12	2
	A2	8	8	4
	B1	---	---	---
	B2	---	---	---
<b>Total Students</b>	40	14	20	6
<b>Percentage</b>	100%	35%	50%	15%

**Table 5-27: Analysis -PE/Activities Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
PE/Activities	A1	9	8	3
	A2	9	6	5
	B1	0	14	4
	B2	16	0	4
<b>Total Students</b>	78	34	28	16
<b>Percentage</b>	100%	44%	36%	21%

**Table 5-28: Analysis – Holy Quran Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Holy Quran	A1	---	---	---
	A2	---	---	---
	B1	12	1	5
	B2	9	9	2
<b>Total Students</b>	38	21	10	7
<b>Percentage</b>	100%	55%	26%	18%

**Table 5-29: Analysis – Reading Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Reading	A1	---	---	---
	A2	---	---	---
	B1	15	0	3
	B2	1	13	6
<b>Total Students</b>	38	16	13	9
<b>Percentage</b>	100%	42%	34%	24%

**Table 5-30: Analysis – Listening Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Listening	A1	---	---	---
	A2	---	---	---
	B1	18	0	0
	B2	2	18	0
<b>Total Students</b>	38	20	18	0
<b>Percentage</b>	100%	53%	47%	24%

**Table 5-31: Analysis – Conversation Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Conversation	A1	---	---	---
	A2	---	---	---
	B1	15	0	3
	B2	2	13	5
<b>Total Students</b>	38	17	13	8
<b>Percentage</b>	100%	45%	34%	21%

**Table 5-32: Analysis - Islamic Studies Female Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Islamic Studies	A1	1	3	4 NM
	A2	4	1	6 NM
Female	B1	5	1	12
	B2	0	12	8
<b>Total Students</b>	47	10	17	20
<b>Percentage</b>	100%	21%	36%	43%

**Table 5-33: Analysis - Arabic Female Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Arabic	A1	3	4	1
	A2	3	8	0
Female	B1	17	0	1
	B2	0	17	3
<b>Total Students</b>	57	23	29	5
<b>Percentage</b>	100%	40%	51%	9%

**Table 5-34: Analysis - Social Studies Female Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Social Studies	A1	1	6	1
	A2	6	4	1
Female	B1	13	1	4
	B2	3	6	11
<b>Total Students</b>	57	23	17	17
<b>Percentage</b>	100%	40%	30%	30%

**Table 5-35: Analysis - Literacy/English Female Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Literacy/English	A1	5	3	0
	A2	5	2	4
Female	B1	4	9	5
	B2	3	16	1
<b>Total Students</b>	57	17	30	10
<b>Percentage</b>	100%	30%	53%	18%

**Table 5-36: Analysis - Math Female Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Maths	A1	4	4	0
	A2	7	3	1
Female	B1	0	14	4
	B2	12	4	4
<b>Total Students</b>	57	23	25	9
<b>Percentage</b>	100%	40%	44%	16%

**Table 5-37: Analysis – Science Female Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Science	A1	2	5	1
	A2	6	5	0
Female	B1	9	7	2
	B2	0	19	1
<b>Total Students</b>	57	17	36	4
<b>Percentage</b>	100%	30%	63%	7%

**Table 5-38: Analysis - Geography Female Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Geography	A1	1	7	0
	A2	9	0	2
Female	B1	---	---	---
	B2	---	---	---
<b>Total Students</b>	19	10	7	2
<b>Percentage</b>	100%	53%	37%	11%

**Table 5-39: Analysis - French Female Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
French	A1	3	5	0
	A2	5	4	2
Female	B1	---	---	---
	B2	---	---	---
<b>Total Students</b>	19	8	9	2
<b>Percentage</b>	100%	42%	47%	11%

**Table 5-40: Analysis -PE/Activities Female Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
PE/Activities	A1	1	6	1
	A2	4	3	4
Female	B1	0	14	4
	B2	16	0	4
<b>Total Students</b>	57	21	23	13
<b>Percentage</b>	100%	37%	40%	23%

**Table 5-41: Analysis - Islamic Studies Male Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Islamic Studies	A1	6	3	3 NM
	A2	4	3	2 NM
Male	B1	---	---	---
	B2	---	---	---
<b>Total Students</b>	16	10	6	---
<b>Percentage</b>	1.0100%	63%	38%	---

**Table 5-42: Analysis - Arabic Male Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Arabic	A1	5	7	0
	A2	5	3	1
Male	B1	---	---	---
	B2	---	---	---
<b>Total Students</b>	21	10	10	1
<b>Percentage</b>	1.0100%	48%	48%	5%

**Table 5-43: Analysis - Social Studies Male Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Social Studies	A1	5	7	0
	A2	5	4	0
Male	B1	---	---	---
	B2	---	---	---
<b>Total Students</b>	21	10	11	0
<b>Percentage</b>	100%	48%	52%	30%

**Table 5-44: Analysis - Literacy/English Male Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Literacy/English	A1	7	5	0
	A2	4	3	2
Male	B1	---	---	---
	B2	---	---	---
<b>Total Students</b>	21	11	8	2
<b>Percentage</b>	100%	52%	38%	10%

**Table 5-45: Analysis - Math Male Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Maths	A1	6	5	1
	A2	3	3	3
Male	B1	---	---	---
	B2	---	---	---
<b>Total Students</b>	21	9	8	4
<b>Percentage</b>	100%	43%	38%	19%

**Table 5-46: Analysis – Science Male Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Science	A1	3	9	0
	A2	4	5	0
Male	B1	---	---	---
	B2	---	---	---
<b>Total Students</b>	21	7	14	0
<b>Percentage</b>	100%	33%	67%	7%

**Table 5-47: Analysis - Geography Male Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
Geography	A1	4	7	1
	A2	6	3	0
Male	B1	---	---	---
	B2	---	---	---
<b>Total Students</b>	21	10	10	1
<b>Percentage</b>	100%	48%	48%	5%

**Table 5-48: Analysis - French Male Percentage of Improved (I), Retracted (R) and Neutral (N) results (Done by the author).**

Subject	Class	I	R	N
French	A1	3	7	2
	A2	3	4	2
Male	B1	---	---	---
	B2	---	---	---
<b>Total Students</b>	21	6	11	4
<b>Percentage</b>	100%	29%	52%	19%

**Table 5-49: Analysis -PE/Activities Male Percentage of Improved (I), Retracted (R) and Neutral (N) Results (Done by the author).**

Subject	Class	I	R	N
PE/Activities	A1	8	2	2
	A2	5	3	1
Male	B1	---	---	---
	B2	---	---	---
<b>Total Students</b>	21	13	5	3
<b>Percentage</b>	100%	62%	24%	14%



The number of students in the different experimental classes varied, and this should be taken into consideration as it might show different results for the subjects. In Table 5-50 the results of both analyses were illustrated for comparison in order to explore the differences between the two analyses conducted for this experiment.

Table 5-50 was conducted from Table 5-15, along with Tables 5-19 to 5-49. Brief discussion would explain the major differences between both analyses in Table 5-50.

In the second analysis seven subjects were improved (Social Studies, Geography, Activities/PE, Holy Quran, Reading, Listening and Conversation), compared in the first analysis in which five subjects were improved (Islamic Studies, Social Studies, Mathematics, Activities/PE, and Holy Quran). Three subjects were improved in both analyses (Social Studies, Activities/PE, and Holy Quran).

Five subjects were retracted in the second analysis (Islamic Studies, Arabic, Literacy/English, Science, and French). Three of them (Arabic, Science, and French) were in common with the first analysis.

Six subjects had the same results in both analyses (Social Studies, Activities/PE, Holy Quran, Arabic, Science, and French), while Mathematics was improved in the first analysis and scored almost equal improved and retracted results (41%:42%) in the second.

**Table 5-50: Analysis – Percentage of Students’ vs. Number of Classes Results in Experimental Classes (Done by the author).**

Analysis – Percentage of Students’ vs. Number of Classes Results in Experimental Classes						
Improved (I) vs. Retracted (R) or Neutral (N)						
Analysis	Percentage Scores			No. of Classes		
Gender \ Subject	All	F	M	All	F	M
Islamic Studies	36%	43%	62%	2/4	2/4	2/2
Arabic	50%	51%	48% = 48%	3/4	3/4	1=1
Social Studies	42%	40%	52%	2/4	2/4	1=1
Literacy/ English	49%	53%	52%	2=2	2=2	2/2
Mathematics	42% 41%	44%	43%	3/4	2.5/4	1.3/2
Science	64%	63%	67%	2.5/4	2=2	2/2
Geography	50%	53%	48% = 48%	1=1	1=1	1=1
French	50%	47%	52%	1.5/2	1=1	2/2
Activities/ PE	44%	40%	62%	3/4	2/4	2/2
Holy Quran	56%	56%	---	1.5/2	1.5/2	---
Reading	42%	42%	---	1= 1	1= 1	---
Listening	53%	53%	---	1= 1	1= 1	---
Conversation	45%	45%	---	1= 1	1= 1	---

The second analysis emphasised the results of the previous seven subjects that were reported from the first analysis. On the other hand, it made the results of the other six subjects clearer. Literacy/English reported equal improved and retracted results in the first analysis, while 49% of the students had retracted results. Four subjects had equal improved and retracted results in the first

analysis, but were improved in the second analysis (Geography 50%, Reading 42%, Listening 53%, and Conversation 45%). Islamic Studies was improved in two classes out of four in the first analysis, while it scored retracted results of 36% in the second.

This analysis produced more accurate results and showed more improvements at the same time. The percentages can be read more comprehensively and give the overall image of the performance of the students under the experimental lighting in this study.

## **6. CONCLUSION AND RECOMMENDATIONS**

### **6.1 Findings of the Study**

Health issues related to lighting pollution and ventilation in the classrooms were common in teachers and students in experimental schools. Headache, wheezing irritation of eyes, nose, and throat, cough, allergy, respiratory irritation and sensation of dry mucous membranes and skin were reported and related to lighting and poor ventilation. Seasonal effects show a clear impact of the experimental lighting on the students' performance. Results in the first semester were retracted and improved in the second semester under experimental lighting. Schools with contrasting interiors did not have a huge impact on results under the experimental lighting. In each school one class was improved and the other retracted. Individual subjects varied in their effect during the first analysis – number of classes with different reference analyses – with significant improvements scored under the experimental lighting. Four common subjects showed improvements in the results, one subject had equal improved with retracted results, and two subjects retracted. Similarly, individual subjects also varied in their effect under the second analysis – percentage of students' results – with the experimental lighting. Two common subjects showed improvement, four subjects retracted, and one subject had almost equal improved and retracted results. Overall, there was no great gender distinction under the experimental lighting during the first analysis, as males and females were both similar in their performance. However, during the second analysis females garnered fewer improved and more retracted results than males.

Some general extra findings were stumbled upon through the experiment. Firstly, classroom design should be spacious and not crowded, for better performance. Secondly, a balanced colour scheme is advised in elementary classrooms, neither too neutral nor too colorful. Thirdly, for better daylight access it is advisable to allocate decent-sized windows with open/close controls on the east, not west, side of classrooms and buildings. Finally, Physical Education proved to be one of the important subjects with the capacity to affect performance in other subjects, especially Mathematics, Reading and Literacy, which improve when PE itself is improved.

## **6.2 Conclusion**

The experiment was conducted to investigate whether warm white light (experimental light) will have a positive impact in elementary school classrooms in the United Arab Emirates on students' performance over the existing light (cool white). The experimental warm white light had predominantly positive impacts on student performance, though some negative impacts were also encountered.

No harmful effects were reported regarding the experimental light, and less maintenance was reported and required than the existing lighting; no economic issues were raised from either school; significant improvements in student performance were recorded in the second semester; it worked effectively with colourful and neutral interiors, achieving improvements in both; it enhanced the grades of Physical Education and Mathematics; Islamic Studies, Social Studies, and Literacy/English improved in two out of four experimental classes (first analysis); both males and females improved under the experimental lighting (first analysis); seven subjects were improved as per the second analysis: Social Studies 42%, Geography 50%, Activities/PE 44%, Holy Quran 56%, Reading 42%, Listening 53%,

and Conversation 45%; Mathematics improved with 41% and retracted with 42% of the total number of students (second analysis); Female students improved in Social Studies 40% (common subject in both schools); female students recorded improvements in Geography 53% (school-A), and Holy Quran 56%, Reading 42%, Listening 53%, and Conversation 45% (school-B); Neutral results were reported in 43% of female students' results; and male students were improved in Islamic Studies 62%, Literacy/English 52%, Mathematics 43%, and Activities/PE 62%.

On the other hand, some disadvantages attributable to the experimental lighting were established: clear retracted results in the first semester; French and Science recorded retracted results; three common subjects between both schools recorded equal scores between retracted and improved (first analysis); students in both schools had retracted scores in Islamic Studies 36%, Arabic 50%, and Literacy/English 49%; female students reported retracted results with 51% in Arabic, and 53% in Literacy/English; 52% of the male students were retracted in Social Studies; and 48% of male students were improved, and 48% retracted in Arabic and Geography.

The experiment, in conclusion, did demonstrate advantages in the experimental lighting, but also encountered a number of disadvantages. The results and findings encourage the use of the suggested light, warm white, in elementary schools in the United Arab Emirates, taking into consideration the time and the allocation of the accessed daylight. As the existing light did show positive impacts in one subject, the requirement for task lighting for better performance should be taken into consideration.

### 6.3 Recommendations

While designing the experiment, some ideas and concepts were intended to be applied but could not be, due to various limitations (such as ethical, time, financial, and lack of expertise). It is recommended to commission similar studies focusing on these factors for better analysis and a more thorough reading of the results.

These factors are:

- Health records of teachers and students
- Attendance with sick leave
- Behavioral reports
- Teachers' comments on students' mood
- Psychological performance
- Cognitive psychological analysis.

By the end of the experiment, and after the analysis and discussion, the benefits of the warm white experimental lighting on the students' performance were observed, though some areas showed disadvantages at the same time. Second semester had the remarkable improvements under the warm white lighting as well as Social Studies, Geography, Activities/PE, Holy Quran, Reading, Listening and Conversation. On the other hand, first semester along with Islamic Studies, Literacy/English, Science, and French showed retracted results under the experimental lighting. Suggested topics for further research and studies include:

- Enhanced illumination in the first semester (could utilise warm white with task lighting, or a different colour of artificial light)
- Factors for retracted results in Islamic Studies, Literacy/English, Science, and French (to explore if it would enhance under different lighting color)
- Health issues under the warm white light

- Applying warm white in different grades and compare the results
- Applying warm white in different interiors (commercial and residential)
- Better ventilation in classrooms



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## **Electronic Resources**

### **Web**

<http://scholar.google.com/>

<http://maps.google.com/>

[www.osram.com](http://www.osram.com)

<http://www.gelighting.com/>

<http://dsc.gov.ae/publication>

[www.estidama.org](http://www.estidama.org)

<http://www.masdar.ae/en/>

[http://www.tutiempo.net/en/climate/sharjah\\_international\\_airport](http://www.tutiempo.net/en/climate/sharjah_international_airport)

### **Software**

Microsoft Office-Word

Microsoft Office – Excel

Google - Sketch Up

Sun Path Study

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## **APPENDICES**

# I. Appendix A: Questionnaire

## Questionnaire:

Name: \_\_\_\_\_ Years of experience in this classroom (----) Specialization: \_\_\_\_\_

Do you have any health issue/s? Yes No  
If yes, what and since when: \_\_\_\_\_

Do you think the lighting is affecting you negatively? Yes No  
If yes, explain: \_\_\_\_\_

How do you describe your overall behavior:  
Early in the morning: \_\_\_\_\_  
Mid of the day: \_\_\_\_\_  
End of the day: \_\_\_\_\_

How do you evaluate the ventilation in your classroom? (1 poor – 5 excellent)  
1 2 3 4 5

How do you evaluate the impact of lighting on you and your performance? (1 poor – 5 excellent)  
1 2 3 4 5

How do you evaluate the impact of lighting on the students and their performance? (1 poor – 5 excellent)  
1 2 3 4 5

Major general issues you have in your classroom (things you wish to change in-order to improve performance):  
1)  
2)  
3)

What is the major health issue you and the students are suffering from mainly:  
Respiratory irritation ---  
Allergy ---  
Eye, nose and throat irritation ---  
Sensation of dry mucous membranes and skin ---  
Headaches ---  
Wheezing ---  
Cough ---

Teacher Comments:  
1)  
2)  
3)  
4)  
5)  
6)  
7)

## II. Appendix B: Climate Study in Sharjah

[http://www.tutiempo.net/en/Climate/Sharjah\\_International\\_Airport](http://www.tutiempo.net/en/Climate/Sharjah_International_Airport)

**Table II-1: : Interpretation / Key of Weather Tables**  
([http://www.tutiempo.net/en/Climate/Sharjah\\_International\\_Airport](http://www.tutiempo.net/en/Climate/Sharjah_International_Airport))

### Interpretation

<b>T</b>	Mean temperature (°C)
<b>TM</b>	Maximum temperature (°C)
<b>Tm</b>	Minimum temperature (°C)
<b>SLP</b>	Mean sea level pressure (hPa)
<b>H</b>	Mean humidity (%)
<b>PP</b>	Precipitation amount (mm)
<b>VV</b>	Mean visibility (Km)
<b>V</b>	Mean wind speed (Km/h)
<b>VM</b>	Maximum sustained wind speed (Km/h)
<b>VG</b>	Maximum wind gust (Km/h)
<b>RA</b>	Indicator for occurrence of: Rain or Drizzle
<b>SN</b>	Indicator for occurrence of: Snow or Ice Pellets
<b>TS</b>	Indicator for occurrence of: Thunder
<b>FG</b>	Indicator for occurrence of: Fog

**Table II-2: Sharjah Weather Table - September 2009**  
 (http://www.tutiempo.net/en/Climate/Sharjah\_International\_Airport)

Weather Sharjah International Airport														
Main   Year 2009 climate ▾   September 2009 ▾														
Climatic mean values														
Day	T	TM	Tm	SLP	H	PP	VV	V	VM	VG	RA	SN	TS	FG
1	34.1	42.2	30	1003	67	0	6.8	8.5	18.3	-				
2	33.9	41	28.9	1002.4	66	0	7.1	7.4	16.5	-				
3	33.2	40.6	28.7	1002	65	0	7.2	9.1	20.6	-				
4	32.6	40.4	27	1002.6	63	0	8	7.2	20.6	-				
5	31.9	39.9	24	1001.6	63	0	9.2	7.8	18.3	-				
6	31.8	39.4	24	999.7	61	0	8.4	6.3	16.5	-				
7	35.3	43.9	26.5	1000.9	42	0	8.5	9.4	20.6	-				
8	35.4	45.6	29	1003.8	38	0	10	9.6	24.1	-				
9	33.1	39.8	26	1004.6	56	0	8.9	7.8	20.6	-				
10	32.8	40	27.1	1002.4	65	0	7.6	9.4	24.1	-				
11	33.6	42.3	27	1003.5	61	0	9.3	8.9	20.6	-				
12	34.6	42.2	27.6	1006.8	40	0	9.7	9.4	22.2	-				
13	33.8	42	27.4	1009.6	50	0	9.8	11.1	22.2	-				
14	33.4	41.4	26.1	1008.8	49	0	9.8	11.3	20.6	-				
15	32.7	38.3	28	1004.9	59	0	9	11.9	24.1	-				
16	33.3	39.3	27	1003.2	52	0	7.9	16.7	27.8	-				
17	32.7	39.4	28.8	1006.5	56	0	9.5	9.6	16.5	-				
18	33.3	41	27	1008.1	55	0	9.3	12.6	25.9	46.5				
19	33.1	40.3	29.6	1009.5	57	0	10	12.4	20.6	-				
20	32.4	39	27	1009.5	47	0	9.3	13.3	24.1	-				
21	32.4	38.8	26.5	1009.9	42	0	10	12.8	24.1	-				
22	32.1	38.9	25.4	1008	58	0	9.2	10.7	20.6	-				
23	32.1	39.1	27	1006.2	62	0	7.6	8.5	14.8	-				
24	32.2	41.1	26.2	1006.4	58	0	8.5	8.7	18.3	-				
25	32.4	40	26.1	1006.8	58	0	8.2	10.2	20.6	-				
26	32.3	38.4	27.2	1006.8	56	0	8.2	15.2	27.8	-				
27	30.6	38.2	25	1006.1	52	0	10	8.9	18.3	-				
28	30.9	38.6	22.8	1006.8	58	0	10.1	7.8	18.3	-				
29	30.9	38.4	23.9	1007.5	62	0	10	8.9	22.2	-				
30	30.5	37.6	25	1007.4	62	0	9	9.1	18.3	-				
Monthly means and totals:														
	32.8	40.2	26.7	1005.5	56	0	8.9	10	20.9		0	0	0	0

**Table II-3: Sharjah Weather Table - October 2009**

(http://www.tutiempo.net/en/Climate/Sharjah\_International\_Airport)

**Weather Sharjah International Airport****Main** | **Year 2009 climate** ▾ | **October 2009** ▾**Climatic mean values**

Day	T	TM	Tm	SLP	H	PP	VV	V	VM	VG	RA	SN	TS	FG
1	30.6	40.3	22.5	1007.4	58	0	8.5	6.7	18.3	-				
2	31.3	40.5	23.6	1007.5	57	0	8.9	6.9	16.5	-				
3	31.9	40.8	24.6	1006.7	56	0	9	8.9	16.5	-				
4	31.1	36.7	26	1006.9	50	0	9	10.6	22.2	-				
5	30.2	38	24.8	1007.6	49	0	9	6.7	16.5	-				
6	30.7	39.7	23.9	1008	44	0	9.2	5.9	14.8	-				
7	30.4	39	23.7	1008.4	37	0	9.5	8.5	20.6	-				
8	30.3	38.3	22.5	1008	43	0	9.2	9.6	18.3	-				
9	29.5	37.4	22.9	1008.7	56	0	9.5	9.1	18.3	-				
10	28.7	37.2	21.6	1010.5	57	0	8.9	8.1	14.8	-				
11	29.4	39.5	19.9	1012	42	0	9.7	8	20.6	-				
12	29.2	38.2	21.1	1012.4	44	0	10	9.1	18.3	-				
13	29.2	37.6	21.5	1012.7	49	0	9.3	9.1	24.1	-				
14	28.5	37.6	21	1014	58	0	8.2	9.3	20.6	-				
15	28.7	37.6	19	1014.4	49	0	9	9.8	20.6	-				
16	28.5	35.4	21.5	1014.2	57	0	10	9.8	18.3	-				
17	28.1	34.9	22.1	1013.2	61	0	9.3	9.1	18.3	-				
18	27.3	35.6	20.9	1011.6	59	0	8.4	9.3	18.3	-				
19	27.1	36.3	18.4	1012	49	0	9.5	7	16.5	-				
20	27.7	36.1	19.5	1012.8	57	0	9.5	8.7	24.1	-				
21	27.6	34.8	20.9	1013.7	62	0	8.4	9.4	22.2	-				
22	27.7	35.4	21.8	1015	61	0	8.4	8.1	20.6	-				
23	27.7	35.4	20.3	1015.3	61	0	9.5	7.8	20.6	-				
24	27.6	36.8	20.7	1013.1	49	0	10	7.8	18.3	-				
25	27.9	37.4	20	1013.3	40	0	8.7	10.2	22.2	-				
26	26.9	36.6	18.4	1014.6	50	0	9.8	10.2	24.1	-				
27	26.8	32.5	19.7	1014	66	0	8.9	7.6	14.8	-				
28	26.7	33.6	21	1012.8	73	0	7.2	7.8	18.3	-				
29	28.2	37.5	18.8	1014.8	48	0	9.3	10.7	14.8	-				
30	27.9	36	21.7	1016.3	47	0	10	9.8	18.3	-				
31	26.5	35.9	19	1015.6	53	0	10	7.8	18.3	-				
<b>Monthly means and totals:</b>														
	28.7	37.1	21.4	1011.9	53	0	9.2	8.6	19		0	0	0	0

**Table II-4: Sharjah Weather Table - November 2009**  
 (http://www.tutiempo.net/en/Climate/Sharjah\_International\_Airport)

**Weather Sharjah International Airport**

**Main** | **Year 2009 climate** ▾ | **November 2009** ▾

**Climatic mean values**

Day	T	TM	Tm	SLP	H	PP	VV	V	VM	VG	RA	SN	TS	FG
1	26	35.9	18.4	1014.1	51	0	9.3	10.2	22.2	-				
2	26.9	35.8	18.8	1014	44	0	9	6.7	14.8	-				
3	26.9	36.7	18.5	1014.6	44	0	9.3	6.9	13	-				
4	27.1	36.4	18.7	1015.8	50	0	9.7	6.7	20.6	-				
5	26.8	35.9	19.7	1015.4	66	0	8.4	6.5	18.3	-				
6	26.3	33.3	21.8	1014.1	77	0	5.8	7.6	14.8	-				o
7	25	34.7	19	1012.7	73	0	6	6.5	16.5	-				o
8	25.1	34.1	18.8	1012.8	61	0	7.2	7.2	18.3	-				o
9	26.2	36	16.7	1012.8	40	0	10	8.5	16.5	-				
10	24.6	32.9	17.8	1009.6	55	0	9.8	7.6	14.8	-				
11	24.3	32.3	14.5	1009.3	42	0	9.7	10.6	20.6	-				
12	22.8	31.6	14.1	1011.3	50	0	10	8.3	14.8	-				
13	23.2	31.1	15.7	1013.8	60	0	9.7	8.3	16.5	-				
14	22.8	32	15.6	1014.8	57	0	9.2	8.3	18.3	-				
15	23.2	31.5	15.4	1014.6	64	0	9.2	8	14.8	-				
16	25	31	18	1013.4	72	0	9.5	8.5	16.5	-				
17	25	32.2	20	1013.8	74	0	7.2	6.3	16.5	-				
18	24.7	33.5	18.7	1014.5	66	0	7.7	8.1	14.8	-				
19	24.9	33.2	18.3	1016.1	47	0	10	10.4	18.3	-				
20	24.8	31.1	18.6	1018.5	63	0	10.5	9.4	22.2	-				
21	24	28.6	18.5	1017.5	59	0	10.6	11.9	22.2	-				
22	24.3	29.2	19.4	1016.7	63	0	10.6	10.4	18.3	-				
23	24.6	28	20.3	1017.3	62	0	10.6	16.3	25.9	-				
24	23.8	28.2	19	1017.4	55	0	10.5	16.3	25.9	-				
25	21.9	28	16	1018.1	60	0	10.6	7.6	14.8	-				
26	21.2	29.9	14	1016.5	63	0	10	6.1	13	-				
27	22.3	29.3	14	1015.6	68	0	9.3	6.5	13	-				
28	24.6	33.5	16.1	1015.2	58	0	9.5	9.8	16.5	-				
29	24.5	30	19	1016.4	61	0	10.3	11.3	20.6	-				
30	23.5	27.3	20	1018	63	0	10.8	11.7	22.2	-				
<b>Monthly means and totals:</b>														
	24.5	32.1	17.8	1014.8	58.9	0	9.3	9	17.9		0	0	0	3



**Table II-5: Sharjah Weather Table - December 2009**  
 (http://www.tutiempo.net/en/Climate/Sharjah\_International\_Airport)

Weather Sharjah International Airport														
Main   Year 2009 climate ▾   December 2009 ▾														
Climatic mean values														
Day	T	TM	Tm	SLP	H	PP	VV	V	VM	VG	RA	SN	TS	FG
1	22.4	26.6	18.6	1019.1	60	0	11.3	10.7	22.2	-				
2	22.3	26.9	16.8	1018.3	57	0	10.5	10.2	20.6	-				
3	21.1	26	17	1018.1	60	0	12.1	11.5	25.9	-				
4	20.1	27.2	12.4	1018.8	54	0	10	5.6	11.1	-				
5	20.1	27.5	13	1017.2	58	0	10	6.5	16.5	-				
6	21.2	28	12.7	1015.5	50	0	10	7.2	16.5	-				
7	23.1	29.6	15.5	1014.1	57	0	10	10.2	20.6	-				
8	27.3	31	22.5	1010.3	46	0	6.6	21.3	37	50				
9	22.8	26.1	17	1013.5	54	2.03	10.6	17.8	31.3	-	o			
10	19.9	25.7	15	1016	62	0	10.5	6.7	14.8	-				
11	18.5	24.4	14.7	1016.4	78	0	10	7	18.3	-	o			
12	20.1	24	16	1016.3	86	6.1	8.9	3.7	7.6	-	o			
13	18	21.2	15	1016.3	93	18.03	6.4	6.1	20.6	-	o		o	
14	19.1	24	14.5	1017.3	81	12.95	9.8	6.7	11.1	-				
15	20.4	25	16.2	1018.8	68	0.25	10.5	7.8	20.6	-				
16	19.6	25	14.5	1019.8	64	0	10.6	4.4	9.4	-				
17	18.9	25.4	13.8	1018.4	70	0	9.2	5.2	11.1	-				
18	21.2	29	13.8	1016.7	64	0	9.3	10.2	20.6	-	o			
19	21.6	26.5	19	1018	76	0.76	10.8	7.6	20.6	-	o			
20	21	25.6	17	1020.2	78	0	9.7	5.9	13	-				
21	20.3	25.9	16.4	1020.6	70	0	8.7	5.6	13	-				
22	20.6	26.3	15	1019.7	73	0	9.5	7.6	13	-				
23	21.8	29.3	17	1019.4	63	0	10	8.9	14.8	-				
24	21.2	28.2	15.5	1018.4	66	0	9.8	6.1	14.8	-				
25	21.2	25.4	15.7	1018.1	74	0	10.1	9.8	20.6	-	o		o	
26	21.6	24.7	17.7	1015.2	67	0.51	10.3	13.5	29.4	-	o			
27	21.6	25.1	17	1013.9	60	0.51	10.8	15.9	27.8	-				
28	20.4	24.9	16.9	1014.6	66	0	10.6	12.6	24.1	-				
29	19.4	25.6	14.6	1015.9	71	0	8.4	5.7	14.8	-				
30	19.3	25.7	14.4	1016.4	73	0	8.4	5.4	13	-				
31	19.7	27.2	14	1015.4	58	0	9.3	10	18.3	-				
<b>Monthly means and totals:</b>														
	20.8	26.2	15.8	1017	66.4	41.14	9.8	8.8	18.5		8	0	2	0

Table II-6: Sharjah Weather Table - January 2010

(http://www.tutiempo.net/en/Climate/Sharjah\_International\_Airport)

**Weather Sharjah International Airport**

Main | Year 2010 climate ▾ | January 2010 ▾

**Climatic mean values**

Day	T	TM	Tm	SLP	H	PP	VV	V	VM	VG	RA	SN	TS	FG
1	18.1	25.9	12	1014.3	68	3.05	9.8	11.1	25.9	-	o		o	
2	19	22.8	15	1017.6	67	12.45	10.5	13.7	25.9	-	o			
3	17.7	24.1	13.6	1021.2	74	0	9.8	6.1	13	-				
4	17.8	23.6	13	1021.1	75	0	8.5	6.9	14.8	-				
5	18.9	23.3	13.8	1018.4	74	0	10	7.4	14.8	-				
6	19.8	24.3	16	1015.7	69	0	9.3	11.3	20.6	-				
7	19.3	26.5	14	1017	74	0	7.4	7.4	14.8	-				
8	19	28	11.7	1018.9	62	0	9.8	7	16.5	-				
9	18.8	26.2	11.3	1018.9	63	0	10.1	6.1	16.5	-				
10	19.1	26.2	12	1018.3	60	0	10.5	9.4	22.2	-	o		o	
11	18.5	24	12.9	1019.9	55	1.02	10.3	7.4	16.5	44.3	o			
12	18	24.7	10.9	1022.2	63	0	10	7	20.6	-				
13	18	25.3	11.7	1022.5	68	0	9.5	5.7	13	-				
14	18.2	25.4	12.5	1023.2	67	0	8	6.5	13	-				
15	17.3	24	11.7	1023.4	68	0	7.6	6.7	13	-				
16	17	24.7	10.7	1024.1	70	0	8	5.4	13	-				
17	16.8	23.8	11	1024.3	75	0	7.2	5.6	13	-				
18	17.6	24.7	9.9	1022	77	0	6.9	5.4	13	-				
19	18.1	26.1	12	1019.7	81	0	5.8	6.3	16.5	-				o
20	19	28.4	11.3	1018.5	59	0	8	5.9	9.4	-				o
21	20.4	30.6	12.8	1018.2	63	0	8.2	6.7	18.3	-				
22	20	27.2	12.8	1018.3	72	0	7.1	6.9	18.3	-				
23	19.6	25.3	14	1018.5	78	0	6.3	10.7	18.3	-				o
24	18.8	26.6	12.6	1017.2	80	0	6.3	6.7	16.5	-				
25	20.4	30	10.6	1016.2	65	0	7.9	7	11.1	-				o
26	22.3	29	15.9	1016.6	57	0	9.8	9.6	18.3	-				
27	19.9	23.4	17	1017.9	63	0	10.6	18	29.4	-				
28	18.9	22.4	12	1019	61	0	10.8	15.9	24.1	-	o			
29	17.1	23.9	10.8	1019.7	68	0	10.1	7.4	18.3	-				
30	18.4	25	10	1020.6	67	0	9.7	8.1	13	-				
31	19.4	26	13	1019.1	73	0	9.2	8.1	14.8	-				
<b>Monthly means and totals:</b>														
	18.7	25.5	12.5	1019.4	68.3	16.52	8.8	8.2	17		5	0	2	4

**Table II-7: Sharjah Weather Table - February 2010**

(http://www.tutiempo.net/en/Climate/Sharjah\_International\_Airport)

Latitude: 25.33 | Longitude: 55.52 | Altitude: 33

**Weather Sharjah International Airport****Main** | **Year 2010 climate** ▾ | **February 2010** ▾**Climatic mean values**

Day	T	TM	Tm	SLP	H	PP	VV	V	VM	VG	RA	SN	TS	FG
1	20.2	27.8	13.9	1016.7	72	0	7.9	8.5	14.8	-				o
2	21.8	28.9	15.5	1014.6	46	0	10	8.5	18.3	-				
3	23	31.9	14.2	1013.1	53	0	10.3	8.5	14.8	-				
4	25.2	31.3	19.8	1011	58	0	10	15.2	22.2	-				
5	22.2	25.7	18	1013	68	-	8.7	15.6	29.4	-	o		o	
6	19.2	22.5	18	1013.5	79	3.05	10.8	5.6	16.5	-	o			
7	20.1	24.4	16.8	1015.7	58	0	10.5	18.7	33.5	40.7				
8	17.8	23.6	11	1018.1	47	0	10.1	9.3	14.8	-				
9	15.8	23.4	7.8	1018.4	54	0	9.3	6.7	14.8	-				
10	16.2	23.2	9.6	1017.5	58	0	8.9	6.9	16.5	-				
11	17.4	25.8	10.6	1019.1	57	0	10	7.2	14.8	-				
12	18.1	27.2	8.9	1020.2	68	0	9.5	5.7	20.6	-				
13	19.1	27.4	12.1	1019.4	68	0	8.5	7	22.2	-				
14	19.9	29	12.3	1018	68	0	7.9	7	16.5	-				
15	20.2	28.7	13.3	1017	71	0	8.7	5	16.5	-				
16	21.3	30.9	12.8	1018.8	58	0	9.5	5.7	16.5	-				
17	20.9	29.8	13.6	1020	70	0	8.4	7.4	22.2	-				o
18	20.1	29.4	13	1018.2	67	0	8.2	8.1	20.6	-				o
19	21.8	29.8	13	1015.3	48	0	9.5	6.3	16.5	-				
20	22.7	32.3	13	1013.1	45	0	10	8.9	20.6	-				
21	22.3	26.8	18	1013.1	55	0	9.5	19.8	35.2	-				
22	20.3	26	15.8	1014.9	66	0	10.3	10.4	18.3	-				
23	21.6	29.2	14.6	1013.4	46	0	9.2	7	13	-				
24	24.2	32.5	14	1009.9	25	0	10	10.2	22.2	-				
25	26.3	36	17.9	1008.4	31	0	9.2	15.6	29.4	-				
26	28.2	35.5	20.2	1008.9	46	0	9.2	20.4	31.3	44.3				
27	25.9	34	19.8	1010.2	65	-	8.4	16.5	35.2	-	o		o	
28	23.1	28	17	1013.8	71	36.32	9.3	8	16.5	-				
<b>Monthly means and totals:</b>														
	21.2	28.6	14.4	1015.1	57.8	39.37	9.3	10	20.8		3	0	2	3

**Table II-8: Sharjah Weather Table - March 2010**

(http://www.tutiempo.net/en/Climate/Sharjah\_International\_Airport)

Weather Sharjah International Airport														
Main   Year 2010 climate ▾   March 2010 ▾														
Climatic mean values														
Day	T	TM	Tm	SLP	H	PP	VV	V	VM	VG	RA	SN	TS	FG
1	22.5	29.3	16	1014	61	0	9.3	7	16.5	-	o		o	
2	19.7	24	16.4	1014.1	85	11.18	8.5	9.3	20.6	-	o		o	
3	21.3	25	17.7	1013.5	68	0	10.8	16.3	27.8	-	o			
4	20.3	24.6	16	1014.1	66	0	10.5	13	20.6	-				
5	20.7	24.9	14.9	1014.7	60	0	7.1	18.9	33.5	-				
6	20.4	24.7	17	1016.7	68	0	4.7	9.4	20.6	-				
7	20.7	26.8	15.4	1018.3	74	0	6.9	7.2	18.3	-				
8	21.3	29.9	15.3	1018.6	78	0	6	4.4	20.6	-				
9	22.8	30	16.4	1018.6	75	0	5	4.6	14.8	-				o
10	23.2	33.3	17.9	1018.7	74	0	4.8	8	18.3	-				o
11	23.1	32.6	16.7	1018.3	60	0	6	8	18.3	-				o
12	22.1	32	12.9	1018.3	65	0	6.8	6.3	16.5	-				
13	22.3	31.2	13.5	1016.8	56	0	8	6.9	16.5	-				
14	23	32.4	14.8	1014.9	49	0	8.4	9.3	22.2	-				
15	23.8	33	15	1014.2	39	0	9.5	8.1	16.5	-				
16	23.6	33.4	15	1013	37	0	10	8.3	18.3	-				
17	23.4	35.1	14.5	1013.9	45	0	9.2	7.2	20.6	-				
18	26.8	39	14.9	1014.9	34	0	9.2	10	18.3	-				
19	26.8	36.8	18.7	1015.3	30	0	10	12	25.9	-				
20	25.3	37	16.2	1014.7	41	0	10	9.8	22.2	-				
21	25.2	33.1	16	1014.7	51	0	8	9.6	18.3	-				
22	24.3	30.2	19.6	1011.9	71	0	7.1	15.6	27.8	-				o
23	24.2	30.1	19	1009.4	66	0	10.1	13	20.6	-				
24	23.9	30.6	18.5	1010.3	75	0	9.2	8.7	18.3	-				
25	25.3	35.2	18	1010	65	0	7.2	10.6	18.3	-				o
26	27	35.7	19	1009	36	0	9.7	7.4	16.5	-				
27	31.4	41.4	18.7	1007.5	21	0	11.6	11.1	20.6	-				
28	28.9	37.1	22	1010.2	40	0	10	7.4	16.5	-				
29	27.1	34.3	18	1013.1	39	0	9.5	10.9	24.1	-				
30	26.1	32.1	17.8	1013	52	0	10	11.9	20.6	-				
31	27.6	35.2	21	1011.9	46	0	10	12	24.1	-				
Monthly means and totals:														
	24	31.9	16.9	1014.1	55.7	11.18	8.5	9.7	20.4		3	0	2	5

**Table II-9: Sharjah Weather Table - April 2010**

(http://www.tutiempo.net/en/Climate/Sharjah\_International\_Airport)

**Weather Sharjah International Airport****Main** | **Year 2010 climate** ▾ | **April 2010** ▾**Climatic mean values**

Day	T	TM	Tm	SLP	H	PP	VV	V	VM	VG	RA	SN	TS	FG
1	27.4	34.6	21.4	1011.8	44	0	9.8	18.9	37	-				
2	24.9	30	19.8	1011.7	57	0	10	19.3	31.3	-				
3	25.2	30.1	18.3	1012.1	56	0	10	17.2	27.8	-				
4	24.4	31.2	17.7	1012.9	62	0	9.8	10	16.5	-				
5	25.3	34.2	16.7	1012	67	0	8.7	8.7	18.3	-				
6	25.1	36.1	19	1011.4	53	0	8.7	10	24.1	-				
7	27.4	36.2	18.2	1012.4	41	0	9.8	7.6	14.8	-				
8	28.1	38.6	18	1013.3	36	0	9.8	6.1	16.5	-				
9	30.2	41.6	21.3	1010.9	29	0	9.8	11.1	22.2	-				
10	29.7	37.6	23	1009	39	0	10.3	10.4	22.2	-				
11	27.1	35.3	21	1009.3	45	0	9.3	13.3	27.8	-				
12	26.6	34.7	18.7	1010.2	56	0	9.8	11.3	29.4	-				
13	28.7	34.6	18.3	1010.5	44	-	9.7	12.6	25.9	-	o			
14	28	34.7	22	1010.4	45	0	9.5	10.6	44.3	-	o			
15	28.8	35	20.5	1012	41	0	10	10.6	24.1	-				
16	28.9	37	21.9	1012.4	49	0	9.5	14.4	44.3	68.3				
17	29.1	35.9	23	1011.9	47	0	10	12.6	27.8	-				
18	30.2	37	19.5	1010.2	38	0	9.8	12	48.2	59.4	o			
19	28.9	35	23	1008.5	50	0	9.8	15.9	25.9	-	o		o	
20	26.9	32.2	22	1007.5	61	0	9.7	16.9	25.9	44.3				
21	26.4	34.5	19	1007.2	61	0	9.7	12.4	25.9	-				
22	27.3	38.3	17.7	1007.8	59	0	8	9.3	20.6	-				
23	30.2	40.9	20.7	1009	38	0	9.2	9.1	20.6	-				o
24	31.2	40.4	23	1009.3	39	0	9.7	15.2	29.4	-				
25	28.5	32	23	1009.6	52	0	10	16.1	31.3	-	o			
26	27.2	33.2	21.2	1011.9	53	0	9.8	13.5	24.1	-				
27	27.7	34.6	19	1013.2	48	0	10	11.3	22.2	-				
28	29.9	36.8	20	1011.1	36	0	9.8	14.3	27.8	-				
29	31.3	38.3	22	1007.9	31	0	9.7	10.2	18.3	-				
30	32.2	41	23.5	1007.2	27	0	9.8	9.1	27.8	-				
<b>Monthly means and totals:</b>														
	28.1	35.7	20.4	1010.5	46.8	0	9.7	12.3	26.7		5	0	1	1

**Table II-10: Sharjah Weather Table - May 2010**

(http://www.tutiempo.net/en/Climate/Sharjah\_International\_Airport)

**Weather Sharjah International Airport****Main** | **Year 2010 climate** ▾ | **May 2010** ▾**Climatic mean values**

Day	T	TM	Tm	SLP	H	PP	VV	V	VM	VG	RA	SN	TS	FG
1	32.4	39.7	22.7	1008.7	34	0	9.7	10	24.1	-				
2	32.8	42.4	24	1007.6	35	0	10	9.3	20.6	-				
3	31.6	35.7	25.2	1007.1	41	0	9.8	11.5	29.4	46.5				
4	30.2	35	27	1007.4	45	0	10	17	38.9	-	o			
5	28.1	32	23	1006.9	52	0	10.1	14.1	27.8	-	o			
6	28.6	33.8	20.6	1006.4	40	0	10.3	18.7	31.3	-				
7	27.8	33.5	18.9	1006.8	46	0	10	15.6	25.9	48.2				
8	28.2	35.5	19.4	1007.6	29	0	10	13.5	27.8	-				
9	29.3	37.2	19	1006.8	30	0	10	11.7	22.2	-				
10	28	38	18	1006.7	32	0	10	8.9	20.6	-				
11	30.6	41	17.7	1006.8	23	0	9.5	8.1	18.3	-				
12	32.3	42	23	1006.5	19	0	9.2	8.9	18.3	-				
13	31.1	41.5	21.4	1006.1	25	0	9.7	8.9	25.9	-				
14	32.4	41.9	20.6	1004.2	25	0	9.7	12.8	29.4	-				
15	34	40.5	28	1003.3	35	0	9.3	16.1	27.8	-				
16	33.9	39.5	27.5	1003.9	31	0	6.3	16.7	46.5	-	o			
17	31.9	37.8	24	1005.6	30	0	9.2	11.1	20.6	-				
18	29.8	38.1	21	1006.9	44	0	8.5	6.9	20.6	-				
19	31.9	43	22.4	1006.8	42	0	8.4	7.2	22.2	-				
20	32.5	44.3	22.8	1005.4	35	0	9.2	9.4	22.2	-				
21	32.9	41.6	22	1004.5	28	0	8.9	10.6	20.6	-				
22	32.7	39.5	23.5	1003.7	45	0	7.6	13.9	22.2	-				
23	33.8	42.7	27	1003.4	44	0	8.5	14.1	22.2	-				
24	32.3	41.8	22	1002.8	49	0	9.7	8.9	18.3	-				
25	33.2	40.2	23.7	1002.9	51	0	8.4	13	20.6	-				
26	32.4	40.4	27	1002.5	50	0	8.9	17.6	24.1	-				
27	31.8	42.2	25.5	1002.5	54	0	9.5	11.7	20.6	-				
28	31.9	40.6	24.5	1003.6	67	0	5.8	9.1	22.2	-				o
29	33.9	43	26	1004.7	49	0	7.4	10	20.6	-				
30	34	44.9	25.4	1004.4	43	0	8.5	14.4	29.4	-				
31	33.7	41.6	23.8	1003.3	35	0	9	13.7	25.9	-				
<b>Monthly means and totals:</b>														
	31.6	39.7	23.1	1005.3	39	0	9.1	12	24.7		3	0	0	1

**Table II-11: Sharjah Weather Table - June 2010**

(http://www.tutiempo.net/en/Climate/Sharjah\_International\_Airport)

**Weather Sharjah International Airport****Main** | **Year 2010 climate** ▾ | **June 2010** ▾**Climatic mean values**

Day	T	TM	Tm	SLP	H	PP	VV	V	VM	VG	RA	SN	TS	FG
1	33.7	43.7	24.5	1001.7	46	0	8.4	9.3	24.1	-				
2	35.1	41.8	26	1002.5	44	0	8.5	19.8	29.4	-				
3	35.3	40.9	30.5	1004.5	46	0	9.3	24.6	31.3	42.4				
4	34.7	40.3	30	1004.7	44	0	9.3	18.3	29.4	-				
5	32.9	38.7	27	1002.3	52	0	9.8	9.8	18.3	-				
6	33	40	25.6	999.3	52	0	9.5	9.6	18.3	-				
7	32.8	40	24.2	999.3	48	0	6.3	7.8	14.8	-				
8	32.9	39.8	25.1	1001.5	55	0	6.4	7.2	18.3	-				
9	32.5	40.7	25	1002	64	0	4	8.1	16.5	-				
10	33.6	41.3	26.8	1001.9	46	0	6	10.2	22.2	-				
11	35.5	44.9	26.7	1001.7	38	0	7.9	7.2	18.3	-				
12	34.7	44.3	26.8	1001.6	41	0	7.7	8.5	20.6	-				
13	34.6	45.1	25.5	1000.8	42	0.51	7.1	10.2	22.2	-				
14	34.9	45.1	25.4	999.4	47	0	7.4	10.2	24.1	-				
15	36.9	45.1	25.9	998.7	22	0	8	10	20.6	-				
16	36.9	46.4	26	999.1	21	0	7.9	9.1	18.3	-				
17	37.6	45.1	27.9	999.3	22	0	7.1	15.7	33.5	-				
18	36.9	46	29.5	1001	19	0	9.2	13.1	29.4	-				
19	36.9	44.9	28.1	1001.9	20	0	8.9	14.1	27.8	-				
20	36.2	44.4	28	1001.4	24	0	9.2	9.6	24.1	-				
21	36.3	43.5	27.6	1000.2	25	0	8.2	9.6	22.2	-				
22	36.3	46.1	27.8	998.6	39	0	8.7	13.1	20.6	-				
23	34.6	41.2	25	998.6	44	0	9.2	18.1	27.8	-				
24	33.8	41.1	25	997.3	47	0	6.3	18.5	27.8	-				
25	33.9	40.9	29	995.8	49	0	4.8	18.9	25.9	-				
26	33.7	42.1	28	997.4	52	0	6.8	12.6	20.6	-				
27	34.7	42.2	28.7	999.5	51	0	6	8.7	24.1	-				
28	34.3	39.9	28.5	1000.1	52	0	6.8	9.3	20.6	-				
29	35.1	42.9	27.8	999.4	46	0	7.1	10.9	24.1	-				
30	34.3	43.3	27.2	998.6	53	0	7.2	13.3	22.2	-				
<b>Monthly means and totals:</b>														
	34.8	42.7	27	1000.3	41.7	0.51	7.6	12.2	23.2		0	0	0	0

**Table II-12: Sharjah Weather Table - July 2010**

(http://www.tutiempo.net/en/Climate/Sharjah\_International\_Airport)

**Weather Sharjah International Airport****Main** | **Year 2010 climate** ▾ | **July 2010** ▾**Climatic mean values**

Day	T	TM	Tm	SLP	H	PP	VV	V	VM	VG	RA	SN	TS	FG
1	34.4	41.3	28.6	996.9	56	0	6.3	13.3	20.6	-				
2	34.6	42.3	28.6	996.7	53	0	8.4	11.5	20.6	-				
3	35.1	43.6	28	998.2	56	0	7.6	10.6	24.1	-				
4	35.4	43.7	30	998.4	53	0	8.9	13.1	24.1	-				
5	34.9	41.4	29	998.2	56	0	8.4	12.6	24.1	-				
6	35.7	42	27.5	997.1	50	0	6.9	9.6	18.3	-				
7	38.4	45	32.6	997.6	43	0	8.4	20.4	29.4	-				
8	37.4	43.7	32	1000.9	42	0	8.4	15.6	31.3	-				
9	37.4	42	33.1	1001.1	40	0	9.2	14.3	25.9	-				
10	35.7	42.1	32	1001.2	50	0	7.7	11.7	22.2	-				
11	36.7	43.4	31	1001.6	46	0	7.7	13.1	25.9	-				
12	37.8	44.5	30.9	999.5	37	0	8.5	14.8	31.3	-				
13	39	45.6	31.4	996.9	29	0	8.9	14.1	25.9	-				
14	41	47	34.1	998.1	27	0	7.7	17.8	29.4	-				
15	38.7	46.6	33	999.5	31	0	7.7	14.1	25.9	-				
16	37.1	45.8	27	998	33	0	8	10.2	20.6	-				
17	36.4	46.1	25.1	996.2	37	0	7.7	8	20.6	-				
18	38.3	46.3	31	996.5	40	0	8.4	15.7	27.8	-				
19	36.8	44.7	31	994.6	44	0	8.7	9.8	18.3	-				
20	36.1	42.6	30.8	992.9	52	0	8	8.1	18.3	-				
21	37.3	45.3	31.9	994.2	51	0	8.7	10.7	24.1	38.9				
22	36.6	43.4	31	994.6	53	0	8.7	8.3	20.6	-				
23	37.7	45.6	31	995	46	0	8.5	15.7	25.9	-				
24	37.2	45.2	33	995.5	45	0	8.7	13.3	24.1	-				
25	35.4	41.5	31	994.9	61	0	8.2	9.8	25.9	-				
26	35.2	39	30	995.3	64	0	7.7	9.6	16.5	-				
27	36.1	41.1	31.7	994.8	58	0	8.5	10.6	16.5	-				
28	38.4	44.9	33.6	995.6	36	0	6.9	14.3	25.9	-				
29	37.7	45	31	996.6	29	0	6.3	10.7	24.1	-				
30	37.5	45.5	30.4	997.7	34	0	7.9	11.1	24.1	-				
31	38.8	47.5	28	998.7	17	0	9.2	12	29.4	-				
<b>Monthly means and totals:</b>														
	36.9	44	30.6	997.2	44.2	0	8.1	12.4	23.9		0	0	0	0



**Table II-13: Sharjah Average Weather Table in First and Second Semester - Academic Year 2009-2010 (Done by the Author)**

**Concluded from tables (II-2) to (II-12)**

Average	T	TM	Tm	SLP	H	PP	VV	V	VM
First Semester	25.1	32.22	18.84	1013.7	60.52	11.532	9.2	8.92	18.66
Second Semester	31.08	38.8	23.6	1005.5	45.48	2.338	8.6	11.72	23.78

### III. Appendix C: The Results (Raw Data)

#### 1.1 Teachers' Questionnaires

**Table III-1: Answers for Question 1 (Done by the Author).**

Do you have any health issue/s?	
School-A	School-B
No	No
No	No
Yes (Migraine)	No
No	No
No	No
No	No
No	No
No	Yes (Hypothyroidism)
No	No
No	No

**Table III-2: Answers for Question 2 (Done by the Author).**

Do you think lighting is affecting you negatively?	
School-A	School-B
No	No
No	No
Yes (Too low)	Yes(Eyestrain and discomfort)
No	Yes
Yes (Migraine)	Yes (Discomfort – Annoying)
No	No
Yes	Yes
No	Yes(Eyestrain and discomfort)
No	No
No	No

**Table III-3: Answers for Question 3 (Done by the Author).**

How do you describe your overall behavior:					
School-A			School-B		
Early in the morning	Mid of the day	End of the day	Early in the morning	Mid of the day	End of the day
Tired	Tired	Good	Active	Active	Tired
Tired	Good	Tired	Active	Active	Tired
Tired	Active	Tired	Good	Good	Good
Good	Good	Tired	Good	Good	Good
Good	Good	Tired	Good	Good	Good
Active	Tired	Tired	Good	Good	Good
Good	Good	Tired	Good	Good	Good
Good	Good	Good	Active	Tired	Active
Good	Good	Good	Good	Good	Good
Good	Good	Good	Active	Active	Tired

**Table III-4: Answers for Question 4 (Done by the Author).**

How do you evaluate the ventilation in your classroom? (1poor – 5excellent)	
School-A	School-B
4	4
4	4
3	3
1	3
2	5
3	5
3	3
3	5
3	5
3	3

**Table III-5: Answers for Question 5 (Done by the Author).**

How do you evaluate the impact of lighting on you and your performance? (1poor – 5excellent)	
School-A	School-B
4	1
3	1
2	5
3	4
3	3
3	5
4	4
5	2
2	5
3	5

**Table III-6: Answers for Question 6 (Done by the Author).**

How do you evaluate the impact of lighting on the students and their performance? (1poor – 5excellent)	
School-A	School-B
4	4
3	4
2	3
3	3
3	3
4	4
4	3
5	2
2	5
3	4

**Table III-7: Answers for Question 7 (Done by the Author).**

Major general issues you have in your classroom (things you wish to change in-order to improve performance):	
School-A	School-B
None	None
None	None
None	None
AC noise and smell Circulation of air Small, cramped space	None
AC that can be controlled	None
Wash sinks in the classroom Bigger space Advanced audio-visual aids	None
Larger classrooms Centers for different activities	None
Storage more child friendly Areas to store artwork	Cooling system (too hot or too cold) never balanced
None	None
None	Ventilation

**Table III-8: Answers for Question 8 (Done by the Author).**

What is the major health issue you and your students are suffering from mainly:		
Health Issue:	School-A	School-B
Respiratory irritation	111	
Allergy	1111	11
Eye, nose and throat irritation	111111	11
Sensation of dry mucous membranes and skin	111	
Headaches	11	
Wheezing	1	
Cough	11111	1

**Table III-9: Answers for Question 9 (Done by the Author).**

Teachers' Comments:	
School-A	School-B
None	None
Need better ventilation as cold are common	The color of light wasn't changed in my class
None	None
None	None
None	None
None	None
None	The experimental lighting isn't suitable in my opinion
Storage for artwork	None
None	None
None	None

## 1.2 Students' Grades

### Results of school-A

#### Class A1

Table III-10: Class A1 Grade Report - First Semester

School-A Class A1 First Semester										
Serial No.	Gender	Islamic Studies	Arabic	Social Studies	Literacy	Maths	Science	Geography	French	PE
1	F	NM	82	89	93	99	95	90	71	82
2	M	72	70	73	64	61	68	72	69	67
3	M	93	98	89	95	94	82	87	81	71
4	F	89	99	89	91	98	91	91	85	82
5	M	92	91	87	92	97	92	85	81	89
6	F	NM	83	88	99	95	95	89	86	80
7	M	NM	95	93	92	90	85	91	81	94
8	F	80	73	82	77	72	69	80	82	70
9	M	NM	70	78	70	73	72	76	74	75
10	M	NM	87	89	89	83	91	91	81	82
11	M	90	91	83	96	95	87	85	88	85
12	M	89	83	93	71	79	94	91	71	71
13	F	NM	64	63	72	76	83	65	72	72
14	M	93	90	91	93	93	85	89	81	90
15	M	80	76	76	78	76	78	75	72	81
16	F	NM	70	78	87	90	80	79	81	89
17	M	87	72	88	76	94	85	90	73	96
18	F	72	70	68	74	72	72	65	75	60
19	M	89	88	82	82	85	83	84	81	92
20	F	93	83	84	79	70	80	80	82	71

Table III-11: Class A1 Grade Report - Second Semester

School-A Class A1 Second Semester										
Serial No.	Gender	Islamic Studies	Arabic	Social Studies	Literacy	Maths	Science	Geography	French	PE
1	F	NM	88	94	97	96	95	92	72	83
2	M	70	76	70	60	60	73	72	67	65
3	M	98	96	93	91	93	94	91	81	71
4	F	84	96	90	93	94	96	92	87	82
5	M	90	96	84	95	99	89	82	89	87
6	F	NM	86	93	96	92	91	95	83	83
7	M	NM	93	94	90	98	93	96	84	93
8	F	82	77	80	74	75	70	78	85	72
9	M	NM	75	81	75	74	80	83	75	70
10	M	NM	83	91	82	81	85	89	81	80
11	M	93	94	88	94	99	92	90	89	82
12	M	85	86	90	73	79	80	88	77	71
13	F	NM	63	73	70	72	76	71	77	76
14	M	91	92	90	96	90	93	92	87	91
15	M	83	70	87	76	71	81	89	70	82
16	F	NM	69	85	89	91	81	84	79	93
17	M	80	75	86	75	95	88	89	71	94
18	F	75	78	68	73	75	74	70	73	63
19	M	85	82	91	87	80	86	88	82	90
20	F	98	83	85	77	72	85	83	88	70



## Results of school-A

### Class A2

Table III-12: Class A2 Grade Report - First Semester

School-A Class A2 First Semester										
Serial No.	Gender	Islamic Studies	Arabic	Social Studies	Literacy	Maths	Science	Geography	French	PE
1	F	NM	89	94	97	95	99	96	98	87
2	M	93	86	85	70	81	80	83	82	79
3	F	NM	97	94	95	87	88	92	93	77
4	M	90	90	83	82	77	92	80	92	90
5	M	NM	50	63	73	70	72	60	63	80
6	F	95	94	92	88	90	98	90	99	88
7	F	NM	92	95	98	100	98	97	96	89
8	M	86	88	77	78	84	94	75	92	98
9	M	NM	89	64	66	70	69	66	83	91
10	M	84	76	63	65	63	74	61	80	93
11	F	NM	77	99	99	100	98	97	92	92
12	M	75	66	64	69	83	78	64	80	90
13	F	NM	73	88	93	92	90	86	94	90
14	F	82	70	75	81	82	83	77	90	93
15	F	77	80	80	78	75	82	78	75	98
16	M	100	87	94	94	87	89	92	99	97
17	F	80	90	92	77	75	93	90	93	92
18	F	66	84	88	79	77	82	80	89	80
19	F	NM	66	84	92	93	89	88	87	82
20	M	96	95	99	97	100	99	97	93	98

Table III-13: Class A2 Grade Report - Second Semester

School-A Class A2 Second Semester										
Serial No.	Gender	Islamic Studies	Arabic	Social Studies	Literacy	Maths	Science	Geography	French	PE
1	F	NM	84	97	96	97	98	99	99	85
2	M	89	88	84	66	81	79	82	81	80
3	F	NM	99	92	97	92	93	94	93	80
4	M	91	89	80	81	82	91	79	90	90
5	M	NM	55	67	73	70	68	65	72	79
6	F	99	85	92	93	92	92	91	95	89
7	F	NM	89	96	98	99	99	98	97	91
8	M	93	86	82	82	84	95	80	94	95
9	M	NM	84	75	71	65	70	74	81	93
10	M	80	78	73	74	73	72	71	82	94
11	F	NM	79	95	99	98	99	97	85	92
12	M	83	69	71	69	81	82	69	80	93
13	F	NM	68	89	91	92	94	91	92	90
14	F	80	66	78	81	83	84	80	93	94
15	F	82	78	75	79	77	76	79	78	98
16	M	99	87	92	91	94	95	90	96	99
17	F	85	89	94	82	80	92	91	87	86
18	F	70	75	82	83	82	81	80	89	80
19	F	NM	67	94	92	89	93	92	90	74
20	M	98	99	97	99	95	97	99	93	97

## Results of school-B

### Class B1

Table III-14: Class B1 Grade Report - First Semester

School-B Class B1 First Semester											
Serial No.	Islamic Studies	Arabic	Social Studies	English	Maths	Science	Activities	Holy Quran	Reading	Listening	Conver- sation
1	100	100	99	97	100	98	100	98	100	98	100
2	100	99	93	74	100	82	100	99	100	98	100
3	98	84	100	67	92	81	100	94	83	83	85
4	97	84	94	96	100	99	99	91	82	83	83
5	100	95	95	84	94	90	100	95	95	95	95
6	100	97	98	95	100	94	100	95	95	95	95
7	99	95	94	94	100	91	99	96	95	93	93
8	100	99	99	98	100	100	100	99	100	98	98
9	100	93	98	79	94	88	100	97	93	95	93
10	99	92	100	87	99	93	100	95	90	85	88
11	100	98	99	86	96	90	100	98	97	98	98
12	100	99	97	96	100	95	100	99	98	98	98
13	100	96	99	84	100	92	100	95	93	93	95
14	97	90	95	78	100	80	100	94	88	85	88
15	98	91	93	85	94	91	100	90	92	88	90
16	98	89	100	74	96	92	100	98	85	85	85
17	98	91	100	77	93	93	100	95	90	85	85
18	100	94	98	93	99	95	99	97	93	93	88

Table III-15: Class B1 Grade Report - Second Semester

School-B Class B1 Second Semester											
Serial No.	Islamic Studies	Arabic	Social Studies	English	Maths	Science	Activities	Holy Quran	Reading	Listening	Conver- sation
1	100	100	100	99	99	99	100	99	100	100	100
2	100	100	96	77	100	84	96	99	100	100	100
3	98	87	100	67	86	82	94	96	90	90	90
4	96	87	96	96	99	98	99	92	87	85	88
5	100	98	98	81	89	91	97	96	100	100	100
6	100	99	99	93	96	94	98	96	98	100	100
7	100	97	97	93	99	92	94	97	97	100	100
8	100	100	100	98	99	98	99	99	100	100	100
9	100	96	99	87	94	91	97	98	98	98	100
10	99	95	100	84	94	93	98	96	97	98	95
11	100	99	99	81	94	88	97	98	100	100	100
12	100	100	99	96	100	96	100	99	100	100	100
13	100	97	100	83	96	89	97	98	97	95	95
14	99	91	97	76	96	86	95	96	90	90	90
15	99	93	97	87	94	92	97	96	95	93	93
16	99	91	99	72	88	88	95	94	90	90	90
17	99	92	100	73	88	87	94	98	93	90	90
18	100	97	99	93	98	94	99	97	100	100	100

## Results of school-B

### Class B2

Table III-16: Class B2 Grade Report - First Semester

School-B Class B2 First Semester											
Serial No.	Islamic Studies	Arabic	Social Studies	English	Maths	Science	Activities	Holy Quran	Reading	Listening	Conver-sation
1	96	96	100	78	93	87	99	99	97	95	93
2	100	99	97	75	90	84	99	100	98	98	100
3	95	94	100	60	90	66	99	96	95	90	90
4	94	94	98	54	71	53	99	99	97	93	93
5	96	97	100	94	100	95	99	100	98	95	98
6	95	93	93	86	97	91	99	98	93	93	93
7	94	9	92	70	92	73	99	98	93	93	93
8	94	89	99	59	74	61	99	99	88	90	88
9	97	98	100	79	90	85	99	98	98	98	95
10	96	95	100	93	93	97	99	99	95	90	95
11	96	99	100	86	96	94	99	97	98	98	98
12	94	88	97	82	99	80	99	98	83	85	88
13	100	100	100	100	100	99	99	100	100	98	100
14	95	95	100	63	92	75	99	96	93	90	95
15	100	99	100	92	91	95	99	100	98	100	95
16	98	95	98	69	84	66	99	97	93	93	93
17	95	88	100	73	76	82	99	97	90	85	85
18	98	95	100	91	100	93	99	97	95	93	93
19	100	99	100	93	99	96	99	99	98	98	98
20	100	94	100	94	92	95	99	100	95	95	93

Table III-17: Class B2 Grade Report - Second Semester

School-B Class B2 Second Semester											
Serial No.	Islamic Studies	Arabic	Social Studies	English	Maths	Science	Activities	Holy Quran	Reading	Listening	Conver- sation
1	97	97	100	84	95	90	97	100	95	100	95
2	100	100	99	80	89	89	97	99	100	100	100
3	95	95	98	58	85	71	95	97	95	95	93
4	96	97	99	62	75	64	94	97	98	100	100
5	97	98	100	94	99	96	98	97	98	100	98
6	96	95	97	89	92	93	97	100	97	98	100
7	95	96	96	75	89	78	98	96	97	95	95
8	95	90	99	65	69	68	90	100	90	93	90
9	97	99	100	86	89	90	96	98	98	100	98
10	98	96	100	95	95	98	99	97	100	93	93
11	97	100	100	90	96	95	99	99	100	100	100
12	94	91	98	87	99	88	98	98	93	95	90
13	100	100	100	99	100	99	99	99	100	100	100
14	96	97	99	71	93	79	98	98	100	95	95
15	100	99	100	93	86	96	98	98	98	98	98
16	99	96	99	70	72	72	94	100	95	95	93
17	96	89	100	74	73	85	95	99	93	90	88
18	99	95	100	92	96	95	98	96	95	90	90
19	100	100	100	97	98	98	99	100	100	100	100
20	100	97	99	93	92	96	98	99	100	98	100

## Results of school-B

### Class B3 (Reference 1)

Table III-18: Class B3 Grade Report - First Semester (Reference 1)

School-B Class B3 First Semester (Reference 1)											
Serial No.	Islamic Studies	Arabic	Social Studies	English	Maths	Science	Activities	Holy Quran	Reading	Listening	Conver- sation
1	96	94	98	82	95	94	99	91	80	78	78
2	92	80	100	69	76	86	99	70	90	90	88
3	95	92	98	63	98	75	99	90	93	90	95
4	95	91	98	79	73	86	98	93	100	100	100
5	100	100	95	69	99	81	99	94	100	100	100
6	100	100	100	97	99	99	99	98	58	70	73
7	82	70	98	97	89	97	99	90	78	88	83
8	92	84	97	75	70	79	99	75	97	98	95
9	100	97	100	58	84	82	99	98	98	100	98
10	100	99	100	77	95	88	99	97	100	100	100
11	100	99	100	79	94	80	99	98	98	98	100
12	100	99	98	85	92	89	99	94	88	90	88
13	96	88	100	84	81	95	99	90	83	85	90
14	95	89	100	50	91	74	99	92	88	88	93
15	97	92	100	64	89	75	99	95	97	98	95
16	100	100	98	65	83	73	99	95	100	100	100
17	99	95	99	74	97	86	99	95	62	78	63
18	100	99	100	98	98	97	99	95	98	98	100
19	75	72	100	83	69	92	99	88	88	90	88

**Table III-19: Class B3 Grade Report - Second Semester (Reference 1)**

<b>School-B Class B3 Second Semester (Reference 1)</b>											
Serial No.	Islamic Studies	Arabic	Social Studies	English	Maths	Science	Activities	Holy Quran	Reading	Listening	Conver- sation
1	97	92	99	83	91	95	96	94	70	75	83
2	93	78	99	65	76	86	89	74	93	90	95
3	79	74	99	60	64	75	93	88	87	80	95
4	96	91	97	78	97	89	94	94	100	100	100
5	95	88	96	62	68	81	89	95	100	100	100
6	100	100	100	97	99	99	98	96	50	70	75
7	100	100	99	95	100	98	98	99	83	80	80
8	84	69	99	59	58	84	90	75	97	100	95
9	92	83	95	71	84	82	95	92	100	100	100
10	99	98	100	76	81	88	92	98	100	100	100
11	100	99	100	80	90	86	94	98	97	100	95
12	100	100	99	86	85	91	98	98	83	90	88
13	99	97	99	85	87	94	99	95	85	90	90
14	95	88	100	62	81	81	95	93	87	88	88
15	94	86	99	56	80	75	89	90	98	100	95
16	100	100	100	75	84	86	97	98	97	100	100
17	95	88	99	65	78	73	93	97	63	88	80
18	99	96	100	94	97	97	98	96	97	100	95
19	100	97	99	84	95	90	97	95	83	90	88



**Results of school-B****Class B4 (Reference 2)****Table III-20: Class B4 Grade Report - First Semester (Reference 2)**

<b>School-B Class B4 First Semester (Reference 2)</b>											
Serial No.	Islamic Studies	Arabic	Social Studies	English	Maths	Science	Activities	Holy Quran	Reading	Listening	Conver- sation
1	100	100	100	95	100	94	96	100	100	100	100
2	96	93	97	94	95	97	94	99	92	90	90
3	100	100	100	87	96	84	98	97	100	100	100
4	100	100	100	97	96	98	97	100	100	100	100
5	96	92	100	97	95	98	99	100	93	95	93
6	100	98	100	78	94	81	95	100	82	100	95
7	94	85	94	62	73	71	80	100	85	85	78
8	97	93	99	61	86	76	90	99	97	90	90
9	95	82	99	51	76	66	96	98	90	88	80
10	100	100	100	99	100	100	99	100	100	100	100
11	99	97	100	79	96	88	99	99	95	98	98
12	98	94	100	84	96	95	99	97	97	95	93
13	94	85	98	41	72	60	97	92	88	83	83
14	78	76	100	53	92	58	98	96	67	75	63
15	95	100	95	85	93	95	98	98	100	100	100
16	100	94	100	80	95	80	99	99	93	93	93
17	63	65	94	27	45	43	97	90	60	65	65
18	70	96	100	74	99	86	99	98	93	93	88
19	91	94	99	82	79	94	99	99	100	100	98

**Table III-21: Class B4 Grade Report - Second Semester (Reference 2)**

<b>School-B Class B4 Second Semester (Reference 2)</b>											
Serial No.	Islamic Studies	Arabic	Social Studies	English	Maths	Science	Activities	Holy Quran	Reading	Listening	Conver- sation
1	100	100	100	95	99	94	99	100	100	100	100
2	96	95	98	94	95	96	98	100	97	95	93
3	100	100	100	93	94	89	98	99	100	100	100
4	100	100	100	98	98	99	99	100	100	100	100
5	98	94	100	97	95	98	98	100	98	100	95
6	99	96	100	82	96	86	97	100	93	100	95
7	94	84	95	65	70	74	88	100	90	85	75
8	97	93	99	69	86	79	95	100	92	93	90
9	92	80	97	52	65	74	90	99	78	78	85
10	100	100	100	99	100	100	100	100	100	100	100
11	99	97	100	83	93	90	98	100	80	98	90
12	98	95	100	88	93	96	98	98	78	98	95
13	94	83	99	54	68	71	91	94	78	80	85
14	83	71	99	58	92	61	96	97	67	50	70
15	96	92	98	84	83	97	98	98	100	100	100
16	100	100	99	85	96	88	96	99	95	90	90
17	67	64	96	31	50	50	90	90	67	50	65
18	98	94	100	72	79	85	97	98	83	90	90
19	100	100	100	84	99	94	99	98	93	95	98

## IV. Appendix D: Detailed Charts for School-A

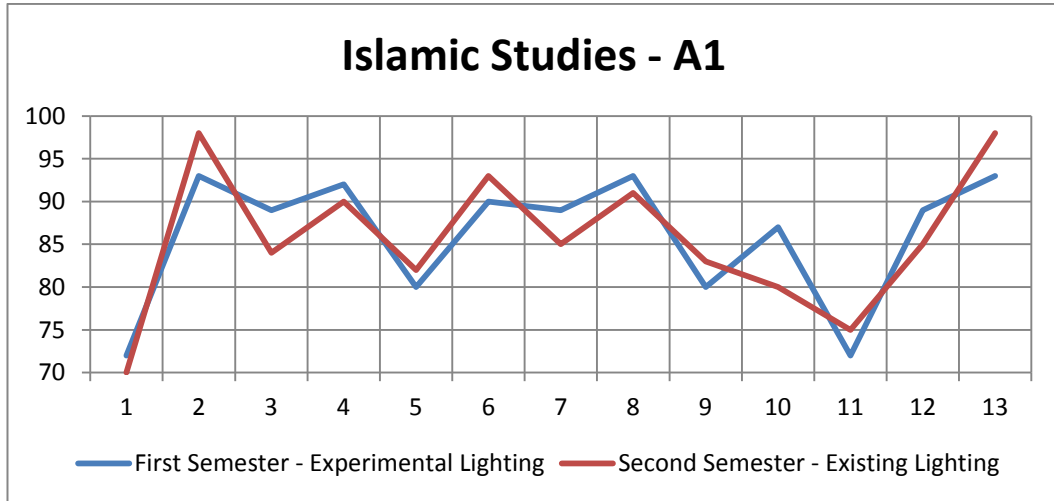


Figure IV-1: Class A1 Islamic Studies Results Comparison Chart (Done by the author).

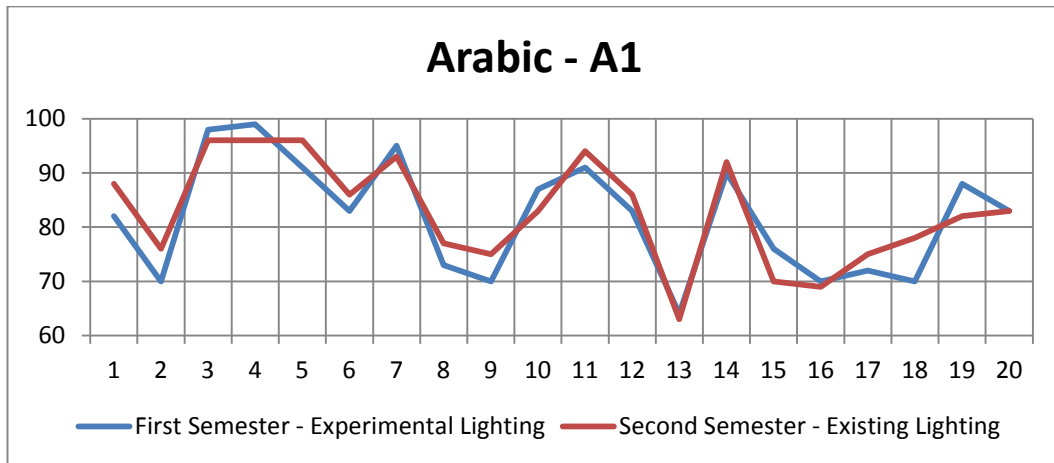


Figure IV-2: Class A1 Arabic Results Comparison Chart (Done by the author).

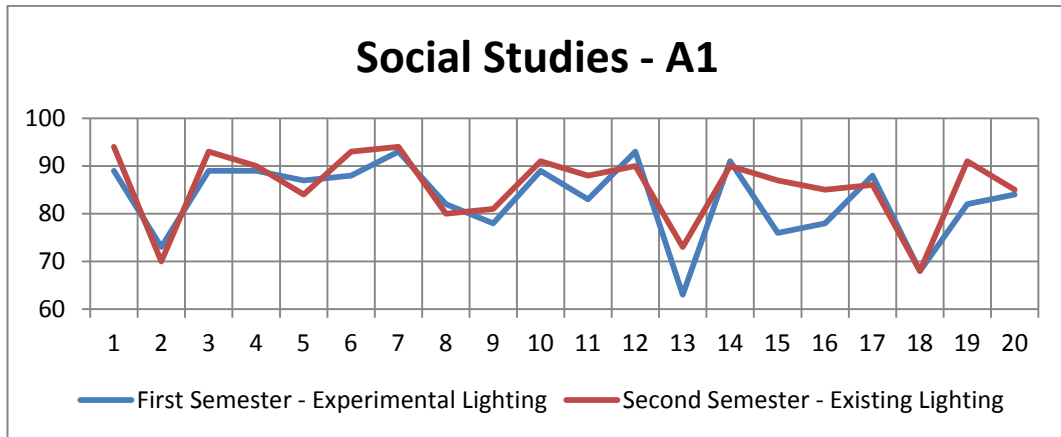


Figure IV-3: Class A1 Social Studies Results Comparison Chart (Done by the author).

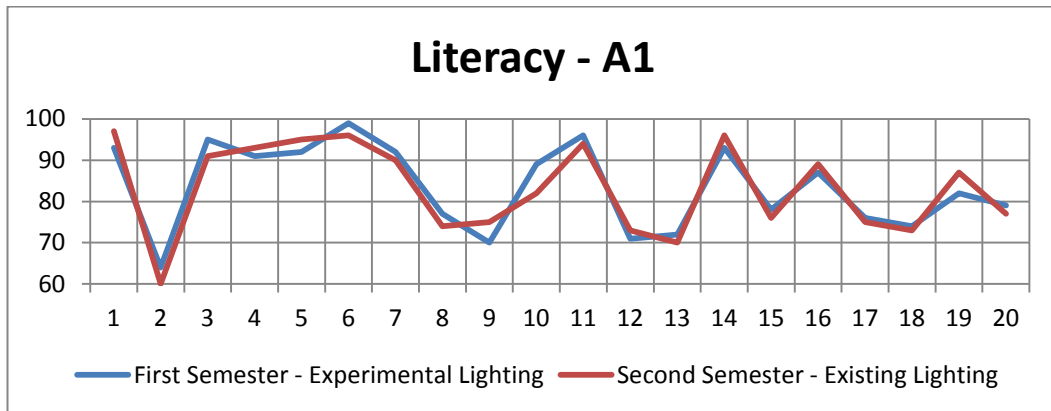


Figure IV-4: Class A1 Literacy Results Comparison Chart (Done by the author).

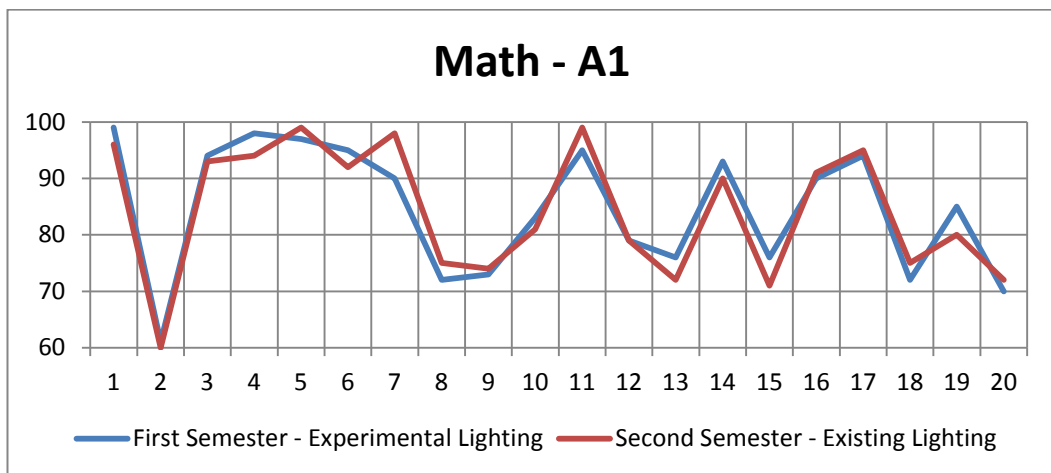


Figure IV-5: Class A1 Math Results Comparison Chart (Done by the author).

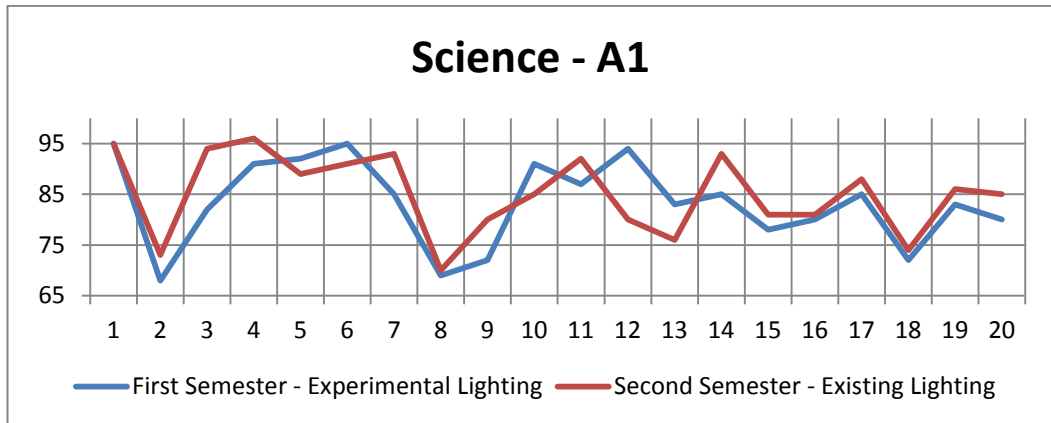


Figure IV-6: Class A1 Science Results Comparison Chart (Done by the author).

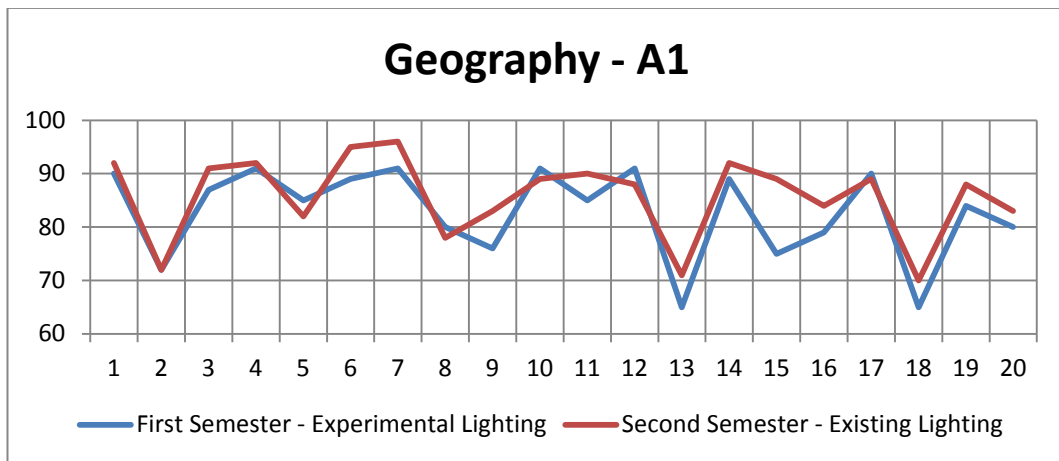


Figure IV-7: Class A1 Geography Results Comparison Chart (Done by the author).

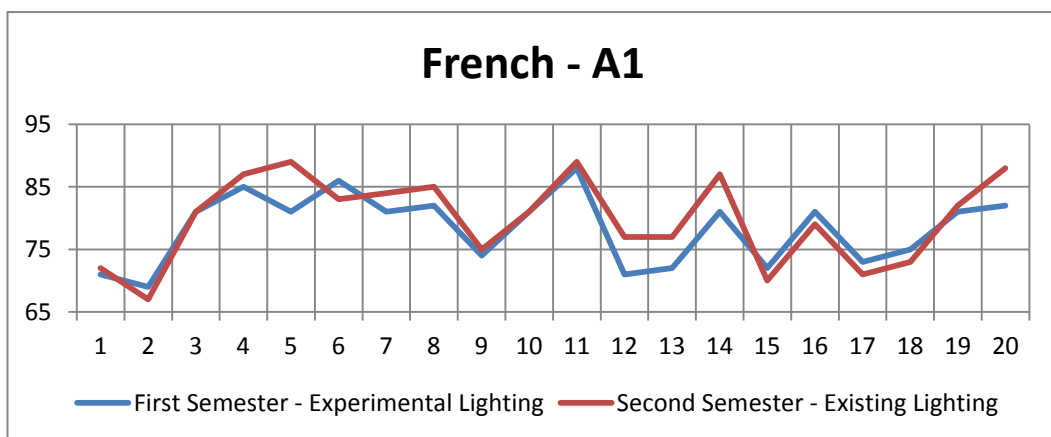


Figure IV-8: Class A1 French Results Comparison Chart (Done by the author).

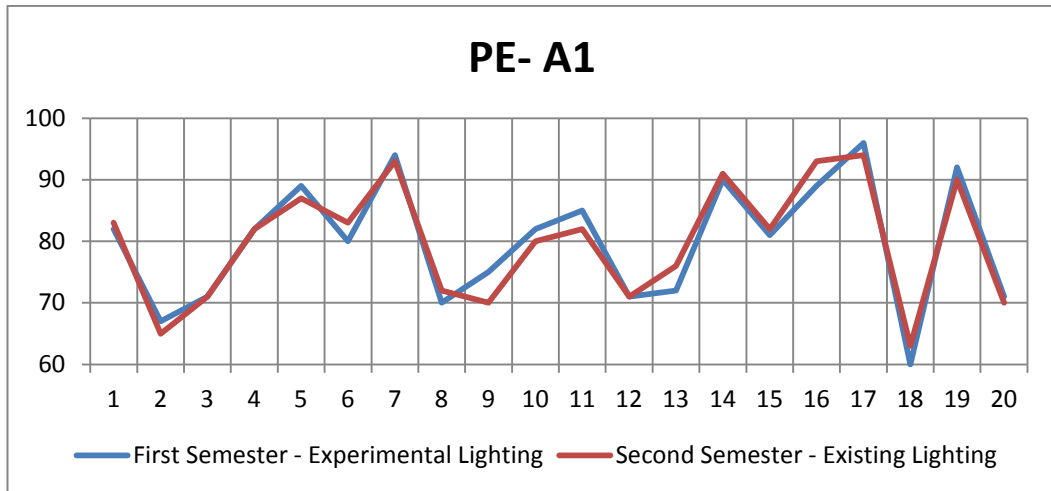


Figure IV-9: Class A1 PE Results Comparison Chart (Done by the author)

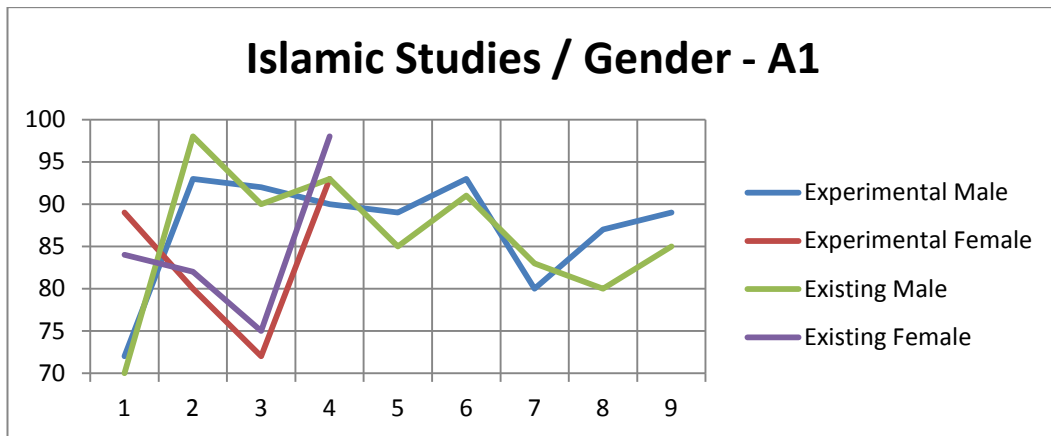


Figure IV-10: Class A1 Islamic Studies / Gender Results Comparison Chart (Done by the author).

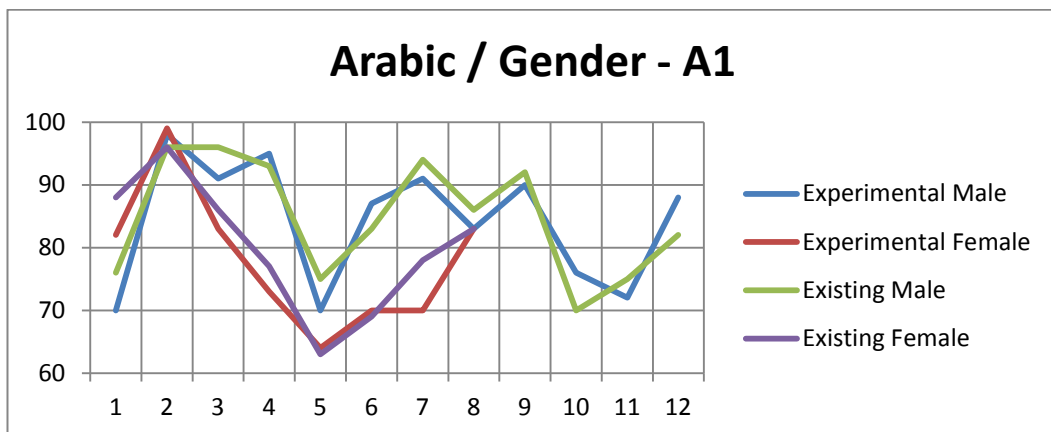
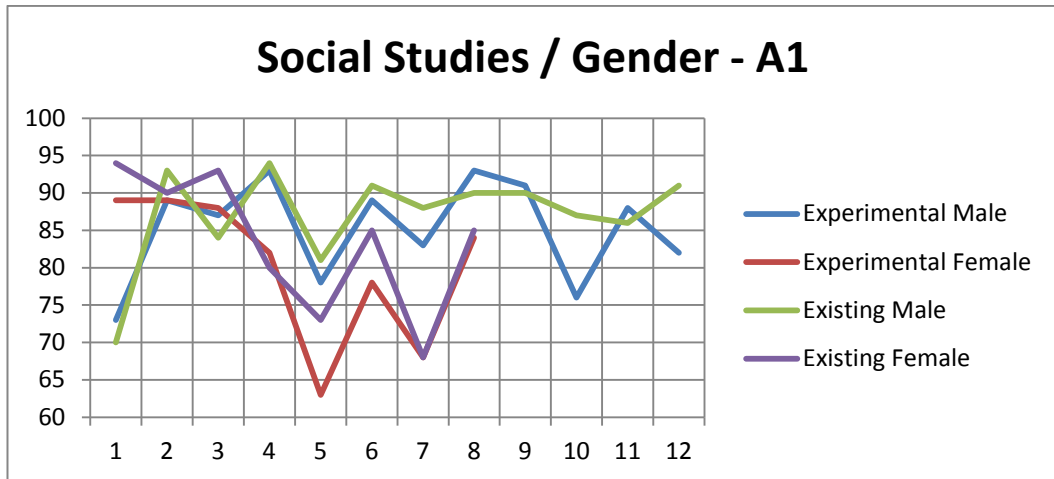
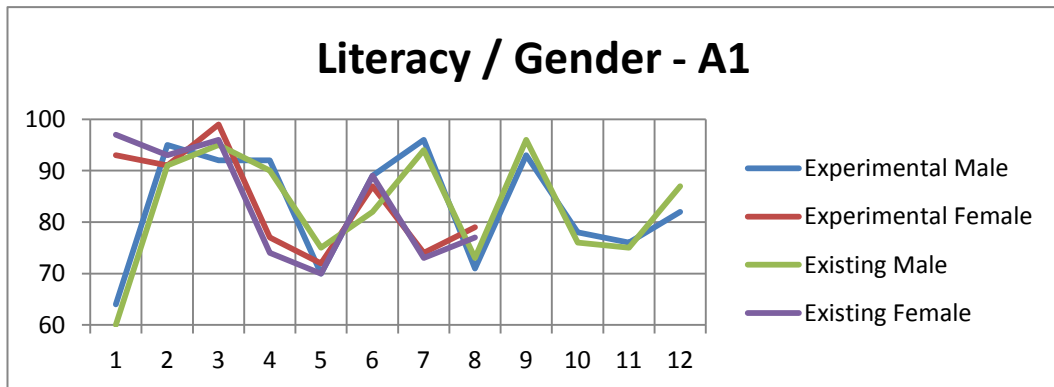


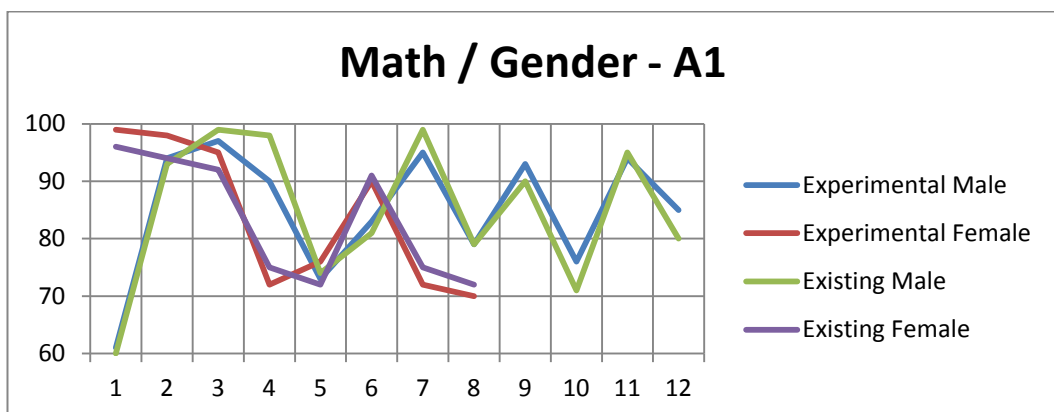
Figure IV-11: Class A1 Arabic / Gender Results Comparison Chart (Done by the author).



**Figure IV-12: Class A1 Social Studies / Gender Results Comparison Chart (Done by the author).**



**Figure IV-13: Class A1 Literacy / Gender Results Comparison Chart (Done by the author).**



**Figure IV-14: Class A1 Math / Gender Results Comparison Chart (Done by the author).**

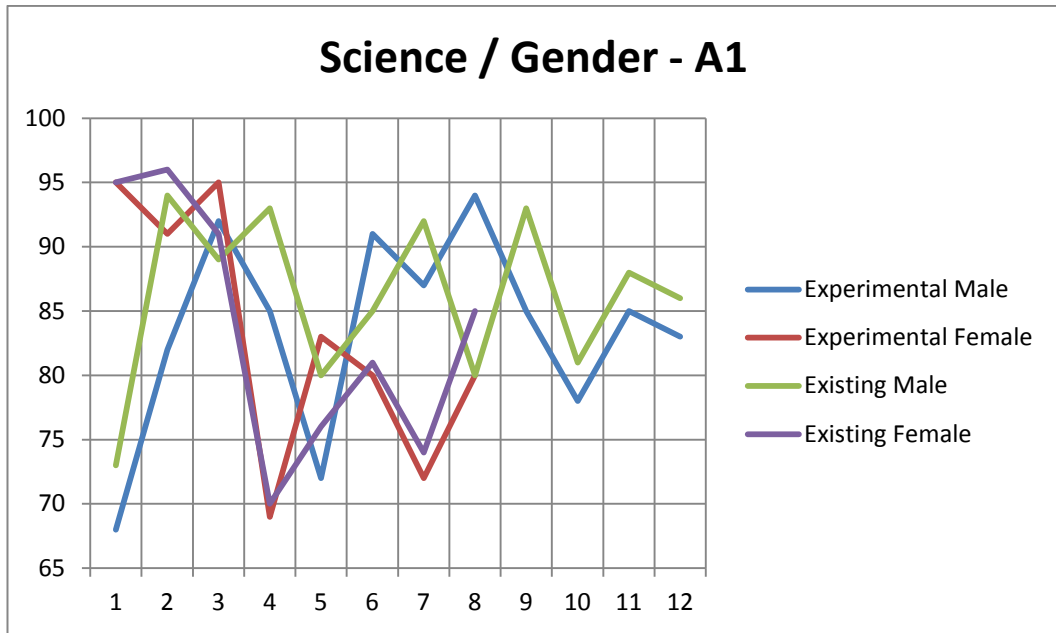


Figure IV-15: Class A1 Science / Gender Results Comparison Chart (Done by the author).

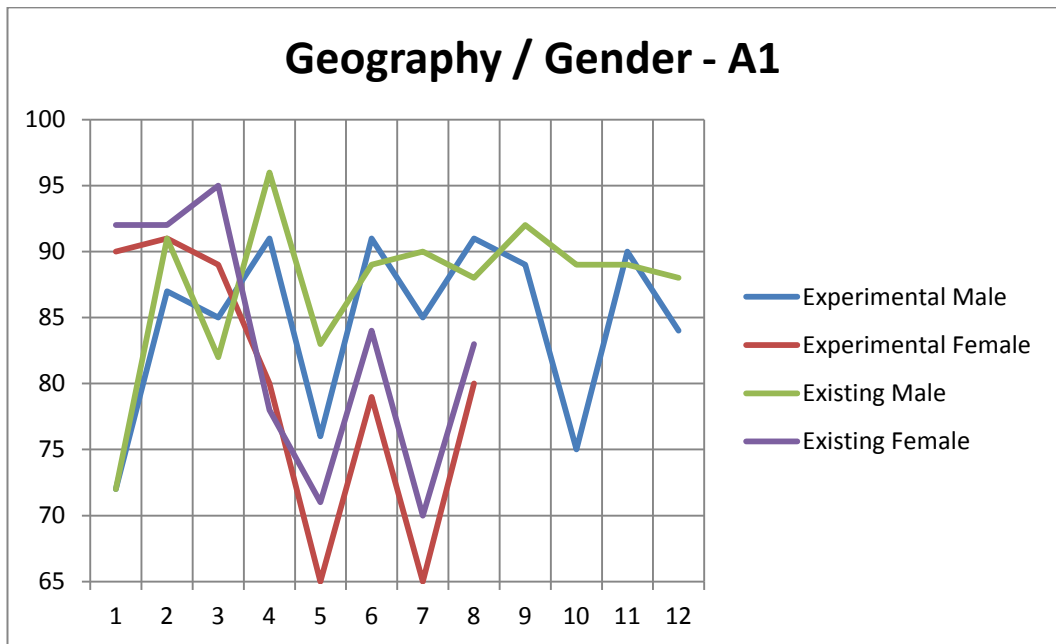


Figure IV-16: Class A1 Geography / Gender Results Comparison Chart (Done by the author).



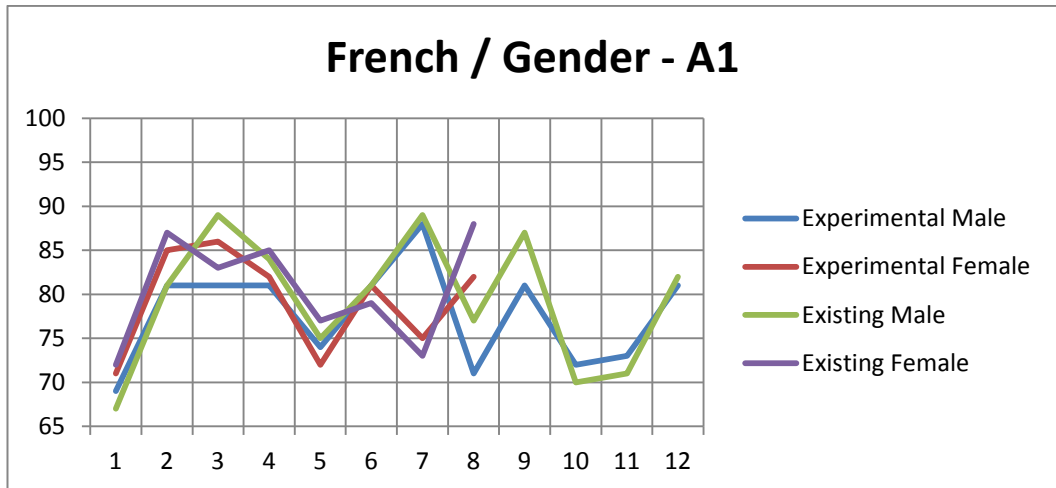


Figure IV-17: Class A1 French / Gender Results Comparison Chart (Done by the author).

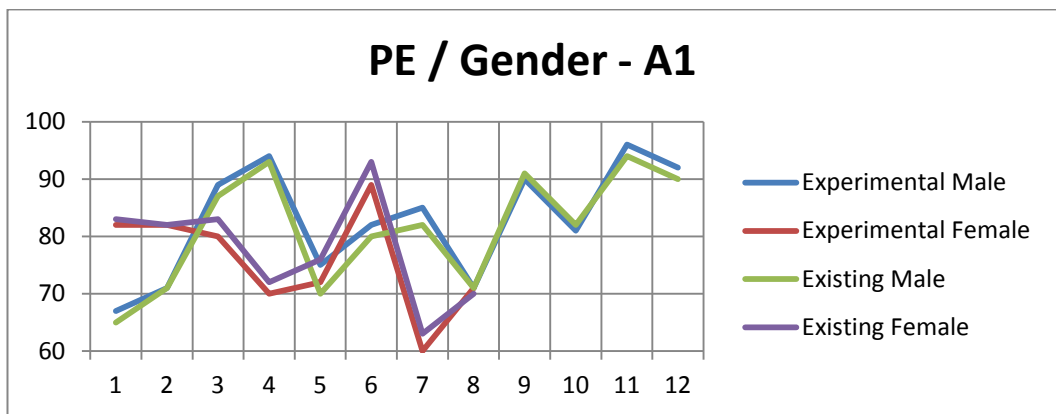


Figure IV-18: Class A1 PE / Gender Results Comparison Chart (Done by the author).

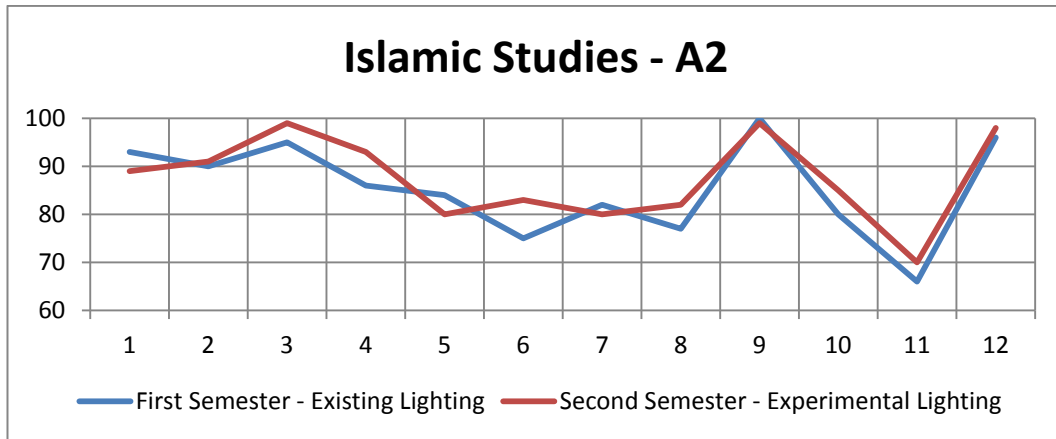


Figure IV-19: Class A2 Islamic Studies Results Comparison Chart (Done by the author).

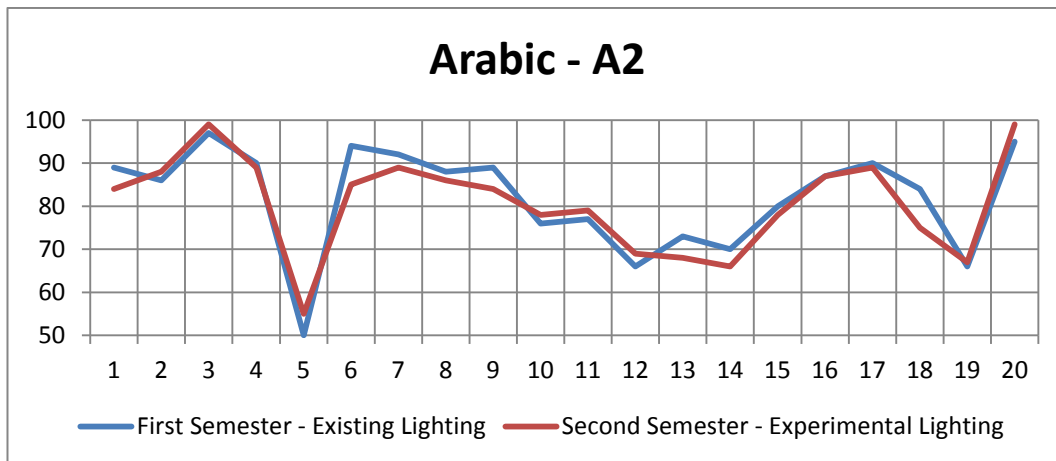


Figure IV-20: Class A2 Arabic Results Comparison Chart (Done by the author).

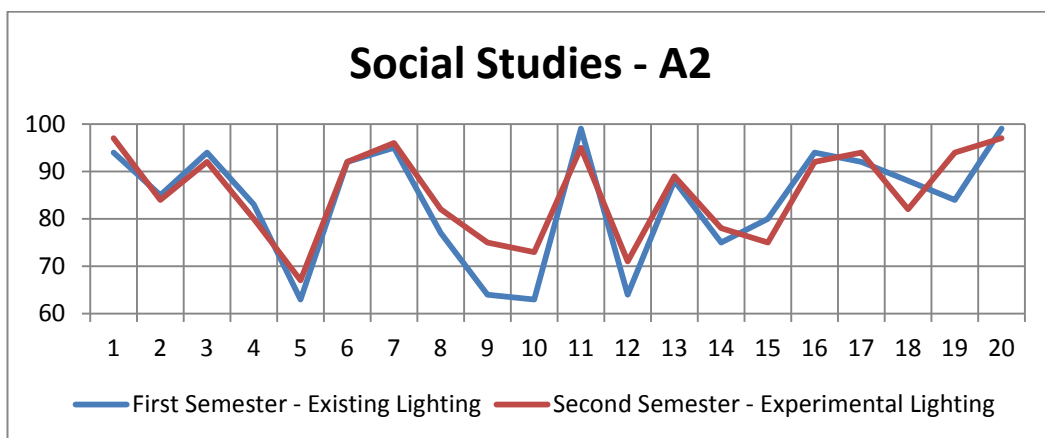


Figure IV-21: Class A2 Social Studies Results Comparison Chart (Done by the author).

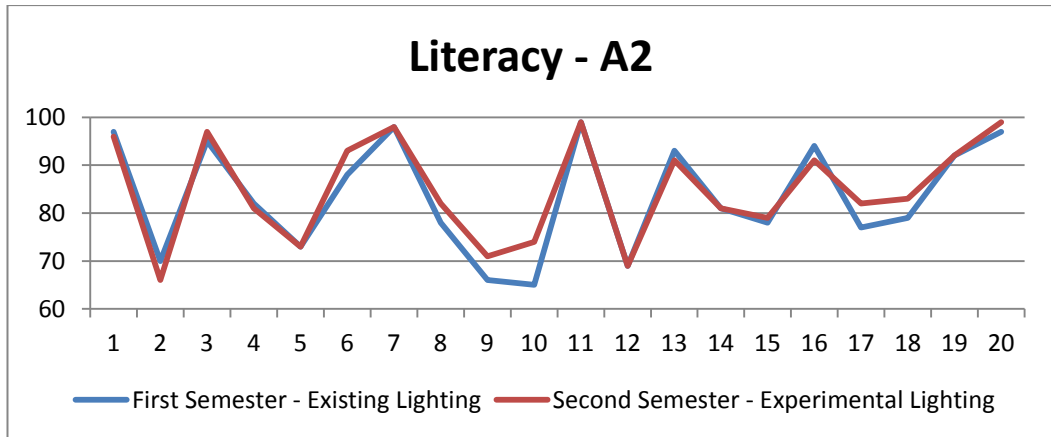


Figure IV-22: Class A2 Literacy Results Comparison Chart (Done by the author).

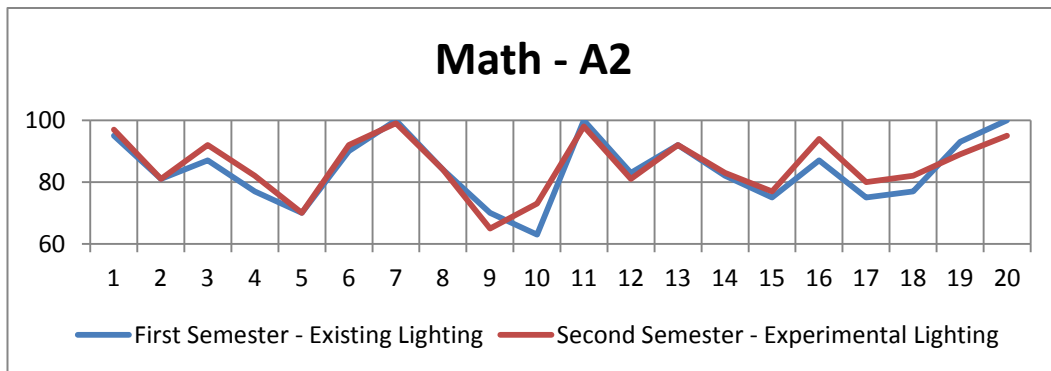


Figure IV-23: Class A2 Math Results Comparison Chart (Done by the author).

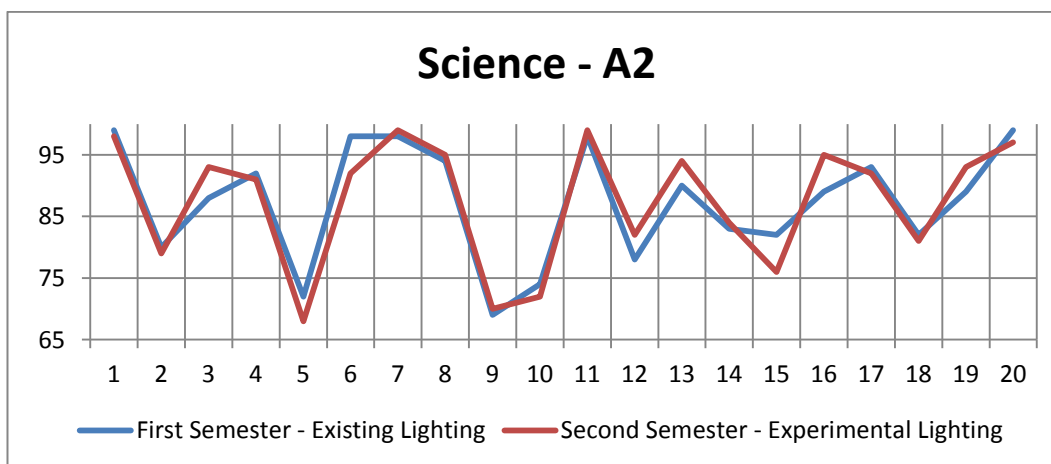


Figure IV-24: Class A2 Science Results Comparison Chart (Done by the author).

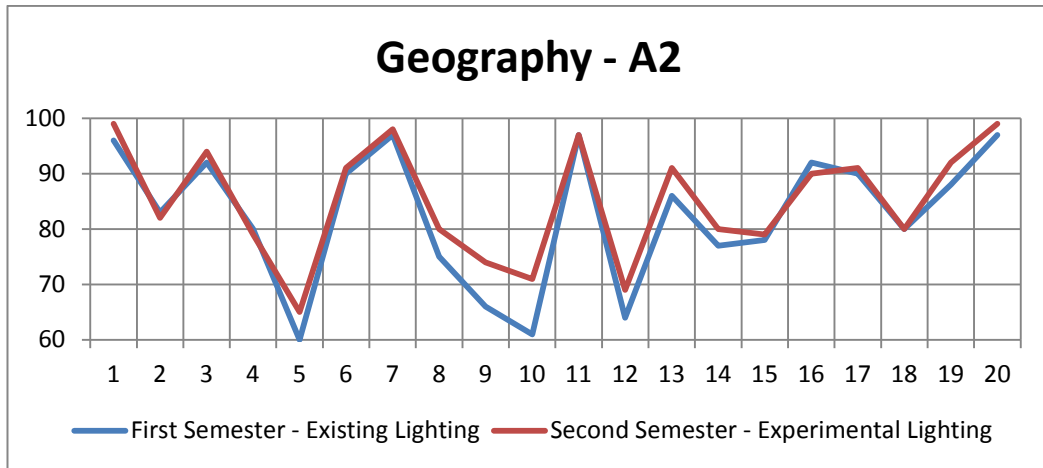


Figure IV-25: Class A2 Geography Results Comparison Chart (Done by the author).

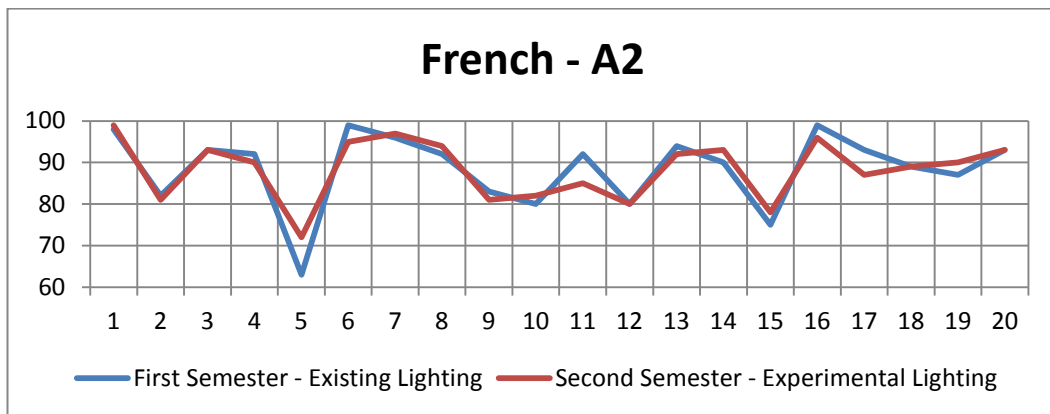


Figure IV-26: Class A2 French Results Comparison Chart (Done by the author).

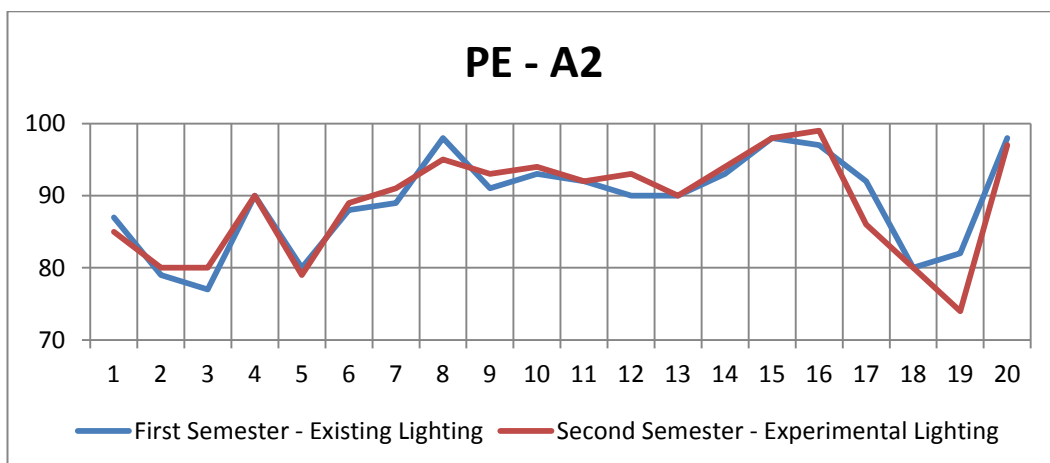


Figure IV-27: Class A2 PE Results Comparison Chart (Done by the author).

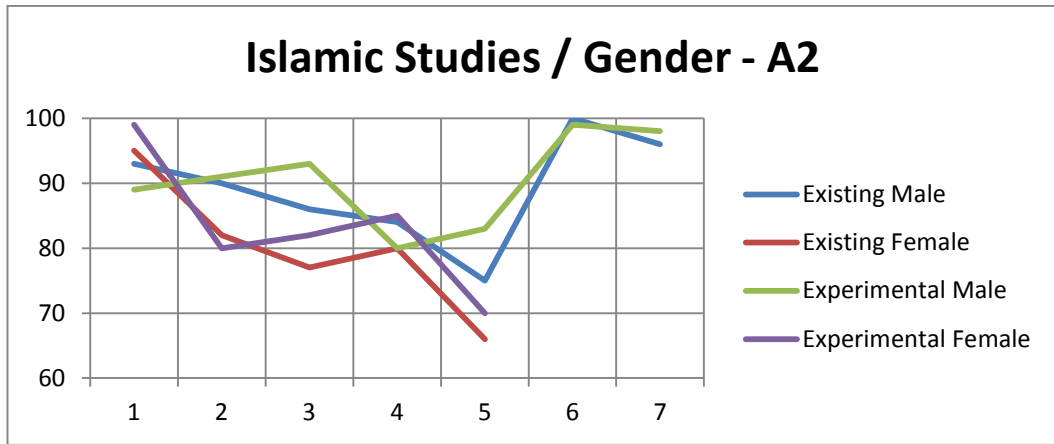


Figure IV-28: Class A2 Islamic Studies / Gender Results Comparison Chart (Done by the author).

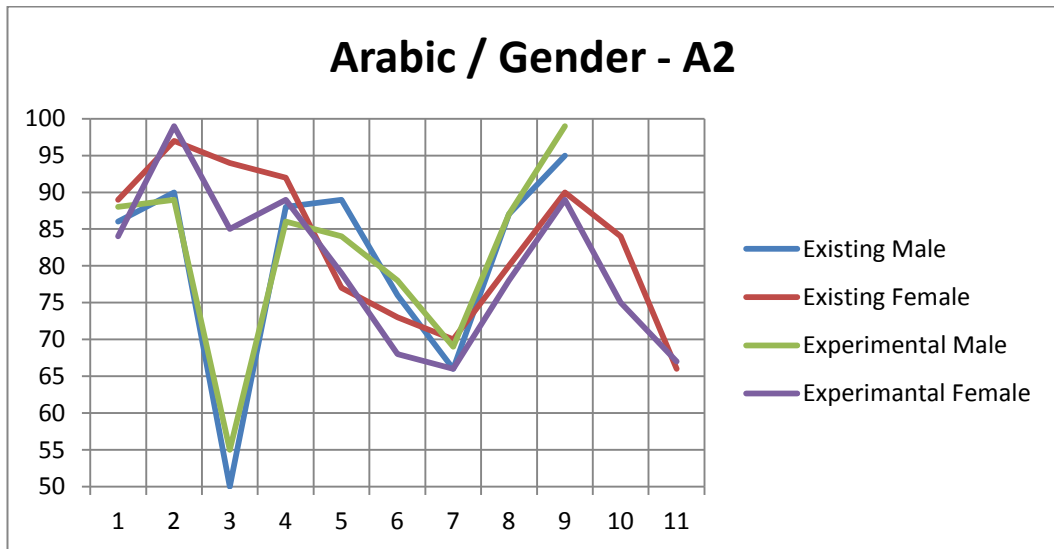


Figure IV-29: Class A2 Arabic / Gender Results Comparison Chart (Done by the author).

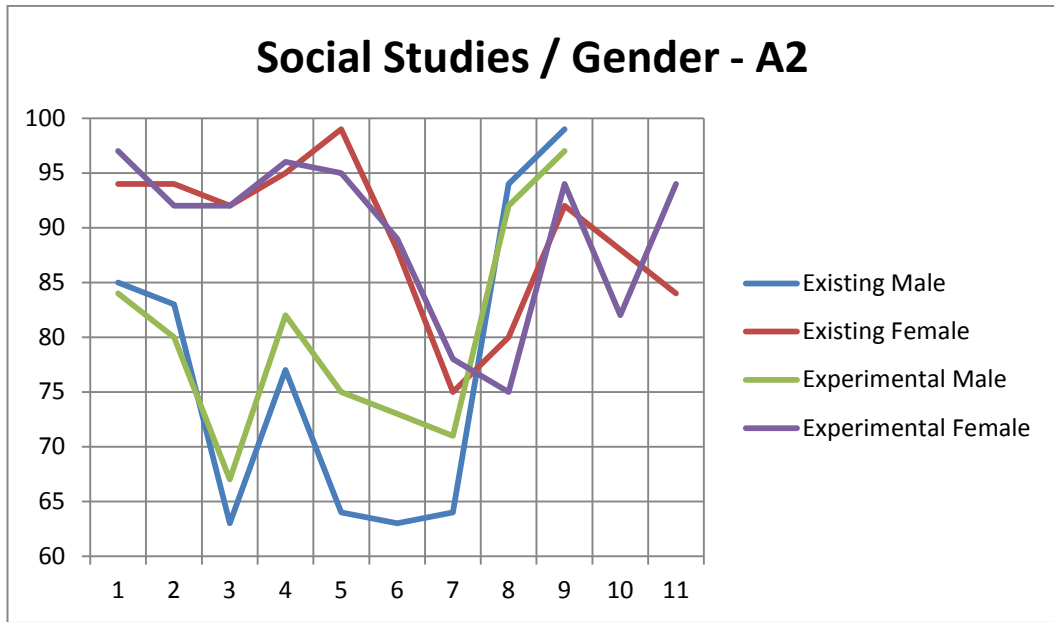


Figure IV-30: Class A2 Social Studies / Gender Results Comparison Chart (Done by the author).

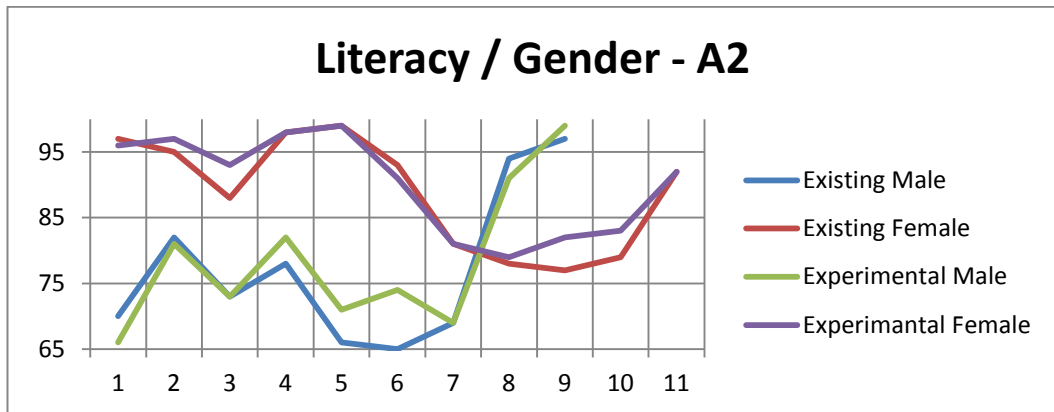


Figure IV-31: Class A2 Literacy / Gender Results Comparison Chart (Done by the author).

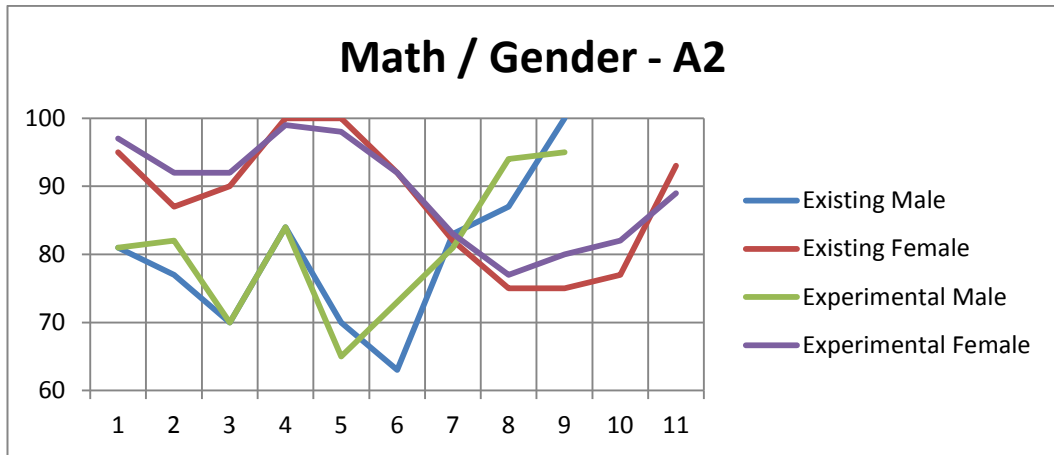


Figure IV-32: Class A2 Math / Gender Results Comparison Chart (Done by the author).

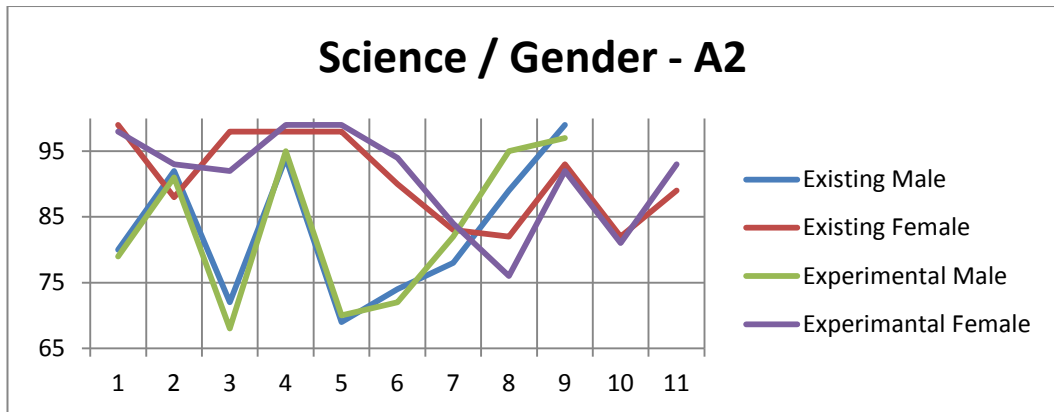


Figure IV-33: Class A2 Science / Gender Results Comparison Chart (Done by the author).

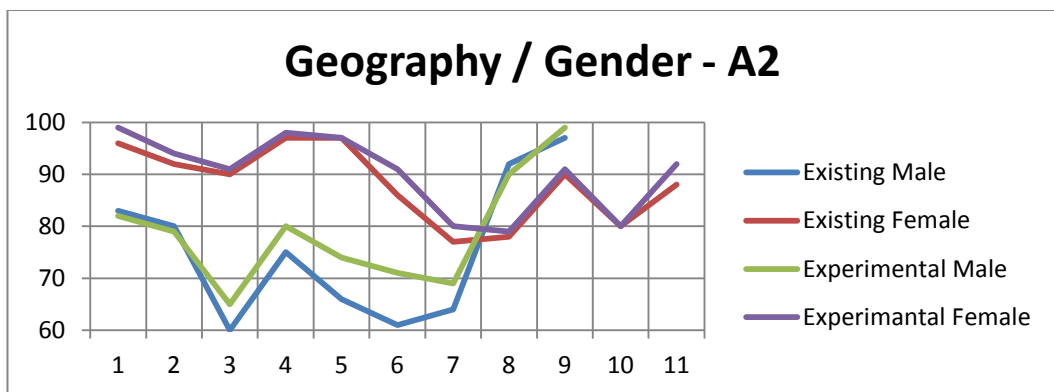


Figure IV-34: Class A2 Geography / Gender Results Comparison Chart (Done by the author).

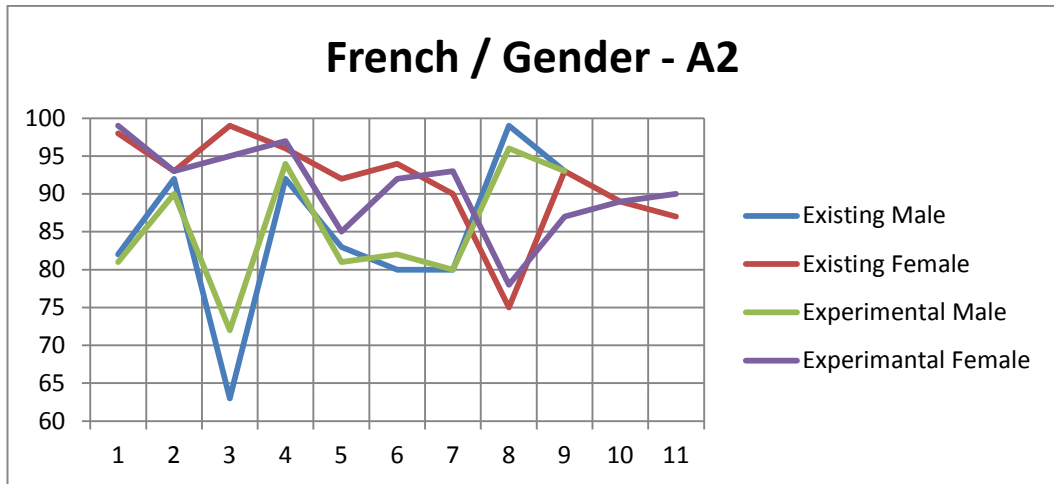


Figure IV-35: Class A2 French / Gender Results Comparison Chart (Done by the author).

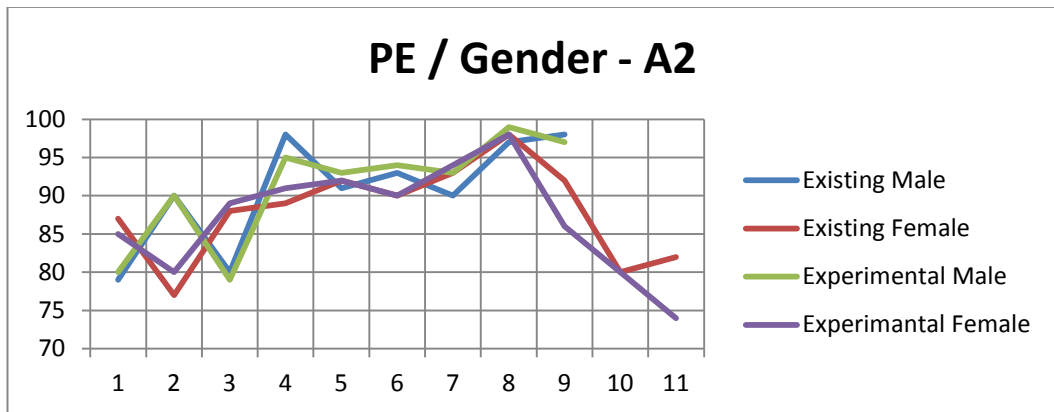


Figure IV-36: Class A2 PE / Gender Results Comparison Chart (Done by the author).



## V. Appendix E: Detailed Charts for School-B

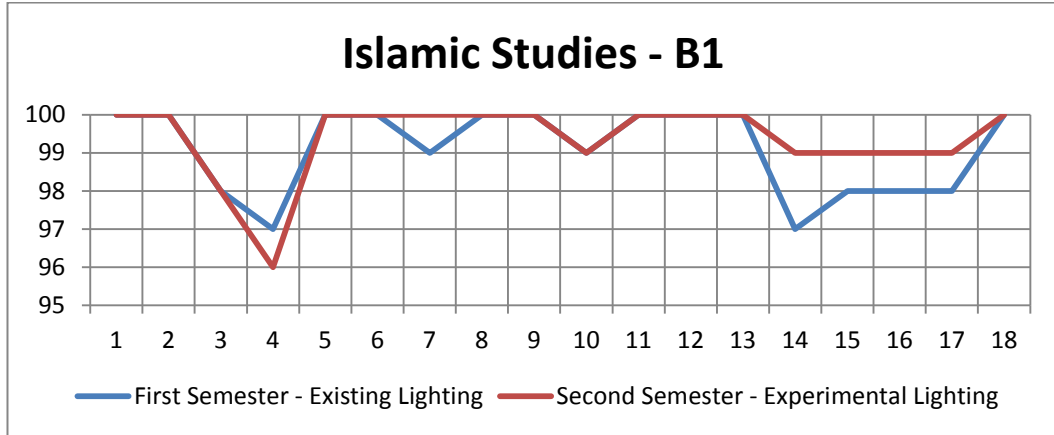


Figure V-1: Class B1 Islamic Studies Results Comparison Chart (Done by the author).

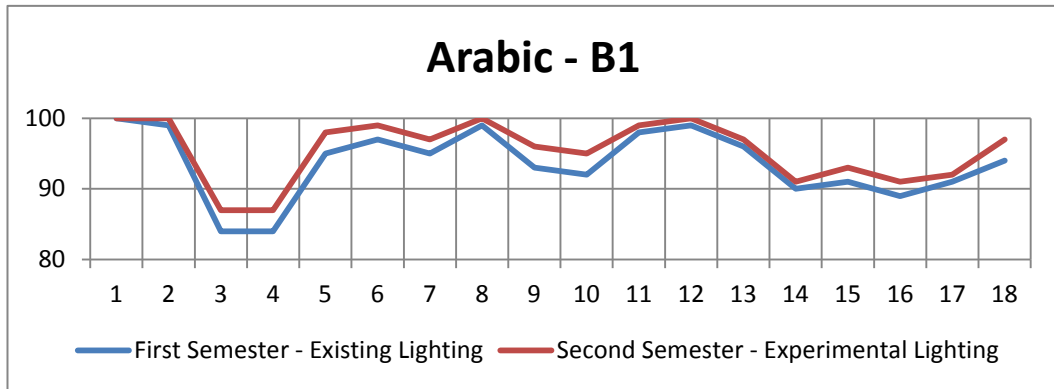


Figure V-2: Class B1 Arabic Results Comparison Chart (Done by the author).

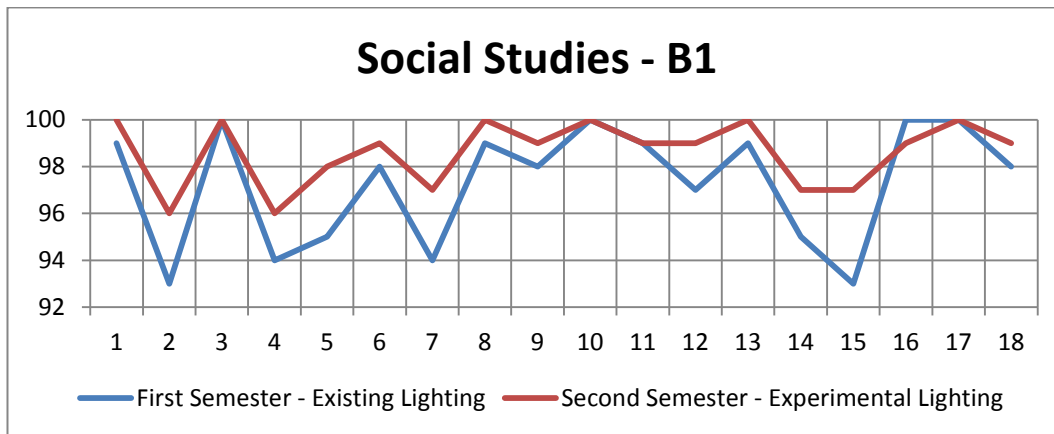


Figure V-3: Class B1 Social Studies Results Comparison Chart (Done by the author).

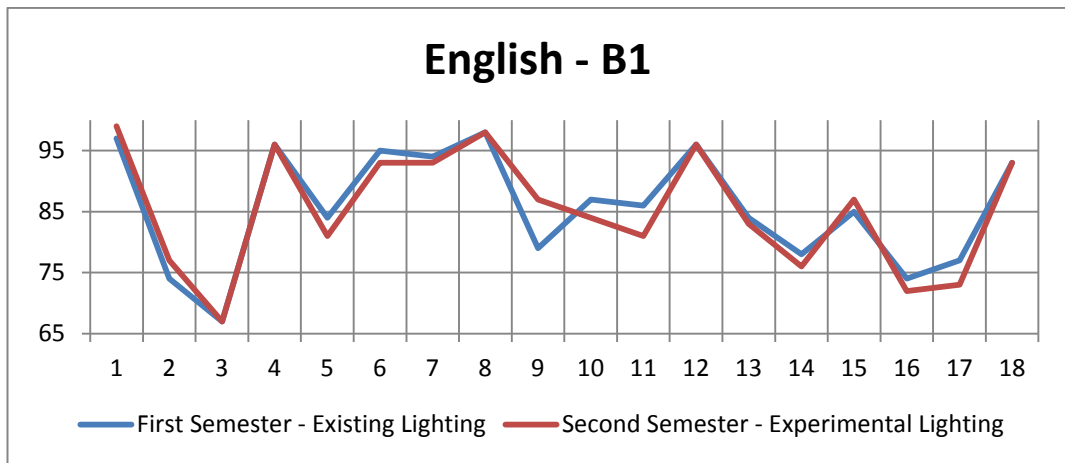


Figure V-4: Class B1 English Results Comparison Chart (Done by the author).

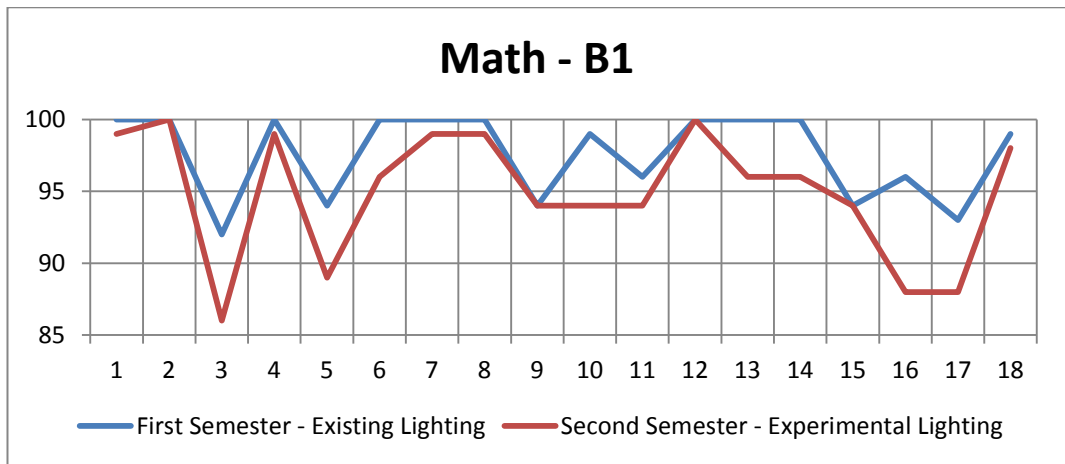


Figure V-5: Class B1 Math Results Comparison Chart (Done by the author).

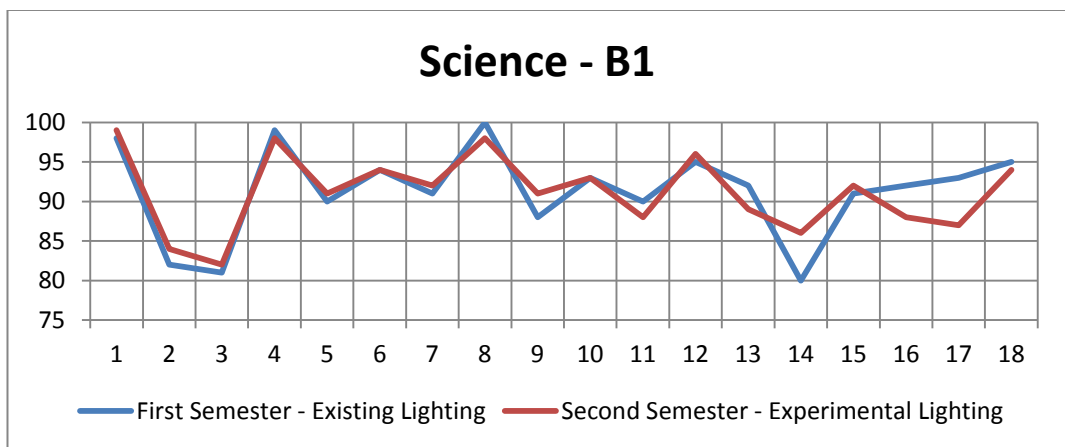


Figure V-6: Class B1 Science Results Comparison Chart (Done by the author).

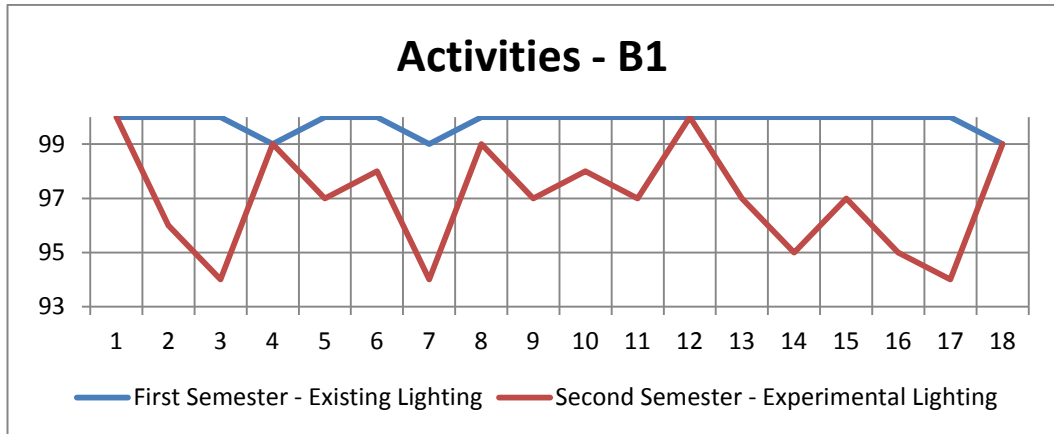


Figure V-7: Class B1 Activities Results Comparison Chart (Done by the author).

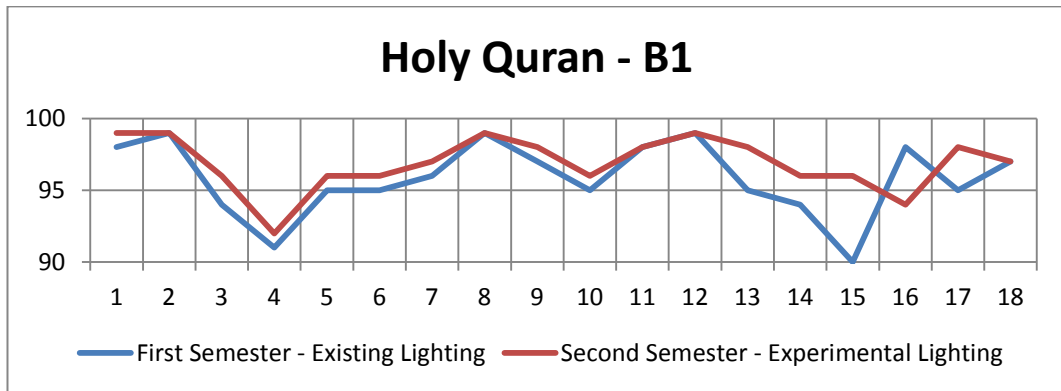


Figure V-8: Class B1 Holy Quran Results Comparison Chart (Done by the author).

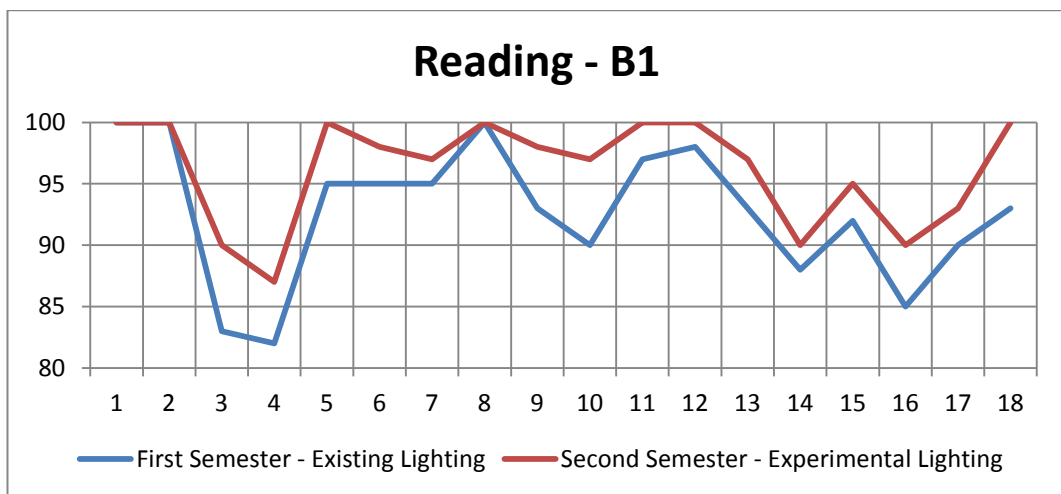


Figure V-9: Class B1 Reading Results Comparison Chart (Done by the author).

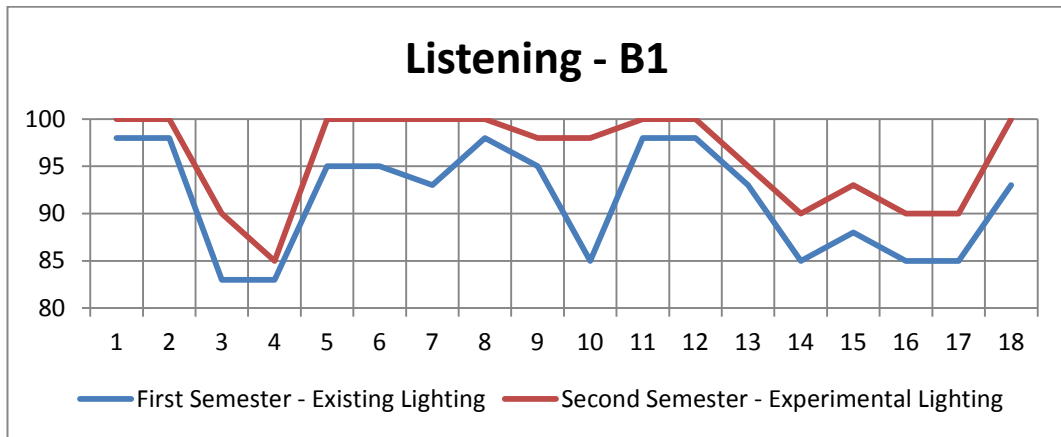


Figure V-10: Class B1 Listening Results Comparison Chart (Done by the author).

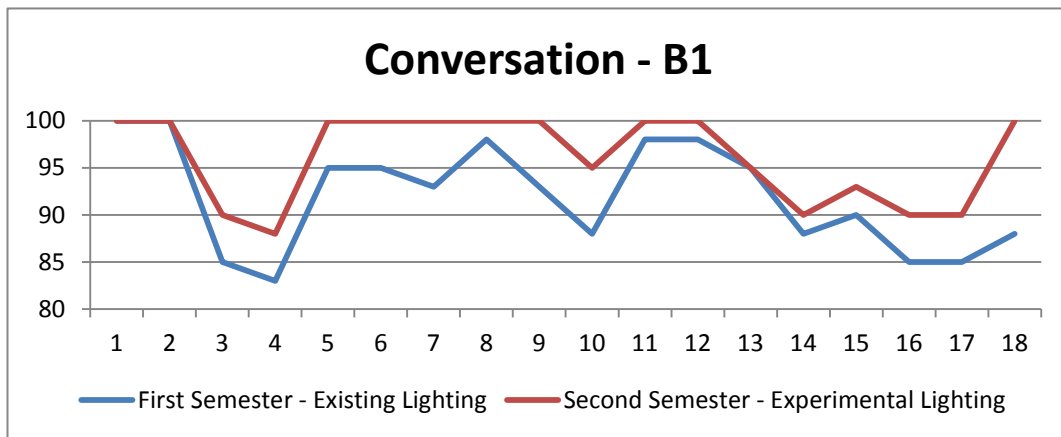


Figure V-11: Class B1 Conversation Results Comparison Chart (Done by the author).

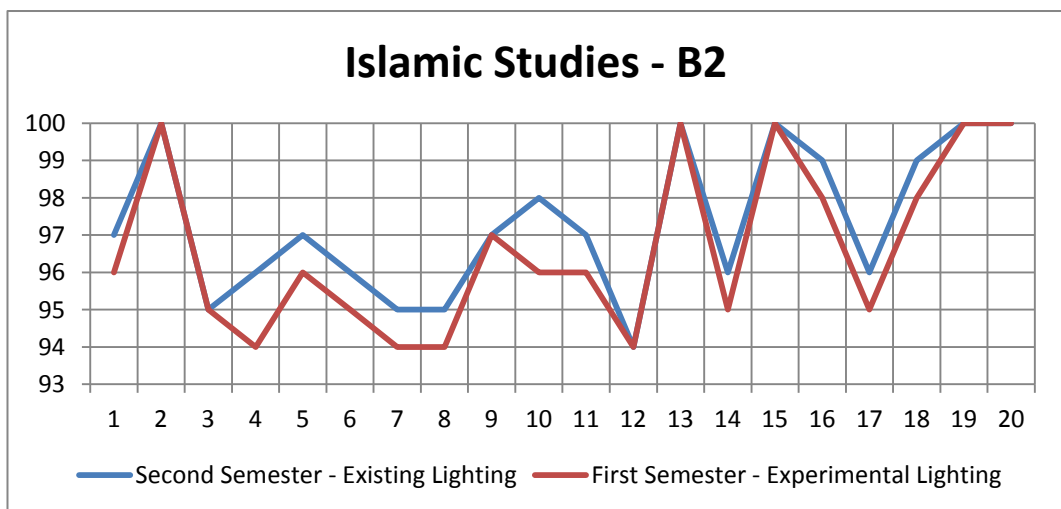


Figure V-12: Class B2 Islamic Studies Results Comparison Chart (Done by the author).

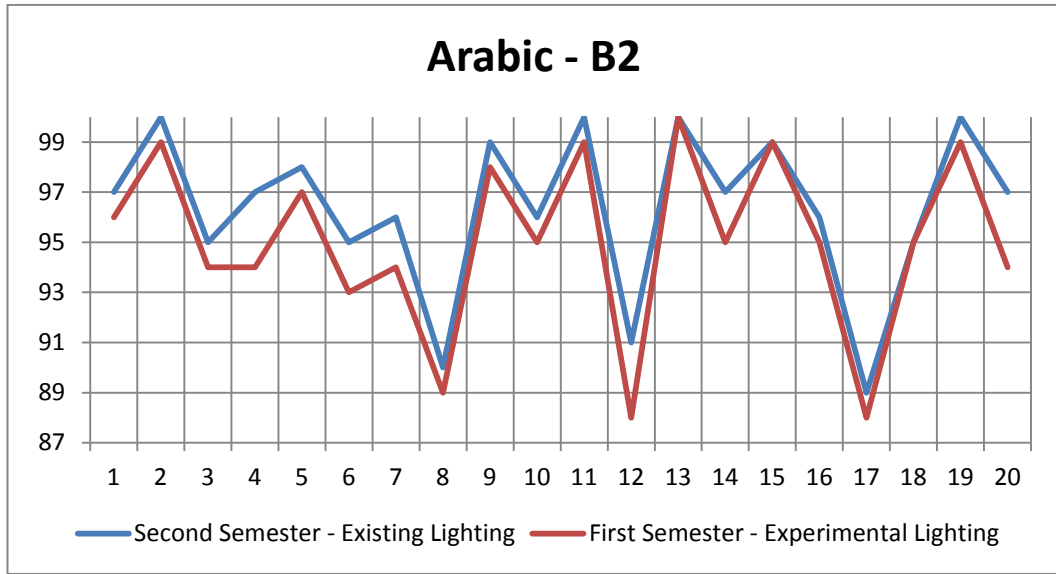


Figure V-13: Class B2 Arabic Results Comparison Chart (Done by the author).

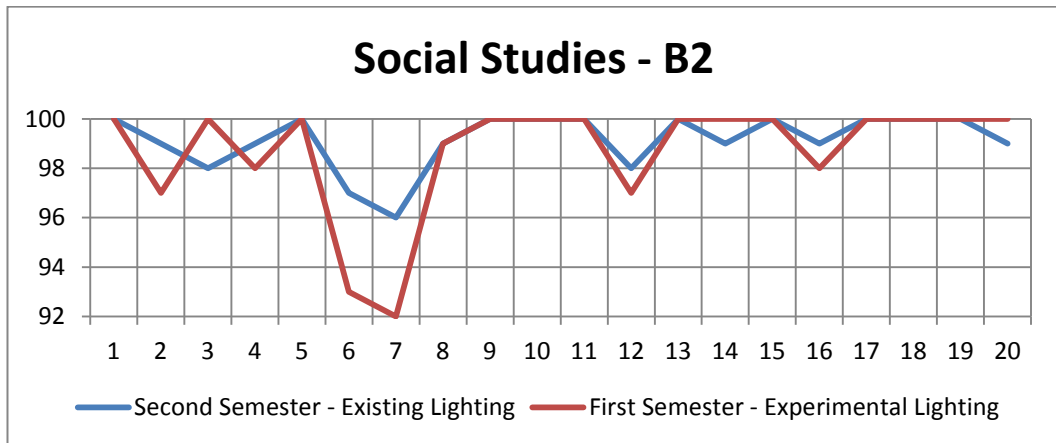


Figure V-14: Class B2 Social Studies Results Comparison Chart (Done by the author).

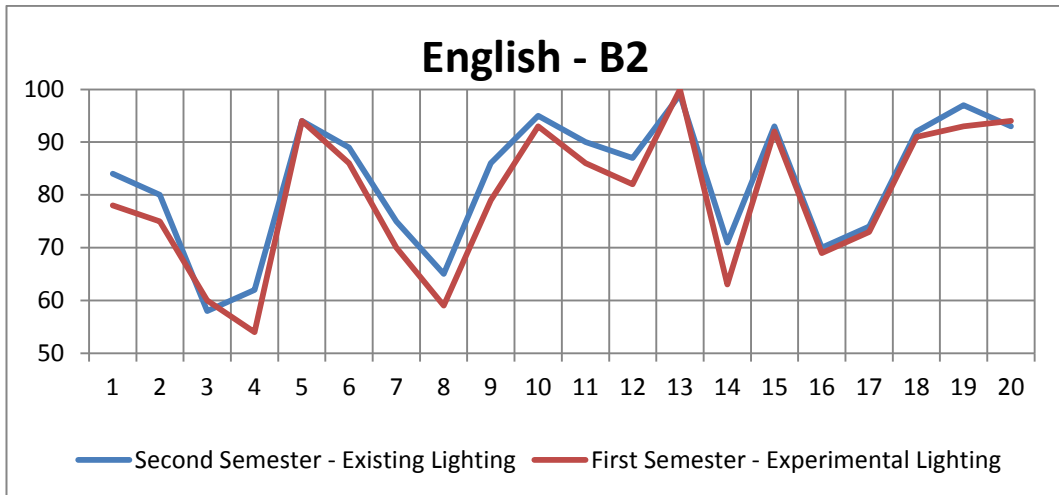


Figure V-15: Class B2 English Results Comparison Chart (Done by the author).

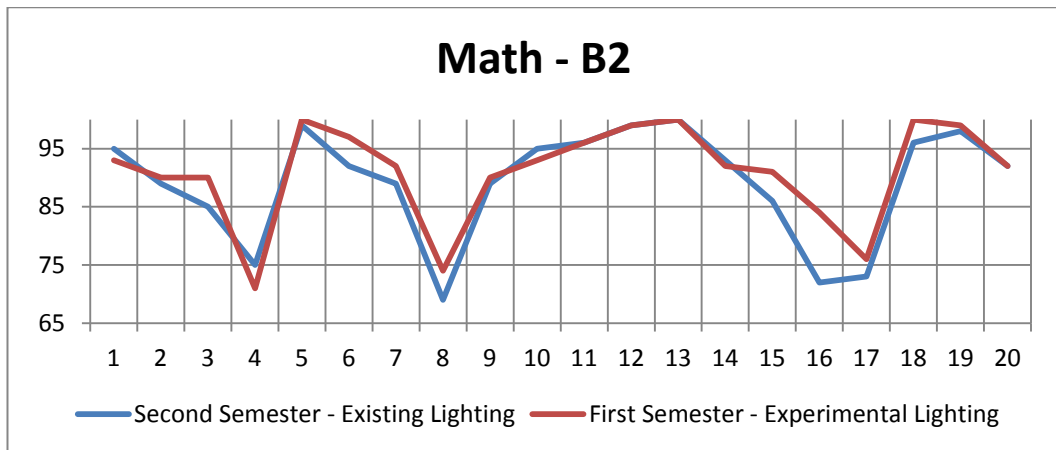


Figure V-16: Class B2 Math Results Comparison Chart (Done by the author).

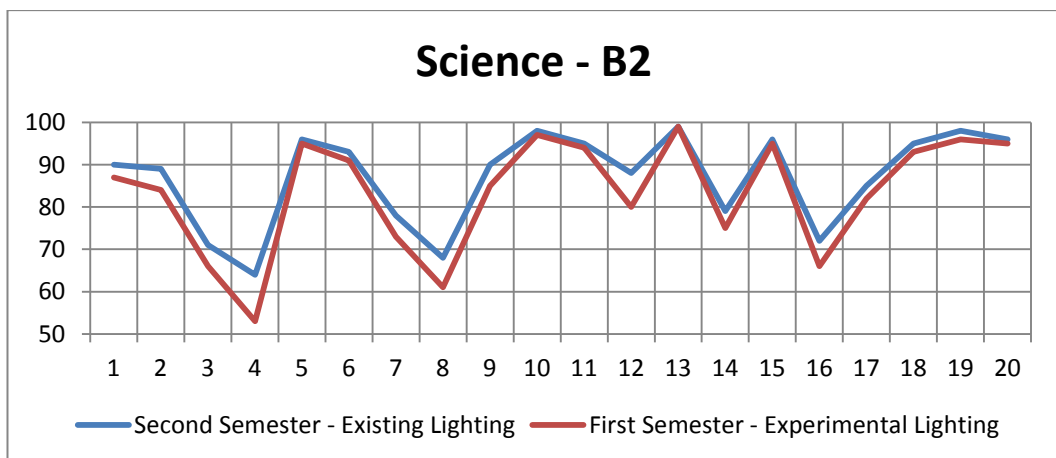


Figure V-17: Class B2 Science Results Comparison Chart (Done by the author).

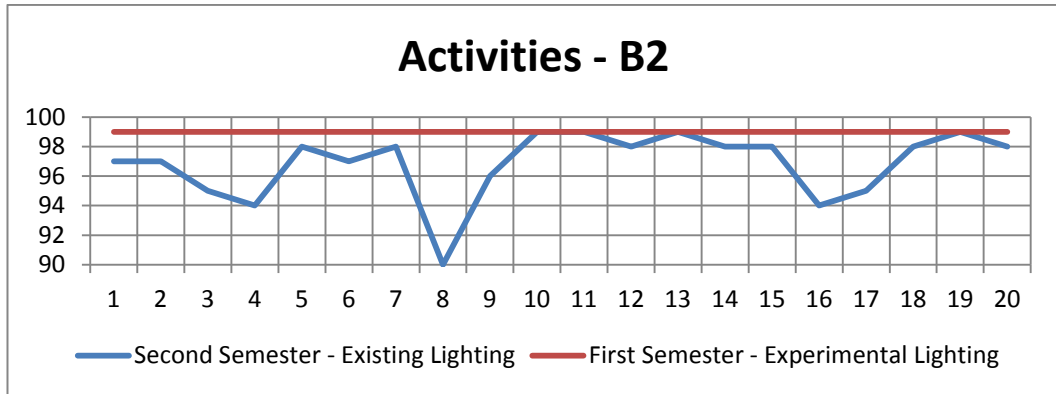


Figure V-18: Class B2 Activities Results Comparison Chart (Done by the author).

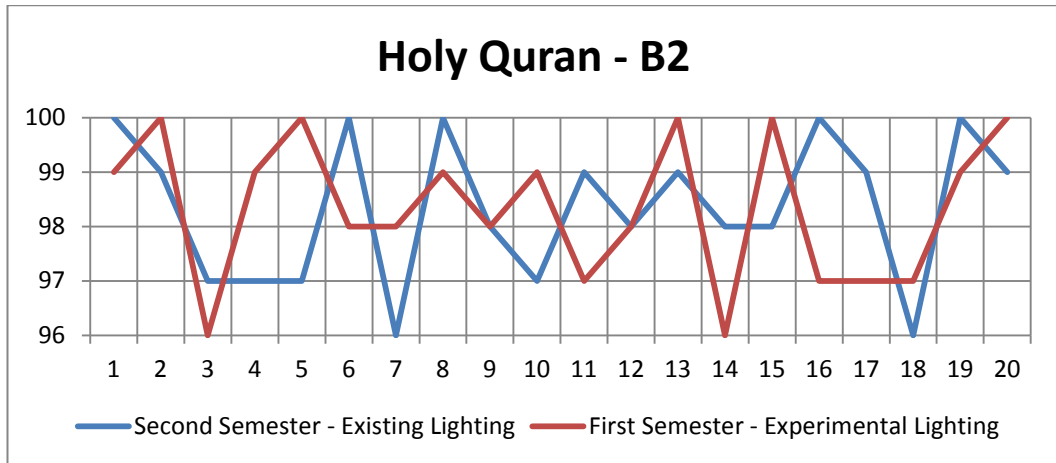


Figure V-19: Class B2 Holy Quran Results Comparison Chart (Done by the author).

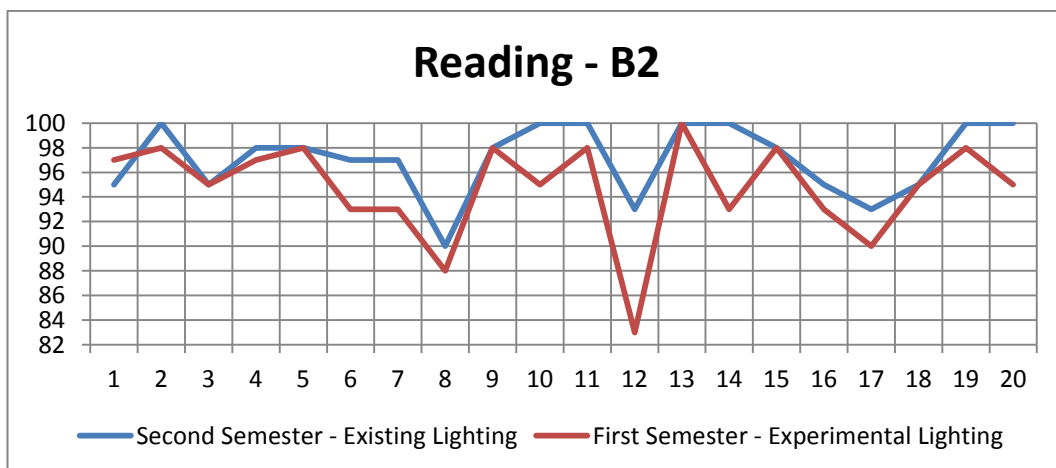


Figure V-20: Class B2 Reading Results Comparison Chart (Done by the author).

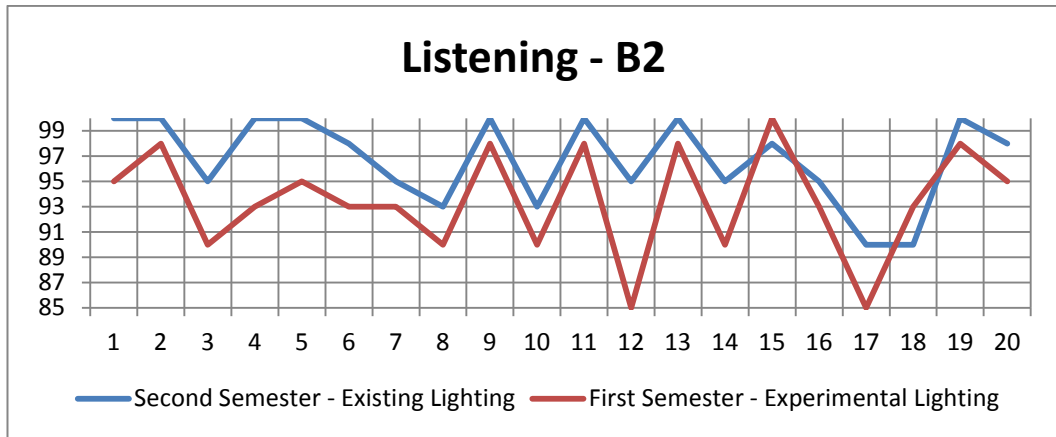


Figure V-21: Class B2 Listening Results Comparison Chart (Done by the author).

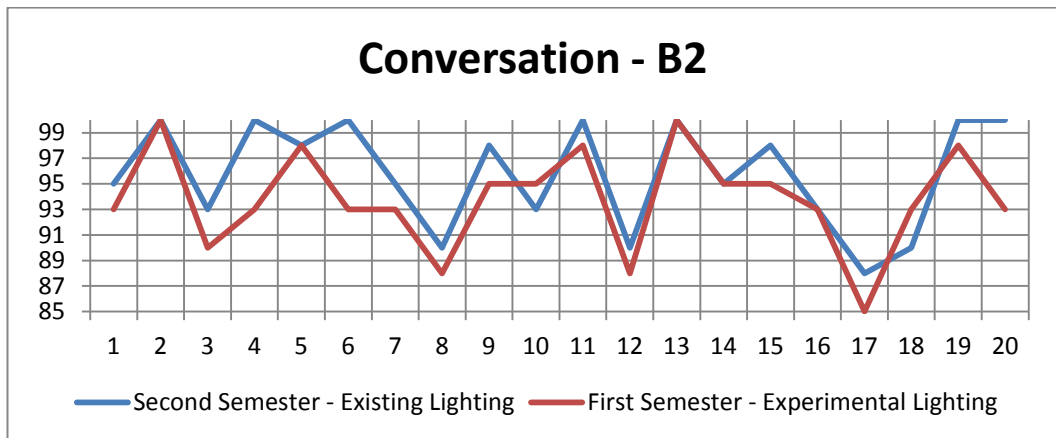


Figure V-22: Class B2 Conversation Results Comparison Chart (Done by the author).



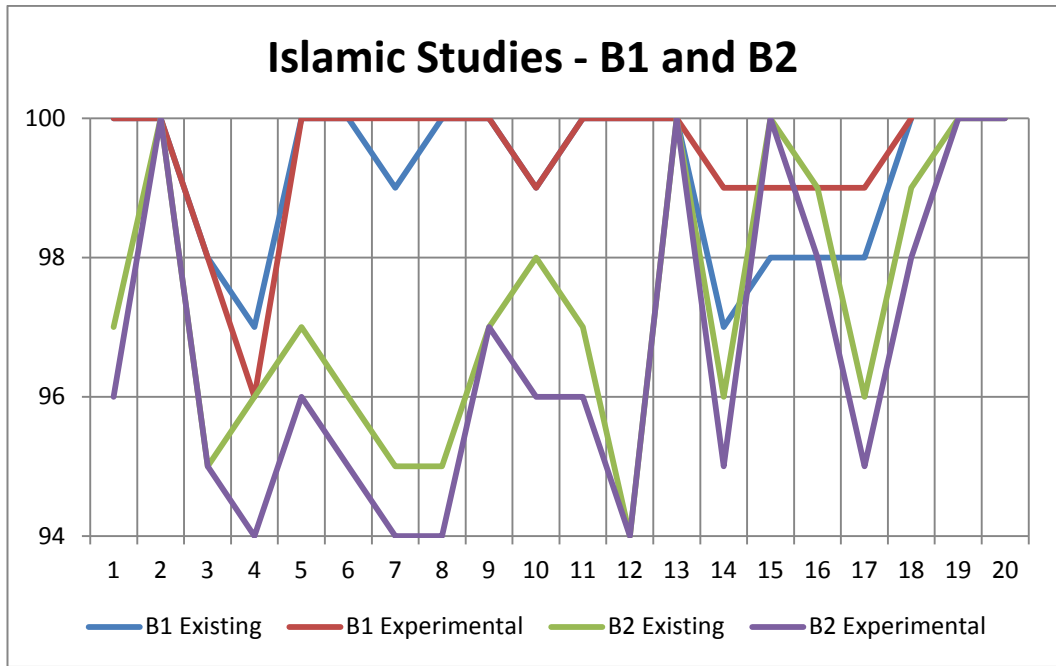


Figure V-23: Classes B1 and B2 Islamic Studies Results Comparison Chart (Done by the author).

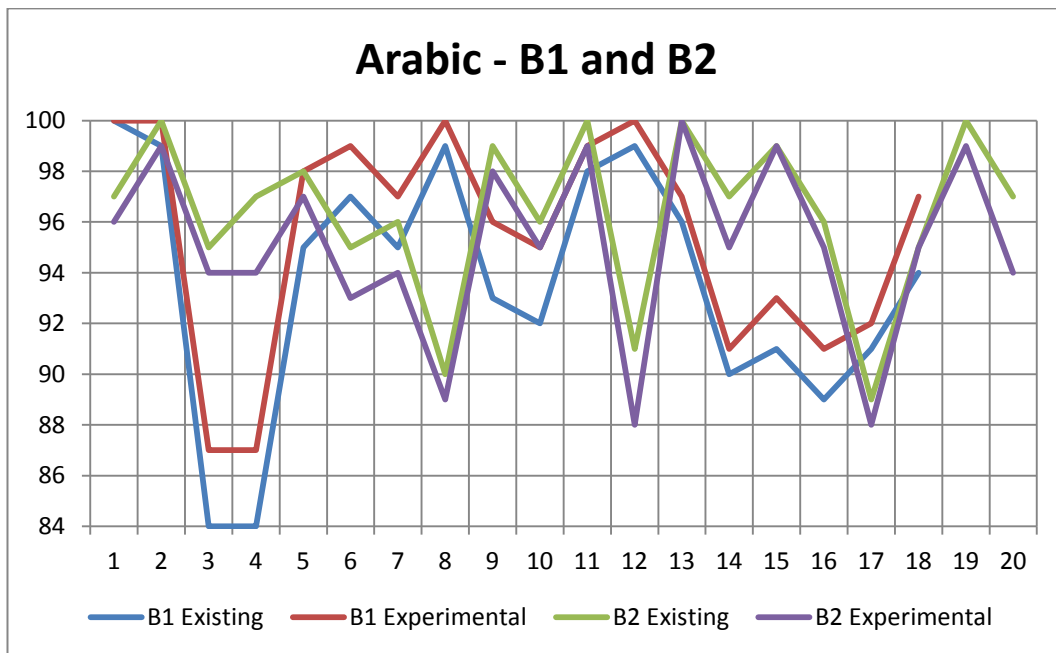
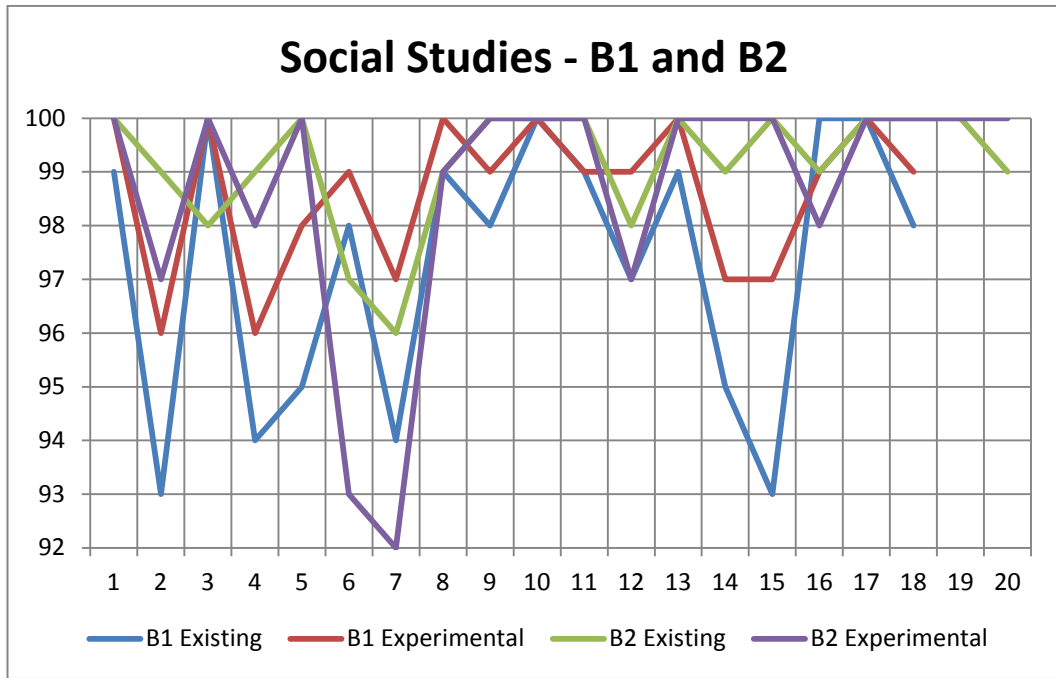
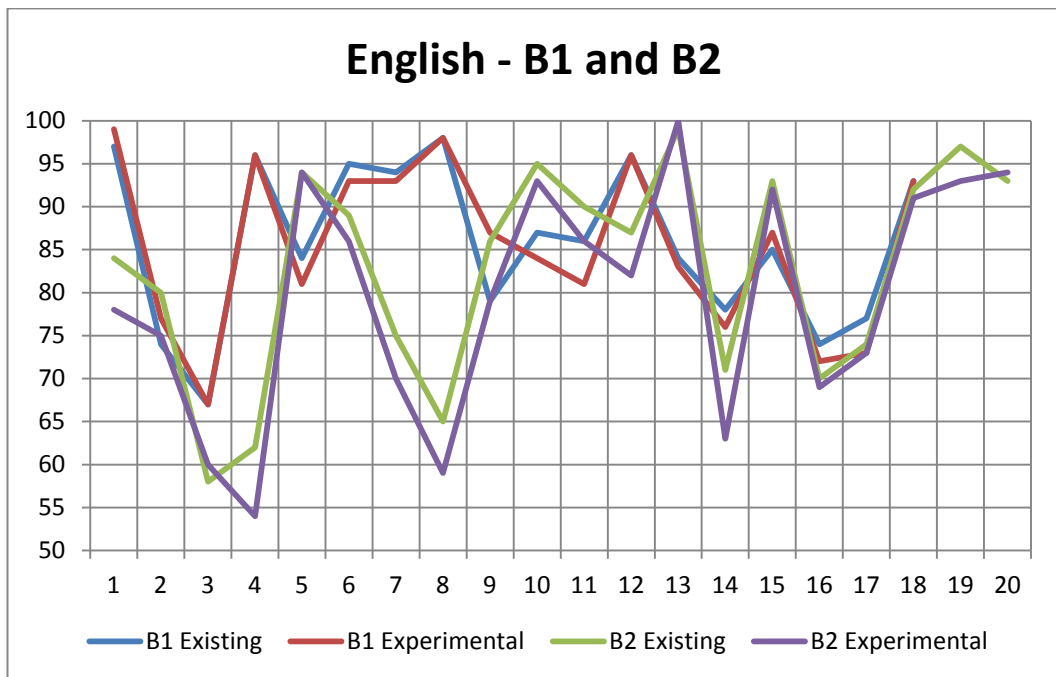


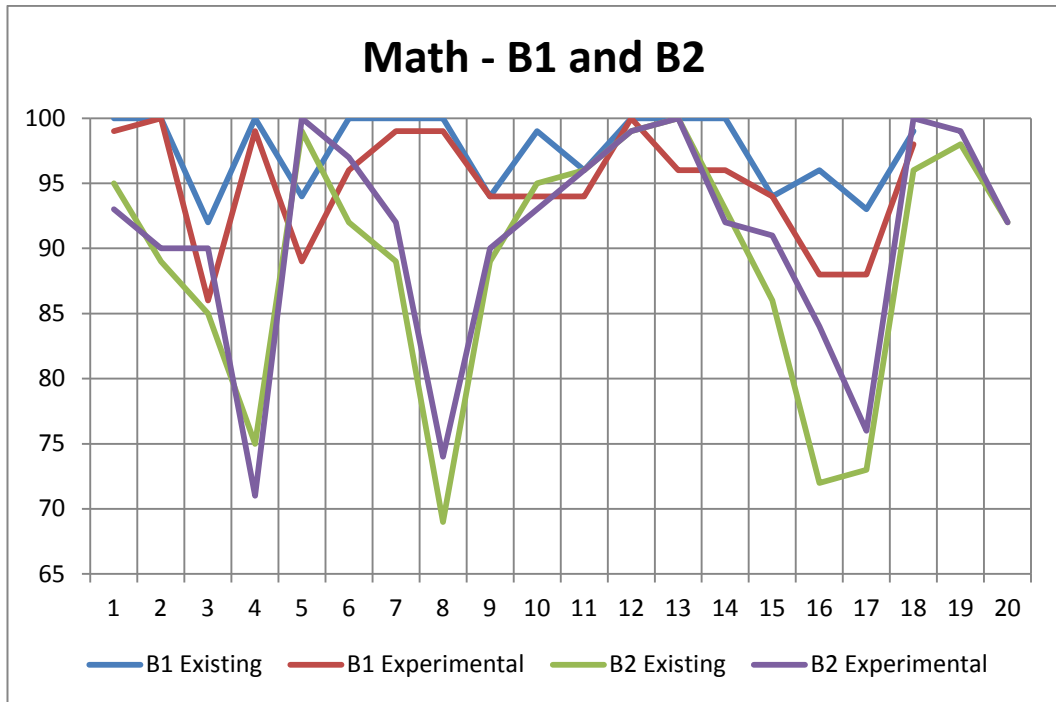
Figure V-24: Classes B1 and B2 Arabic Results Comparison Chart (Done by the author).



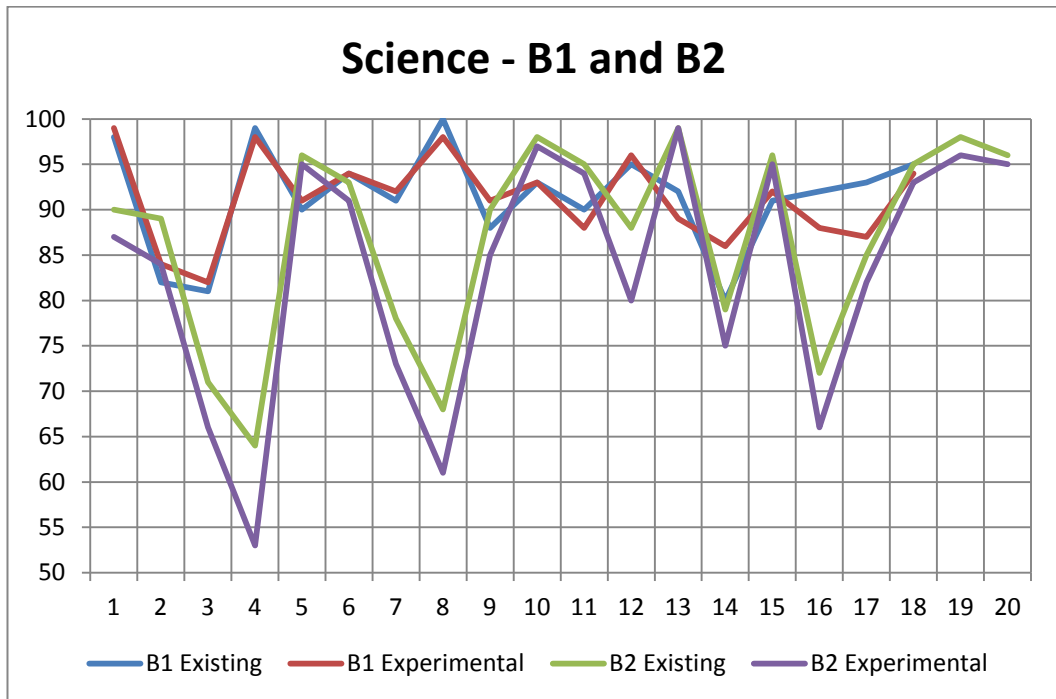
**Figure V-25: Classes B1 and B2 Social Studies Results Comparison Chart (Done by the author).**



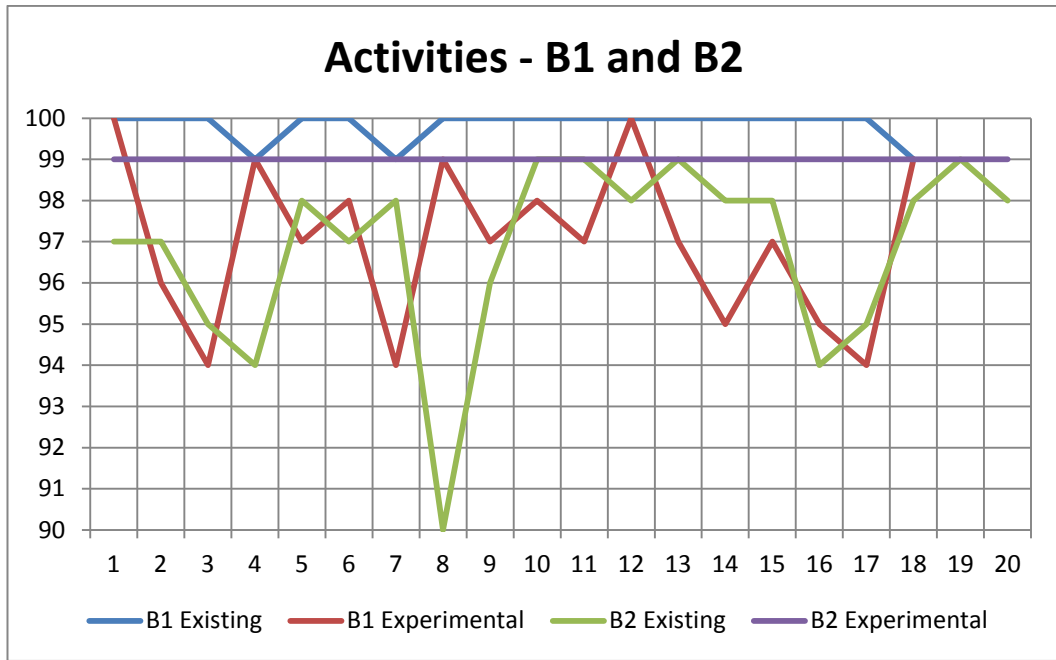
**Figure V-26: Classes B1 and B2 English Results Comparison Chart (Done by the author).**



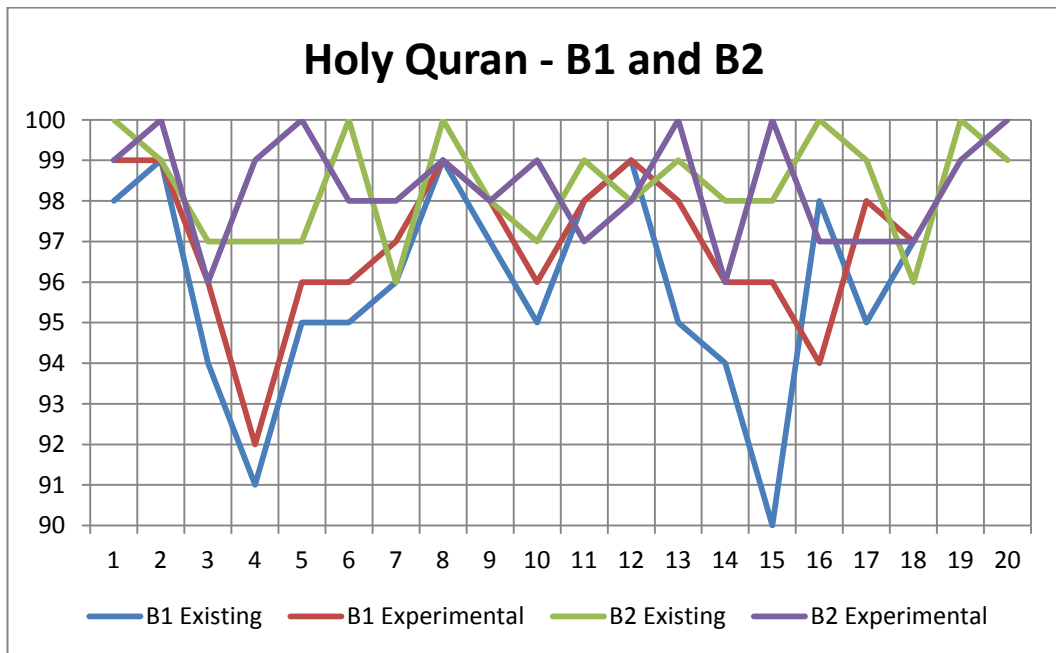
**Figure V-27: Classes B1 and B2 Math Results Comparison Chart (Done by the author).**



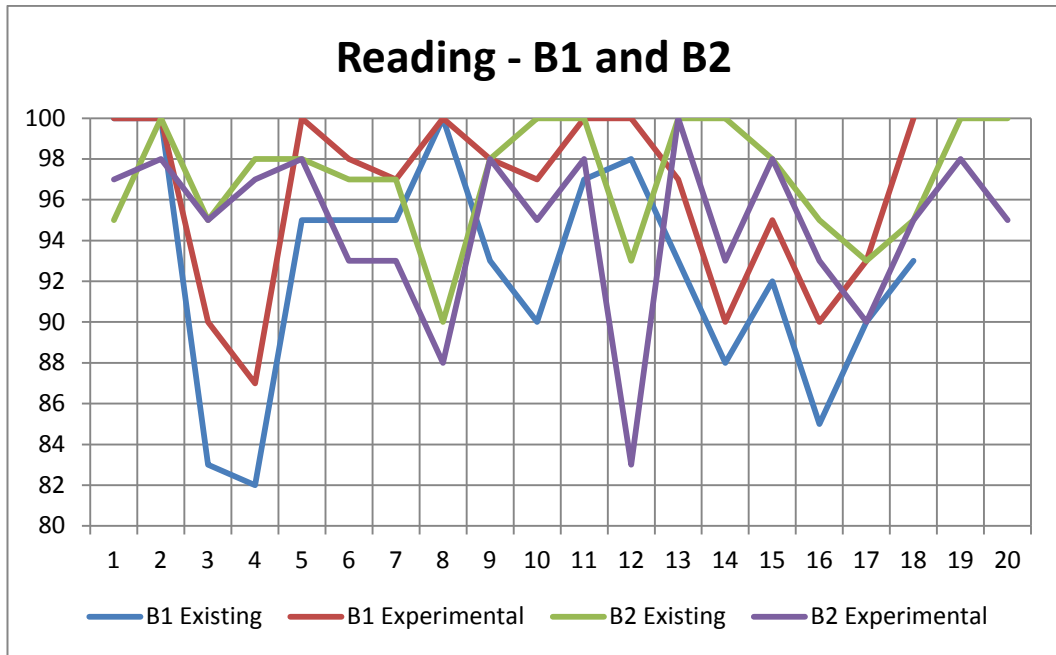
**Figure V-28: Classes B1 and B2 Science Results Comparison Chart (Done by the author).**



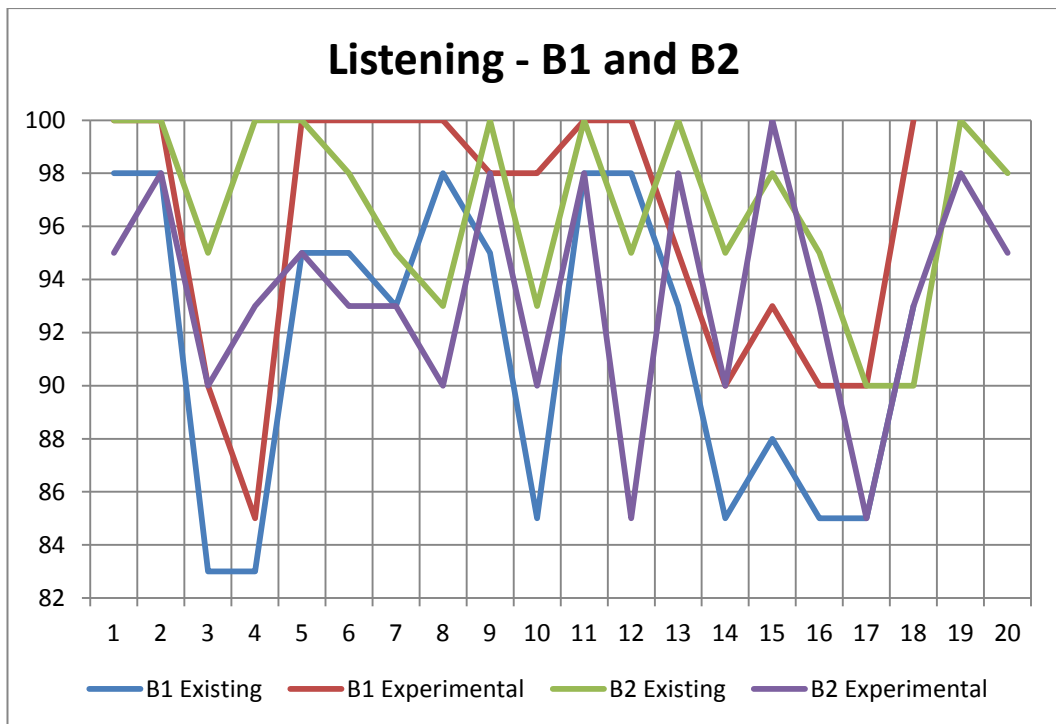
**Figure V-29: Classes B1 and B2 Activities Results Comparison Chart (Done by the author).**



**Figure V-30: Classes B1 and B2 Holy Quran Results Comparison Chart (Done by the author).**



**Figure V-31: Classes B1 and B2 Reading Results Comparison Chart (Done by the author).**



**Figure V-32: Classes B1 and B2 Listening Results Comparison Chart (Done by the author).**

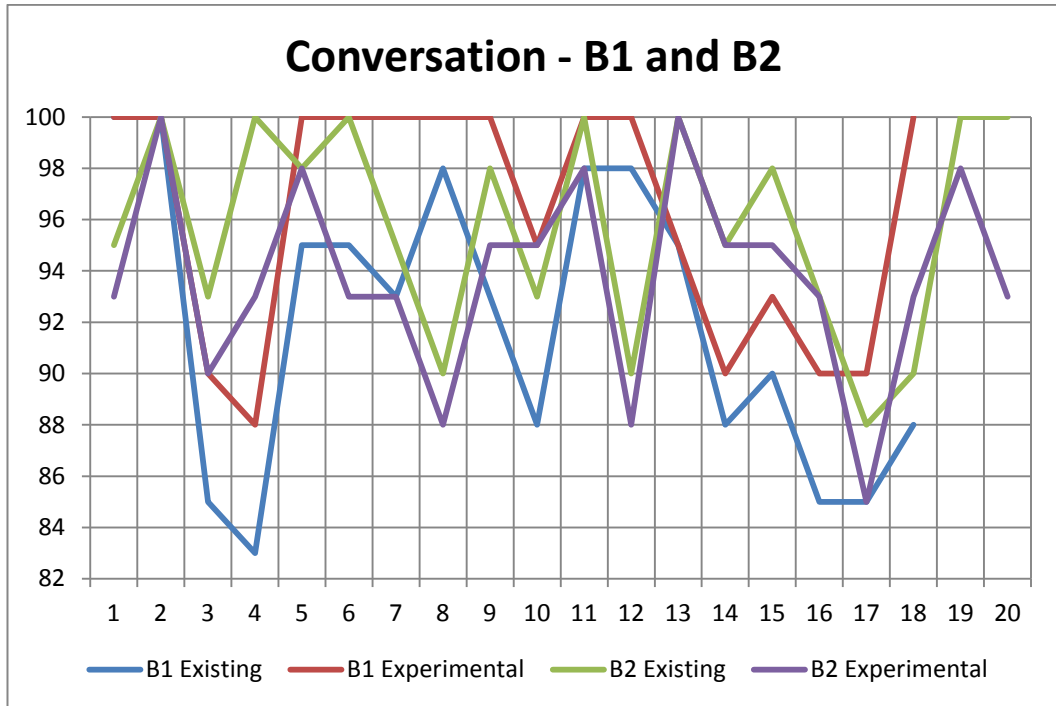


Figure V-33: Classes B1 and B2 Conversation Results Comparison Chart (Done by the author).

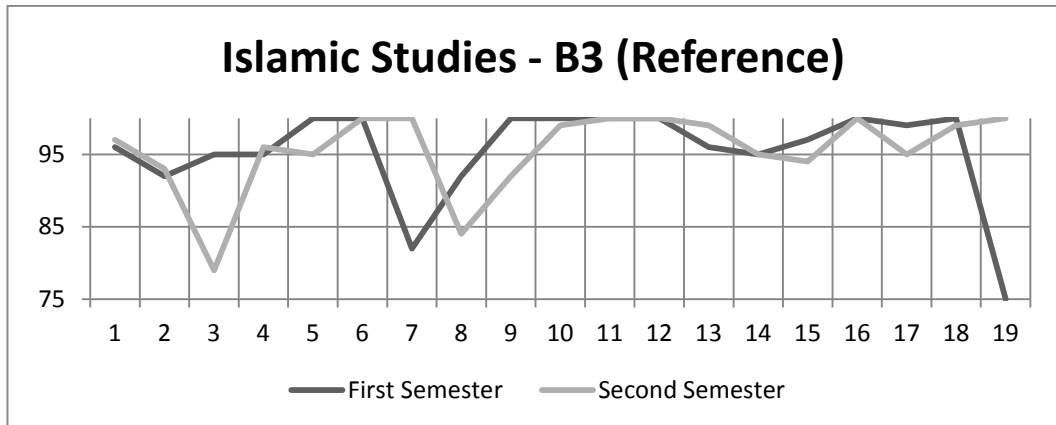


Figure V-34: Class B3 Islamic Studies Results Comparison Chart (Done by the author).

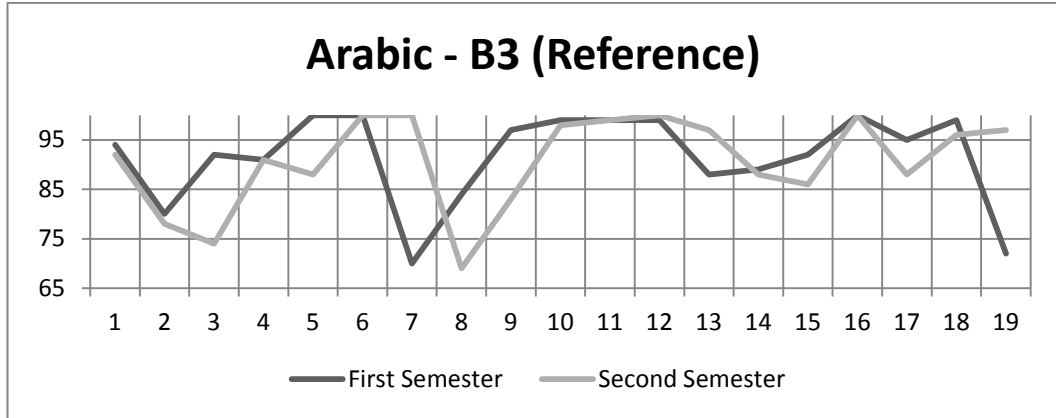


Figure V-35: Class B3 Arabic Results Comparison Chart (Done by the author).

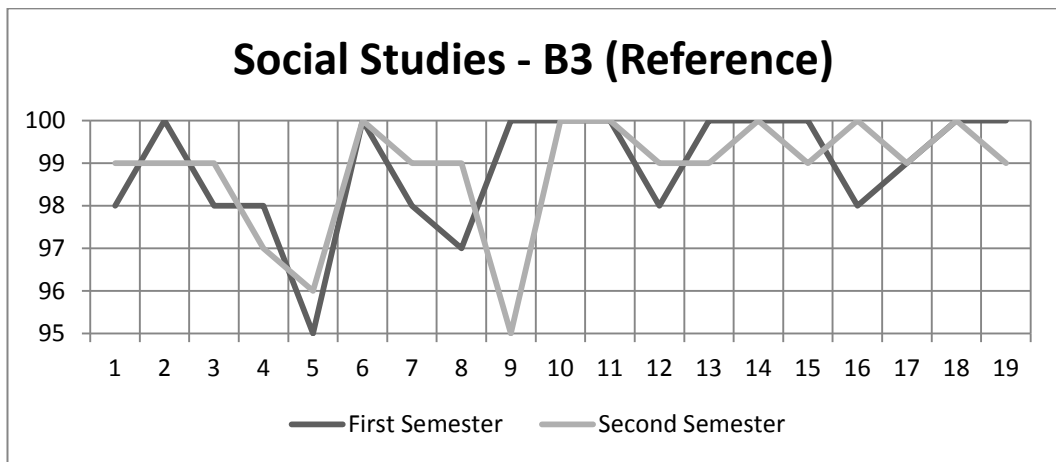


Figure V-36: Class B3 Social Studies Results Comparison Chart (Done by the author).

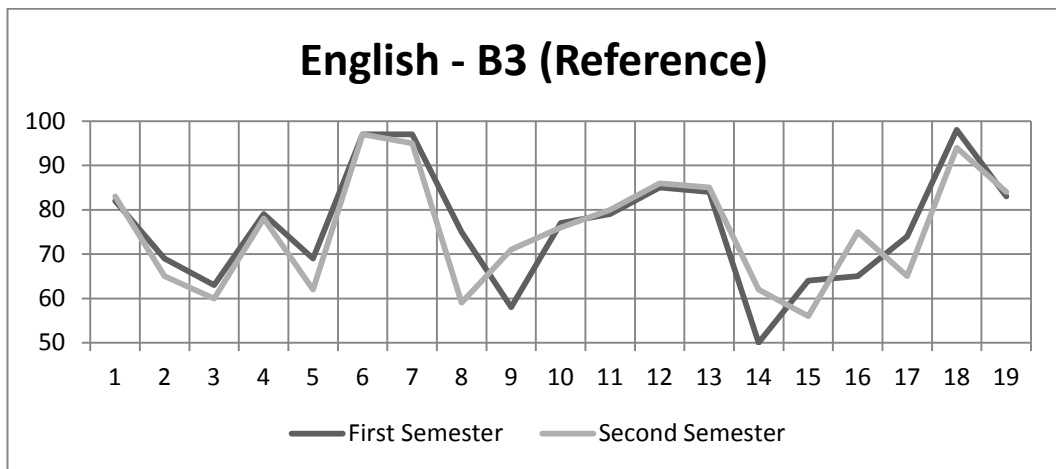


Figure V-37: Class B3 English Results Comparison Chart (Done by the author).

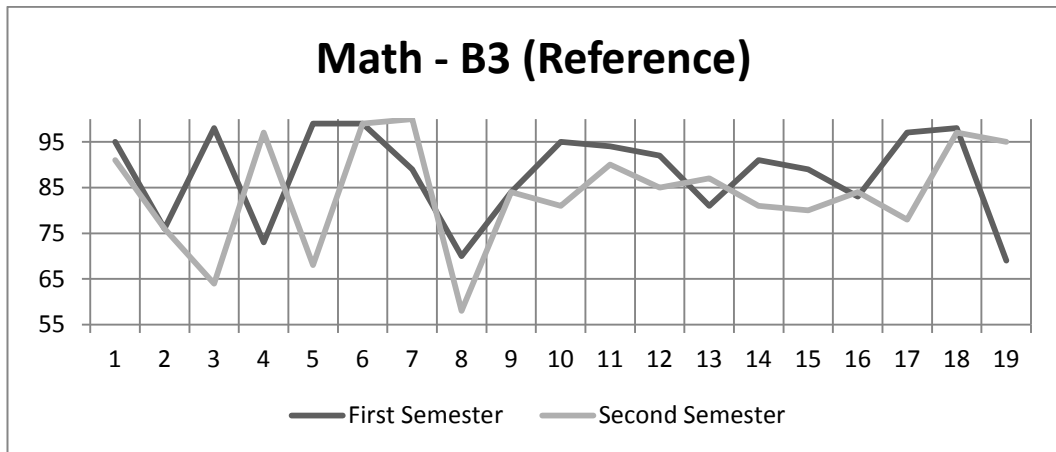


Figure V-38: Class B3 English Results Comparison Chart (Done by the author).

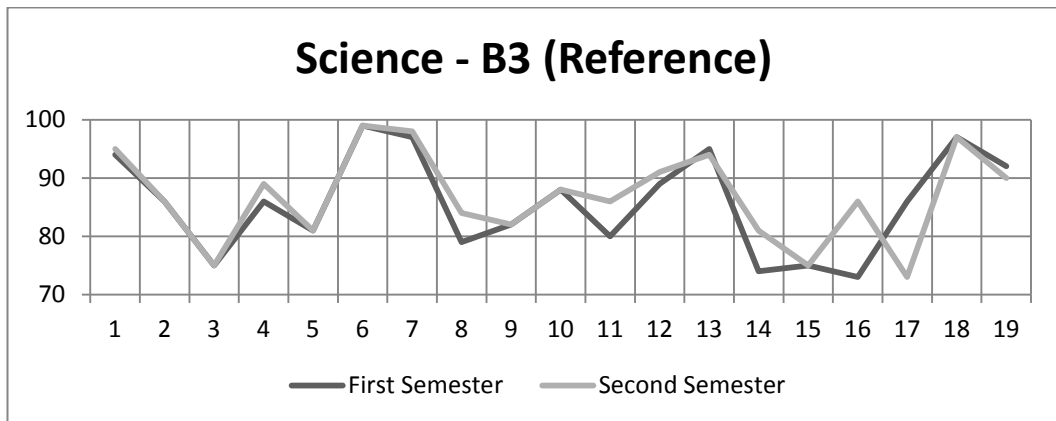


Figure V-39: Class B3 Science Results Comparison Chart (Done by the author).

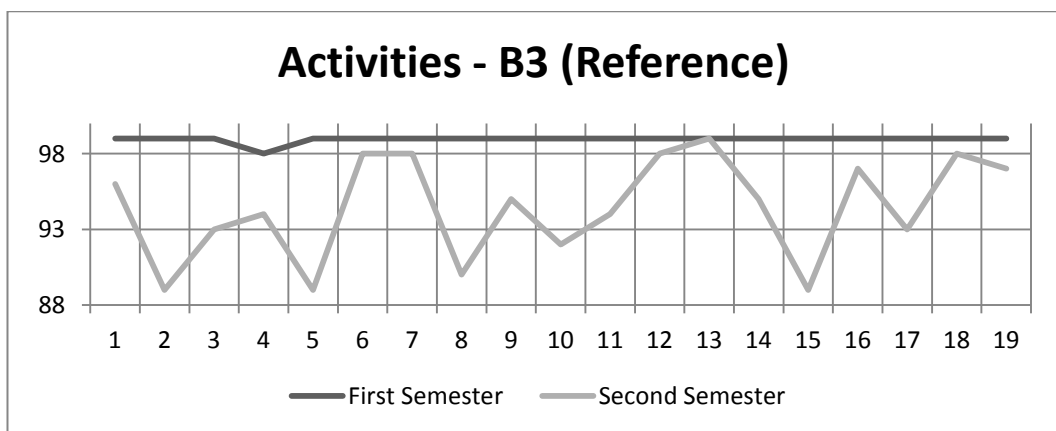


Figure V-40: Class B3 Activities Results Comparison Chart (Done by the author).



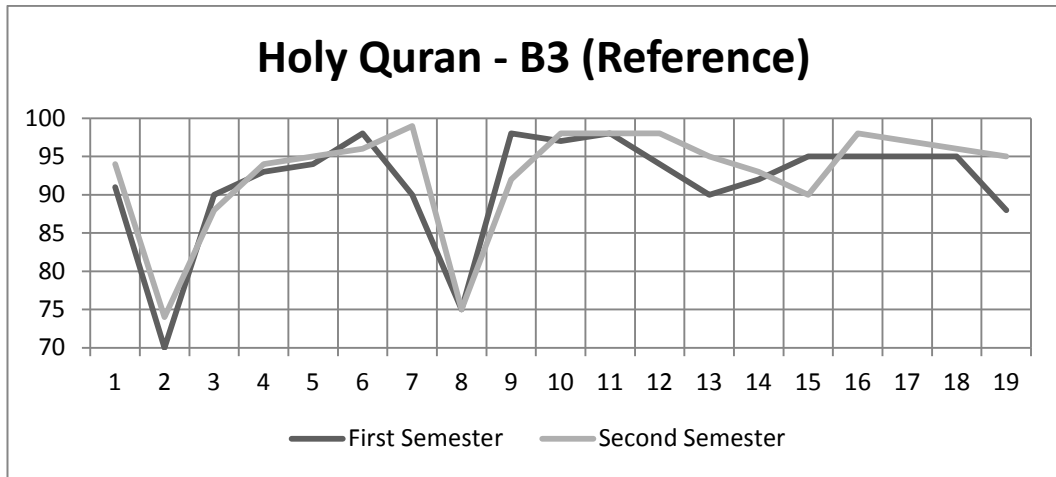


Figure V-41: Class B3 Holy Quran Results Comparison Chart (Done by the author).

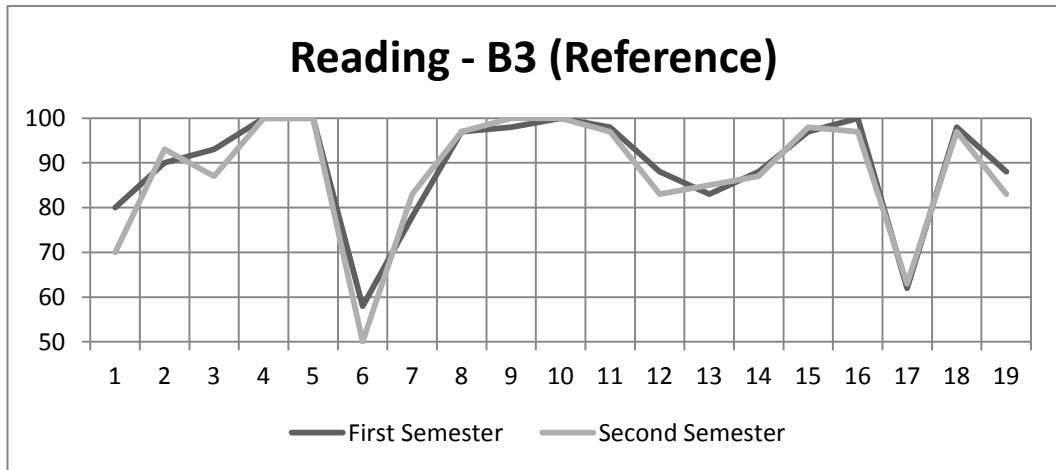


Figure V-42: Class B3 Reading Results Comparison Chart (Done by the author).

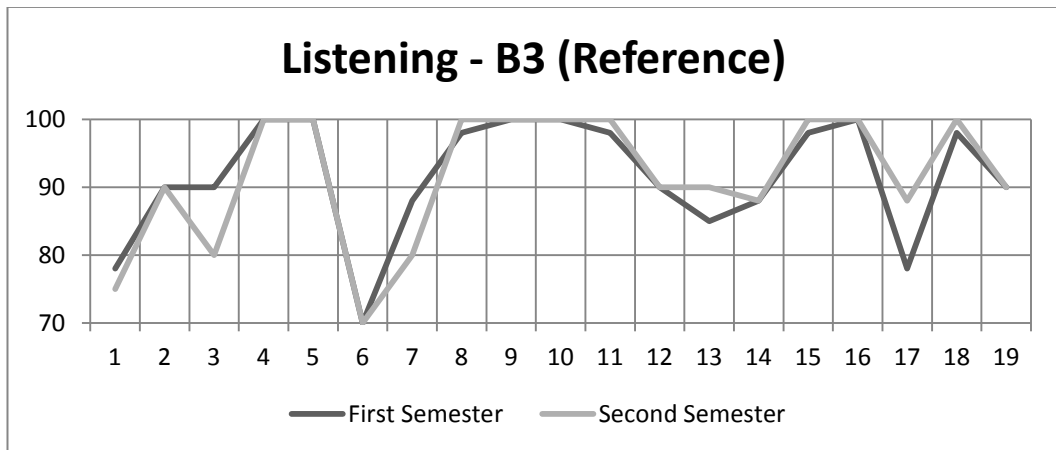
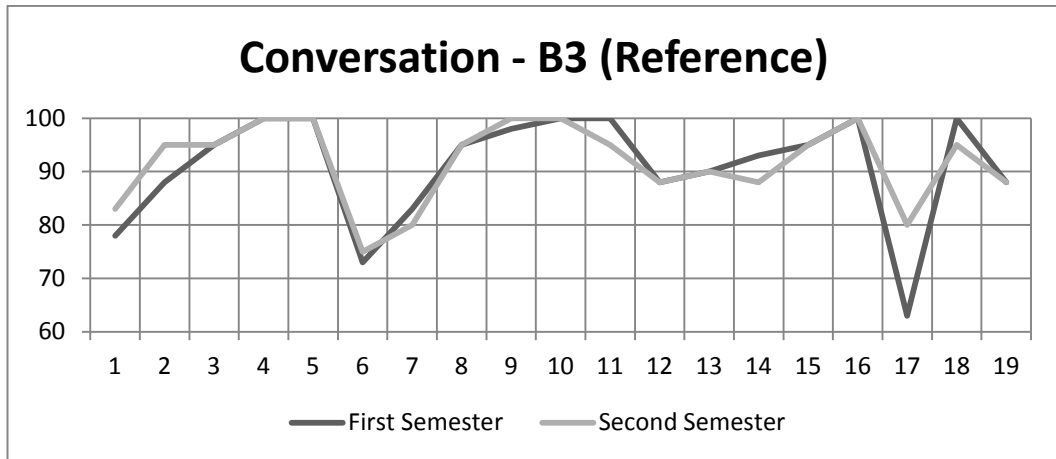
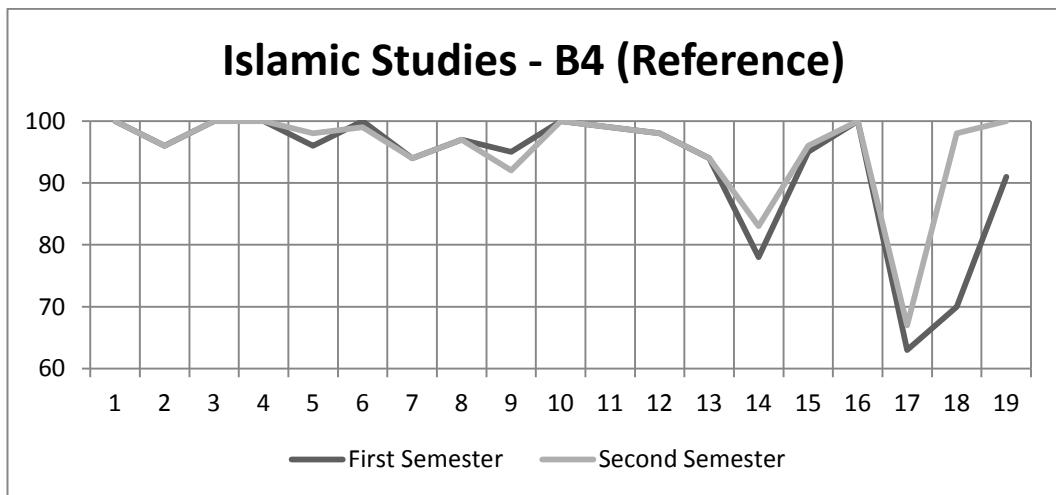


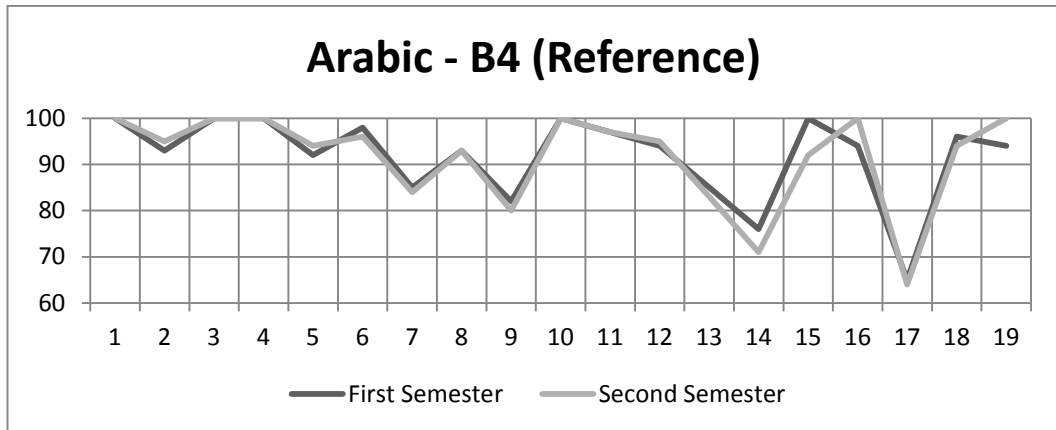
Figure V-43: Class B3 Listening Results Comparison Chart (Done by the author).



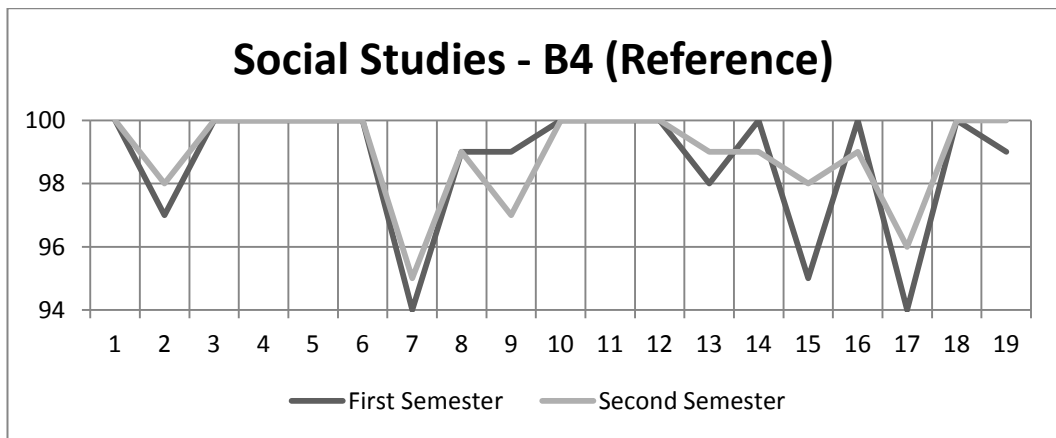
**Figure V-44: Class B3 Conversation Results Comparison Chart (Done by the author).**



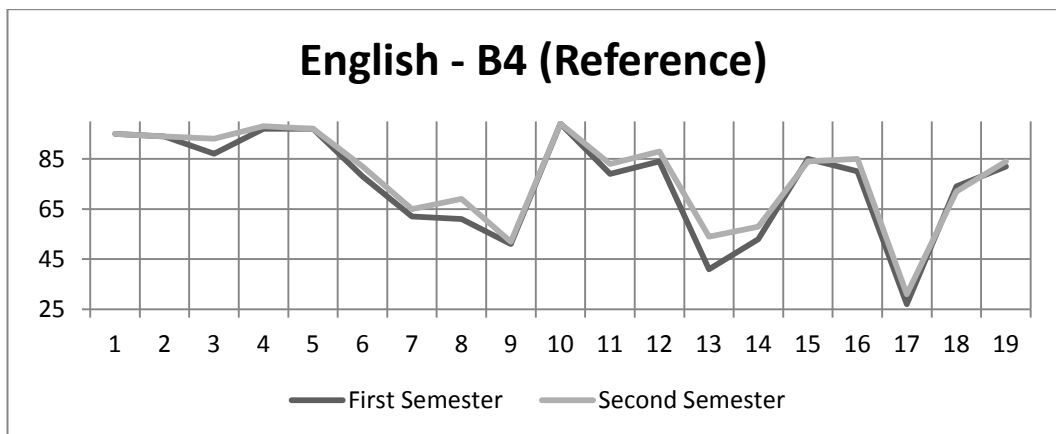
**Figure V-45: Class B4 Islamic Studies Results Comparison Chart (Done by the author).**



**Figure V-46: Class B4 Arabic Results Comparison Chart (Done by the author).**



**Figure V-47: Class B4 Social Studies Results Comparison Chart (Done by the author).**



**Figure V-48: Class B4 English Results Comparison Chart (Done by the author).**

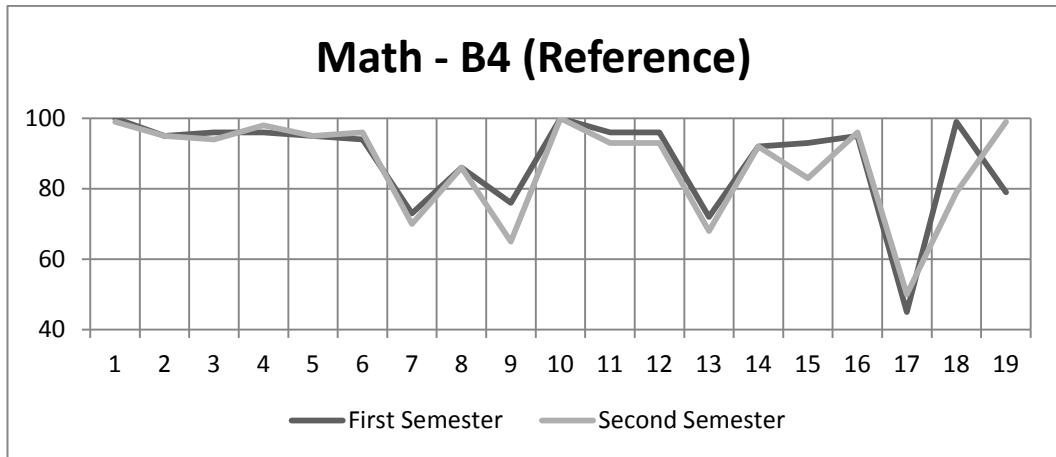


Figure V-49: Class B4 Math Results Comparison Chart (Done by the author).

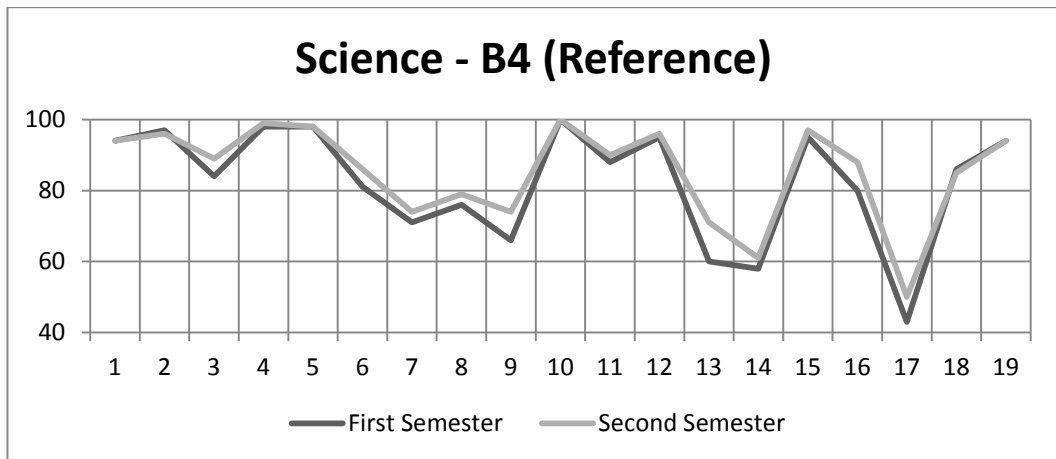


Figure V-50: Class B4 Science Results Comparison Chart (Done by the author).

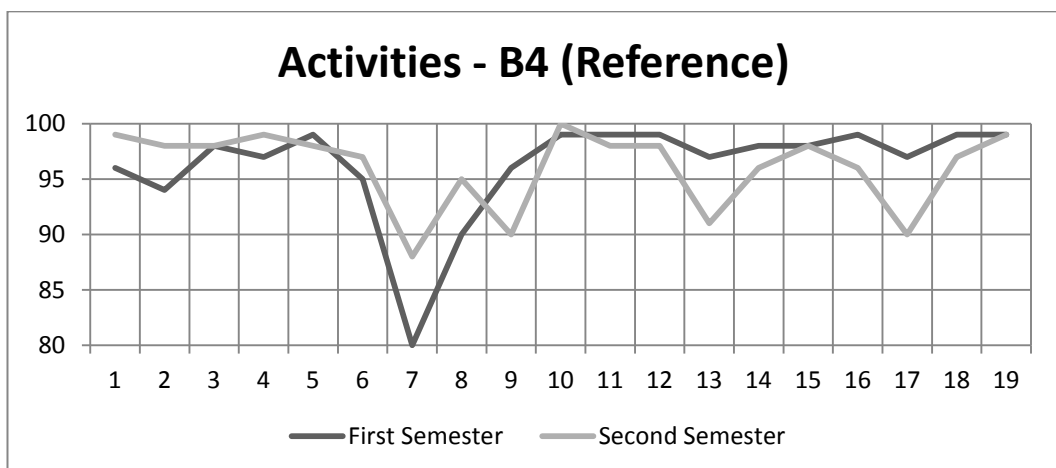


Figure V-51: Class B4 Activities Results Comparison Chart (Done by the author).

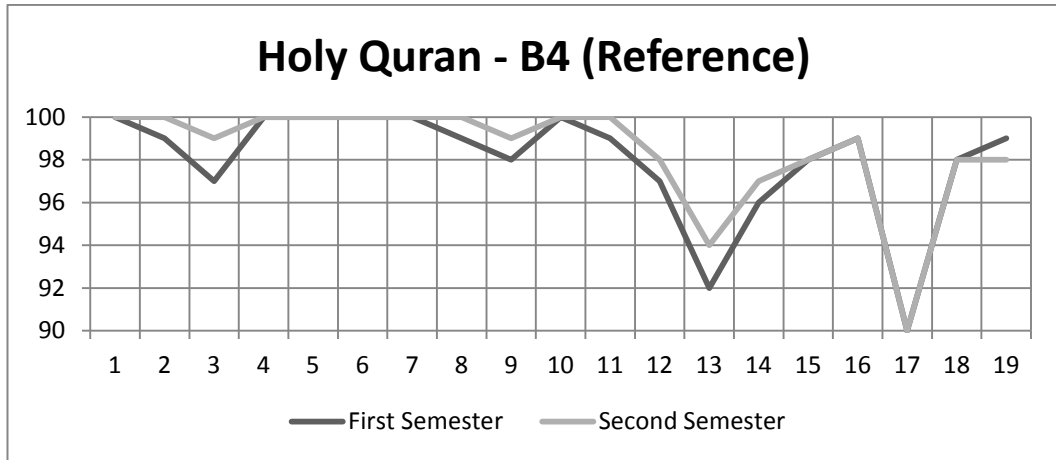


Figure V-52: Class B4 Holy Quran Results Comparison Chart (Done by the author).

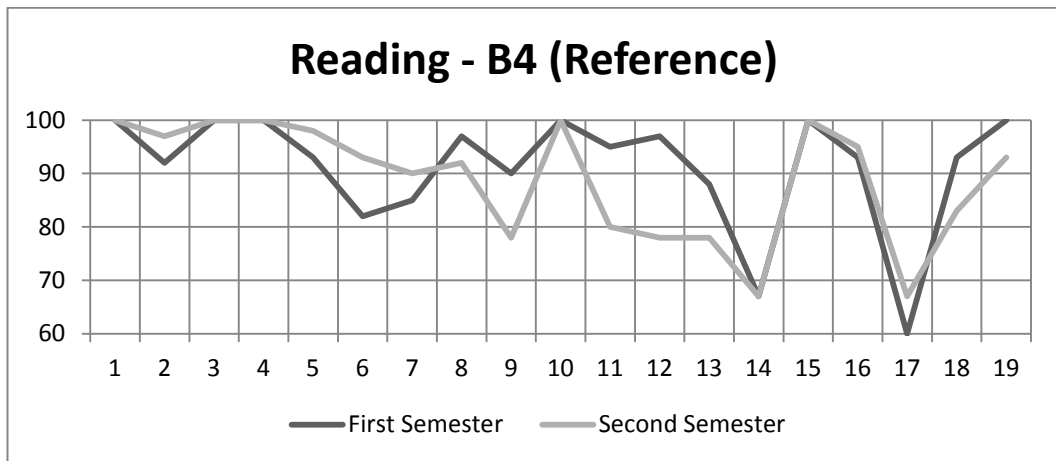


Figure V-53: Class B4 Reading Results Comparison Chart (Done by the author).

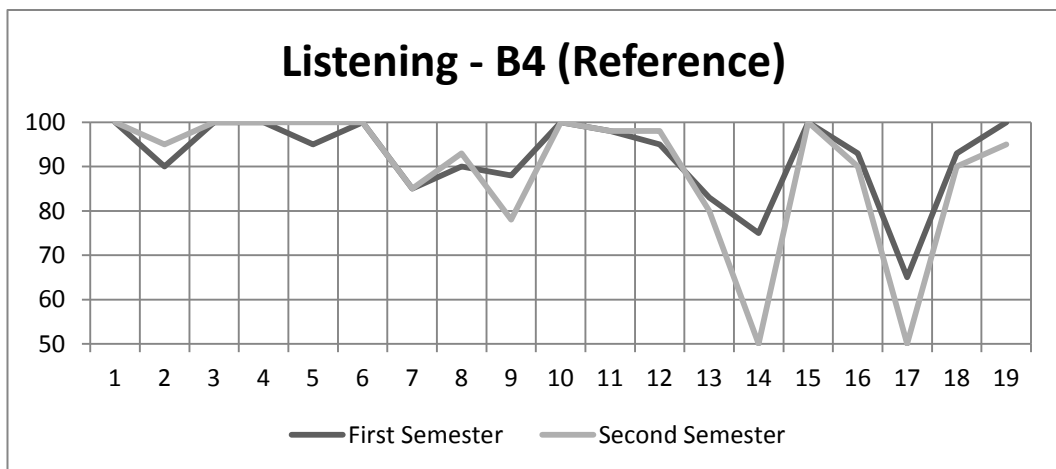
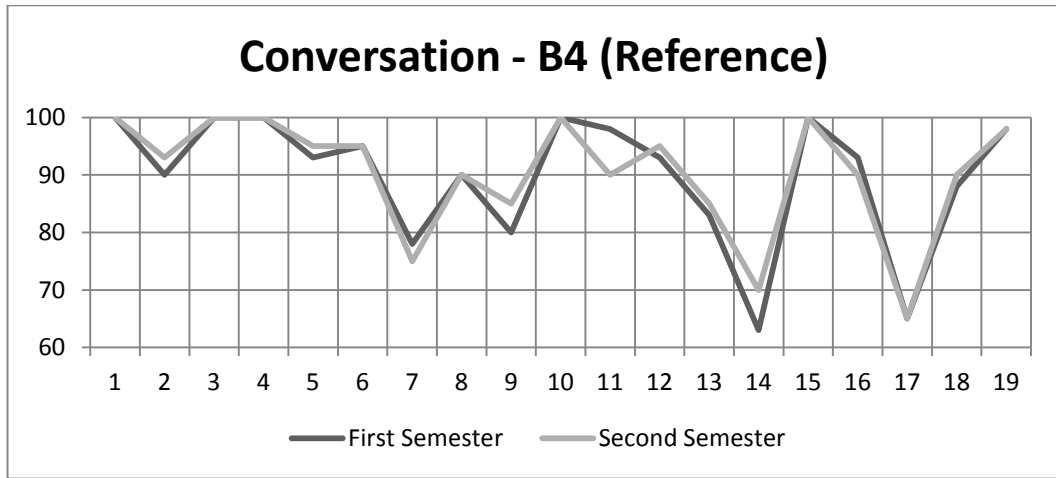


Figure V-54: Class B4 Listening Results Comparison Chart (Done by the author).



**Figure V-55: Class B4 Conversation Results Comparison Chart (Done by the author).**