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Human Engineering Assessment of a Classroom's Environment: Application on LAU Engineering Classrooms

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ABSTRACT

This paper proposes a new methodology to assess student classroom environment from an ergonomic point of view. In a first step, a state of the art on previous assessment methodologies is presented. Then, a study of the influential factors that might affect the academic performance of the student will be identified. These factors will have weights attributed to them in order to generate the Ergonomic Classroom Assessment (ECA) index. As a follow up to the definition of the ECA index, we will apply the methodology on selected classrooms in the Lebanese American University (LAU) classrooms and we will compare them with student surveys. The application will make use of DELMIA © in order to analyze student posture where a locally generated Lebanese Anthropometric table will be used. Finally, conclusions and recommendations on the presented work will be addressed as well as few perspectives.

Keywords: human engineering design, ECA, anthropometry, academic performance.
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1 INTRODUCTION

Musculoskeletal disorders or MSDs have become a serious problem in many children and teenagers' lives. A main reason behind this fact is maintaining a static and non-ergonomic position in the classroom for a long period of time [7]. In reality, a fact we are facing nowadays is the worldwidenon-ergonomic designs of the classrooms. Moreover, the classroom environment is not only a major factor of the teachers and students' health, but also a crucial factor of the students' academic performance. For example, if a student is not comfortable in the desk chair and is facing a back pain, this will automatically generate a lack of concentration and thus this will affect the academic performance of the student[5].

This paper includes all possible factors in a classroom that influence on one's health and that may affect a student's performance academically. A first factor is the actual workstation which is the desk chair that should be in consistence with the anthropometry of the population taken into consideration. Other factors studied are the classroom environment (lighting, ventilation, temperature, and acoustical conditions), classroom design (walls' color, seating strategy, teaching aids)... After inspectingeach factor individually and finding the optimal conditions, the Ergonomic Classroom Assessment (ECA) index, based on value engineering, is then developed.The proposed ECA index is later on verified through the application on selected classrooms in the Zakhem Engineering Building at the Lebanese

American University. In order to assess human posture using DELMIA © a Lebanese anthropometric table is generated and computed into DELMIA © thus generating the Lebanese Manikin Model for both genders. As a follow up, the ECA index is filled for the selected classrooms and the results are compared with the survey results. Finally, the paper ends up with conclusions with respect to the enhancement of the ECA index as well as recommendations to the facilities management office at LAU.

2 STATE OF ART

Previous research related to ergonomic designs of classrooms is mostly based on surveys done in several schools and universities of different regions in the World. First, ergonomics in a classroom is found to be a very important aspect since bad designs of chairs may cause back and neck pain[5]. Moreover, this article presents a study of different sitting postures of 66 children for certain periods of time versus self-reported back and neck pain. It was concluded that the sitting posture rather than sitting itself has a serious effect on the back and neck pain.In addition,[10]shows how crucial ergonomics has become in the designs of the classrooms and it presents several factors that might affect a classroom's environment such as the chair comfort ability, the desk suitability, the whiteboard visibility, the classroom layout, the ventilation and other factors. Furthermore, [7]and [1]both discuss the safety in a classroom and give an idea of how a survey can be made by showing many factors with the possible risks that they might encounter on the students. The major risks discussed are the musculoskeletal disorders and the back and neck pains encountered due to non-ergonomic desk chairs.[6]also presents a study on the sitting postures of schoolchildren in classrooms. It includes a questionnaire based on the Nordic Musculoskeletal Questionnaire that reports data of self-reported pain and consequences. In addition, a Portable Ergonomic Observation method PEO was conducted and it consists of videotaping the children in the classroom and analyzing their postures and the time spent in each posture. After gathering all the data, a study was made to examine the relationship between the student's postureswith the pain complaints. It was concluded that sitting in a static position in a classroom may not be the reason behind the neck and back pains, but the non-ergonomic static postures are the main reason behind these risk factors and the postural discomfort. Moreover,[4]presents a study on the ergonomic design of primary school students' chairs and desks in Taiwan and it shows how the anthropometry of a population is used in designing the desks and chairs; thus it helps in applying the proposed classroom environment in this paper on LAU classrooms by using the anthropometry of the LAU students. [9]also discusses how anthropometry is directly related to the chairs' designs in a classroom. [9]shows the different measurements of the chairs that should be taken into consideration with the adjustability feature and furthermore, it studies Greek students' anthropometry with a discussion of how they fit in their desk-chairs. On another hand, [12]evaluates the acoustic comfort in classrooms by taking a sample of Brazilian teachers and students and studies the effect of different materials on the reverberation time. It was concluded that the classrooms studied were facing an acoustical problem and should be treated to become more comfortable.[11]encounters the problems of the sitting postures and discusses the seven phases of designing an individual workstations. The first phase consists of the decisions that have to be made concerning the requirements needed and the importance of the project. The second phase is the detection of the constraints encountered form the workplace. Next comes the identification of the user's needs and tasks to be performed on the appropriate workstation to be designed. The fourth phase consists of setting the goals of the design such that the determination of the percentile the workstation should fit along with all necessary measurements that should be in consistence with the anthropometry of the population taken into consideration. The fifth phase is the construction of a prototype of the design that could consist of a Computer Aided Design so that as a next phase, an assessment of the prototype is made followed a simulation to improve the design and finally come up with the final design of the workstation. Moreover, [2] embraces work environment factors such as the illumination, noise, ventilation and temperature along with appropriate recommended levels of each factor to implementan ergonomic workplace environment with minor risks and maximal performance. Finally, [3]shows the importance of risk assessments and provides guidelines to implementing any risk assessment in the workplace.

3 IDENTIFICATION OF INFLUENTIAL FACTORS

Classroom environment is influenced by many factors that can be divided into three categories. The first category consists of the actual student workstation which is the deskchair. [4]discusses the importance of the deskchair and how its dimensions should be in consistence with the anthropometry of the students. Another category of the influential factors is the classroom environment which consists of the ventilation, the classroom temperature and the lighting extracted from [10], as well as the acoustical conditions as stated in [12]. Finally, the last category is the classroom layout and design. As [1] and [10]affirm, this category includes the seating strategy, the board and the visual aid's positions along with the walls' color.

In parallel to the identification of influential factors, we will determine the selected values for the identified parameters based on the Lebanese anthropometric table Tab. 5. These values will be taken into consideration in the case study.

3.1 Student Workstation

A typical workstation should be comfortable for the student who will be sitting in itover a long period of time. The desk should be big enough for the student to take notes and use calculators.Nevertheless, the desk chair hasseveral parameters that should be interpreted and that should be in consistence with the anthropometry of the population in consideration. The desk chair is designed to fit 70% of the population and thus its features depend on the 70th percentile of the anthropometry.

3.1.1 Seat Surface Height

The seat surface height should be in consistence with the poplitealsitting height of the 70th percentile(dimension 12 of Tab. 5**Error! Reference source not found.**) with a 5% allowance. Thus, the student's thighs would be expanded and relaxed while being parallel to the floor. The seat surface height is then the average value of the 70th percentile popliteal sitting height of both genders of the Lebanese anthropometric table:

$$Seatsurfaceheight = \frac{([Pop.H.]_{Male} + [Pop.H.]_{Female})}{2} \times Allowance = \frac{(48 + 48.4)}{2} \times 1.05 = 50.61 \sim 51cm$$

3.1.2 Seat surface width

The seat surface widthis defined by the hip breadth (dimension 15 ofTab. 5) of the 70th percentile with a 10% allowance. This feature is very important since it determines whether the student would actually fit in the desk chair or not; therefore, the allowance is taken as 10% instead of the general 5%.

$$Seatsurfacewidth = \frac{([HipB.]_{Male} + [HipB.]_{Female})}{2} \times Allowance = \frac{(40.8 + 36.7)}{2} \times 1.1 = 42.625 \sim 43cm$$

3.1.3 Seat surface depth

The seat surface depthcan beassumed equivalent to the reduction of the chest depth from the buttock-knee length (dimension 11−dimension 13 of Tab. 5) so that the student's thigh would lay down on the seat surface. The 70th percentile with a 5% allowance is required.

$$Seatsurfacedepth = \frac{([But.L.-Ch.D.]_{Male} + [But.L.-Ch.D.]_{Female})}{2} \times Allowance = \frac{(35 + 32.3)}{2} \times 1.05$$
$$= 35.3325 \sim 35cm$$

3.1.4 Back support length

The back support length is determined by the reduction of the elbow rest height from the sitting height of the 70th percentile, with a 5% allowance (dimension 6– dimension 8 of Tab. 5). The back of the student would then be straight which will prevent low back pains to occur.

$$Backsupportlength = \frac{([Sit.H.-Elb.H.]_{Male} + [Sit.H.-Elb.H.]_{Female})}{2} \times Allowance = \frac{(68.64 + 93.65)}{2} \times 1.05$$
$$= 85.20225 \sim 85cm$$

3.1.5 Back Support Width

The back support width is designed to be as the seat surface's width, thus of 43cm.

3.1.6 Back Support Angle

The back support angle should be of 100° as stated in [4] that consists of a study of an "Ergonomic Design of Desk and Chair for Primary Students in Taiwan". This angle is also valid for University students since it does not depend of the anthropometry.

3.1.7 Desk Surface Height

The desk surface heightshould be in consistence with the sitting elbow rest height of the 70th percentile (dimension 8 of Tab. 5) so that the students would have their elbows angled 90°.

$$Desksurfaceheight = \frac{([Elb.H.]_{Male} + [Elb.H.]_{Female})}{2} \times Allowance = \frac{(26.16 + 22.35)}{2} \times 1.05 = 25.46775 \sim 26cm$$

3.1.8 Desk surface width

The desk surface width is determined by the elbow-to-elbow breadth of the 70th percentile (dimension 14 of Tab. 5) with a 5% allowance for placing stationery.

$$Desksurfacewidth = \frac{([Elb.Elb.]_{Male} + [Elb.Elb.]_{Female})}{2} \times Allowance = \frac{(52 + 44)}{2} \times 1.05 = 50.4cm$$

3.1.9 Desk Surface Depth

The desk is the student's working area that should fit the books, calculator and stationery. As stated in Figure 5.13 of [2], the maximum hand extension in working areas for men and women is of 30.52in and 28in respectively. The desk surface depth is designed as the average between the two values; thus it is of 29.26in or 74.3204~74cm.

3.1.10 Desk Surface Angle

As for the desk surface angle, it should be between 0° and 10° as stated in [4]. This angle is also valid for University students since it is not dependent of the anthropometry.

3.2 Classroom Environment

3.2.1 Ventilation

Ventilation must be provided in a classroom to supply fresh air devoid of odors. The ventilation requirements are directly related to the volume of air per person as stated in Table 6.15 of[2].Assuming an average volume of air per student as 300 ft^3 with a moderate intensity of odors in the classroom, the ventilation should be of 15ft^3/min.

3.2.2 Temperature

The thermal comfort zone is illustrated in Table 6.12 of [2]as the range of temperatures from 18.9°C to 26.1°C with a relative humidity range of 20% to 80%.

3.2.3 Lighting

From Table 6.3 of [2], the category that includes an ergonomic illuminance in a working area is category E, whereas categorizes D and F are somehow acceptable.

3.2.4 Acoustical conditions

The average background noise limit in Brazil, France, Germany and USA in a classroom is of 40dBA as stated in Table 1 of [12]. As for the OSHA permissible noise exposures with respect to the duration of the exposure to the noises per day, the maximum noise for a duration of eight hours is of 90dBA as stated in [8].

3.3 Classroom Design

3.3.1 Seating Strategy

The seating strategy of a classroom influences the student's concentration. Thus, it should be considered as a factor that influences the classroom environment. Possible ergonomic seating strategiesare the "U shape", clustered desks anddesks in rows.

3.3.2 Board or Visual Aid Position

The student in a classroom is often exposed to presentations on visual aids and to writings on the board of the classroom. For this reason, the position of these two elements is critical to the student's eyes and to the student's concentration. Furthermore, the board or visual aid should be positioned in thecone of sight of the students; thus between -15° to -10° from the line of sight.

3.3.3 Walls' Color

The colors of the walls influence on the reflectance of the light in the room. Therefore, this factor should be considered and studied. The walls' color is preferable to be white and thus the reflectance would be of a high percentage (85%).

3.3.4 Floor, Desk and Seat Colors

Also, the colors of the floor, the desk, and the seat influence on the reflectance of the light in the room and thus these factors should be studied.

4 ERGONOMIC CLASSROOM ASSESSEMENT (ECA) INDEX

In this section we present the methodology used to obtain the ECA index. At first, we list the different parameters identified in the previous section along with a proposed classification. The latter splits the possible values for each parameter into threelevels: Satisfactory (0), Unsatisfactory(1) and Dangerous (2) for the student workstation and the classroom design whereas a value of (10) will be assigned to the Dangerous level of the classroom environment factor.Then we compile the parameters in a second stage to form the ECA index.

4.1 Parameters Classification

4.1.1 Student Workstation Index

The student workstation is considered as the primary factor in a classroom environment since its design may cause neck and back pains for the students. Each parameter will be attributed a value depending on its computed level: (0) for Satisfactory, (1) for Unsatisfactory and (2)or (10) for Dangerous. The different elements'average would constitute the *student workstation index* (SWI) value.For every parameter the different levels are presented in
Tab. 1, the values are represented function of μbeing the value identified in section 3.

Parameter	*0*	*1*	*2*
Seat surface height	$[0.95\mu - 1.05\mu]$	$[0.85\mu - 0.95\mu[\cup]1.05\mu - 1.2\mu]$	Other
Seat surface width	$[0.95\mu - 1.05\mu]$	$[0.85\mu - 0.95\mu[\cup]1.05\mu - 1.2\mu]$	Other
Seat surface depth	$[0.95\mu - 1.05\mu]$	$[0.85\mu - 0.95\mu[\cup]1.05\mu - 1.1\mu]$	Other
Back support length	$[0.95\mu - 1.05\mu]$	$[0.85\mu - 0.95\mu[\cup]1.05\mu - 1.2\mu]$	Other
Back support width	$[0.95\mu - 1.05\mu]$	$[0.85\mu - 0.95\mu[\cup]1.05\mu - 1.1\mu]$	Other
Back support angle	$[0.95\mu - 1.05\mu]$	$[0.85\mu - 0.95\mu[\cup]1.05\mu - 1.1\mu]$	Other
Desk surface height	$[0.95\mu - 1.05\mu]$	$[0.85\mu - 0.95\mu[\cup]1.05\mu - 1.1\mu]$	Other
Desk surface width	$[0.95\mu - +\infty[$	$[0.85\mu - 0.95\mu[$	Other
Desk surface depth	$[0.95\mu - +\infty[$	$[0.85\mu - 0.95\mu[$	Other
Desk surface angle	$[0° - 10°]$	$]10° - 15°]$	Other

Tab. 1: Student Workstation Index SWI.

4.1.2 *Classroom Environment*

The factors of the second category include the classroom environment and may affect the student's concentration as well as the teacher's. Each parameter will also be attributed a value depending on its computed level according to the *classroom environment index* (CEI).

Parameter	***0***	***1***	***10***
Ventilation	[14.25 – 15.75]	[12.75 – 14.25[∪]15.75 – +∞[	Other
Temperature	[18.9 – 26.1]	[15 – 18.9[∪]26.1 – 30]	Other
Lighting	E	D-F	Other
Noise	[0 – 50]	]50 – 70]	Other

Tab. 2: Classroom Environment Index CEI.

Ergonomic Classroom Assessment ECA Index		
University	Classroom Area	Date
Campus	# Students	Analyst
Class	# Males	

Student Workstation	Satisfactory (0)	Unsatisfactory (1)	Dangerous (2)
Seat surface height	[48.45 - 53.55]	[43.35 - 48.45[U]53.55 - 61.2]	Other
Seat surface width	[40.85 - 45.15]	[36.55 - 40.85[U]45.15 - 51.6]	Other
Seat surface depth	[33.25 - 36.75]	[29.75 - 33.25[U]36.75 - 38.5]	Other
Back support length	[80.75 - 89.25]	[72.25 - 80.75[U]89.25 - 102]	Other
Back support width	[40.85 - 45.15]	[36.55 - 40.85[U]45.15 - 47.3]	Other
Back support angle	[95° - 105°]	[85° - 95°[U]105 - 110]	Other
Desk surface height	[24.7 - 27.3]	[22.1 - 24.7[U]27.3 - 28.6]	Other
Desk surface width	[47.88 - +∞[	[42.84 - 47.88[	Other
Desk surface depth	[70.3 - +∞[	[62.9 - 70.3[	Other
Desk surface angle	[0°-10°]	]10°-15°]	Other
	Workstation Factor = Sum of points / 10 =		

Classroom Environment	Satisfactory (0)	Unsatisfactory (1)	Dangerous (10)
Ventilation	[14.25 - 15.75]	[10 - 14.25[U]15.75 - +∞[	Other
Temperature	[18.9 - 26.1]	[15 - 18.9[∪]26.1 - 30]	Other
Lighting	[50 - 100]	[20 - 50[∪]100 - 200]	Other
Acoustical conditions	[0 - 50]	]50-70]	Other
	Environmental Factor = Sum of points / 4 =		

Classroom Design	Satisfactory (0)	Unsatisfactory (1)	Dangerous (2)
Seating Strategy	U, In rows, Cluster	Other	-
Board or visual aid Position	[-15° - -10°]	[-30°, -15°[∪]-10° , 5°]	Other
Walls' Color (reflectance)	[60 - +∞ [	Other	-
	Design Factor = Sum of points / 3 =		

Miscellaneous Factor	Satisfactory (0)	Unsatisfactory (1)	Dangerous (2)
Student's concentration			
Student load			
Teacher's excitement			
	Miscellaneous Factor:		
	General Factor = 0.3 WF + 0.3 EF + 0.3 DF + 0.1 MF =		

Tab. 3: Ergonomic Classroom Environment ECA index.

4.1.3 Classroom Design

The last category includes the factors in the design of the classroom that might affect the student's academic performance. As well, each parameter in this category will be attributed a value depending on the computed level according to the *classroom design index* (CDI).

Parameter	***0***	***1***	***2***
Seating Strategy	U, In rows, Cluster	Other	-
Visual aid position	$[-15°, -10°]$	$[-30°, -15°[\cup]-10°, 5°]$	Other
Walls color (reflectance)	≥60%	Other	-
Floor color *	≥60%	Other	-
Desk and Seat color *	≥60%	Other	-

Tab. 4: Classroom Design Index CDI.

* These values are not assessed in the current presented study.

4.2 ECA Index

The above defined parameters constitute together the ECA index in Tab. 3.

5 CASE STUDY

5.1 Lebanese Anthropometric Table

To generate the Lebanese anthropometric table, a random sample of 47 students from LAU (Byblos campus) was chosen. This sample consisted of 35 males and 12 females. All necessary body dimensions were measured (Fig. 1) and thus a Lebanese anthropometric table was built (Tab. 5).

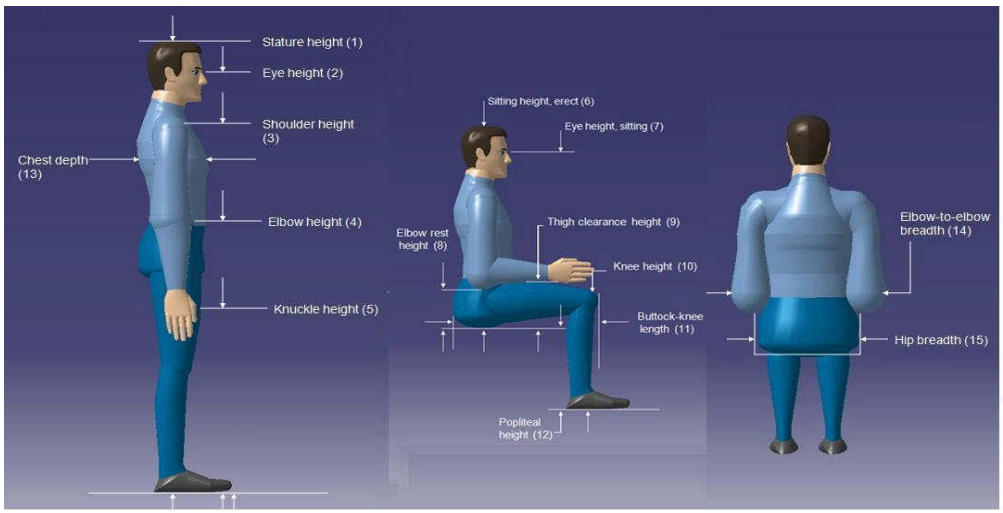

Fig. 1: Selected body dimensions.

The Lebanese anthropometric table was then embedded in DELMIA© to generate the Lebanese manikin. Fig. 2 shows the 50th percentile man and woman manikins of the Lebanese population.

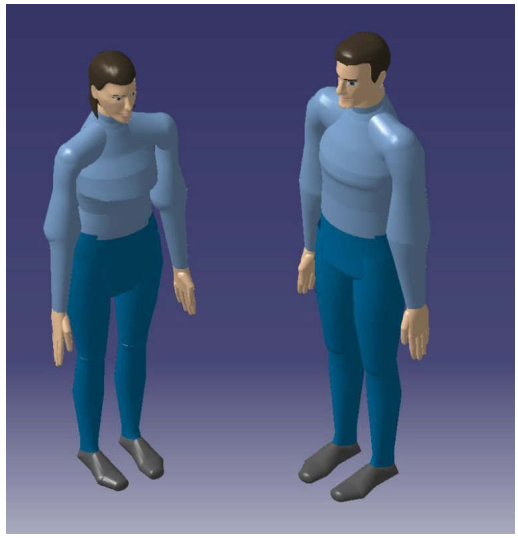

Fig. 2: Lebanese manikins.

Body dimension	Gender	Dimension (cm) 5th	50th	70th	95th	Dimension (in) 5th	50th	70th	95th
1. Stature (height)	Male	165.85	177.00	180.9	189.90	65.30	69.69	71.22	74.76
	Female	151.55	164.50	167.1	179.90	59.67	64.76	65.77	70.83
2. Eye height	Male	155.00	165.00	170	177.10	61.02	64.96	66.93	69.72
	Female	141.20	153.50	157.8	168.05	55.59	60.43	62.13	66.16
3. Shoulder height	Male	139.10	150.00	153	164.00	54.76	59.06	60.24	64.57
	Female	124.75	137.75	141.7	154.58	49.11	54.23	55.79	60.86
4. Elbow height	Male	102.20	112.80	116.8	131.40	40.24	44.41	45.98	51.73
	Female	95.38	104.75	108.4	114.80	37.55	41.24	42.68	45.20
5. Knuckle height	Male	72.00	79.00	82	87.85	28.35	31.10	32.28	34.59
	Female	66.20	72.50	75	86.28	26.06	28.54	29.53	33.97
6. Height sitting	Male	82.40	90.00	94.8	127.00	32.44	35.43	37.32	50.00
	Female	78.40	85.50	116	93.35	30.87	33.66	45.67	36.75
7. Eye height, sitting	Male	72.00	78.00	82	115.90	28.35	30.71	32.28	45.63
	Female	67.30	74.50	101.9	77.35	26.50	29.33	40.12	30.45
8. Elbow rest height, sitting	Male	19.40	23.00	26.16	32.00	7.64	9.06	10.30	12.60
	Female	18.28	21.50	22.35	23.90	7.19	8.46	8.80	9.41
9. Thigh clearance height	Male	11.00	14.00	16.4	21.20	4.33	5.51	6.46	8.35
	Female	10.55	13.00	13	17.35	4.15	5.12	5.12	6.83
10. Knee height sitting	Male	51.40	56.00	59	64.30	20.24	22.05	23.23	25.31
	Female	45.10	54.50	56.55	59.45	17.76	21.46	22.26	23.41
11. Buttock knee distance sitting	Male	53.70	60.00	61	66.00	21.14	23.62	24.02	25.98
	Female	51.55	57.00	59	62.13	20.30	22.44	23.23	24.46
12. Popliteal height, sitting	Male	45.05	47.00	48	51.00	17.74	18.50	18.90	20.08
	Female	44.17	46.00	48.4	52.90	17.39	18.11	19.06	20.83
13. Chest depth	Male	20.00	25.00	26	29.30	7.87	9.84	10.24	11.54
	Female	20.78	24.50	26.7	33.33	8.18	9.65	10.51	13.12
14. Elbow-elbow breath	Male	42.80	51.00	52	63.15	16.85	20.08	20.47	24.86
	Female	38.55	42.50	44	54.35	15.18	16.73	17.32	21.40
15. Hip breadth, sitting	Male	30.00	38.00	40.8	50.60	11.81	14.96	16.06	19.92
	Female	32.10	35.50	36.7	44.85	12.64	13.98	14.45	17.66
X. Weight (kg and lb).	Male	59.70	80.00	86.8	111.70	131.58	176.32	34.17	246.19
	Female	50.65	60.75	62	84.25	111.63	133.89	24.41	185.69

Tab. 5: The generated Lebanese Anthropometric Table.

5.2 ECA Index of the two assessed classrooms

Ergonomic Classroom Assessment ECA Index			
University Lebanese American University		Classroom Area	Date 16 Dec 2009
Campus Byblos campus		# Students	Analyst
Class ENG 502		# Males	
Student Workstation	Satisfactory (0)	Unsatisfactory (1)	Dangerous (2)
Seat surface height	[48.45 - 53.55]	]43.35 - 48.45[U]53.55 - 61.2]	Other
Seat surface width	]40.85 - 45.15[	[36.55 - 40.85[U]45.15 - 51.6]	Other
Seat surface depth	[33.25 - 36.75]	[29.75 - 33.25[U]36.75 - 38.5]	Other
Back support length	[80.75 - 89.25]	[72.25 - 80.75[U]89.25 - 102]	Other
Back support width	]40.85 - 45.15[	[36.55 - 40.85[U]45.15 - 47.3]	Other
Back support angle	]95° - 105°[	[85° - 95°[U]105 - 110]	Other
Desk surface height	]24.7 - 27.3[	[22.1 - 24.7[U]27.3 - 28.6]	Other
Desk surface width	[47.88 - +∞[	[42.84 - 47.88[	Other
Desk surface depth	[70.3 - +∞[	[62.9 - 70.3[	Other
Desk surface angle	]0°-10°]	]10°-15°]	Other
	Workstation Factor = Sum of points / 10 = 9 / 10 = 0.9		
Classroom Environment	Satisfactory (0)	Unsatisfactory (1)	Dangerous (10)
Ventilation	]14.25 - 15.75]	[10 - 14.25[U]15.75 - +∞[	Other
Temperature	]18.9 - 26.1]	[15 - 18.9[U]26.1 - 30]	Other
Lighting	[50 - 100]	]20 - 50] U]100 - 200]	Other
Acoustical conditions	[0 - 50]	]50-70]	Other
	Environmental Factor = Sum of points / 4 = 1 / 4 = 0.25		
Classroom Design	Satisfactory (0)	Unsatisfactory (1)	Dangerous (2)
Seating Strategy	U, In rows, Cluster	Other	-
Board or visual aid Position	[-15° - -10°]	[-30°, -15°[U]-10° , 5°]	Other
Walls' Color (reflectance)	[60 - +∞ [	Other	-
	Design Factor = Sum of points / 3 = 0		
Miscellaneous Factor	Satisfactory (0)	Unsatisfactory (1)	Dangerous (2)
Student's concentration			
Student load			
Teacher's excitement			
	Miscellaneous Factor:		
	General Factor = 0.3 WF + 0.3 EF + 0.3 DF + 0.1 MF = 0.345		

Tab. 6: ECA index of ENG502 classroom.

Ergonomic Classroom Assessment ECA Index			
University Lebanese American University		Classroom Area	Date 18 Mar 2010
Campus Byblos Campus		# Students	Analyst
Class ENG 405		# Males	
Student Workstation	Satisfactory (0)	Unsatisfactory (1)	Dangerous (2)
Seat surface height	[48.45 - 53.55]	]43.35 - 48.45[U]53.55 - 61.2]	Other
Seat surface width	]40.85 - 45.15]	[36.55 - 40.85[U]45.15 - 51.6]	Other
Seat surface depth	[33.25 - 36.75]	[29.75 - 33.25[U]36.75 - 38.5]	Other
Back support length	[80.75 - 89.25]	[72.25 - 80.75[U]89.25 - 102]	Other
Back support width	]40.85 - 45.15]	[36.55 - 40.85[U]45.15 - 47.3]	Other
Back support angle	]95° - 105°]	[85° - 95°[U]105 - 110]	Other
Desk surface height	]24.7 - 27.3]	[22.1 - 24.7[U]27.3 - 28.6]	Other
Desk surface width	[47.88 - +∞[	[42.84 - 47.88[	Other
Desk surface depth	[70.3 - +∞[	[62.9 - 70.3[	Other
Desk surface angle	[0°-10°]	]10°-15°]	Other
	Workstation Factor = Sum of points / 10 = 9 / 10 = 0.9		
Classroom Environment	Satisfactory (0)	Unsatisfactory (1)	Dangerous (10)
Ventilation	]14.25 - 15.75]	[10 - 14.25[U]15.75 - +∞[	Other
Temperature	]18.9 - 26.1]	[15 - 18.9[U]26.1 - 30]	Other
Lighting	[50 - 100]	[20 - 50[U]100 - 200]	Other
Acoustical conditions	[0 - 50]	]50-70]	Other
	Environmental Factor = Sum of points / 4 = 11 / 4 = 2.75		
Classroom Design	Satisfactory (0)	Unsatisfactory (1)	Dangerous (2)
Seating Strategy	U, In rows, Cluster	Other	-
Board or visual aid Position	[-15° - -10°]	[-30°, -15°[U]-10° , 5°]	Other
Walls' Color (reflectance)	[60 - +∞ [	Other	-
	Design Factor = Sum of points / 3 = 0		
Miscellaneous Factor	Satisfactory (0)	Unsatisfactory (1)	Dangerous (2)
Student's concentration			
Student load			
Teacher's excitement			
	Miscellaneous Factor:		
	General Factor = 0.3 WF + 0.3 EF + 0.3 DF + 0.1 MF = 1.095		

Tab. 7: ECA index of ENG405 classroom.

5.3 Surveys Conducted

A survey for an ergonomic classroom assessmentwas conductedin LAU classrooms to compare its result with the ECA index findings. It included questions about the different factors that influence on the classroom environment, and were categorized as in paragraph 651.During the week extending from 11/15/2009 till 11/25/2009, 277 students filledthe survey by answering the questions subjectively of the classroom they are attending in the specific day the survey was given to them.

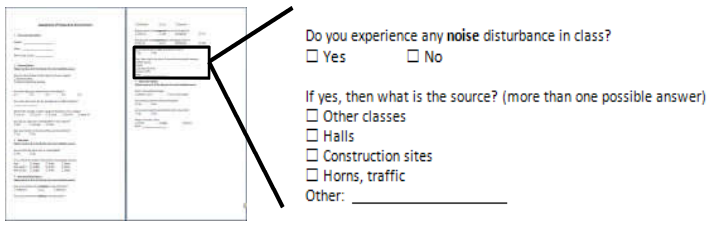

Fig. 3: Sample of the conducted survey.

The two main buildings at the LAU are the Science and the Zakhem Engineering buildings. These two departments include most of the classrooms at LAU (Byblos Campus). Therefore, selected classrooms

from these buildings were chosen to be assessed. Students attending the following classrooms filled the conducted survey: SCI404, SCI405, SCI406 from the Science building and ENG405, ENG502, ENG503, ENG504, ENG507, ENG602, ENG604, ENG605 from the Zakhem building; the last three classrooms are computer labs.

Classroom	*Number of students*
SCI404	25
SCI405	22
SCI406	13
ENG405	41
ENG502	51
ENG503	25
ENG504	28
ENG507	20
ENG602	18
ENG604	9
ENG605	25

Tab. 8: Appropriate classroom with the number of students filling the survey.

As shown in Tab. 8, thetwo highly assessed classroomsareENG502 and ENG405.

As for the results of the survey, below is a table that summarizes them with respect to the specified factors.

Classroom	*Comfortable Desk chair*	*Teacher influences on concentration*	*Sufficient ventilation*	*Sufficient lighting*	*No noise disturbance*	*Moderate Temp. by AC*	*Moderate Temp. by Heating System*
SCI404	16%	80%	48%	68%	28%	62.5%	56%
SCI405	14%	77%	50%	64%	14%	23%	55%
SCI406	23%	77%	46%	54%	0%	61.5%	85%
ENG405	27%	78%	34%	73%	27%	58.5%	56%
ENG502	37%	86%	35%	74.5%	14%	44%	80%
ENG503	28%	76%	40%	80%	56%	56%	62.5%
ENG504	54%	86%	32%	75%	36%	43%	64%
ENG507	25%	95%	60%	95%	5%	60%	60%
ENG602	50%	67%	67%	67%	28%	41%	67%
ENG604	55.5%	89%	55.5%	44%	0%	22%	67%
ENG605	40%	76%	42%	76%	24%	59%	64%
Weighted Average	**33%**	**81%**	**43%**	**73%**	**23%**	**50%**	**65%**

Tab. 9: Summary of the survey results.

5.4 ECA Index Compared to the Survey's Output

5.4.1 ECA Index of ENG502 vs. Survey's Output

The ECA index resulted that the student desk chair is ergonomically accepted but has a value of 0.9 which is very close to 1; it is therefore unsatisfactory and support the 63% of the students of this specific classroom's subjective opinion about it. In addition, 80% of the students consider the temperature by the Heating System is moderate, which is in consistence with the ECA result index. On the other hand, a large proportion of the students considered the ventilation and the lighting as insufficient and that the background noise in the classroom is high,whereas the ECA index proved the opposite to each one of these factors.

5.4.2 ECA Index of ENG 405 vs. Survey's Output

The student desk chair is the same in all of the classrooms and therefore we have the same ECA index result of 0.9 which is unsatisfactory and support the 73% of the students of this classroom's opinion. Furthermore, the ECA index and the students' subjective opinions are also in consistence considering the background noise which issomehow disturbing, and the temperature which is moderate. On the other hand, a large proportion of the students considered the ventilation as not sufficient and the lighting as sufficient whereas the ECA index proved them wrong.

6. CONCLUSION AND PERSPECTIVES

Neck and back pain have become a serious problem found in a large proportion of students worldwide. Thus, the classroom environment is important to be studied since it is of major cause to this problem.First, the influential factors that affect the academic performance of studentswere identified to generate as a next step the Ergonomic Classroom Assessment ECA index. This index constitutes points appointed to each range of parameters for each factor. In addition, an application of the Lebanese American University LAU classrooms ENG502 and ENG405 were done and the appropriate ECA indexes resulted values of 0.345 and 0.1095respectively.This shows that the first selected classroom has an ergonomic environment but the second classroom isn't. Furthermore, the Lebanese Anthropometric table was built and the Lebanese manikins were inserted in DELMIA©. A generation of the student desk chair in the same software was performed; an ergonomic posture analysis on this desk chair model was initiated and will be exposed in future publications. Furthermore, a survey was conducted to compare its results which are the subjective opinion of the students, with the ECA results of the LAU classrooms ENG502 and ENG405 which are results of scientific and objective research and study.

In addition to this analysis, the factors of the ECA index have to be assigned certain weights to value their influence on the classroom environment.

This article forwarded a complete methodology to assist human engineering design for classroom assessment. Future work should include the miscellaneous factor study as well as the cognitive design influence on the student academic performance and should further expose the weight values evaluation.

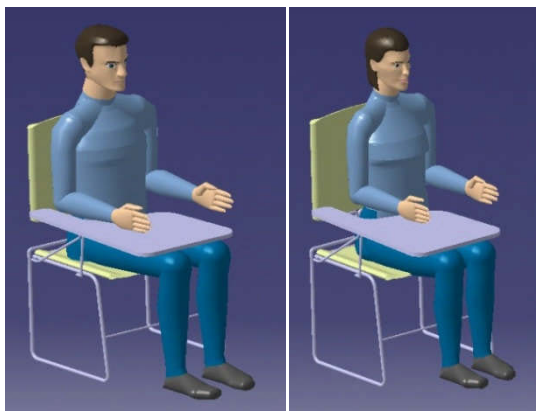

Fig. 4: Human ergonomics assessment of the classroom desks.

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