Mismatch between classroom furniture and students' anthropometric measurements in UAE

Salaheddine Bendak

Dept. of Industrial Engineering and Management, University of Sharjah, PO Box 27272, Sharjah, United Arab Emirates, Email: sbendak@sharjah.ac.ae, Fax: 971-6-5053963

Abstract

School-age children spend five hours every day sitting at school. Any mismatch between their anthropometric measures and classroom furniture dimensions has the potential to cause anatomical and learning problems. In many developing countries, anthropometric measures are rarely available. In these countries, dimensions of school furniture are either based on anthropometric measures from developed countries or are arbitrarily determined. The purpose of this study is to compare students' anthropometric measures with classroom furniture dimensions in United Arab Emirates. Relevant anthropometric dimensions of a sample of 200 grade 6 students were measured in two large schools in Dubai and Sharjah. Dimensions of furniture used by these students were also measured and compared to their anthropometric measures. Results show that there was a major mismatch between many anthropometric measures and classroom furniture dimensions. Finally, a new set of furniture dimensions for grade 6 classrooms was suggested based on anthropometric dimensions of students.

1. Introduction :

School-age students spend approximately five hours every day seated in classrooms. Suitable school furniture is essential for assuring correct sitting posture of students and preventing musculoskeletal symptoms (Cranz, 2000). This suitability of school furniture is determined by having their dimensions being comparable to anthropometric measures of students.

Any mismatch between school furniture dimensions and students' anthropometric measurement carries potential physiological strain on the muscles, ligaments and discs (Bendix, 1987). This mismatch has been reported in many recent studies in several countries (e.g. Gouvali and Boudolos, 2006; Castellucci et al., 2010; Mokdad and Al-Ansari, 2009; Parcells et al., 1999). Learning at schools can be affected by this mismatch since uncomfortable and awkward body postures can harm the students' learning interest and enthusiasm, even during interesting and stimulating lessons (Hira, 1980). Moreover, using furniture that promotes proper posture is more important to children than adults because it is at this young age that sitting habits are formed. Bad sitting habits acquired in childhood are very difficult to change later (Yeats, 1997).

Gender and socioeconomic background are also sources of anthropometric variability that need to be addressed. The growth surge that instigates adolescence occurs earlier usually among females than among males (Oxford, 1969).

Research has documented an increase in health problems among school students in the last few decades (Vikat et al., 2000). Those students are experiencing increased neck, shoulder and back pain problems due to low

quality and badly designed school tables and chairs. Usually students' sitting posture is influenced by activities performed in the classroom, anthropometric measures of school children and the design features of school furniture (Troussier et al., 1999).

Numerous research studies have focused on the design of work furniture based on the biomechanics of the human body (e.g. Naqvi, 1994; Burgess-Limerick et al., 1999). However, only a few studies has shown interest in the design of school furniture (Castellucci et al., 2010; Gouvali and Boudolos, 2006; Mokdad and Al-Ansari, 2009).

In a study conducted on grade 8 students in three Chilean schools by Castellucci et al. (2009), it was found that seat height, which is the starting point in classroom furniture design, was appropriate for students' popliteal height in only 14% of students in two schools and 28% in the third school. It was found also that seat to desk height was too high and mismatched 99% of the body dimensions of students in one school and 100% in the others. As a result of this, children were required to work with shoulder flexion and abduction or scapular elevation, causing more muscle work load, discomfort and pain in the shoulder region.

Again and according to Castellucci et al. (2009), 86% of students in one school, 72% in the second and 85% the third school used seats that are higher than required. This means that those students will not be able to support their feet on the floor, generating increased tissue pressure on the posterior surface of the knee (Milanese and Grimmer, 2004). Finally, Castellucci et al. (2009) reported that seat depth was short, and therefore did not fit students' buttock-popliteal length, in 25%, 24% and 39% of the students in the three schools respectively. The authors concluded that classroom furniture was inadequate and that anthropometric measures of students were not taken into consideration while designing classroom furniture.

Similar results to those of Castellucci et al. (2009) were found by Gouvali and Boudolos (2006) who studied the match between school furniture dimensions and body dimensions of 274 students in Athens aged 6-18 years. They found that seats and desks were too high and that seat depth was inappropriate for most students.

Findings of the above-mentioned studies also match results of a study by Parcells et al. (1999) on 11-14 years old students in a school in the Michigan district. Only 20% of the students who participated in that study could find an acceptable desk–chair combination. For the rest of the children the seats were too high and/or too deep. Desks were too high, while only desk clearance was not a problem for any student. This is specifically disturbing as high seats prevent students from splitting their body weight appropriately by supporting their feet on the floor. This lack of foot support may increase tissue pressure on the posterior area of the knees (Milanese and Grimmer, 2004).

Such studies are specifically rare in developing countries including United Arab Emirates (UAE). No study has ever been conducted to evaluate design of school furniture in UAE up to the knowledge of the authors. Only one study was conducted in this country to assess anthropometric measures of 21,068 children (including 12,159 females) between the ages of 0 and 18 years. In this study weight for age and length and height for age were

analyzed without assessing anything related to school furniture (Abdulrazzaq et al., 2008). This current study aims to fill in this gap. It aims to analyse the suitability of school furniture from an ergonomics perspective and based on anthropometric measures of school students.

2. Methodology

2.1 Schools

UAE has a multicultural society where UAE nationals and expatriates from all nationalities live together. Schools sought for data collection in this current study were international schools (where the language of instructions is English) serving all nationalities. To save time, it was thought that collecting data from two large private international coeducational schools located in two Emirates will serve this purpose. One large international school in Dubai (coded as school A) and another one in Sharjah (school B) accepted to participate in this study.

2.2 Participants

For the purpose of assessing the suitability of school furniture, anthropometric measures of 100 able students (50 male and 50 females from ethnically diverse background) attending grade 6 were taken from each school. Grade 6 was chosen as students in this grade are at a vital age when sitting habits, that continue throughout later stages in life, are formed (Yeats, 1997).

Information on the study was given to the school administration, teachers, parents and students and parents' written permission was sought after assuring them of full confidentiality of all data collected. No names were taken during the course of data collection. Approval of the study was overwhelming.

In total, 200 students participated in this study. This is thought to be a healthy sample size given that similar studies involved similar, if not smaller, sample sizes (e.g. Castellucci et al., 2009; Gouvali and Boudolos, 2006).

2.3 Dimensions of furniture to be considered

School work for students in grade 6 consists of basic study skills like writing, reading, note-taking, drawing, looking at the board/screen, etc. Keeping this in mind and following the lead of similar studies (e.g. Castellucci et al., 2009, Gouvali and Boudolos, 2006; Mokdad and Al-Ansari, 2009), school furniture dimensions measured in the current study (also illustrated in Figure 1) were as follows:

1. Desk width (DW)
2. Desk depth (DD)
3. Seat width (SW)
4. Seat depth (SD)
5. Seat height (SH)
6. Seat to desk height (SDH)
7. Seat to desk clearance (SDC)
8. Upper edge of backrest (UEB)

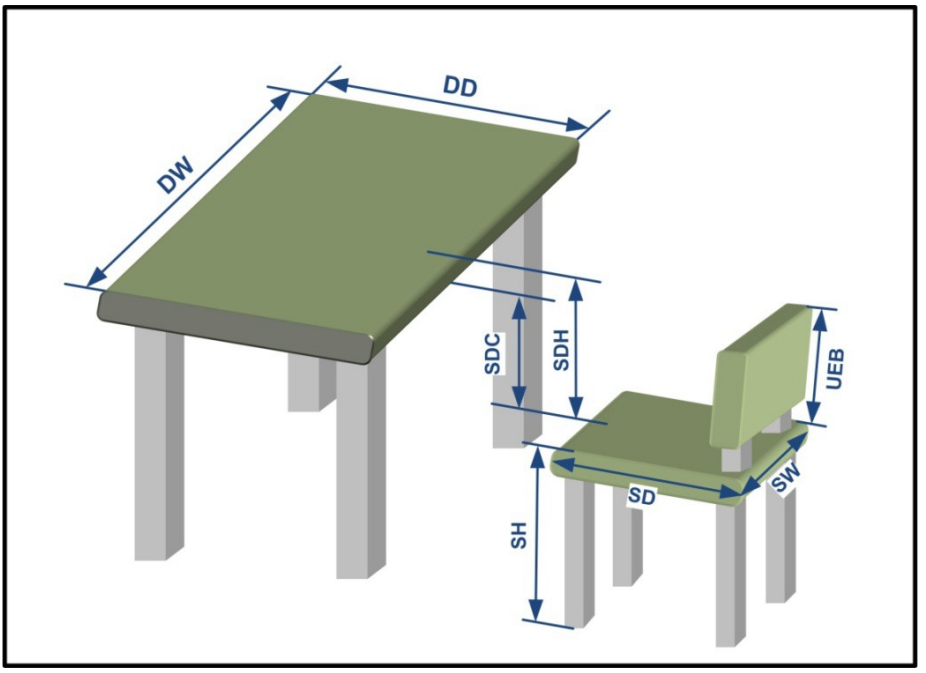

Figure 1: Furniture dimensions studied.

2.4. Anthropometric measures considered

Based on ISO standard 7250 (ISO, 1996), Pheasant (2003) and similar studies like Castellucci et al. (2009), Gouvali and Boudolos (2006) and Mokdad and Al-Ansari (2009), relevant students' anthropometric dimensions that were thought necessary in the evaluation of school furniture are as follows (illustrated in Figure 2):

1. Elbow height sitting (EHS) taken with a 90^{o} angle elbow flexion. Pheasant (1991) recommend that:
   $EHS \leq SDH \leq EHS+5$ (1)
2. Thigh thickness (TT) which is needed to determine SDC. In order to permit leg movement, Parcells et al. (1999) suggested that:
   $SDC > TT + 2$ (2)
3. Popliteal height (PH) which is the distance between footrest and popples with a right angle between the thighs and the shins. According to Gouvali and Boudolos (2006), the relationship between PH and SH is as follows:
   $PH(\cos 30) \leq SH \leq PH(\cos 5)$ (3)
4. Buttock-popliteal length (BPL) which is necessary to determine SD. In order to achieve a comfortable depth for the vast majority of the user population, Parcells et al. (1999) suggested the criterion given in the following equation: $0.80\ BPL \leq SD \leq 0.95BPL$ (4)
5. Hip width (HW) which is needed to determine SW (Helander, 1997; Sanders and McCormick, 1993) where: $SW > HW$ (5)
6. Subscapular height (SUH) which is necessary to determine UEB (Garcia-Acosta and Lange-Morales, 2007) where: $UEB \leq SUH$ (6)

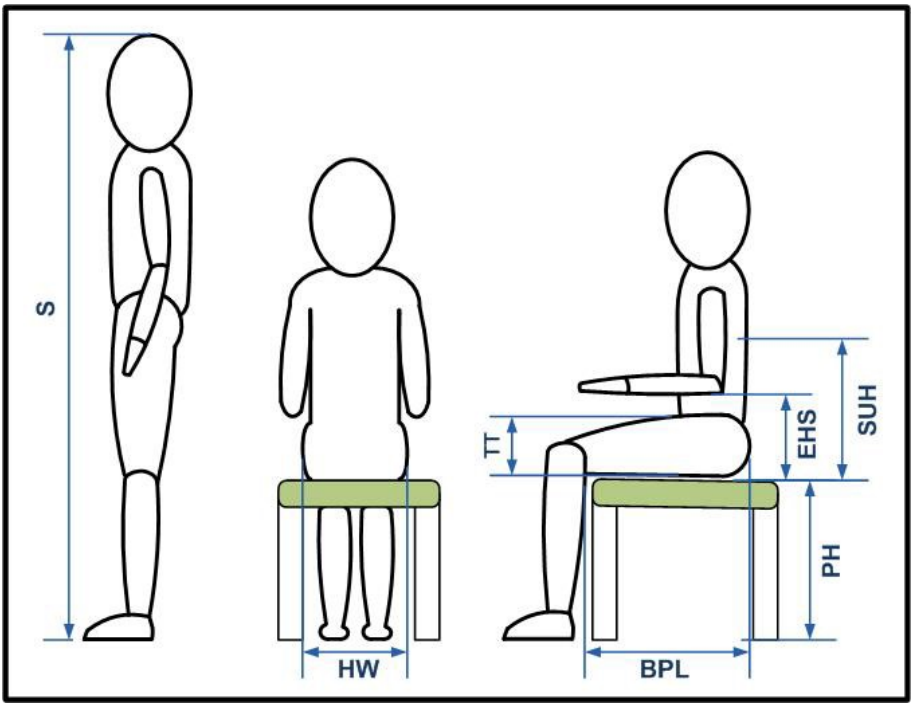

Figure 2: Anthropometric measures investigated.

2.5 Equipment

In this study, equipment used to take anthropometric measures were::

a) Large and small anthropometers
b) Measurement tapes
c) Height measuring instrument.

3. Results and Discussion

3.1 Furniture Measures

It was found that each school has only one set of chairs and desks used across all grade 6 sections. This meant that all grade 6 students were using the same type of chairs and desks. Furniture dimensions in schools A and B are given in Table 1. As can be seen in that table, there were wide differences in most classroom furniture dimensions between the two schools.

Furniture Dimension	School A	School B
DD	60	40
DW	70	60
SDC	21	14.5
SD	41	36
SW	42	39
SH	45	37
UEB	37.5	34
SDH	27	26.5

Table 1: Furniture dimensions (cm) at both schools.

3.2 Anthropometric Measures

Mean and standard deviation of anthropometric measures obtained from schools A and B are given in Table 2.

	School A (n=100)		School B (n=100)	
	Mean	S.D	Mean	S.D
PH	52.9	2.67	52.9	3.44
BPL	54.9	4.78	54.9	4.39
EHS	19.3	4.64	19.4	4.63
HW	32.1	5.34	32.5	6.16
TT	12.9	2.43	12.9	2.44
SUH	41.3	3.08	40.9	3.3

Table 2: Mean (cm) and standard deviation of anthropometric measures collected.

An unpaired double-sided t-test (with 95% confidence interval) was performed on each measurement to check if there were any differences between the two schools. T-test results are shown in Table 3. Since all p-values given in Table 3 are greater than 0.05, it can be concluded that there were no significant differences in anthropometric measures between grade 6 students of these two schools.

Dimension	PH	BPL	EHS	HW	TT	SUH
p-value	0.971	0.968	0.863	0.646	0.899	0.347

Table 3: t-test p values.

3.3 Mismatch between Anthropometric Measures and School Furniture

In order to compare anthropometric dimensions of students with furniture dimensions for one-way equations, two categories were defined: 'Match' and 'Mismatch'. For two-way equations, three categories were defined as follows:

1. 'Match' when the anthropometric measure is between the limits
2. 'High mismatch' when the minimum limit of the criterion equation is higher than the anthropometric measure, and
3. 'Low mismatch' when the maximum limit of the criterion equation is lower than the anthropometric measure.

Seat width (SW)

Comparisons of SW vs hip width (HW) show that narrow seats (mismatch) were experienced by 8% and 16% of students in schools A and B respectively. Accordingly, those school children were not able to dissipate the pressure at the buttock causing discomfort and mobility restrictions (Evans et al., 1988; Helander, 1997; Occhipinti et al., 1993; Orborne, 1996; Sanders and McCormick, 1993).

Seat depth (SD)

Bar chart illustrating comparisons of SD vs buttock-popliteal length (BPL) is given in Figure 3. As is clear in that figure, SD was too low (high mismatch) for 69% and 98% of students from schools A and B respectively. This meant that their thighs were not adequately supported, the case which could generate discomfort and hinder blood circulation (Milanese and Grimmer, 2004; Pheasant, 2003). Seats were not found to be deeper than

required for any student in both schools which meant that kyphotic postures are unlikely to occur (Hira, 1980; Khalil et al., 1993; Knight and Noyes, 1999; Orborne, 1996).

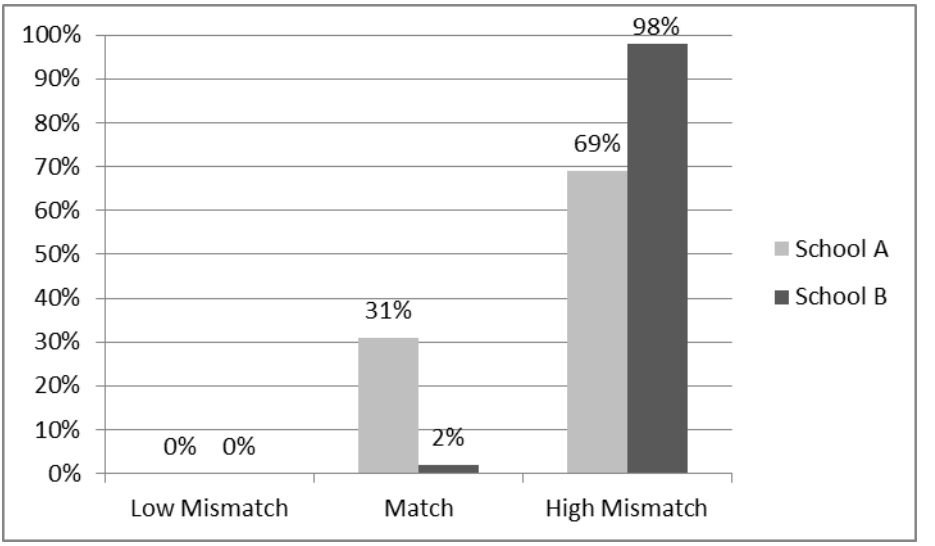

Figure 3: Percentages of students by match/mismatch level for SD vs BPL.

Seat height (SH)

Bar chart illustrating comparisons of SH vs popliteal height (PH), as given in Equation 3 earlier, is given in Figure 4. As is clear in Figure 4, SH was high (i.e. a high mismatch occurred) for 68% of school A students and all school B students. No low mismatch case was recorded in either school. This widely spread high mismatch means that most students are not able to support their feet on the floor and, therefore, are likely to be experiencing high tissue pressure on the posterior surface of the knee (Dul and Weerdmeester, 1998; Milanese and Grimmer, 2004; Oxford, 1969; Parcells et al., 1999; Sanders and McCormick, 1993).

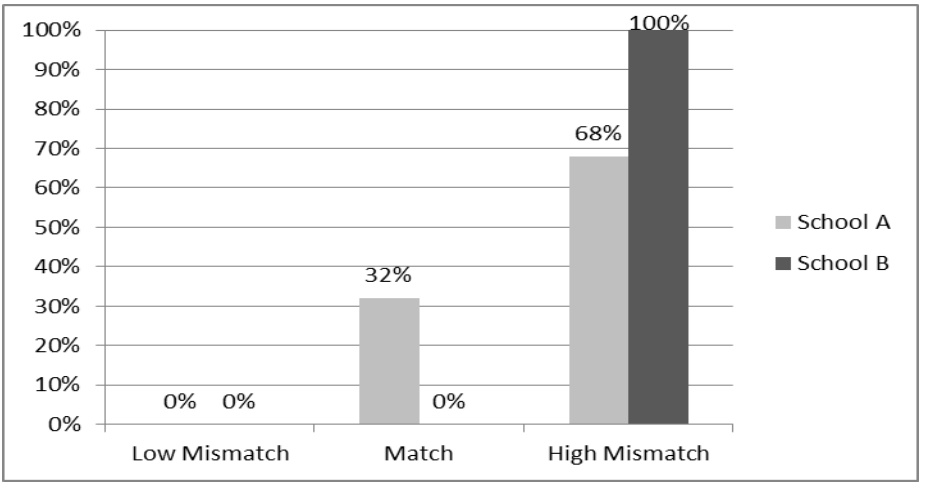

Figure 4: Percentages of students by match/mismatch level for SH vs PH.

Seat-to-desk height (SDH)

Bar chart illustrating comparisons of SDH vs elbow height sitting (EHS) is given in Figure 5. It is clear from that figure that for 75% of grade 6 students in school A and 66% of those in school B, the desk was too high (i.e. low mismatch). As a result of this, students were required to work with shoulder flexion and abduction or scapular elevation which might cause increased muscular workload, discomfort and pain in the shoulder region. For 5% of students in School A and 8% of students in School B, the desk height was low (i.e. high mismatch) which could cause students to bend forwards to work on the desk. This also had the potential to cause shoulder and back problems (Szeto et al., 2002).

Seat-to-desk clearance (SDC)

Comparisons of Seat to Desk Clearance (SDC) vs thigh thickness (TT) revealed that SDC mismatched 49% of students in school B and none of the students in school A. This meant that 25% of all students had their thighs in contact with the desk, thus restricting movement of the legs (Dul and Weerdmeester, 1998; Evans et al., 1988; Parcells et al., 1999; Sanders and McCormick, 1993).

Upper edge of backrest (UEB)

Comparisons of UEB vs subscapular height (SUH) showed a mismatch for 9% and 3% of students of schools A and B respectively, meaning that the backrest was higher than their scapula. This had the potential to lead to restricted arm mobility (Evans et al., 1988; Orborne, 1996).

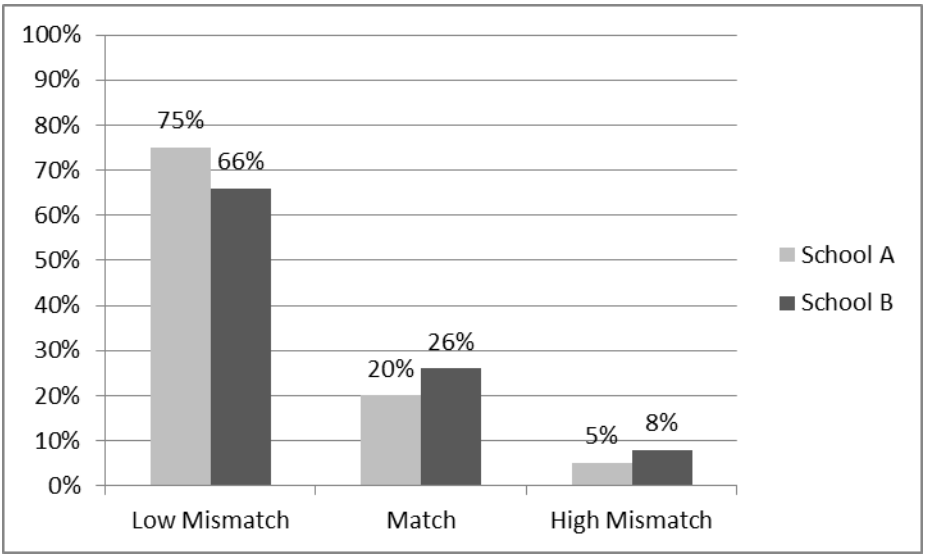

Figure 5: Percentages of students by match/mismatch level for SDH vs EHS.

Overall, results obtained indicate that some dimensions of furniture used by students in both schools don't match anthropometric measures of many students. This, in turn, has the potential to exert physiological strain on the muscles, ligaments and discs (Bendix, 1987) and harm students' learning interest and enthusiasm (Hira, 1980). Therefore, a new set of school furniture dimensions for grade 6 students is recommended.

4. Recommending a New Furniture Design

SH (seat height) should be determined in a way that allows short students with short PH to rest their feet on the floor knowing that a seat that accommodates short-legged children will also accommodate long-legged children as mentioned earlier. Recommended SH would be determined from the 5th percentile of the sample (Keegan, 1953; Evans et al., 1988; Gouvali and Boudolos, 2006; Pheasant, 1991; Helander, 1997). Hence, the recommended SH would be 5th percentile of the students PH minus one cm, which is 47 cm.

SW should be designed to accommodate large hip width. Small SW will cause discomfort to some users as it will compress the soft undersides of the hips whereas large SW will cause no harm to anyone at all. In other words, if a seat surface is designed to accommodate children with large hip width, it will also easily accommodate those with small hip-width. In this case, 95th percentile of hip width is used as recommended by many researchers (e.g. Evans et al., 1988; Helander, 1997; Keegan, 1953; Pheasant, 1991; Sanders and McCormick, 1993). Hence, the recommended SW would be 95 percentile of the students HW + 2 cm. This is equal to 44 cm.

UEB (upper edge of backrest) should be designed to support the scapula. So, it should be designed in a way that supports students with short scapular height (Garcia-Acosta and Lange-Morales, 2007). Hence, the recommended UEB would be 5th percentile of students SUH, which is 36.23cm.

Table depth and width should be determined based on the functional requirements of work. In a school environment, tables should be large enough to accommodate students' pens, tools, books, etc. and to give them space to read and write (Mokdad and Al-Ansari, 2009). Hence, there is no evidence to suggest that table depth and width are not satisfactory in either school. Based on the above justifications, recommended dimensions are plotted in Figure 6.

4. Conclusions

This study aimed to anthropometrically analyse the suitability of school furniture in the United Arab Emirates. A sample of 200 grade 6 students was chosen from two schools in Dubai and Sharjah for this purpose. Chairs and tables used by those students were measured and compared to the students' anthropometric measures. Compatibility of the furniture was found by using the match/mismatch criteria (furniture dimensions versus anthropometric measures). Results showed that there is great discrepancy between furniture dimensions and anthropometrics measures of students. This has the potential to increase the chance of health problems amongst them. Based on students' anthropometric measures, new dimensions of desks and chairs used by students in UAE schools were recommended.

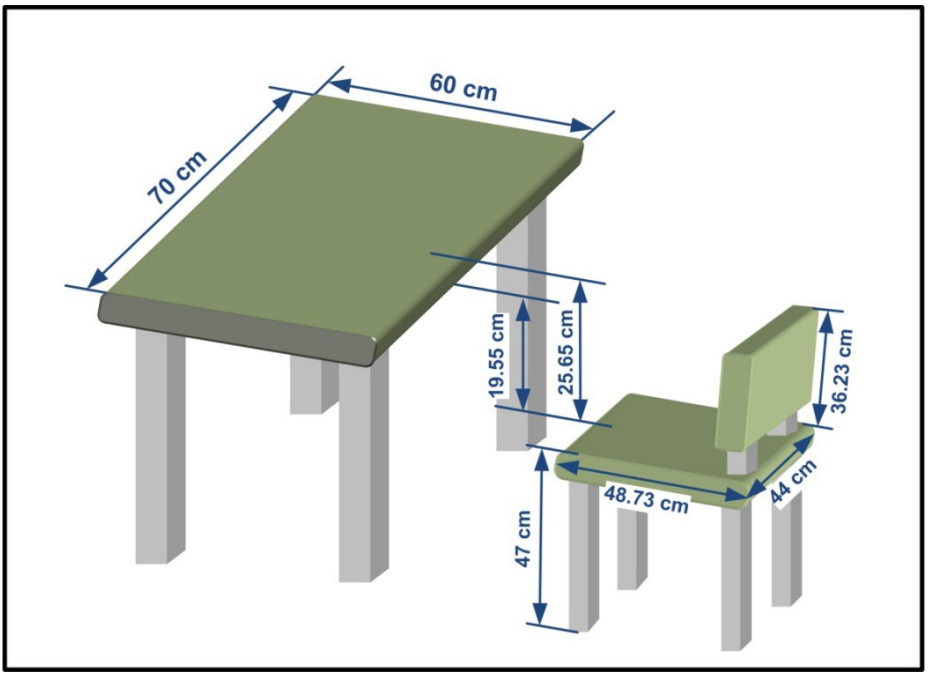

Figure 6: Recommended furniture dimensions.

Finally, researchers have been stressing on the importance of making the workplace adjustable, whenever possible, after taking into consideration other design requirements and financial constraints (due to the cost increase associated with adjustability). Similarly, the issue of adjustability should also be considered when evaluating the suitability of school furniture to students. According to many researchers (like Evans et al., 1988; Parcells et al., 1999), the need for adjustable school furniture is becoming increasingly important. However, this issue was outside the scope of the current study. It can be suggested as a topic for future research projects.

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