

Designing Student's Seating Furniture for Classroom Environment

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KEYWORDS Environment. Ergonomic. Educational Institution. Students. Furniture.

ABSTRACT Classroom furniture is an important facility that helps in providing a conducive, comfortable and functional environment for students in educational institution. To explore the design compatibility of the existing furniture for the of students use in classroom, the study was conducted in twin cities of Hyderabad and Secunderabad covering 100 students randomly selected as sample representing 10 undergraduate colleges. Four types of furniture were found to be in use in classrooms viz., sled desks, chair with arm tablet, table with chair and table with bench. The opinion of the students with regard to classroom seating furniture revealed that some furniture parts and their dimensions were inconvenient for use and uncomfortable to sit. From the opinion and suggestions given by the students and the anthropometrical consideration; the guidelines for designing students seating furniture were framed. Two types of furniture designs namely chair with arm tablet and sled desk were evolved to overcome the design deficiency.

INTRODUCTION

Furniture is one of the important physical facilities provided in a classroom environment where the students spend most of their time working with different learning activities. The design of workplace for students should ensure effective learning process and comfort. The functional utility of the student's classroom furniture is a result of its physical design in relationship to the physical structure and biomechanics of human body.

Human body is intended for movement and regular changes of posture are necessary for its normal functioning. Seating furniture for classroom shall support the body weight and enable postural movement and circulations. Chaffin and Anderson (1991) opined that the work seat alone is insufficient for stabilization and the use of the legs, feet and back in contact with other surfaces, as well as muscular forces, are necessary to produce equilibrium. Leg support is also critical for distribution and reducing buttock and thigh loads. Feet need to rest firmly on the floor or foot support so that the lower leg weight is not supported by the front part of the thighs resting on the seat.

Studies on classroom seating furniture revealed that students reported to have experienced musculoskeletal pains, headache and low back pain due to incompatible seating furniture in a number of schools. So the

ergonomists need to treat the issue of furniture design for students as a necessity and educational institutes should treat the selection of right kind of furniture as social responsibility towards the student community.

The present study was an attempt to evolve student's seating furniture for college classroom.

MATERIAL AND METHODS

This research was aimed to explore student's opinion on the type of furniture used by them in classroom and its suitability to personal and task needs and evolve user-friendly furniture design. This study was conducted by taking the opinion of 100 students as sample who were randomly selected from 10 undergraduate colleges in twin cities of Hyderabad and Secunderabad, who had used the students classroom seating furniture at least for one academic year. An observation sheet and an opinionnaire were developed to collect the information about the existing furniture design. The information collected from students on their choice of furniture for classroom formed the criteria for identifying the types of furniture designs to be designed. From the suggestions and recommendations given by the students, the furniture design needs were identified. Based on the analysis and interpretation of information, the guidelines for developing furniture design were set. Dimensions for the proposed designs were determined taking the anthropometrics into

consideration. The dimensions for seat-height, depth, width, backrest-height, length, width, work surface-height, length width and inclination angle were given importance to increase utility and convenience of furniture in classroom. Apart from these, features like lumbar support, footrest angle, adjustable seat height and the table height, provision for books and water bottles were also taken into consideration in the design of furniture. Auto CAD 2000 software was used to develop the draft model of furniture.

RESULTS AND DISCUSSION

Out of the 10 colleges explored for the study - 5 colleges provided sled desks, 3 had chair with arm tablet and one each had table with chair and table with bench. Preferences made by the students in opinion survey revealed that 62 percent of the students preferred chair with arm tablet, while the rest 38 percent preferred sled desk for use in classrooms. Opinion of students on desired features of student's classroom seating furniture is shown in Table 1.

Student's opinion on desired design features revealed that, the entire student felt that the furniture should be strong and finished with smooth surface. Almost 85 percent of the

students preferred the seat to be broad and wide for body to get complete support while 78 percent preferred the feet to touch floor as it facilitates correct sitting posture. Almost 72 percent felt the need for of lower back support and preferred a support at the lower back, while seventy one percent preferred free movement space for thighs and legs. Nearly 68 percent recommended footrest for the worktable. Sixty Five percent stressed on the need for proper work height and width for the table and fifty eight percent perceived the need for storage provision to keep books and water bottle. Almost 55 percent of the sample felt that arm tablet should be at correct height and provide sufficient space for keeping books and papers. Fifty four percent recommended adjustment in height for both chair and table and another 53 percent wanted the furniture to be less noisy during use in the classroom.

From the observations made on the design features of furniture and the recommendations of the users, the guidelines for improving the design features of furniture were evolved.

Design Guidelines for Proposed Furniture Designs

Design Criteria Based on Student's Recommendation:

- Furniture should be strong and durable
- Seat should be broad and wide for complete body support
- Seat should facilitate the foot to rest on the floor while sitting straight
- Lower back support should be provided to prevent backache
- Thighs and Legs should have free moving space
- Footrest should be provided for table / desk
- Table should be at convenient reach and wide
- Provision for keeping books and water bottles
- Arm tablet should be at correct height
- Arm tablet should provide space to write comfortably
- Height of the chair and table should be adjustable to users needs
- Provision for rubber casing/bush to prevent noise

From above it can be inferred that to fulfill

Table 1: Opinion of students on desired features of students classroom seating furniture (N = 100)

S. No.	Desired features in students seating furniture	Percentage
1	Furniture should be strong and smooth	100
2	Seat should be broad and wide for complete body support	85
3	Seat should facilitate the foot to rest on the floor while sitting straight	78
4	Lower back support should be provided to prevent backache	72
5	Thighs and Legs should have free moving space	71
6	Footrest should be provided for table / desk	68
7	Table should be at convenient reach and wide.	65
8	Should provide facility for keeping books and water bottles	58
9	Arm tablet should be at correct height	57
10	Arm tablet should provide space to write comfortably	55
11	Height of the chair and table should be adjustable to users needs	54
12	Furniture should be less noisy during use	53

*Data presents multiple responses

the needs of users it was essential to determine dimensions for different parts of the furniture and choose the materials and finishes suitable for each component. Hence the following targets were set to arrive at the design decisions.

- Identification of dimensions for seat width and depth.
- Identification of suitable dimension for seat height
- Provision for lower lumbar support
- Provision for adequate clearance space at thigh, knee, leg and foot level
- Provision of footrest at correct height and angle
- Identification of comfortable work height in sitting posture for alert work
- Identification of suitable place and type of provision for books and water bottles
- Identification of correct height for arm tablet
- Identification of writing surface area for arm tablet
- Provision for adjustment of seat and table height
- Selection of material and finish for furniture body and supports
- Provision for rubber bush to minimize noise during use

Determination of Furniture Dimensions

Determination of dimensions was a crucial step in design development. To determine the dimensions for different parts of selected furniture designs, recommended percentile value, clearance allowances for body movements as suggested by different authors in review of literature were considered. Adult women anthropometry data (Chakrabarti, 1997) was used to determine the dimensions for proposed design

Seat Width: The hip dimensions were used for a static fit work. The relaxed mid - thigh -to - thigh distance, the 75th percentile value, that would accommodate the 95th percentile of the hip breadth was recommended by Chakrabarti, 1997, he stated that the seat width should never be less than 400 mm.

Seat Depth: The effective seat length suggested was that it should be 1/5th less than the buttock - popliteal length, with 5 degrees back slope from 3/4th of the seat depth. The front edge of the seat should have a curvature,

preferably water fall seat of 3 degrees slope. The recommended dimension of 400 mm was considered (Chakrabarti, 1997)

Seat Height: The height of the seat should match the length of the footrest and the popliteal distance, To facilitate comfort for tall and short persons the adjustable height in seat was attempted. 50th percentile (399 mm) was chosen for normal individual and adjustment provision of 5th percentile value (365 mm) for short persons and 95th percentile value (441 mm) for tall persons were considered. (Chakrabarti, 1997)

Backrest Height and Angle: As suggested by Chakrabarti (1997) the height of the lower backrest from the seat surface was in tune with the 5th percentile value of the lower lumbar height (100 mm) so that all persons having a greater height can get support, and the 95th percentile of upper lumbar height (346 mm) and the 75th percentile value of Acromion (525 mm) were considered. The backrest angle preferred was 100 degrees since all the classroom activities call for alert sitting posture.

Backrest Width: The width was taken into consideration by taking the 95th percentile of the shoulder bi - deltoid breadth i.e., (369 mm) (Chakrabarti, 1997)

Arm Tablet: Fiftieth percentile value of elbow rest height was considered for determining the height of arm tablet height (194 mm). Student's have opined that it should be large enough to accommodate a book or paper. Opinion survey revealed that students were comfortable with the arm tablet width of 300 mm and length of 500 mm. Hence these dimensions were considered with the clearance allowance of 100 mm from seat back.

Desk Height: The desk height was taken according to the value recommended by Panero and Zelink (1979), Phesant, S(1986) and it was taken as 750 mm.

Desk Depth: Panero and Zelink (1979), Phesant, S(1986) also mentioned that the individual space requirement for work table, the minimum arm reach should be considered which is taken as the 50th percentile minimum arm reach value. The dimension taken for desk width was 375 mm.

Desk Width: Panero and Zelink (1979), Phesant, S (1986) recommended relaxed elbow to elbow width at 50th percentile value (439 mm) along with clearance for a work table was taken into consideration. The proposed value for desk width to accommodate three individuals was 1467 mm.

Desk Top Angle: The inclined angle of the desk top was taken as 10 degrees as suggested by de Wall et al. (1991)

Footrest Angle: The footrest angle was recommended as the 15 - 30 degrees by Chakrabarti (1997) and it was taken into consideration.

Footrest Height: The footrest height of 50 mm was taken into consideration from the student's opinion.

Book Case: dimension of 200 mm X 200 mm X 100 mm was considered as an ideal dimension by the investigator since it can hold 6 - 8 books which are used by students.

Dimensions Proposed for Selected Furniture Design

The data emerged out of study indicated a substantial degree of mismatch between the recommended standard of furniture which were based on standard anthropometrics dimension of adults the existing designs. The study revealed that designing each component of furniture with care and attention to user's need can result in user-friendly design. With the above-defined guidelines, the following measurements were proposed for the two types of furniture viz., Chair with Arm Tablet and Sled Desk. Table 2 gives the dimensions proposed for selected furniture designs.

Table 2 shows the observed dimensions in different models of chair with arm tablet and sled desk models of classroom furniture. In the proposed designs the dimensions and features recommended by Chakrabarti (1997) for alert sitting was taken. This includes - seat width as 400mm; seat depth as 400mm with 5 degrees back slope from 3/4th of seat depth, the front edge of the seat with a curvature like water fall seat of 3 degrees slope; seat height as 399mm (50th percentile), 365mm (5th percentile) for short persons and 441mm (95th percentile) for tall persons; Backrest height and angle as 100mm (lower lumbar height), upper lumbar as 346mm (95th percentile), Acromion as 525mm (75th percentile) and a backrest angle of 100 degrees; Backrest width as 369mm (95th percentile of shoulder breadth); However the arm tablet height was taken as 194mm; footrest height as 50mm and footrest angle as 15 degrees were taken as per the students preferences in opinion survey.

Panero and Zelik (1979) recommended desk height as 750mm; Desk depth as 375mm; Desk

width as 439mm and hence a proposed width of 1467mm for three individuals was taken. The desktop angle was taken as 10 degrees as suggested by de Wall et al. (1991).

Material and Finishes for the Proposed Design

This was mainly based on student's opinion survey. Majority of the student's preferred metal/ wood for furniture frame body and wooden components for the furniture parts where users body comes in contact with furniture. The furniture parts and the type of material used in the existing furniture and the material proposed for the new furniture along with the justification are given in Table 3.

With the set in guidelines and defined dimensions, chair with arm tablet and sled desk type of furniture were developed in draft mode and AutoCAD 2000 software. The description of the designs developed for each type is given below.

Description of the Design - Chair and Arm Tablet

Body Frame: The frame, on which seat, backrest support, arm tablet and bookcase rested, was divided into two parts namely leg frame and seat frame. The distance between the leg frame and seat pan met the requirement of seat height. The leg frame was provided with the provision to

Table 2: Dimensions of the observed furniture and proposed furniture

S.. No.	Design feature	Observed dimensions (mm)	Proposed dimensions (mm)
<i>Chair with Arm Tablet</i>			
1	Seat height	450 - 465	435**
2	Seat depth	350 - 455	400**
3	Seat width	350 - 455	400**
4	Backrest height	400 - 500	525**
5	Backrest width	440 - 455	369**
6	Arm tablet height	220 - 240	194
7	Arm tablet length	500 - 680	500
8	Arm tablet width	250 - 300	300
<i>Sled Desk</i>			
9	Desk height	765 - 825	750*
10	Desk width	280 - 470	375*
11	Desk length	1155 - 1540	1467*
12	Desk- bench clearance	120 - 230	227
13	Bench height	455 - 505	435
14	Bench width	240 - 395	400
15	Bench length	1155 - 1540	1467
16	Book rack height	180 - 200	210

*Panero and Zelik (1979), ** Chakrabarti (1997)

Table 3: Materials and finishes proposed for selected furniture design

<i>Furniture designs and parts</i>	<i>Existing</i>	<i>Proposed</i>	<i>Justification</i>
<i>Chair with arm tablet</i>			
Body and Leg frame	Buffed metal Painted or buffed metal / wood	Strong and Durable	
Back support	Painted metal / Polished wood	Laminated Wood (Eco board)	Durable, aesthetic, smooth durable finish
Seat pan	Painted metal / Polished wood (Eco board)	Laminated Wood	Durable, aesthetic, smooth durable finish
Arm tablet	Painted metal / Polished wood	Laminated Wood (Eco board)	Durable, aesthetic, smooth durable finish
<i>Sled Desk</i>			
Main body frame	Painted metal	Buffed metal	Due to its strength and durability.
Back support	Wood with polish or Decolum finish/ metal sheet	Laminated wood (Eco board)	Safe, not hard to the body, flat and comfortable
Table top	Wood with polish or Decolum finish	Laminated wood (Eco board)	Safe, does not cause injuries, flat and comfortable for writing
Bench top / seat pan	Wood with polish or Decolum finish	Laminated wood (Eco board)	sit, suits the body Safe and comfortable to
Case for Books	Battened or Polished wood / Metal sheet	Laminated wood (Eco board)	Easy to clean and can with stand the weight

increase or decrease the height of seat frame to facilitate the variations in dimensions of tall and short persons. Leg frame was provided with the provisions to move the seat frame up and down and combined to form a single unit. The edges and corners of body frame were smoothly finished to prevent accidents or hurts from any sharp edges. To protect the classrooms flooring from scratches, the leg frame was fitted with a suitably designed rubber bushes.

Seat: The dimensions specified in the guidelines were used to create seat pan design. Seat pan was at the highest elevation at $\frac{1}{4}$ distance of seat depth from the front. The elevation was inclined by 5 degrees at back for the buttock to receive proper support in the sitting posture and permit easy movement during the change in posture. Three degrees inclination in the front was provided and the curve was created to form water fall design. This feature is supported by Chakrabarti (1997) to minimize strain under the knee and to permit free movement of leg. The edges of the seat pan were smoothly finished to prevent any accident from any sharp edges.

Backrest: The seat frame was designed to take 100-degree angle at seat height. The seat frame was fixed with the backrest support. The height between the seat pan and top of backrest support defined the backrest height. The frame of the backrest was provided with lumbar support at

the 50th percentile value. Since the seat height was designed with adjustment provision, the lumbar height gets decreased or increased along the frame. Backrest support was designed to give support to the body from upper lumbar to acromion. The edges and corners of the backrest support were smoothly finished to prevent any accident from any sharp edges.

Arm Tablet: This arm tablet is flat surface, smoothly finished and designed to ease the strain on the arms and hands during writing activity. The design was developed taking into consideration the dimensions of body parts like body depth below the chest, elbow rest, arm length from loosely held elbow, and the dimensions of open book. The dimensions chosen for the design of arm tablet is shown in Figure. This part was designed separately, and mounted on the seat frame, where the requirement of arm tablet support was considered.

Bookcase: This is an important facility that provides space for keeping the personal belongings like books and water bottle etc. Its location was an important criterion in the design since students frequently reach the book case provision for changing books. The dimension of the bookcase is shown in Figure. It was a metal casing, meshed with smooth metal rods. This was mounted on the left side of the chair, as it is convenient to pick while sitting erect. This provision is presumed to reduce awkward posture

that student's normally take when they leave their books on floor or below the chair. The different components of the chair with arm tablet along with the assembled view are shown in Figure 1

Description of Furniture Design - Sled Desk

Body Frame: The frame, on which seat, backrest support, desk and bookcase rested, was divided into two parts namely leg frame, seat frame and the desk frame. The distance between the leg frame and seat pan met the requirement of seat height. The leg frame was provided with the provision to increase or decrease the height of seat frame and desk frame to facilitate the variations in dimensions of tall and short persons. Leg frame was provided with the provisions to move the seat frame and desk frame up and down and joined together to form a single unit. Figure 2 shows the dimension and views of leg frame and seat frame and their assembly. The edges and corners of body frame were smoothly finished to prevent accidents or hurts from any sharp edges. To protect the classrooms flooring from scratches the leg frame was fitted with a suitably designed rubber bushes

Bench: The dimensions specified in the guidelines were used to create bench height and

depth. This was similar to the seat pan dimensions of the chair with arm tablet design. Three degrees inclination in the front was provided and the curve was created to form fall design. This feature is supported by Chakrabarti (1997) to minimize strain under the knee and to permit free movement of leg. The edges of the bench were smoothly finished to prevent accident from any sharp edges. The dimension of the bench width was made to accommodate three persons.

Backrest: In the same manner of chair with arm tablet, the seat frame for sled desk was designed. It was designed with 100-degree angle at seat back. The seat frame was fixed with the backrest support. The height between the seat pan and top of backrest support defined the backrest height. The frame of the backrest was provided with lumbar support at the 50th percentile value. Backrest support was designed to give support to the body from upper lumbar to acromion. The width of the backrest was specified according to the bench width. The edges and corners of the backrest support were smoothly finished to prevent any accident from any sharp edges.

Desk: This desk had a 10 degrees inclined surface, smoothly finished and designed to ease the strain on the arms and hands during writing

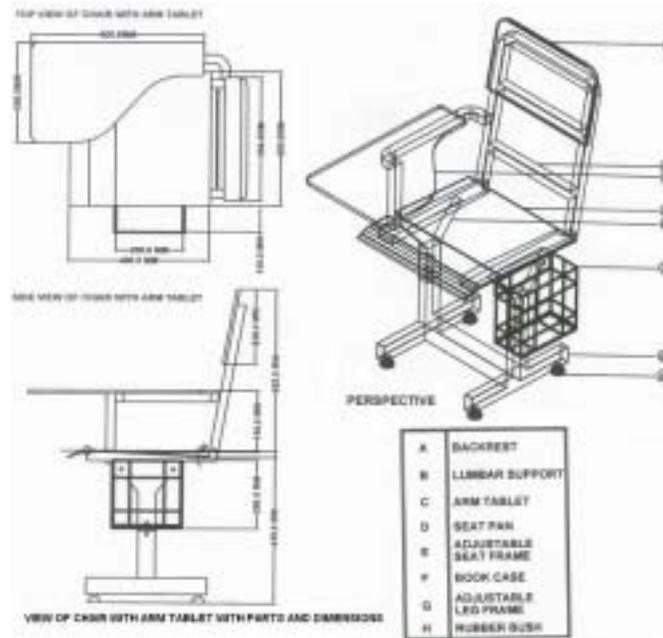


Fig. 1. View of chair with arm tablet with dimensions and parts

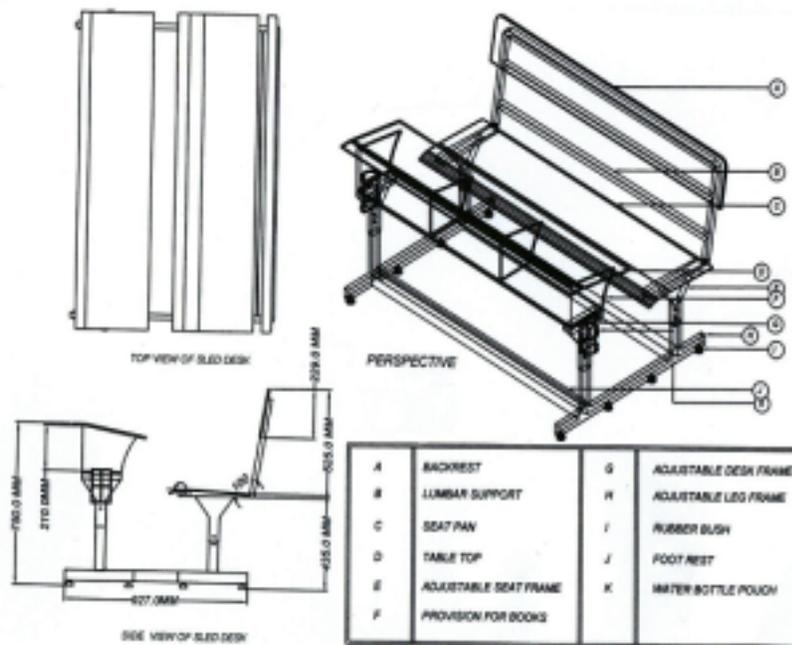


Fig. 2. View of Sled desk with Dimensions and Parts

activity. The design was developed taking into consideration the dimensions of body parts like minimum arm reach from loosely held elbow. The width of the desk was taken as the relaxed elbow - elbow width as mentioned by Panero and Zelnik (1979). The dimensions chosen for the design of desk were shown in Figure 2.

Footrest: It was provided underneath the desk at a height of 50 mm as majority of students opined comfortable only at this height. This was provided with an inclination of 15 degrees angle so that the student's can rest their feet comfortably.

Provision for Books: This was an important facility that provides space for keeping the personal belongings like books etc. Its location was an important criterion in the design since students frequently reach the book case provision for changing books. It was made of wood beneath the desk top with three partitions to provide individual space requirement for the student's to keep their belongings.

Water Bottle Pouch: This is another facility designed to keep water bottles. It was provided on both sides of the desk and at the centre below the tabletop. This was proposed to be designed with adjustable nylon belts.

SUMMARY AND CONCLUSION

College students in the age group of 18 - 22 who had one-year experience of using the furniture in classroom environment expressed their opinion on the choice of furniture. The information emerged out of the study revealed that the type of furniture provided in classroom were incompatible to users in many respects. To make the classroom furniture user-friendly, designing each component of furniture with care and attention was considered essential. Opinion of the students and the ergonomists guidelines for evolving good furniture formed the criteria for new furniture designs. Two types of designs emerged out of the study were chair with arm tablet and sled desk.

In chair with arm tablet, the body frame was designed to provide adjustment of height to suit to tall and short persons. Leg frame was fitted with rubber bushes and had provisions to move the seat frame up and down and screw to fasten both frames. Seat frame was designed to accept the body curves. Backrest support was suggested at lower lumbar, upper lumbar and acromion. Arm tablet was designed with due consideration to body depth, elbow rest height,

arm length and the dimension of books used by student. The bookcase that can be attached to side of the seat was designed to handle books in the sitting posture and thus relieve the user from using awkward postures.

In sled desk type of furniture the seat frame and bench frame were designed to provide adjustment of height for tall and short persons. Leg frames of both seat and desk were fitted with rubber bushes and had provisions to move the seat frame and the desk frame up and down from 50th percentile height to 5th and 95th percentile value height and tightened by a screw to form into a single unit. Seat frame was design to accept the body curves. Backrest support was provided at lower lumbar, upper lumbar and acromion. Desk was designed with due consideration to the minimum arm reach, elbow rest height and arm length. The provision for books was designed and provided below the desk top with three partitions. Water bottle pouch was also provided for the convenience of the users within easy reach.

The above designs were drafted and modeled in AutoCAD 2000 software. It was possible to

evolve the dimension specific designs and view the parts in multi dimensions.

It can be concluded that the importance of user assessment in ergonomic research studies of this type needs to be recognized, since subjective perceptions of comfort are the most valid expressions of appropriateness. Outcome of such research may be further field tested to refine the design and make it user-friendly.

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