Development of a furniture system to match student needs in New Zealand schools

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Abstract

New Zealand studies have identified up to 96\% mismatch between the dimensions of school furniture and student body size. Poor posture in students using school furniture is considered to contribute to the prevalence of musculoskeletal disorders. This paper describes the development of dynamic furniture designed to be appropriate for the sizes of students in years 1-13 (ages 5-17 years) and conducive with both their classroom activities and their physiological requirement to move. It describes the development of a height band system of sizing according to student statures, which is a major advance over the traditional practice of sizing by year level. Data was collected on the age (self-reported), year level, gender, ethnicity, height (stature) and weight of 19,000 New Zealand school pupils. Formulae were developed to provide indicative furniture size requirements for the pupils in every New Zealand classroom, and a simple three-step self-guide was created to assist students to determine the size of furniture to best fit them. Because an appropriate relationship between desk and chair height effectively eliminates under desk storage, alternative storage systems were developed and consequential changes in classroom management proposed. The chairs, desks and storage systems were trialed in classrooms, produced commercially and have been in use in schools since February 2005. Subjective feedback from pupils and teachers indicates very high approval of the furniture, especially the chairs, and high success of the implementation system particularly where it is well understood by the teachers. Implementation challenges include overcoming teacher fears of negative social and/or classroom management consequences of having more than one height of desk and chairs in a classroom, and some reluctance to change classroom practices to accommodate the removal of under desk storage. The introduction of an educative process at time of installation has proven successful in addressing these issues. Observations during the measurement process highlighted variances in body proportions amongst genders, ethnicities and ages. Given particularly the diverse ethnic mix in the New Zealand school population, data from a more detailed anthropometry survey will be required to refine the system.

Keywords: anthropometry, furniture, school, students, chairs, desks

1. Introduction

Legg et al (1) found that 96\% of students in three New Zealand secondary schools (years 9 to 13) were seated in furniture that was unsuitable for their body size. Concurrently, in a series of observations in thirty primary (years 1 to 6) and middle (years 7 and 8) school classrooms it was noted that most, and in many classrooms all students were seated at desks and chairs that were too high for them (personal
observations, Kane, Pilcher, 2004). Furniture mismatch is thought to contribute to the high prevalence of reported musculoskeletal disorders and low back pain amongst adolescents (2), (3), which can range from 28% to 50% of the adolescent population (4), and which has been shown to be a strong predictor of having future back pain (5).

2. Design Innovation – the dynamic chair

Murphy et al (6) highlighted the predominant postures assumed by students while working at their desks. Furnware’s interpretation of this was that a fixed position chair would meet less than 30% of the postural support requirements of students. The design would need to allow for the backwards tilt on the backrest part of the chair when students are leaning back (reading the board, watching the teacher) while still providing support when sitting ‘up straight’, and that allowed the seat surface to tilt forward to support the student leaning forward working at the desk.

Existing school chairs that attempt to meet these needs generally comprise a pivoting shell with seat and backrest in one piece. In the reclining position these create upward pressure under the thigh, equivalent to having a seat too high, which causes discomfort leading to fidgeting. The proposed solution was to have seat and back pivot separately, enabling genuine relief of pressure on the legs in both the reclining and forwarded seated position. This would also allow the user to move seamlessly from one position to another without it being necessary to move the chair itself.

Cardon, Briethecker, et al (7) provide an analysis of the physiological and pedagogical benefits of furniture that moves or can be adjusted to meet different postural requirements of students working within classrooms. In October 2003 at an education conference in Hobart, Tasmania, Dr Dieter Briethecker (8) delivered a presentation of his work at the ‘Federal Working Group of Posture and Movement, Wiesbaden, Germany’, and subsequent education furniture developments with the German company “Vs”. His studies found physiological and educational benefits of movement during class time compared to the ‘static’ classroom pattern that predominates internationally. He affirmed that when children are forced to maintain a fixed posture as with conventional education furniture they need to fidget and move constantly to be comfortable. This presentation and a subsequent personal discussion with Dr Briethecker confirmed the validity of the design concept. The challenge then was to provide a method of flexion for both seat and back surfaces that was functional, robust and cost effective.

In the absence of an up to date New Zealand standard and relevant anthropometric data, Furnware engaged in the advancement of the draft Australia New Zealand standard ASNZS 4610 that was in turn based on the draft European standard prEN 1729 (1997), which provided guidance on strength, stability and dimensions. Consultation was held also with school property managers and caretakers, including a 25-member focus group, which identified key elements of physical manageability (such as ability to stack), component durability, ventilation, ease of cleaning, and price. These considerations have been applied, along with the movement provision, to what is now called the Bodyfurn® chair (see Fig. 1).

3. Determining chair heights

The draft ASNZS 4610 used height bands described in prEN 1729 (1997) and stressed the importance of sizing furniture to the user (9), a departure from the existing ‘one size fits all’ based on year levels. The concept of height-adjustable furniture was dismissed, consistent with prEN 1729 (1997), and also on grounds of cost, poor durability and anecdotal advice from senior staff of the New Zealand Accident Compensation Corporation (ACC) and others, that people fail to adjust furniture to the correct height regardless of intense training. The
range of fixed heights option was thus adopted, including compatible heights for desks. This required detailed knowledge of the sizes of students.

Preliminary measurements of 900 New Zealand students were used to compare the chronological/class year based system with the proposed draft ASNZ 4610.1. The results, when the height bands were applied, confirmed the need for more than one height per year level. However, because they also revealed differences in both average and maximum heights between the New Zealand and Australian samples, and given the 29% representation in the school population of NZ Maori and other Polynesian students (see Table 1), neither group having been measured, Furnware established a programme to acquire measurements of a large student sample, with advice on method and interpretation provided by the Centre for Ergonomics, Occupational Safety and Health (CErgOSH), Massey University, Palmerston North New Zealand.

3.1. Data collection

The measurement programme was undertaken in 42 schools in 5 geographical regions to record age (self reported), year level, gender, ethnicity, height and weight of students. A minimum representative sample of 50 measurements per cell was sought, a cell being defined by year level, gender and ethnicity. Physical Education (PE) teachers, using instructions provided by Furnware, recorded the first 5,600 measurements in secondary schools. A further 13,400 were recorded by two researchers, both former teachers, using two commercial heights/weights machines linked to laptop computers. Ethical considerations were managed by the schools.

Limitations of this process are acknowledged. For practical reasons, the instruments and methodology used by PE teachers were unable to be monitored, although instructions were given. Any distortion from this was considered likely to be randomly distributed and offset by the large sample size, and further diluted by the results obtained from the height/weight machines, which were calibrated professionally and checked for accuracy after every 300 measurements. Geographical clustering, and in secondary schools an element of self selection may have influenced results, as will have time of year and to a lesser extent time of day (personal communications, A Noble and M Marfell-Jones, 2005).

3.2. Data interpretation and implications for sizing furniture

The data was assembled by gender and in 12 ethnic categories provided in NZ Ministry of Education (MoE) annual summary of schools ethnicities (9). Year levels were used in preference to age, being the natural groupings used in schools. In terms of stature, besides obvious growth as year levels progress, differences were found in growth patterns (a) between genders (Appendix A.1.) and (b) between ethnicities (Appendices A.1., A.2. and A.3.). In addition, the MoE data (10) showed significant differences between schools in terms of their ethnic mixes (see Table 1).

Table 1
Ethnic mixes in a sample of NZ secondary schools (%) compared with national average

<table>
<thead>
<tr>
<th>Ethnicity</th>
<th>NZ European</th>
<th>NZ Maori</th>
<th>Pacific Island</th>
<th>Indian</th>
<th>Chinese</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>NZ Total</td>
<td>57</td>
<td>21</td>
<td>8</td>
<td>2</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Papatoetoe HS</td>
<td>20</td>
<td>14</td>
<td>17</td>
<td>27</td>
<td>8</td>
<td>14</td>
</tr>
<tr>
<td>Sir Edmund Hillary C</td>
<td>1</td>
<td>13</td>
<td>85</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Mt Roskill Grammar</td>
<td>16</td>
<td>5</td>
<td>19</td>
<td>24</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>John McGlashan C</td>
<td>87</td>
<td>1</td>
<td>19</td>
<td>24</td>
<td>17</td>
<td>19</td>
</tr>
</tbody>
</table>

To provide indicative sizing per classroom, therefore, a formula was required which would factor in the number of students, their year level, gender, and the ethnic mix of the school. Because it was impractical to measure popliteal heights of such a large sample, popliteal/stature ratios (11) were applied to determine the likely relationship between stature and recommended chair height.

4. Introduction into schools

Given the long history of ‘one size fits all’ the task of implementing the system would for most teachers involve significant changes in classroom management practices. The considerations would include understanding and acceptance of (a) the importance of height (stature), and the need for more than one height of furniture in a classroom, (b) the importance of the height relationship between the chair and the desk, (c) the consequential reduction in the depth or
elimination of under desk storage commonly used in years 4 to 8 and hence (d) the need for alternative storage that would be workable and accepted by teachers, and (e) the benefits of movement. And the proposed systems had to be proven to work.

4.1. Consultation - a partnership approach

Critical to the success of the project was inclusion and participation of stakeholders throughout the development process. Besides the caretaker/property managers group Furnware established further focus groups comprising (a) six secondary school core subject teachers, (b) eight primary and middle school principals, and (c) six primary and middle school teachers recommended by the principals. Participants were selected from a range of schools with differing demographic, resource and (for secondary schools) gender profiles. The focus group sessions were held away from schools and outside school hours to promote a reflective atmosphere and avoid distraction. In addition, individual interviews were held with five school architects, six other principals and four other property managers. Discussions were held with teachers and students in forty classrooms, often coupled with prolonged periods of observation of classroom facilities and practices.

Responses to the concepts of more than one height of furniture in the classroom and the replacement of under desk storage were at first almost entirely negative. Control problems, difficulties with group work and social issues were anticipated. Attitudes generally softened however with discussion of the rationale, and all agreed to conduct classroom trials, albeit with a degree of skepticism. Eleven teachers from the focus groups and their students took part in the concept trials, which were held in four co-educational and two single sex secondary schools, one middle and one primary school. A total of forty-three classes took part, each over a minimum period of ten weeks.

4.1.1. Multi-height trial

The multi-height trial was conducted using furniture similar in design to that existing in the classrooms but in sizes to match the height-band profiles of the student participants, who had been measured by Furnware in advance. The outcome in every case was extremely positive. No resistance to using the wall chart (described below) was reported. Teachers reported less fidgeting, improved focus on class work, and more settled classrooms. Students reported greater comfort and less tiredness. The anticipated issues were absent in all cases.

4.1.2. Trials for replacing under-desk storage

Coupled with the multi-height trial in years 4 to 8 classrooms was the removal of under desk storage. One year 4 classroom was provided with tote tray storage units, designed to occupy the minimum of space in a room already quite full. All other classes were asked to create their own systems as a joint teacher and student exercise. These invariably chose to store both exercise books and textbooks in containers and/or on existing shelves as class sets. Systems to manage group sets of pencils and other implements were adopted by some whilst in other rooms the students managed their own using pencil cases.

During and after the trial period the teachers reported decreased damage to exercise books and a reduction in time wasted searching for them inside desks. The arrangements provided more ready access for assessment and opportunities to delegate the distribution and collection of books to students who might benefit socially from the responsibility. Improved control over textbooks and other resources was also reported. Accumulation of rubbish in desks was eliminated, however an increase in untidiness of the rooms was said to occur because materials needing ready access during an activity tended to be kept on the desk or on the floor.

Additional benefits from the elimination of under desk storage were reported at year levels 7 and 8. The teachers found that changing group configurations was easier because students were not confined to the desks containing their own books, and the desks themselves were easier to move around, being less weighty. The students reported that they met more people in the class and that this provided social benefits.

5. Self selection of furniture

A system was devised whereby each chair and desk is coded with a coloured dot to match a colour band on a wall chart, which is provided for each classroom. The bands represent the six height bands proposed in the draft Australia New Zealand standard. Molenbroek et al (12) cited observations that two people of the same stature can have very different popliteal heights, concluding that this provided social benefits.
more appropriate measurement. Our observations of students sized by popliteal strongly support this, so the students are advised to use the chart as a guide only to their likely ‘height colours’. They are advised to, secondly, stand beside the highest point of the front edge of the seat, which should be no higher than the bottom of the kneecap (a convenient if approximate indicator of popliteal height). Thirdly they try the chair for comfort, and if there is any doubt they should try one chair higher or lower before making their final chair decision. Finally, they select a desk with the same colour dot.

6. Market application and acceptance

Molenbroek et al (10) supported the CEN recommendation that instructions on using a height system be provided to schools. Our findings strongly support this. 113 teachers using the Bodyfurn® furniture and systems were surveyed after the first 10 weeks to assess understanding and approval rating. Whilst approval of the dynamic chair was unanimously high, approval of the height band and storage system was high where it was well understood and lowest where the furniture had been placed in the room unannounced, even with written instructions. Subjective qualitative data obtained by class discussions and teacher comments during the first year of Bodyfurn® in schools has been consistent with this. As a result Furnware has adopted a policy of explaining the system and its rationale in person to at least one class in the presence of the teacher as close as possible to the time of delivery of the furniture. ‘Ownership’ of the system and its application, as intended, then becomes very high.

15,000 units were installed in schools in the first year. One month into the start of year 2, with new student intakes, there have been strong commendations from principals and teachers on the validity of the heights formulae and no reports of teachers who had used the new system wishing to revert to the old. However, it is recognized that an objective case controlled investigation is needed to confirm these qualitative descriptive observations, which in themselves are very positive.

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Appendix A. Samples of different growth patterns

A.1. M/a/f growth comparisons - NZ Maori

A.2. M/a/f growth comparisons - Chinese
Appendix B.

B.1. Discussion

Assessment of the Bodyfurn® furniture and system has thus far been reliant on subjective appraisals by teachers and students, and informed observation of classes in action. These provide strong indications that major advances have been made, however independent scientific evaluation of the chair and system is desirable, to include motion analysis of posture using this and other school furniture, and to assess impact on learning. A longitudinal survey on health implications, in particular the incidence of musculoskeletal disorders, is also envisaged.

The height and weight measurements of the diverse ethnic groups represented in the New Zealand school student population has the potential to be applied by extrapolation to a more detailed anthropometric survey which could prove valuable for future furniture development, both within New Zealand and elsewhere. Some impressions during our observations also suggest the popliteal/stature ratio in particular may vary between genders and ethnicities, and that socioeconomic factors may influence stature. These are potential subjects for further research.

References


