Development and Testing of School Furniture Suitable for Disabled Pupils

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Day school with several school and therapy offerings, lunchtime programme and rooms for a rest period

- **Kindergarten:**
  - prepares children for school

- **Classes of 4 - 6 pupils (9 years):**
  - aim at the academic goals of a public school

- **Other school services:**
  - Instruction on an individual level
  - Support
  - Various therapeutic treatments and aids
Objectives

2004: decision to replace all the furniture

New furniture has to meet:

- Ergonomic regulations
- The very individual needs of the disabled pupils

Pupils’ desks and chairs:

- Shift from individually tailored solutions to products with a modular concept
• Steering committee was established

• Three Steps
  1. Definition of the requirements for the future furniture
     • Walk-through combined with interviews
     • Review of literature and anthropometric data
  2. Product search
  3. Testing of products by pupils, teachers and therapists
     • By means of Questionnaires (comfort, satisfaction)
     • Comparison with requirements defined

• Discussion of results with steering committee

• Order of new furniture
1st Step: Walk-through

• Walk-through and semi-structured interviews in 9 different but representative rooms

• Rooms were chosen by the members of the steering committee

• Results:
  • Furniture was old
  • Furniture did not correspond to the expectations of teachers and therapists
  • Many chairs and some tables were adapted
  • Many individual tailored solutions
  • Pupils mentioned restricted leg space for wheelchair users and some degree of discomfort
Some Impressions
1\textsuperscript{st} Step: Requirements desks and tables

Defined important features for pupils’ desks (incomplete list)

- **Leg space:**
  - Accessible with wheelchairs

- **Sit/stand desks**

- **Height:**
  - Adjustable, covering 5–95\textsuperscript{th} percentile of users (43-116 cm)

- **Desktop:**
  - Can be tilted to 15°
  - Different shapes of desktops depending of the needs of the pupils

- Desks are mobile, having possibility to clamp or lock

Teachers’ desks had to meet the usual ergonomic requirements
1st Step: Requirements chairs

Defined important features for pupils’ chairs (incomplete list)

- **Height:**
  - Adjustable, covering 5 – 95\textsuperscript{th} percentile of users (29– 49 cm)

- **Footrest:**
  - Available

- **Sitting surface:**
  - Adjustable in depth, tiltable between 0\textdegree–5\textdegree
  - Rotatable, having the possibility to clamp or lock

- **Backrest:**
  - Adjustable in height and depth
  - Lumbar support to maintain lumbar spine in lordosis
  - Easily exchangeable in case of special needs (custom-built backrest)

Teachers’ chairs and stools had to meet the usual ergonomic requirements
2nd Step: Product search

- Product search, based on the defined requirements
- Products were standard products, chosen either out of school- or office-furniture sector
- Number of selected furniture to be evaluated:

<table>
<thead>
<tr>
<th>Age / Application</th>
<th>Chairs</th>
<th>Pupils desks</th>
<th>VDU desks</th>
<th>Group work tables, dining tables</th>
<th>Stools for teachers / therapists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kindergarten</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 - 12</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 – 20</td>
<td>4</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Therapy</td>
<td>1*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Not specific</td>
<td>1</td>
<td></td>
<td>4</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

* Chair which should be adaptable to very individual needs due to a handicap
3rd Step: Product Tests

• 1 week: All products tested by all interested users

• 3 weeks: Pupils’ desks and chairs tested in certain classes
  - Latin Square Design was used for the avoidance of coincidence effects.

<table>
<thead>
<tr>
<th>Age between 7 - 12</th>
<th>Subjects Class A</th>
<th>Subjects Class B</th>
<th>Subjects Class C</th>
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<tbody>
<tr>
<td>1. Week</td>
<td>Chair 50, 51</td>
<td>Chair 52</td>
<td>Chair 53</td>
</tr>
<tr>
<td>2. Week</td>
<td>Chair 53</td>
<td>Chair 50, 51</td>
<td>Chair 52</td>
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<tr>
<td>3. Week</td>
<td>Chair 52</td>
<td>Chair 53</td>
<td>Chair 50, 51</td>
</tr>
</tbody>
</table>
3rd Step: Subjects

- Overall data from 225 questionnaires:
  - 38 pupils out of 72
  - 14 teachers
  - 12 therapists

- 60 questionnaires concerned pupils’ desks, 122 their chairs

- Individual data were available from 22 pupils:

<table>
<thead>
<tr>
<th>N = 22</th>
<th>Mean</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>11.4</td>
<td>5</td>
<td>18</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>46.3 kg</td>
<td>30 kg</td>
<td>63 kg</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>152.2</td>
<td>140</td>
<td>163</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Health problems</th>
<th>N max. = 22</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>18</td>
</tr>
<tr>
<td>Wheelchair use</td>
<td>10</td>
</tr>
<tr>
<td>Instability in trunk</td>
<td>18</td>
</tr>
<tr>
<td>Affected coordination of movements of body/arms/legs</td>
<td>14</td>
</tr>
<tr>
<td>Vision affected</td>
<td>8</td>
</tr>
</tbody>
</table>
### 3rd Step: Evaluation by Questionnaire

#### Pupils’ desks
**Comfort** (5-point scale *unpleasantly* to *very pleasantly*)
- Neck/shoulders
- Elbow/forearms
- Back

**Satisfaction** (5-point scale *applies not at all* to *applies completely*)
- Adjustability height
- Height while standing
- Desktop tilt
- Falling down of articles
- Desktop dimensions
- Desktop material
- Storage space
- Leg space
- Tilt resistance
- Manoeuvrability
- Usability adaptation mechanism
- Global evaluation

#### Pupils’ chairs
**Comfort** (5-point scale *unpleasantly* to *very pleasantly*)
- Knee/thighs
- Bottom/lumbar spine
- Back

**Satisfaction** (5-point scale *applies not at all* to *applies completely*)
- Adjustability height
- Seat depth
- Tilt of seat
- Slipping
- Comfort seat
- Mould of backrest
- Adaptability of backrest
- Usability adaptation mechanism
- Adaptability to needs
- Tilt resistance
- Manoeuvrability
- Global evaluation
3rd Step: Pupils’ Desks

- 5 desks from 4 manufacturers were tested
- Desks number 4, 6 and 8 showed highest score
- All did not meet all of the requirements defined
- Discussions in steering group: desk 4 had high acceptance, manufacturer showed interest for improvements
- Desk number 4 was finally selected with conditions
3rd Step: Selected Pupils’ Desk

Improvements:

- Adjustability of height
- Addition of a desktop side edging
- Development of storage space
- Displacement of the height adjustment lever (safety reasons)

Some features (final version):

- Leg space 60 x 75 cm
- Height adjustability
  - 43 – 90 cm (primary students)
  - 53 – 120 cm (high school students)
- Desktop 80 x 80 cm, tiltable 0° - 75°, desktop side edging
- Pneumatic spring, easily operated with one hand
3rd Step: Pupils’ Chairs

- 9 chairs were tested
- 6 chairs showed high satisfaction
- None of them met the requirements sufficiently
- New needs arose during the tests
- Optimisation was not possible without large effort
- New product search out of the school-furniture sector

- Chair with a modular concept used in industry was found
- Prototype was designed and tested for 1 week
- Optimisation in 3 steps, e.g.:
  - Levers
  - Dimensions and form of seat and backrest
  - Range of height adjustability
  - Range of seat tilt
- Final version was brought into production
3rd Step: Final Version Pupils‘ Chair

Some features:

• **Height adjustability:**
  - 31 – 38 cm (primary students)
  - 36 - 48 cm (high school students)
  - Pneumatic spring

• **Sitting surface:**
  - adjustable in depth
  - tiltable between 0°-5°
  - rotatable or fixable

• **Backrest:**
  - adjustable in height and depth
  - lumbar support

• **Armrest and footrest available**
Conclusions

• All furniture has now been replaced
• New furniture meets ergonomic regulations
• Pupils’ desks/chairs: from individually tailored solutions to modular concept
  • Pupils’ desks: no individual solutions were necessary
  • Pupils’ chairs: First-time individual adaptation in shorter period of time
• First feedback indicates high rate of satisfaction
• Reduction of diversity of furniture in school stock: costs could be lowered

Keys for success:
• Requirements for future furniture defined within participative process
• Products were tested by teachers, therapists and pupils
• Test results: discussed in steering committee, considered when selected final products
• Manufacturers interested in optimisation of their products
• Modular concept of pupils’ desks and chairs: products adjustable to the very individual needs of the disabled pupils
Thank you for your attention!