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QAS 515
HFE in a CADD Work Lab Environment
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## Introduction

Around May of 2002 some of my students and myself came up with an idea that was of a “redesign and improvement” approach to the Ergonomics of a Computer Designer’s workspace and placement specifications involving VDU. We wanted to find something that could be economical, space saving and also be multi task oriented. We brainstormed and reviewed the ideas on various websites and decided on a desk that could be expanded into many different heights and levels. This was a completely new and improved design of a portable desk (Figure A). We devised a method for portability by making it breakdown small enough to fit or attach to a briefcase. We were striving to make this a user-friendly desk by researching different aspects of ergonomics to see what else we can do to this new age table to make it more comfortable yet use sturdy and lightweight materials to keep the price and weight to a minimum. For example, using a curved top with adjustable legs to help support the neck, shoulder, and the wrist. This helps to prevent Upper or lower body stress, CDT, back pain, headaches, and other potential HFE problems. The more multi-tasks an item is the more chance of purchase increases. You have to look at the variety that is in the world today and realize that just one method will not do. You must have multiple methods of using things to suit everyone. The more you design your product for suitability and variety the more you will sell the product.
Some of the potential Questions we set out to find answers for, were:

- Where is it to be performed (in our case, on Campus)?
- Who would be the potential customer and is it worthwhile?
- Will that work for what I or the school need?

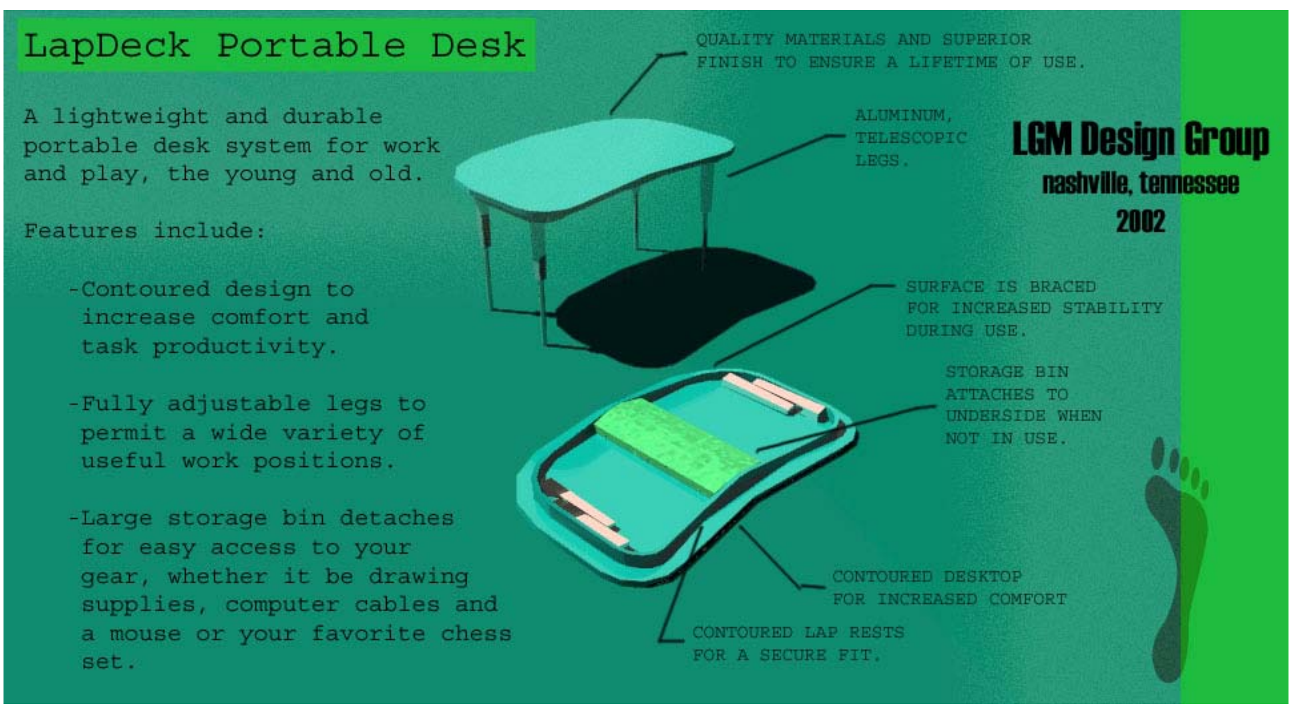


**Figure A**

Some of the risks involved are as follows:

- Durability
- Expense to Build
- Eye Catching
- Easy To Use

**Project Selection and Customer Need:**

- We have selected the Lap-Deck portable desk as our project. We feel that there is a need among traveling professionals and people who need a lightweight and convenient, portable work surface.
- Research has found that over longer periods of time, working in a single position causes considerable strain on the back, arms, neck, arms and wrists. The Lap-Deck provides full adjustability for use in multiple positions. It can be used while seated on the floor, sitting on a couch or chair, sitting in bed or lying on the floor. The telescopic legs allow the Lap-Deck to be converted into an easel for use at a table for good drawing or painting posture.
- The value of the Lap-Deck lies in its low-cost, durability, portability and the ergonomic benefits it provides to its user. Considering the amount of time professionals today spend working at a desk, the Lap-Deck provides a viable and beneficial alternative to the traditional desk.
- The Design group wishes to provide a product to the public that is useful for more than one purpose, while maintaining it's integrity or primary purpose.
- The other portable desks on the market do not provide the flexibility and functionality in a portable desk that is both lightweight and durable at such a low-cost.
- We are using the ITT Computer Lab 3 in Nashville, Tennessee for all the group work. We are to use this lab for R&D, and the future adoption of the project by ITT nationwide.
- This desk concept can be for laptop use, legs extend for use as a table, or on a table as an easel. One model breaks down to a small and portable size that would mainly be used for mobile computing. The other model has a one-piece surface area, ideal for writing and drawing. The folding model has drawers on the surface for storing desk accessories or computer cables. The drawing desk has a large, detachable storage box that stows underneath the desk. When the desk is setup at an angle, there are flip-up tabs to hold items in place.

**Ergonomic needs assessment pertaining to use with a VDU:**

As an increasing proportion of the workforce spends a great part of their work (and leisure) time interacting with computers, the object of the visual interaction, the Visual Display Unit (VDU), becomes a critical component in the interaction. The Lap-Deck provides for additional options with optimal placement of a VDU in terms of vertical height, lateral location, eye-screen distance and VDU tilt.

This discussion is focused on a single computer screen office workstation using the newly designed Lap-Deck as its new home, although most of the principles can be applicable to other workstations. VDUs for office work are usually placed in one of three vertical locations, as described below.

*-'High' - top of screen level with sitting eye height*

The traditional recommendation for VDU placement has been to locate the top of the screen at sitting eye height. With a typical 13" monitor at 750mm from the user's eye this results in viewing angles (angle between horizontal and a line from the eye to the visual target) from 0-15 degrees.

*- 'Mid' - bottom of screen level with desk surface*

Recently, more researchers have advocated a lower VDU position, with the bottom of the screen at desk height, see Figure A. For a user of average height sitting upright at a desk just above elbow height and viewing a 13" monitor at 750mm, this would give viewing angles from 15-30 degrees.

*-'Low' - bottom of screen just visible over keyboard*

The third option for VDU vertical placement is as low as possible given cathode ray tube monitor and keyboard input device, see Figure A. Using current desktop computer and keyboard technology, the lower limit is probably formed by the viewing angle to the far edge of the keyboard. For the same situation as described above, where the user has full forearm support on the desk with the keyboard furthest edge about 500mm from the user's abdomen, the lowest possible viewing angle is around 45 degrees. Thus with a 13" screen the viewing angle range could be 30-45 degrees.

*-'Ultra-high' and 'Ultra-low' positions*

'Ultra-high' positions are above sitting eye height with viewing angles of 5-25 degrees above the horizontal.

'Ultra-low' positions would also be possible with flat screen technology by placing the screen on the desk just in front of the user's abdomen. This would be comparable to reading a book placed flat on the desk and result in viewing angles from 45-65+ degrees.

**Discussion of which was best utilized using Lap-Deck:**

The main argument for the 'high' position is to reduce musculoskeletal strain on the neck by keeping the head in the 'normal' upright standing position. A 'high' VDU position is likely to result in less neck flexion, and to a lesser extent less thoracic flexion. Based on modeling of neck muscle forces suggests neck extensor muscle forces are minimized by a head position with 30 degrees *extension* relative to 'normal' standing head posture.

At the other extreme, excessive neck flexion results in increased neck muscle loads and discomfort. There is general agreement that extremes of neck extension and flexion should be avoided, however the optimal neck position is debated. 'High' VDU placement will result in less flexion than lower positions, but may result in undesirable neck extension. Research in the laboratory found reduced cervical and thoracic activity in the 'high' position compared to the 'mid position. As neck flexion became near end-of-range, we expected extensor muscle activity to reduce due to increased passive tension. Whether or not this was desirable we didn't know, unless we tested more people than the class that volunteered.

We found that these subtle adjustments of the Lap-Deck provided reasonable evidence that, when our users worked in an upright sitting posture, a 'high' VDU position became associated with reduced neck flexion and reduced cervical and thoracic activity, while the lower positions reduced visual strain by locating the VDU where it was easier to accommodate and converge for close visual work and to reduce Muscular-skeletal strain. Since visual accommodation is the change in the shape of the eye lens capsule to achieve focus. Insufficient accommodation results in blurred images. Convergence is inward turning of the eyes to keep a single binocular visual image. Inaccurate convergence results in double images. The eyes have natural resting points for accommodation and convergence, and as a visual target moves in closer from these points more eye muscle activity is required. Thus just as there is a convenient reach zone for touching, there is a similar zone for visual 'touching'. The visual 'reach' zone extends out from the resting points and comes closer to the user with increasing downward viewing angle. The resting point of accommodation averages about 800mm with young people and shifts farther with increasing age (Krueger 1984). The resting point of convergence averages 1120 mm with a horizontal viewing angle and comes in to 900mm with a 30degree downward viewing angle. A lower monitor position will allow for closer viewing distances without an increase in visual strain. This was another factor in our design being adjustable to meet multi-users, and aside from less strain on eye muscles, with lower gaze angles the eyelid covers more of the eyeball helped to reduce the likelihood of dry eyes. The support for a lower VDU position being less straining visually comes from the general knowledge of human visual performance but also from laboratory and field studies. There is little doubt that from a visual system point of view, lower VDU placement is preferable (assuming suitable non reflective environmental lighting). Proponents of lower VDU positions argue that users typically flex their lower cervical spine and extend their upper cervical spine (to give the chin jutting forward posture) when working with 'high' VDU monitors. Upper cervical spine and head-neck extension is maintained by static muscle activity, probably by small, deep neck muscles in particular. The sustained activity may result in discomfort and disorder. Fatigue in the muscles supporting head-neck extension is more likely as the muscles would be working in shortened positions.

**Issues complicating recommendations for VDU height:**
There is a relationship between the length of a muscle - compared to its resting length - and the tension or force it can generate such that the more shortened a muscle is the less force it is able to generate. In essence a shorter muscle equals a weaker muscle. Current technology in office furniture and lighting design often restricts the option of 'low' VDU height as a separate support surface below desk height is required and office luminaries may not be designed to reduce reflections on 'low' VDUs. A further example of possibly important interactions between VDU height and posture is that the 'low' position may restrict the use of the backward tilting sitting posture. This posture has some research support and is probably a useful alternative sitting posture. In contrast, the 'low' VDU position may encourage a forward tilting posture, which is also probably a useful sitting posture. Individual variation may also mean one position is not suitable for all users. For example, a user who has played a piano regularly since childhood may be adapted to an upright sitting posture and 'high' to 'low' visual target.
**Eye-Screen Distance Placement:**
Appropriate eye-screen distance interacts with height, so that as the VDU is placed lower, it can be placed closer to the user. Lower gaze angles bring the resting point of convergence closer, and sustained viewing of visual targets closer than the resting point of convergence has been found to increase eyestrain. Therefore, at any one VDU height, users will tend to find viewing more fatiguing at closer eye-screen distances. Optimal eye-screen distances are also dependent on the user's visual capacity (which is age related) and the clarity and size of the visual image. Greater eye-screen distances are probably also suitable, as long as screen font sizes are increased. However office space and increased costs for large screens may constrain more distant VDU placement, which made our breakdown type of adjustable table even more practical.

**Our Recommendations**
VDU workstations should allow for considerable adjustability in VDU position to allow for individual visual system differences, task differences and environment differences (especially lighting). VDU workstations should preferably be adjustable enough to allow the VDU to be:

1. Directly in front of the use
2. 600mm -1000mm distance
3. Tilted slightly back from a right angle to the line of sight
4. With the top of the screen to be as high as a 5 degrees viewing angle
5. With the bottom of the screen as low as 50 degrees viewing angle, directly in front, at 1000mm, tilted slightly back from at right angles to the line of sight and with a viewing angle of 30 degrees to the bottom of the screen.

In conclusion, we found the Lap-Deck very user friendly using the criteria above.