

# ERGONOMICAL STUDY OF ADJUSTABLE WORKTABLE FOR WORKSHOP

S.P. RAMACHANDRAN<sup>1</sup>, K. MUTHUKUMAR<sup>2</sup>

<sup>1</sup>PG student, Industrial Safety Engineering, Department of Mechanical Engineering, BIT, Sathyamangalam

<sup>2</sup>Professor, Industrial Safety Engineering, Department of Mechanical Engineering, BIT, Sathyamangalam

\*\*\*

**Abstract:** The main of this project is to redesign an worktable into an adjustable worktable. Its focus is based for institute laboratory and designed for the students. The idea come from the problems observed in students while using correct tables and later ergonomic study about it. All its characteristics makes the new table an innovative product that fulfils the user's requirement and solves the problem analyzed.

design and its environment paying particular attention to the ergonomic part and development of the product. The result of the project is to have a presentation of the final product



1.1 EXISTING WORKTABLE

## 1. Introduction

This report describes the redesign of an adjustable table for the college workshop

## 1.2 Background

It is a fact that students have health problems while using worktable. Form Bannariamman institute of technology is a college dedicated to design worktable for students concerned about past experience which aim is to avoid this kind of problems with a new set of products based on ergonomics.

The idea is to redesign a desk for college environment adapted to students that makes better their experience while using this kind of equipment as well as the activities that they perform normally. The college requires a new design of the existing table in order to be more adapted to the environment and the user and improve its design in general taking into account ergonomics, student interaction, aesthetics, functionality and sustainability

## 1.3 Objectives

The project, developed in co-operation with the college includes the redesign of an adjustable worktable for college. The desk is part of a biomechanical project developed by the student.

The design has to be based on function, ergonomics, quality and sustainability and be suitable for the target user considering all their needs. This new desk attempts to help the students (between ages 17-24) to have a good position while standing on their worktable and using their equipment and hand tools.

The objective is to implement the knowledge acquired in the program regarding the key aspects in the product

## 1.3 Purpose and research questions

The design framework of the project is defined by the following questions which must be answered in the final design in order to have a successful product:

- How does a worktable have to be designed in order to be suitable for the college environment?
- What are the student's requirements?
- What are the students' feedback?
- What are the environment requirements?

## 1.4 Delimitations

The project is not going to focus on any manufacturing methods. Since the college already have their own model of the table, the project is going to include a new design of the "adjustable" system.

## 2. THEORETICAL BACKGROUND

### 2.1 Design thinking

To understand a bit more about the process that is going to be followed in this project, it is important to understand what design is about. In this project, it has been used the design thinking theory in order to develop the idea.

Design thinking is a methodology of design used as an innovation tool that applies design processes in order to achieve the best results. It is focused on finding the best solutions for problems and explores different ways to solve them.

It is made up from different activities. These activities are mainly divided in several stages: empathize, define, ideate and test.

**Empathize:** "To create meaningful innovations, you need to know your users and care about their lives." This first step consists in understanding how people do things and why do they do it that way, their thoughts and needs. This is a very important stage since the problems that designers try to solve are basically other people's problems. Designers put it in practice through observation and recognizing the different needs or manifestations of the users. A good empathize work helps to be more creative and see things from another point of view.

**Define:** "Framing the right problem is the only way to create the right solution." The main goal of this step is to clarify and focus in the problem in order to start looking for possible solutions. It is a way of arranging all the information gathered in the first step. Designers craft a problem statement to work on. This statement guides the designer to focus in the different needs of the user based on the designer's new understanding of it. It also narrows the problem just to make easier to find the solution.

**Ideate:** "It's not about coming up with the 'right' idea, it's about generating the broadest range of possibilities." Ideation is about generating different ideas in order to solve the problem that the statement contains. It provides the main information to create the final solution. The more ideas the designer has, the better. It is about finding the most ideas possible so the designer can select the best one afterwards and work on it.

## 2.2 Evolution of college worktable

Worktable are an important part of the school environment. Students spend most of the time in the college behind this product. The different styles, materials and costumer needs through time have influenced the evolution of this furniture.

## 2.3 Human factors

Human factors or comfort design is based on designing products taking into account the interaction of the product with the user. It studies the different users and their interactions in order to improve it and optimize the products. The aim of this science is to design the best working place so the users don't suffer any injuries.

### 2.3.1 Posture-related injuries from hand tools

Many people unknowns the different kind of injuries that the misuse of this product, that is so common nowadays for many different activities, can cause in their bodies. This kind of risk can be significantly reduced choosing the correct table and having a proper posture. The biggest problem is remaining in the same position for long periods of time. In case of college students spend an average of 6 hours every day. If the workstation is not designed properly, so that the students can have the most appropriated posture, their blood circulation can be reduced leading to pain in some parts of their body. The most common injuries are neck pain, headaches and shoulder and arm pain.

**Neck pain:** It is caused by doing the work all the time with same position by tilting the head down for a long period of time. This produces pain the neck. to overcome this problem, it is important to adjust the height of the work table.



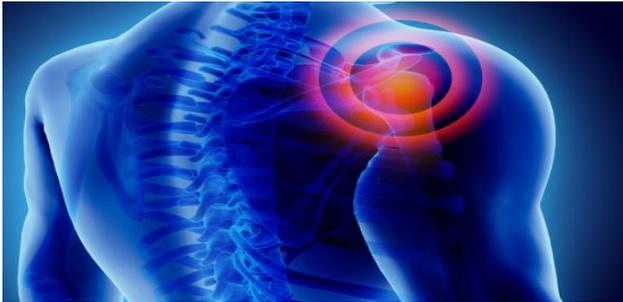
2.1 Neck pain

**Hand or arm:** It is called overuse injury. It is caused by doing the same movement all the time with the same muscle position for long periods. This produces localized pressure on tendons that damage the joints. In order to avoid this problems, it is important; to choose the correct surface finish. Hard or sharp surfaces can damage wrists and elbows. Take some breaks while using working. Try to adopt the most neutral joint position that allows more freely movement to reduce injuries.



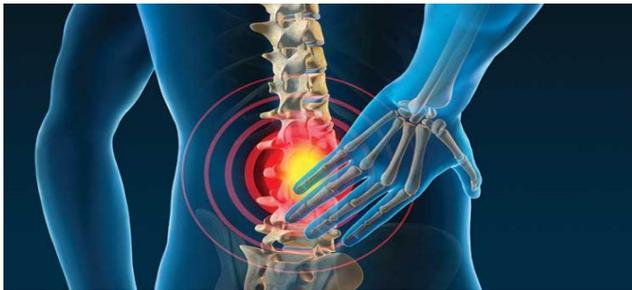
2.2 Hand and arm pain

Shoulders: The use of use of laptops, makes the shoulders be forced to work too high, and keep this position for long periods. The joints that join tendons and muscles become damaged because of this it. To prevent this kind of injurie is important to select the best workspace for the task that are going to perform..



2.3 Shoulder pain

Back pain: Having a bad position while using these devices causes back pain. This action added to the backpacks that students use to carry to school aggravate student's health.



2.4 Back pain

### 2.3.2 Desk design and injuries

While designing this kind of furniture is very important to take into account all the different positions of the students in this case. To avoid the problems shown above

The desk should be adjustable in height so all the students can adjust it to their most comfortable position since not all of them are the same height.

### 2.4 workshop design

Ergonomics play an important role since all he areas and worktable should be designed taking it into account. College spaces should be the more flexible possible as not every student are the same and each of them have their specific needs. It needs to be able to adapt to all of them and improve the learning experience to all of the students.

### 2.5 manual screwjack adjustable system

The adjustable system that is going to be attached to the tabletop in order to change its dimension in height is based on worktable. It consists on a manual screw jack that supports the tabletop. Compared to the electric adjustable system, manual lifting systems need to be plugged, this is an advantage when talking about a workshop where there are going to be many students working at the same time. In its advantages, it also stands out by its quiet guide system and precision. The mechanism to activate this system is quite simple. The user has to rotate the hand wheel in case he wants the table to be higher or lower.

## 3. METHODOLOGY

### 3.1 Method

The design process chosen for this project is a user-centered design. This kind of process is focus on the user needs and requirements. It is developed as follows:

### 3.2 Product design specifications (PDS):

The product specifications it's a very important tool while developing the product. It is used to enumerate all the requirements that must be met in the product that has to be designed, in order to define it, and complete the first brief.

**3.3 Student analysis:** This analysis is used in order to identify who the different students of the collegeare, their interest and requirements in order to know what to focus on for our design. The techniques used are:

**3.3.1 Ability analysis:** In order to know what the student can or cannot do, it is necessary to analyze their abilities so that their limitations when using something can be taken into account.

**3.3.2 Requirements:** This analysis is based on the requirements of the users regarding the product. It is used to know more of our student's needs, which are the most important features for them or how they use the product Method and implementation

### 3.4 Evaluation of the existing adjustable table:

This analysis provides information of the usability of the worktable, how the users interact with it and how are they features. It can be used to improve the new table taking into account the problems that the user has with it or the things that can be changed in order to improve the product.

### 3.5 Task analysis:

This analysis helps to understand better the relation between the product, the task and the user. How the task is going to be developed by the user concerning the product and how to make it easier.

### 3.6 Analysis of the product environment:

The analysis of the product environment helps to understand the space in which the product is going to be used and placed, so that the design can be adapted to it following its requirements.

### 3.7 Ergonomic analysis:

In order to have the best design for the product is important to take into account some characteristics of the user and the way he interacts with it. Ergonomics is based in the study of interactions between the product and the user. Ergonomics works together with anthropometrics in order to apply to the products measurements based on the study of the human body and its movements. The final design is based on anthropometric charts of students on the age range of 17-24 as it is the age range of the users of this new desk.

### 3.8 Related standards:

Standards are the different norms established that regulate the design of this kind of products and are necessary to take into account while designing. These standards stem from institutes that create them and establish them in the place they belong to Method and implementation.

### 3.9 Idea generation:

**3.9.1 Brainstorming:** The aim of this technique is to come up with as many thoughts and ideas as possible. Some of this ideas are used after as a creative solution for the problem and others can be used in order to develop more ideas. Brainstorming sessions are very helpful since they are held by a group, avoiding criticizing which provides a free and open environment where lots of ideas grow.

**3.9.2 Sketching:** Making easy drawings in order to understand the ideas that have emerged before. It is an easy method to visualize ideas and give them a shape.

**3.9.3 3D modeling:** 3D Modeling the process of emerging with representations of a three-dimensional surface of an object. Although they are in 3D, they can be shown as a 2D image through rendering. This kind of representations usually follow the sketching process and they help to visualize the product with computer. It's used to develop

the concepts and represent ideas. Models can be created manually or automatically with a SOLID WORKS software. The software that is going to be used and it belongs to Autodesk. SOLID WORKS software that allows to create mechanical design, documentation, and product simulation tools in a professional-grade. It is similar to other CAD programs such as 3D MODELING, Pro ENGINEER, CATIA and Solid EDGE. It provides tools to create different pieces and assemblies. The basics of this program are pieces, built by 2D sketches that can be drawn in a plane and extruded afterwards. This modeling system is very intuitive since it is quite easy to control all the dimensions and parameters of the piece. It provides modeling flexibility, with its parametric parameters. It can work with any kind of files from other SOLID WORKS programs maintaining the same settings.

### 3.10 Idea selection:

**3.10.1 Concept evaluation:** Concept evaluation is a method that helps to choose the correct concept in order to develop it in the following steps. It provides the correct information to make the decision. Each of the concepts are evaluated according to how much value they bring to users and providers. Each of the concepts are given different scores in their user-value and provider-value. This scores are plotted in a diagram, translated into coordinates. This provides a basis to compare them and gives an idea about which concept to develop and which could be combined.

## 4. APPROACH AND IMPLEMENTATION

### 4.1 Definition of the problem:

To find a solution, the first step is to define the problem, in order to do that it's necessary to contact the college students which is going to explain it in detail to have an overall idea of it. So that the project started with a brief made in Bannariamman institute of technology, sathyamangalam and presentation of the actual product. In the brief there were all the specifications and requirements for designing the table.

### 4.2. Existing tables

A bench could be simply a hardwood tabletop (or metal tabletop) with sturdy wooden or metal legs to hold it up. These types of workbenches are typically used for heavy duty projects because of its ability to handle heavy objects and some relatively hard hits and bangs. They are also easy to replace and install.

This table doesn't do well in regards for storage. Having this type of workbench assumes you have other means of storing tools and materials.



4.1 Table work bench

If you are the type of handyman who has a large collection of equipment, tools, and materials and also like them to be within easy reach as you work on your project, a cabinet style workbench will work well. Drawers will be either underneath the table, on top, or both. This type of workbench will often have a pegboard alongside the wall, convenient for hanging tools for easy access.



4.2 Cabinet Style Workbench

The portable workbench will be small, collapsible, and relatively light. They are ideal for the handy-person

This type of workbench will have multiple power outlets mounted at strategic and convenient positions around the bench as well as heavy duty power cords. This is for the power tool maniac.

Specialized workbenches can be designed for making furniture, cabinets, trimming, or hobby carving. These types of workbenches will have a dog ear or planning stop, which is a small piece of metal or wooden peg that the work is pressed against. The tabletop may also have hard-points, which are simply nuts embedded into the wood, which make it easier to bolt a tool or jig to for making disassembling and reassembly easy.

These types of benches will be hardcore and able to handle the harshness of forging, casting, grinding, and welding. A vise will often be mounted at the tabletop.



4.3 Metalworking Workbenches

This is a specialized workbench that will have a small wooden surface that sticks out, close to the worker for close detailed work on small objects. There will also be a surface underneath to easily catch fallen stones or pieces that wouldn't be found well on the floor. These types of benches will be built to handle the constant exposure to dirt and moisture. The wood will be treated to prevent rotting and mold growth.

These types of benches will often be round so that the work can be accessed from all sides. Sculptures, carvers of wood and stone, pottery makers, and other artists use this type of workbench.

These are the more delicate type of workbenches. Harsh power tools won't be beating the tabletops. They will serve the biological and chemical scientists. They will be found in hospitals and science labs. Water and gas sources will be fixed in convenient spots and the tabletop will be a smooth slate. It will be made out of metal for easy cleaning and the most efficient management of infectious or toxic contaminants.

#### 4.3. Requirements:

##### 4.3.1 Evaluation of the existing adjustable table:

The existing work table is part of a project developed by the college. The idea of the table came from the idea of creating a modern workspace focused on better work experience of the students and posture while working mainly with hand tools.

##### 4.3.2 Environment analysis:

The environment in which the product is going to be placed is the scholar space. In this place, the pupils develop their learning, so that, the environment is an important tool to help the students with this process. It has to be a good atmosphere so that the students can feel motivated and stimulates them to discover and develop their creativity.

#### 4.4 Ergonomics analysis:

##### 4.4.1 Standards:

This analysis describes all the standard research for the product that is going to be designed. These rules serve as a guide for designing the table and ensure that it accomplishes the international requirements for this kind of products and it can be sold on the market. The following information is taken from three different brochures provided by the company and belongs to the Swedish standards institute. From these standards it has been taken the main points, the ones that are going to affect directly the design, so that it is not going to appear in this research all the points that doesn't have any impact on it.

##### 4.5 Concepts generation:

After the research about the topic, the next step was to generate different concepts to find solutions to the problems defined. In this stage, the aim was to generate as many ideas as possible so that it could be easier to find a good one to develop afterwards. In Approach and implementation 38 the end, three concepts are created and only one of them is the one chosen to be improved as the final one.

##### 4.5.1 Main shape exploration:

To begin with the concepts, some exploration about the shape that the table has to acquire. The idea is to make the table a modular piece that the children can use around the classroom and can use it while working together in groups.

##### 4.5.2 Quick sketching:

The first quick concepts were created to visualize the ideas that came up to the mind while the problem definition. These first sketches were used after to create better ones and develop it into new ideas for the three concepts. The first concepts were created mixing some of the ideas generated in the quick sketching. The intention for the first concepts was to find a solution for all the problems that came from the research and visualize different ways to solve them.

**4.6 Concepts Evaluation:** This evaluation was done in collaboration with the company. A meeting was held in Stockholm in order to receive some feedback for the concepts. The company decided to continue with concept 3 due to its possibilities although it needs some modifications in order to fulfil the company requirements for the product.

1. The weight for the drawer has to be taken into account in order to avoid problems with the gas spring since it has a max weight that can lift.

2. The hook for the backpack should be kept Approach and implementation

3. The up/down button should be kept

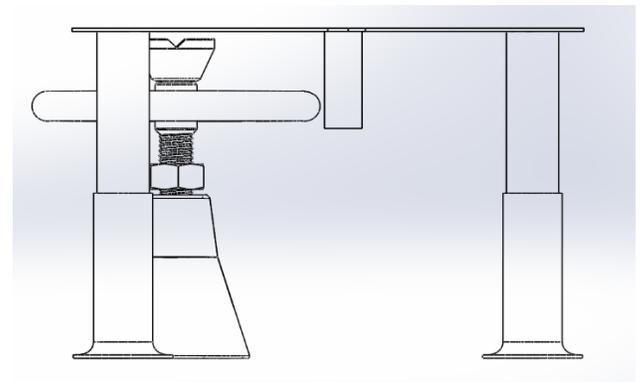
4. The tilt support should be kept but developed further in order to avoid pinching risk.

5. The pen drawer is not necessary and can be skipped.

6. The frame should be kept but the placement of the wheels has to be different to enable easier movement. After the new requirements and direction, the next step was to generate new concepts.

##### 4.8 Design and development:

The CAD models were made with the CAD program Inventor. The purpose of this final CAD model was to solve all the problems that were noticed during the second concepts while doing the easy 3D models and define all the different mechanical elements.



4.4 final model 2D diagram

##### 4.9 Technical specifications:

##### 4.9.1 Materials:

The materials chosen for the whole product accomplish the product requirements established in the PDS. The main restriction for all of them is that they have to fulfil the environmental friendly requirements. The material chosen for the table surface is birch plywood. This material is perfect for the application it is required because of its properties.

Wood is a renewable natural resource which means that it is environmental friendly. It has great values in bending,

tension, compression and strength. It can acquire several finishes depending on the customer needs. Plywood is also very stable with high temperatures; its ignition point is at 270°C when exposed to a naked flame. It has also good insulating properties, that is why it is good for acoustic improvement solutions. And has a good resistance to many acids.

For the base, lifting cylinder and upper part structure the material selected is steel since it was the original for this three elements and the idea is trying to keep the same aesthetics as in the company products. The idea for the drawer was to find a plastic with the best properties and also good surface quality since the product must look robust and good quality.

Within the group of plastics, the most appropriated is polypropylene. This plastic is commonly used for toys and kids' furniture because of its resistance properties. Other interesting property is that it can be colored. It is a plastic with low density, that makes it lighter and allows to produce molding parts with lower weight. It has good resistance to fatigue, is tough and flexible and it can be copolymerized in order to get better properties. Polypropylene is also recyclable. The reason why the best material for this part is a plastic and not metal or wood (with better surface quality and resistance properties) is that due to its complex shape it is impossible to build it with these materials. The best way to produce it is with injection molding



4.5 workbench design

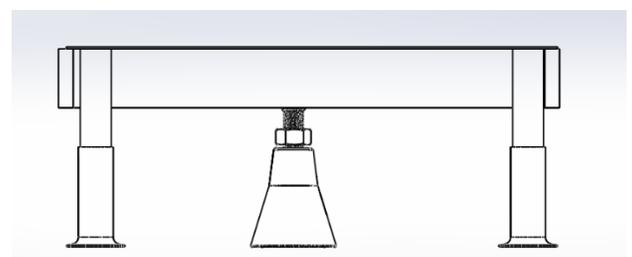
#### 4.9.2 Dimensions:

The final dimensions of the desk are defined by using the European Standards shown in the section "4.5 Ergonomic analysis", electronic devices measurements and also anthropometric charts of Swedish children focusing on the ages 7 to 16. In this case, it was used the percentile P5 7 years- old girl and P95 16 years old boy (see in appendix 3) in order to establish the maximum and minimum measurements for the desk and ensure that the product is suitable to all the range of possible users. Other measurements like thicknesses are defined by the

materials used in each case. The main pieces and their measurements are:

- Table top: this value is defined by the dimensions of the children's shoulder width in the anthropometric chart for P95 16 years old boy. The table has to make sure that this user, that is the biggest one, can fit into it and use it without problems and put his arms on it. For the tilted support for electronic devices, the measurement was determined by a normal laptop since it was considered to be the biggest electronic device that was going to be put in there. The length of the table was chosen taking into account the standards and also thinking about the optimal length in order to use an electronic device with its wireless keyboard.
- Drawer: the dimensions of the drawer are determined by the table top dimensions since it has the same shape as this one but it is 2cm smaller in each side just to make sure that if the user is grabbing the table, he doesn't pinch his fingers between the table top and the drawer. This measurement was also taken from the P 95 16 years old measurement of 2nd and 3rd phalanx length of the middle finger (the largest). This measurement is an approximation given the of the finger length measurement. The depth was also chosen taking into account standards and also the quantity of things that the users can put on it. It was calculated that users can put maximum 5 books.
- Adjustable system: the measurements for this adjustable system are predefined by the manufacturer of this product.

- The rest of the parts of the table base their measurements in the pieces they are attached to and its components.



4.6 Side view 2D model

#### 4.9.6 Safety:

Since it is a product for children it implements high safety level for the user:

- The edges of the product are rounded, as it was on the standards. This avoids that the user gets injured. It also gives a better aspect of the product due to its soft surface and corners.
- In pieces that the user has to grab, there is enough space for the user to put his fingers without suffering pinching.
- The hinges used are soft closing, so in case the children have their hands under the table top, he has time to remove them from there or in case it closes on them, the damage is less.
- There are no small

parts that could be choking hazards in the product. • All the materials used to manufacture the product are not toxic.

## 5. CONCLUSIONS

Collage furniture market is big and you can find many different kinds of companies all over the world with different products. Formbannariamman institute of technology pretends to design a unique desk, which is a challenge due to the market possibilities, taking advantage of ergonomics and after a detailed study about children and children health while using electronic devices. The new desk will make the company acquire great success in the market thanks to the possibilities of this new product. Nowadays the most common activities on the school are done with computers help. Children start to learn how to use them since they are very young at the school. But this fact that looks an advantage, also has his disadvantages. It is not a good idea if we take into account children's health. The misuse and take a bad position while sitting in front of this technologies can seriously damage children's health. This new ergonomic desk is my response to the problems that normal desks can produce. It is a new product that fits on the market and clearly differentiate it for the others. It is distinguished by its characteristic pneumatic adjustable system, drawer and tilted computer support. It is innovative, collaborative, durable and designed for modern environments. In order to develop this product, it would be necessary to test it with the final user after producing some real desks in order to observe the interaction between the user and the product and evaluate its effectiveness and find possible problems of it.



5.1 completed 3D design of worktable

## 6. REFERENCES

- [1] <http://www.dailymail.co.uk/news/article-3175192/Children-spend-30-minutes-time-iPads-suffer-chronic-neck-pain-later-life.html> (Acc. 25 July 2016)
- [2] Form oMiljö <http://www.formomiljo.se/> (Acc. 12 Aug 2016)
- [3] Kathryn Best MA, MSc (2011) What can Design Bring to strategy? Designing thinking as a tool for innovation and change, Inholland university of applied research, Rotterdam, ISBN 978-90-77812-33-4
- [4] An Introduction to Design Thinking PROCESS GUIDE (2010) <https://dschool.stanford.edu/sandbox/groups/designresources/wiki/36873/attachments/74b3d/ModeGuideBOOTCAMP2010L.pdf?sessionID=68deabe9f22d5b79bde83798d28a09327886ea4b> (Acc.31 July 2016)
- [5] School of furnishing, History of the desk (2014) <http://www.schoolfurnishings.com/history-of-the-desk-2/> (Acc. 25 July 2016)
- [6] Visual history of school desks (2012) <http://www.edtechmagazine.com/k12/article/2012/10/visual-history-schooldesks> (Acc. 31 July 2016)
- [7] Better Health channel, Computer related injuries (2016) <https://www.betterhealth.vic.gov.au/health/healthyliving/computer-relatedinjuries> (Acc.26 July 2016)
- [8] Posture science, how to have a good posture (2013) <http://theramart.com/uncategorized/la-ciencia-de-la-postura-como-sentarse-recto-lo-hara-mas-feliz-mas-confiado-y-mas-saludable/> (Acc.31 July 2016)