

# Comparative study of Design and analysis of Portable adjustable stands for laptop

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**Abstract:** This paper explains how a quality function deployment is one of the tools for defining your design, focusing primarily on its key features. This paper looks at the evolution of laptop stands and how its feature is changed revolving around human centered design, as well as offering a design solution. The product's design specifications are identified and prioritised, and a set of metrics is developed to measure how well different product features meet customer needs. The entire product development can use quality function deployment to prioritise their development activities in a systematic, analytical manner. It creates an "audit trail" that reminds everyone involved in the project, new and old, why certain decisions were made in the past.



Figure 1 Discover, Design, Deliver diagram

**Index Terms:** Quality function deployment, Laptop- Stands, Product design and development, Ergonomics

## I. INTRODUCTION

A laptop is not an ideal product from an ergonomic standpoint because it forces the user to look downwards. This leads to musculoskeletal disorders, such as RSI or CANS, which are exacerbated by the rise in telecommuting jobs [12]. Working at a computer terminal while sitting in the same position can increase the risk of herniated discs and bad posture[13], which is a dilemma among office employees, who tend to nosedive their shoulders inward as they sit and type, causing muscle atrophy and increased strain on musculoskeletal joints [14]. Additionally, users frequently encounter charging issues, even though the laptop has a charging port, the developed laptop stand simplifies the process of using a laptop without having to move it around for charging [15]. The development of a laptop stands with a charging port that can be used to charge the laptop enables the lifestyle of using a laptop without having to go anywhere to charge it. The development of a concept for a multiuser laptop and projector stand ensures an aesthetic and effective design through the use of appropriate materials[16].

Talking about materials, natural fibres can be seen as an option because it helps in reducing reliance on non-renewable resources while also contributing to environmental preservation because composite furniture is derived from natural fibre[17]. It has a wide spectrum of uses in which kenaf fibre reinforced polymer composite is an example of how natural fibres can be used as a petroleum replacement[18]. It is renowned for its non-abrasiveness during manufacturing, biodegradability, low density, and superior specific mechanical properties[19]. Additive manufacturing can also be seen as an alternative to fabricate which results in a sustainable product that leads towards a better future[20]. The term "Additive Manufacturing (AM)" refers to the process of creating components by gradually adding material layer by layer, as opposed to traditional machining, which removes material[21]. When compared to a component made using a traditional manufacturing process, the surface roughness of AM components is extremely high[22]. Heat treatment, on the other hand, can greatly improve the fatigue performance of the AM component[23]. The properties of the laptop stand materials were discovered to have a significant impact on the antenna's performance [24]. As the properties or overall structure of the cover materials change, the observation may change [25]. Some covers may not have consistent thickness throughout the cover, resulting in varying attenuation as the antenna location changes, while other covers with geometrical irregularities at the edges, such as the plastic joints used to close the laptop lid, could cause diffraction and lead to multiple nulls in the antenna radiation pattern[26].

To answer its research question, the study uses a Quality function deployment[27]. Thus, giving credence to how a specific design thinking framework can help the reader quickly identify the inadequacies of the previous invention, resulting in a phenomenal configuration.

- This paper contributed to the current literature and can be used as a unique way to develop a better human-centered design by the other non-profits.
- This paper looks at how laptop stands have continued to evolve and this reviewing method will help in understanding previous inventions and then followed by new design that should have all features.
- Conducting a detailed literature review on the history of Quality Function Deployment, its applications, and the various methods used to gain a thorough understanding of Quality Function Deployment.
- To gain a better understanding of the laptop-stand, how it has evolved over time, and how companies have dealt with issues that have arisen along the way.
- Predicated on the most preferred laptop-stand features, data will be collected.
- Evaluate and come to a conclusion, based on all of the data gleaned, on whether Quality Function Deployment and its methodologies are meaningful enough just to assist businesses in adapting to the present socio-political context.

## II. LITERATURE REVIEW

Laptop stands, which sit on or around the lap and elevate the laptop, and fixed frame desk/table stands, which sit on the floor or mount to something, are the two types of laptop stands currently available. Both are difficult to manoeuvre into different positions and even more difficult to move around once in place. Most current stands jeopardize the laptop's protection and/or stability when maneuvered, requiring the user to remove the laptop to adjust it. Aside from the ability to adjust vertically and/or horizontally, no stand currently offers much flexibility. Comprising different prior art will result in providing features for developing a house of quality.

### 2.1. Improve body posture

Working on a laptop for an extended period while maintaining an odd body posture causes neck, wrist, and back pain. It becomes a serious problem for the user if it is repeated for a long time. To avoid neck, arm, and back pain, the health authorities recommend that the laptop screen be 2 inches above the eye level and the keyboard be below the user's elbows. However, no laptop meets these requirements. As a result, a laptop stand is a good solution to this problem.

### 2.2. Increases laptop life

Working on a laptop for an extended period causes the laptop to overheat due to poor ventilation and the proximity of the hardware assembled inside the laptop. Furthermore, heating causes the battery to drain at a faster rate, slowing down the system. Laptop heating is a productivity and laptop safety hazard. The laptop stand, on the other hand, provides adequate ventilation for the laptop, extending its life and increasing productivity.

### 2.3. Adjustable angle and height

Because most laptop users experience stiffness and pain in their neck while working for long periods, one of the most important functions of a laptop stand is the ability to adjust the angle, height, and distance of the laptop table to the body. The main cause is the laptop screen's low height, which forces the user to look down to see it. The majority of studies show that when the neck bends forward, it puts a lot of strain on it. When you bend your neck to 15 degrees, the weight of your head is twice as much as it should be on your neck, which can cause neck pain if you do it for a long time. Another example of a 2015 survey conducted in the United States found that 65 percent of adults in the United States suffer from computer vision syndrome and eye strain as a result of using a digital screen. The above problem can be solved by raising laptops to eye level and keeping the body in the proper position, which necessitates the use of laptop stands with adjustable angles and height.

### 2.4. Ergonomics

Ergonomics plays a key role in increasing productivity and reducing discomfort by promoting good body posture, which reduces back and neck pain. It also aided in the creation of a work environment that met the needs of the users. The majority of laptop keyboards are not designed to be as ergonomic as possible. However, adding an external keyboard may be able to solve this problem to some extent, but this increases the distance between the user and the laptop screen, causing discomfort to the user once again. In the case of a laptop, the user can easily adjust the distance and height of their laptop screen to meet their needs.

### 2.5. Portability

It is another nailing feature of laptop stands. Portable laptop stands which foldable and easily fits in laptop bags provide excellent features that users can use in their living room or it can be carried outdoor workspace as well.

### 2.6. Stability, Durability

Stability and sturdiness work is to provide safety to the laptop while working on a laptop stand. The laptop stand should be capable to carry laptop load and it should be a non-slip base so that the user keeps their laptop at any angle without discomfort, moreover laptop legs capable to balance laptop load at any surface and position.

The ability of the laptop stands to remain functional without requiring extensive maintenance or repair for a long time gives another important feature to laptop stands. The durability of laptop stands mostly depends on the material that used for sturdiness and durability. However, durability depends on the materials, so considering good material with lightweight

is an important factor such as those tables made of plywood and MDF have good durability and lightweight as compared to other materials. Moreover, if the laptop tables made of steel than it has good durability, but it would be heavier.

### 2.7. Material and weight

The weight of the laptop stand is described by its material which is used. One of the important features of a laptop stand is portability, which depends on the weight of the laptop stand. If it is lightweight it's easy to carry from one place to another place to get this feature, the majority of laptop stands are made of engineered wood, plastic, metal in India.

### 2.8. Good ventilation

Prevent your laptop from overheating and improve its performance. When working with laptops for long periods, laptop stands with good ventilation are essential. This is due to the proximity of hardware components in laptops, which has a direct impact on the laptop's performance and battery life. Laptop stands with ventilation or an additional cooling fan improve performance and laptop life.

### 2.9. Storage for accessories

The laptop stand should have enough room for USB ports, a cooling fan, speakers, and a mouse pad so that users can take advantage of this feature without difficulty. Laptop stands with accessory storage are more ergonomic and user-friendly.

### 2.10. Appearance and Versatility

The aesthetic appearance of the laptop stand is important because it provides a pleasing view of the workspace through the sleek design of the laptop stand and enhances the appearance of the place, whether it is at work or home. The laptop stand is designed in such a way that it can be used in both personal and professional settings. It is critical to design a laptop stand in such a way that it can be used in a variety of settings.

### 2.11. Size and compatibility

Design laptop refers to the consideration of design in such a way that it can be used on a variety of laptops. Size and compatibility are important features for portability because if the size of a laptop stand is bulky, it will be difficult to transport and will reduce the portability of laptop stands.

## III. EXISTING LAPTOP STAND: COMPARISON

### 3.1. Ergotron LX Notebook Arm [1]



Figure 2. Ergotron LX Notebook Arm

Features:

Allows for easy modification to meet ergonomic standards.

Easily mounts any type of notebook or laptop computer.

Maximize the amount of space available by removing the desk.

It has a dual-display setup that improves efficiency.

Cable control hides wires under the shoulder.

7.8 lb. weight

Measurements: 17.75" x 10.5" x 6.75"

Lack of laptop Protection, the stand must be mounted, cannot rotate, no extra workspace for other accessories, like – keyboard, mouse.

### 3.2. Aviator laptop stand [2]



Figure 3. Aviator laptop stand

Features:

Provides an ease able and ergonomic workstation by promoting good posture when working.

Laptop efficiency is improved by air ventilation.

0.5-pound weight

Measurements: 12.5" x 9" x 3.5

Adjustment is limited, lacks in laptop Protection, no extra workspace needs a flat surface to put on,  
Cannot rotate.

### 3.3. Portronics POR-704 Adjustable Laptop Table [3]



Figure 4.Portronics POR-704 Adjustable Laptop Table

Features:

It includes a table/stand with double folding legs that are more convenient for Storage and manoeuvrability.

This has nice features for working on your laptop in bed, at a desk, or on the coach. The height can be changed by pressing a button on the side of the legs.

It has a stand that can be angled for easier typing and viewing

A small fan is placed on this stand for air circulation and is connected via USB cable.

Gross weight: 3.3 lbs.

Measurements: 20.50" x 11.8" x 5.12"

Legs are made of aluminium which lacks in sturdy design, it is not suitable for big size laptop with a mouse.

### 3.4. Adjustable laptop stands for a vehicle [4]



Figure 5.Adjustable laptop stand for vehicle

Features:

This laptop stand is placed between the driver and passenger seats of a car, giving both the driver and passenger access to the laptop.

This provides the laptop with a stable and flexible stand.

The stand can be moved forward/backward, as well as left/right, to meet the user's needs.

A ratchet-style set screw is mounted in this stand, allowing 360-degree rotation.

### 3.5. Kootek Laptop Cooler Cooling Pad [5]



Figure 6.Kootek Laptop Cooler Cooling Pad

Features:

It has an adjustable pad and a slim build with cooling fans, making it ideal for laptops.

The laptop's power is used to power the cooling fan, which can be connected via USB cable.

Gross weight: 2.9 lbs.

Measurements: 15.71" x 12.99" x 1.85"

Height adjustability is not there, lacks in Protection.

### 3.6. Nulaxy C1 Laptop Stand [6]



Figure 7.Nulaxy C1 Laptop Stand



Features:

It's ideal for working at various heights.

It provides steadiness and can Easily carry up to 44 pounds.

Rubber pads on the top and front lip of the stand keep the laptop from slipping.

Holes are drilled into the surface of the stand to allow for laptop ventilation.

Gross weight: 2.1 lbs.

Measurements: 9.85" x 10.23" x 0.78"

Height adjustment is limited, needs a flat surface to put on, cannot rotate.

### 3.7. Barbieya laptop bed table [6]



Figure 8.Barbieya laptop bed table

Features:

This laptop has nice features for working at a desk, in bed, or with the coach.

You can have a cup of tea on the table when working because there is a dedicated place for it.

It has a design that allows you to keep the tab/Laptop stand on the table while using the mouse.

It has a rugged construction made of heavy and robust aluminium alloy and wood, and the legs can be folded when not in use.

Gross weight: 5.1 lbs.

Measurements: 23.6" x 15.74" x 10.6"

No ventilation, not portable, height and inclination of the stand were fixed.

### 3.8. Combined laptop case and laptop stand [7]



Figure 9. Combined laptop case and laptop stand

Features:

This is a laptop carrying case that also serves as a laptop stand.

It has a well-designed ventilation system.

It ensures that the can is stable and safe.

The stand's height can be changed.

It has multiple compartments for holding extra objects, and it also has a mouse pad for use when operating on a laptop.

Classical and bulky look, heavyweight.

### 3.9. Voroly foldable height adjustable laptop stand [8]



Figure 10.Voroly foldable height adjustable laptop stand

Features:

This laptop stand is highly lightweight, with a compact and durable build.

This laptop stand is entirely foldable and laptop-stand.

This stand's architecture allows for space savings.

Because of its small size, it is convenient to move to various locations.

The height change is small, but the inclination angle is fine.

It provides adequate ventilation.

0.7-pound weight

Measurements: 11.96" x 2.12" x 1.26"

### 3.10. Height adjustment mechanism, platform, and method [9]

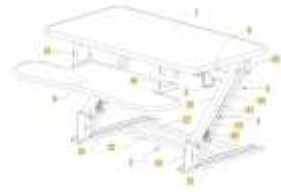


Figure 11.Height adjustment mechanism, platform, and method

Features:

It has a feature for changing the height of a laptop stand.

A driving mechanism is set up to move and lock the lifting arm, which is used to change the height of the stand/table to the user's preference.

There is an additional position to rest the keyboard.

Not portable, heavy and bulky

Cannot rotate.

### 3.11. Laptop stand [10]

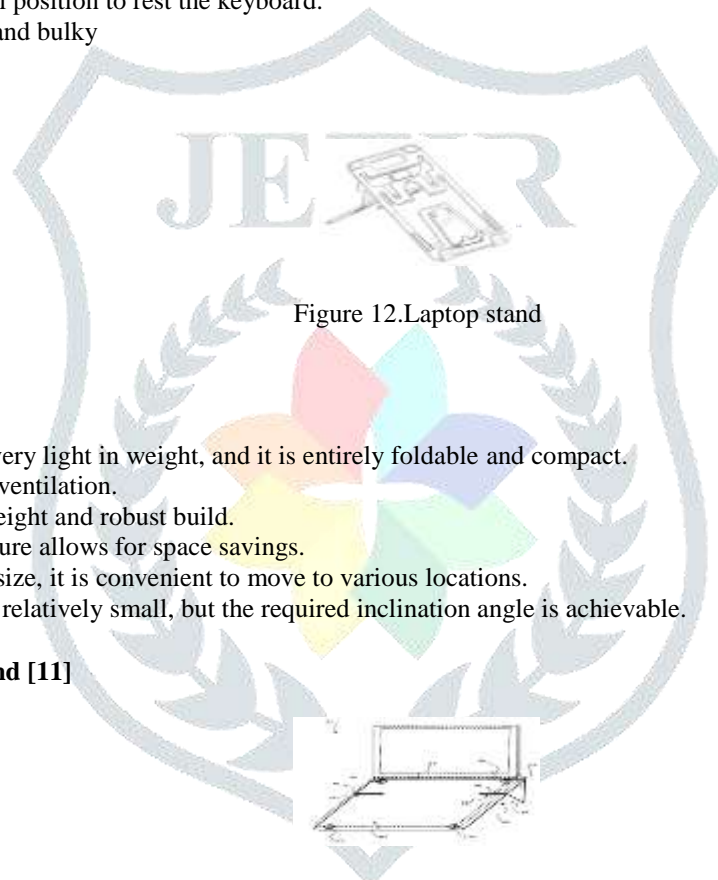


Figure 12.Laptop stand

Features:

This laptop stand is very light in weight, and it is entirely foldable and compact.

It provides adequate ventilation.

It has a rather lightweight and robust build.

This stand's architecture allows for space savings.

Because of its small size, it is convenient to move to various locations.

The height change is relatively small, but the required inclination angle is achievable.

### 3.12. Portable laptop stand [11]

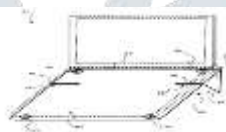


Figure 13. portable laptop stand

Features:

It comes with a rectangular and foldable flat board.

This board can be used as a laptop case as well as laptop stand.

Here the height or inclination of laptop is limited to some fixed angle

Adjustable inclination, light in weight,

No ventilation.

## IV. METHODOLOGY

Students, home users, companies, and end-users were all polled for the Portable Laptop Stand survey. Thirty individuals were polled in total. A list of features was created using the survey results[28], in order of importance Table1.

These characteristics were then used to decide the qualities required to create the most common laptop stand among consumers. According to the Quality function deployment, the most important feature is steadiness, which is followed by cost, weight, and Sturdiness for Portable Laptop Stand. These matrices connect a wide range of product features to customer desires and needs. As a result, the geometry, connection configuration, and construction materials all play a part in meeting the customer's requirements.

Table Style Laptop Stand Customer Survey							
I am a senior at the University of Cincinnati studying Mechanical Engineering Technology. This survey is to help in the design of a table style laptop stand for my senior design project. Please take a few minutes to answer the following questions to help me better the design.							
What is important to you for the design of a new table style laptop stand? Please circle the appropriate answer.							
	1 = low importance					5 = high importance	
1 Safety	1 (0)	2 (4)	3 (10)	4 (6)	5 (10)	N/A (0)	Avg. (3.73)
2 Durability	1 (0)	2 (0)	3 (3)	4 (17)	5 (10)	N/A (0)	(4.23)
3 Stability	1 (0)	2 (0)	3 (0)	4 (9)	5 (21)	N/A (0)	(4.7)
4 Ease/Speed of Adjustment	1 (0)	2 (0)	3 (11)	4 (12)	5 (7)	N/A (0)	(3.87)
5 Portability	1 (0)	2 (2)	3 (8)	4 (12)	5 (8)	N/A (0)	(3.87)
6 Range of Adjustment	1 (0)	2 (4)	3 (2)	4 (21)	5 (3)	N/A (0)	(3.77)
7 Low Cost	1 (0)	2 (0)	3 (4)	4 (8)	5 (18)	N/A (0)	(4.47)
8 Appearance	1 (5)	2 (14)	3 (11)	4 (0)	5 (0)	N/A (0)	(2.2)
9 Lightweight	1 (0)	2 (0)	3 (5)	4 (16)	5 (9)	N/A (0)	(4.13)
10 Comfort	1 (0)	2 (1)	3 (11)	4 (7)	5 (11)	N/A (0)	(3.93)
11 Good ventilation	1 (2)	2 (7)	3 (6)	4 (8)	5 (7)	N/A (0)	(3.37)
12 Compact Storage	1 (3)	2 (12)	3 (6)	4 (4)	5 (5)	N/A (0)	(2.87)
13 Storage of Accessories	1 (2)	2 (13)	3 (7)	4 (5)	5 (3)	N/A (0)	(2.8)
14 Cord Consolidation	1 (2)	2 (10)	3 (8)	4 (7)	5 (3)	N/A (0)	(2.97)
15 Large Workspace	1 (4)	2 (7)	3 (9)	4 (8)	5 (2)	N/A (0)	(2.9)
16 Ability to Secure Laptop	1 (0)	2 (3)	3 (3)	4 (8)	5 (16)	N/A (0)	(4.23)
Thank you for your time.							

Figure 14 Customer Survey table

Without a doubt, the importance of all requirements is not equal from the perspective of the student or the producer. As a result, the authors used a rating system (from 1 to 5) with five selection points to determine the level of importance for all requirements[29]. Number 1 was assigned to requirements that were not very effective in terms of student satisfaction, and number 5 was assigned to

the most important requirement in their opinion (step 3). The information gathered was entered into the quality matrix house. The number of complaints and competitor evaluations were taken into account in stage three[30]. This matrix compares a product's ability to satisfy a customer with the ability of other competing companies. Other data was compiled in the house of quality weight, a calculated value based on the customer's importance, row weight, and improvement ratio. This data will assist us in determining which customer requirements are the most critical to address and invest time and money in[31]. In stage 4, authors converted the student's requirements, referred to as the "What's" in this matrix, into technical specifications, referred to as the "How's." In this regard, the authors inquired on how these requirements should be measured by manufacturers[32]. The following sing-scale denotes the positive degree of correlation between student requirements and technical requirements: strong (9), medium (3), weak (1), and empty box (0). Then, matrices such as targets, enhancement ratios (which relate targets to current performance measures in a specific requirement), sales points (which the company must meet to sell the product), and row weight were completed[33]. Design specifications were given priority in the quality house, and implementation model parameters were allocated to these metrics. The results of this paper concentrated on the first matrix for determining the most important aspect of a product that needs to be improved[34]. Variables for another matrix are taken from the "How's" section of the preceding matrix, which then is placed on "What's" in the new matrix, so until the next matrix is built.

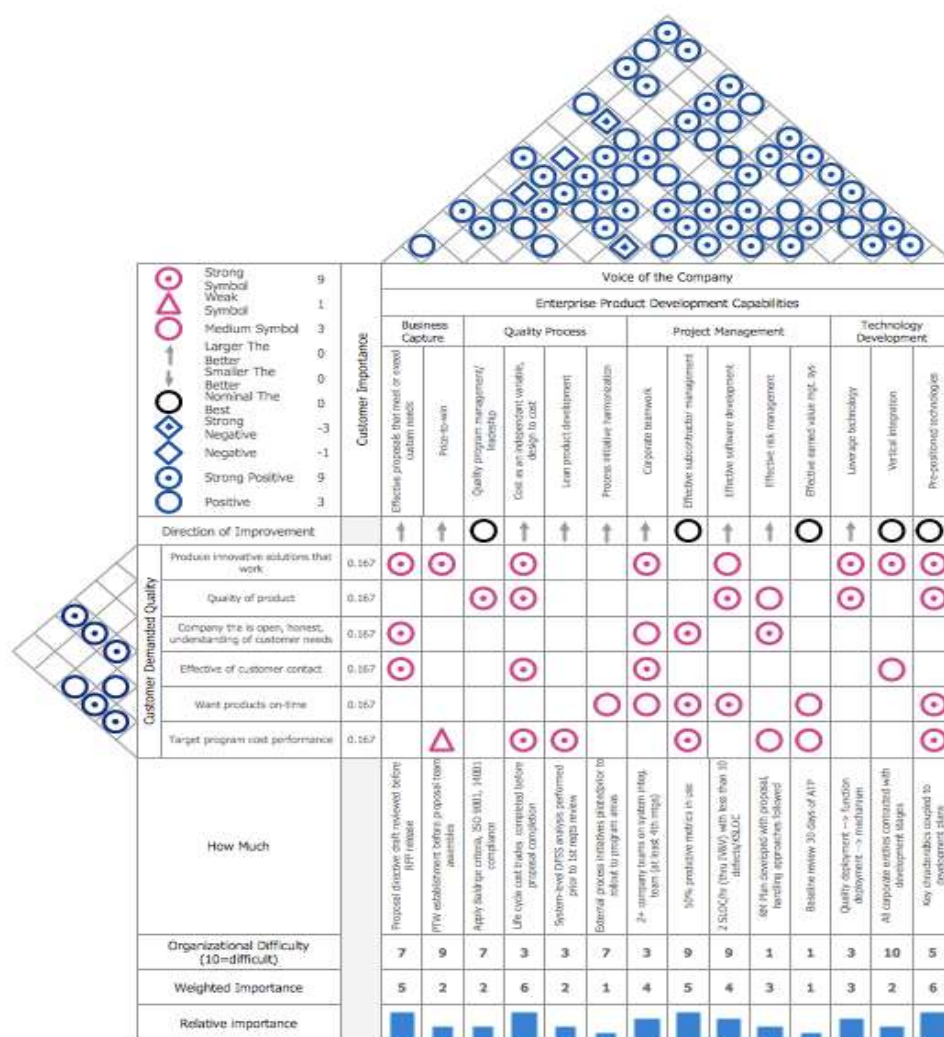


Figure 15. House of matrix

Table 1. Order of important features

No.	Features	Rel. pt.
1.	Steadiness	(4.69)
2.	Price	(4.46)
3.	Laptop Security Capability	(4.22)
4.	Sturdiness	(4.22)
5.	Lightweight	(4.12)
6.	Ease	(3.91)
7.	Manoeuvrability	(3.86)



8.	Adjustment Ease/Speed	(3.86)
9.	Adjustment Range	(3.76)
10.	Protection	(3.72)
11.	Optimal Ventilation	(3.36)
12.	Consolidation of Cords	(2.96)
13.	Workspace Area	(2.89)
14.	Storage	(2.86)
15.	Accessory Storage	(2.79)
16.	Physical Appearance	(2.19)

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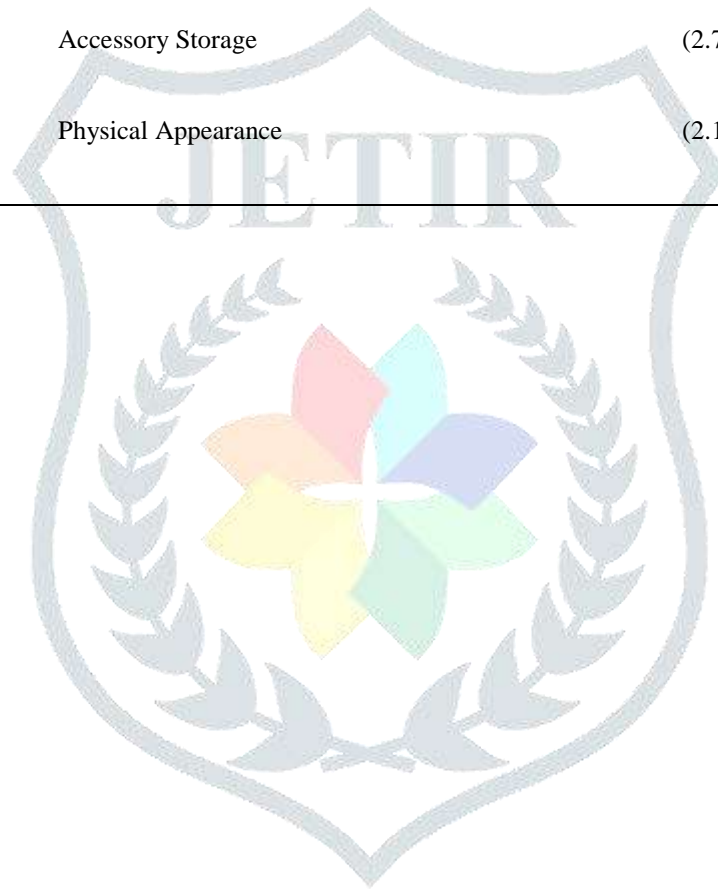


Table 2. Quality function deployment

	Physical Material	Surface Coating	links	No. Parts	Table design	Type of joint	clamping	footprint	Price	Importance of customer	Points	Improved ratio (modified)	Rel. Weight
<b>Protection</b>			9.0	3.0			3.0			3.7	1.19	4.47	0.059
<b>Sturdiness</b>	9.0	3.0								4.2	1.19	5.07	0.069
<b>Steadiness</b>	9.0		9.0					9.0		4.7	1.19	5.63	0.079
<b>Adjustment Ease/Speed</b>			3.0	9.0		9.0				3.8	1.49	5.79	0.079
<b>Manoeuvrability</b>			3.0		3.0					3.84	1.19	4.63	0.059
<b>Adjustment range</b>			9.0			9.0				3.72	1.49	5.64	0.079
<b>Physical Appearance</b>	9.0									2.21	.9	2.19	0.029
<b>Weight</b>	9.0									4.11	1.19	4.95	0.069
<b>Ease</b>		3.0			9.0					3.92	1.49	5.89	0.079
<b>Optimal Ventilation</b>					9.0					3.36	1.39	3.36	0.049
<b>Storage</b>			9.0	1.0	3.0					2.86	1.19	3.43	0.049
<b>Accessory Storage</b>					9.0					2.79	.99	2.79	0.039
<b>Consolidation of Cords</b>					9.0					2.98	.99	2.96	0.039
<b>Large workspace</b>			3.0		9.0					2.89	.99	2.89	0.039
<b>Laptop Security Capability</b>						9.0				4.22	1.49	6.34	0.089
<b>Price</b>									9.0	4.46	1.49	6.69	0.089
<b>Absolute imp</b>	1.9	1.14	2.91	0.94	2.54	1.40	0.96	0.69	0.84	13.39		72.77	1.0
<b>Relative Imp.</b>	0.13	0.08	0.21	0.06	0.18	0.10	0.05	0.04	0.05	1.0			

## V. RESULTS AND DISCUSSION

Modern quality function deployment (matrix-free) was used to respond to changing customer needs because traditional quality function deployment may not cover all of the urgent deployments[35]. The cycle of product design, the risk of product development, and costs can all be reduced using the quality function deployment method, while product quality is improved and enterprise competition is increased. The use of quality functions in design is a useful and adaptable tool. It has provided the tools, methods, and structures needed to complete those tasks, especially during the critical-to-satisfaction phase.

The order of parts and steps in the quality function deployment process can be changed depending on the design team's strategy. The correlation matrix is at the heart of the quality function deployment process, storing vital data for design enhancement. The current research is one of the first to use the quality function deployment method to investigate laptop stands. Using quality function deployment, we were able to obtain crucial and accurate information about the needs and demands of our users. According to the quality function development, the most important feature is consistency, which is followed by price, geometry, connection setup, and construction materials, all of which play a role in meeting the customer's requirements. The design of a table based on the house of quality matrix may solve stand problems and satisfy users, but more empirical and field research over a longer period is required to achieve a satisfactory result.

## VI. CONCLUSION

The Quality Function Deployment method is extremely useful for analysing customer needs and providing solutions, as well as a new design, to produce high-quality and competitive products and processes. This method's credibility as a means of meeting customer expectations is growing. This methodological tool has the potential to provide a better solution to problems involving all aspects of product design. Many of the data in the artefacts created during studies closely match the data required as input to various popular object-oriented methodologies. It allows you to determine which user requirements are the most critical and should be included in the final new product. To improve product design quality in laptop stands, quality function deployment was used. The quality-based requirements are considered first in this study, followed by scheduling issues. According to the quality function development, the most important feature is consistency, which is followed by price, geometry, connection setup, and construction materials, all of which play a role in meeting the customer's requirements. The design of a table based on the house of quality matrix may solve stand problems and satisfy users, but more empirical and field research over a longer period is required to achieve a satisfactory result. It should be noted that because this is just a framework for incorporating customer requirements into product design, other approaches must be used to make the method more effective. The study's analysis has confirmed that the new design, based on findings, is relevant and effective, providing a theoretical foundation. Using this method, the most important points in the existing stand that need to be corrected can be identified, and a technical solution can be provided as technical targets during the product planning stage. Finally, deploying quality functions has proven to be a successful method of process development and product deployment. This study provided foundational information about students and their needs, which could be used in future studies to move forward. To create a more complete expert system, the authors will consider the conflict and optimization between quality and schedule, as well as resource limitations in future work.

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