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# Drive-Thru Fixture Design

**Fahad AlHadyan, Faris AlMosa, Khalid AlKhateeb, Musaad AlHobayb, Tareq AlMohawis and Dr. Wasim AlShammary**
Industrial Engineering Department, College of Engineering and Architecture
Al Yamamah University
Riyadh, KSA
f.alhadyan@hotmail.com; w_alshammary@yu.edu.sa

## Abstract

The project focuses on designing an ergonomic drive-thru fixture to reduce workplace injuries in the fast-food sector. It addresses the occurrence of musculoskeletal injuries among drive-thru workers, caused by repetitive leaning and awkward postures during long shifts. The project aims to develop a product that minimizes these risks, improving the working environment and employee satisfaction. An initial RULA assessment indicated a high-risk score, prompting the design of a fixture that attaches to drive-thru windows, reducing the need for leaning. The project considers factors such as cost, durability, simplicity, and efficiency, resulting in the development of a mechanical fixture as the optimal solution. This fixture moves forwards, backwards, and upwards, thus reducing the need for leaning. The prototype testing showed improved ergonomic conditions, with a lower RULA score, demonstrating the fixture's effectiveness in creating a safer work environment for drive-thru employees. The project's impact extends to reducing healthcare costs and enhancing workplace safety and ergonomics.

## Keywords
Ergonomics, Drive-thru, Musculoskeletal Injuries, Workplace Safety, Mechanical Fixture.

## 1. Introduction
In 2023, the Saudi Arabian food sector was valued at $61.5 billion and is projected to grow annually by 4.13% (Statista, 2023). With 70% of the population being young, the biggest segment in the food sector was found to be the fast-food segment due to the changes in lifestyle. The fast-food sector has multiple ways in which it serves food: dine-in, ordering at the counter (takeaway), ordering at a drive-thru (takeaway) or delivery (Morder Intelligence, 2021). As the young population values convenience, a drive-thru offers extreme comfort as one can order food or drinks without getting out of the car. The concept of a drive-thru has been around for decades and has grown even more in popularity in the past couple of years. A study conducted by Quantum (2021) has shown that 60% to 70% of most fast-food sales generated in the United States was from drive-thru windows. These fast-food chains tend to build drive-thru windows to give food to their customers without observing the physical motion of the labor at the window. The current design of the workstation at a drive-thru is not convenient and could result in physical injuries to the worker, as it requires the workers to lean for 8 to 10 hours during his/her working shift.

The proposed project is to create a fixture that attaches to the drive-thru window, that can extend to the customer's window, to decrease the amount of leaning required from both the drive-thru worker and the customer. Our product will mostly be used by the fast-food sector as these restaurants have a drive-thru service. Our product will greatly benefit the drive-thru workers as they are frequently exposed to repetitive leaning which can lead to back strains and shoulder injuries.

### 1.1 Objectives
The primary objective of this research is to design and test a mechanical fixture that can be added to existing drive-thru windows, enabling movement in multiple directions to reduce the need for leaning; RULA will be used to assess

the impact of the designed mechanical fixture. The resulting objectives of deploying the fixture includes, decreasing the number of workplace injuries by 20% and improving the work environment of drive-thru workers by increasing the satisfaction score by 50% within a year of installing the fixture.

## 2. Literature Review

As drive-thrus become more popular, most people do not consider the physical strain that drive-through workers face. The design and layout of a drive-thru can cause ergonomic problems for employees, leading to musculoskeletal injuries. Drive-through workers stand all day at the window leaning forward to give the customer his/her food followed by collecting payment, this requires the worker to use around 50% of his back strength and 30% of his shoulder strength – each time the load increase (i.e., two drinks instead of one or a heavier bag of food) more strength is required, according to Taylor'd (2023). Over time, this repetitive movement can lead to injuries. According to Baillie (2016), a human anatomist and physiologist, bending from the hips and waist stretches the muscles and ligaments in the back and causes the back to strain, over time this can weaken the muscles which decreases the level of support to the spine.

Prolonged standing and leaning are two common tasks for a drive-thru worker. McCulloch (2002) summarized the findings from 17 studies that investigated the health risks associated for standing for more than 8 hours a day, the usual shift of a drive-thru worker, and found that musculoskeletal pain of the lower back and feet were most found. Yazuli et al. (2019) studied the musculoskeletal disorders associated with prolonged standing among Malaysian manufacturing workers and found that muscle discomfort and muscle fatigue were early symptoms that can turn into serious disorders such as disc herniation or damage to ligaments and tendons; with time these disorders may lead to permanent, irreversible conditions. Hassani et al. (2022), assessed the risks that arose on agricultural laborers that included leaning as one of the postures during their work. The study found that among the 150 workers, the incidence rate of lower back pain was 94%, neck pain was 69% and upper back pain was 63% were calculated. Finally, Jia et al. (2022) conducted a survey on 57,501 Chinese workers and found that frequent standing and leaning at work was associated with lower back pain ($p < 0{,}05$).

Several sources have investigated ways to improve the workplace ergonomically for jobs that require prolonged standing and leaning. Raynsford (2021) suggests that workers shift body positions frequently to improve blood supply to the working muscles, decrease the strain on the muscles and reducing overall fatigue. She also suggested the installation of anti-fatigue mats to help ease discomfort, as the mat absorbs the shock of the hard floors. OSHA (n.d.), recommends providing stools at drive-thru workstations to allow employees to alleviate the weight from the feet while maintaining reach as well as providing anti-fatigue mats. As for leaning, OSHA (n.d.), also recommends the redesign of the workstation to include drop boxes to put the order into to allow customers to reach for their order and rotating the workers to limit their experience of frequent leaning and standing. Finally, Wiener-Bronner (2022) discussed the concept of using automated conveyer belts that delivered the order from the kitchen to the customer, however there are two main drawbacks to the concept; it requires customers to pick up their order from inside the restaurant and requires that customers order online before arriving – reducing the benefits of drive-thru windows.

In conclusion, many drive-thru workers face ergonomic challenges that lead to musculoskeletal injuries due to repetitive motions, prolonged standing, and leaning. It is necessary that the industry adopts new techniques that help reduce these injuries to improve the productivity and satisfaction of their employees. A drive-thru fixture is an ergonomic intervention that will help employees stand for shorter periods of time, reduce any unneeded repetitive motions, and eliminate leaning completely.

## 3. Methods

### 3.1 Design Approach

The project followed an eight-step approach, Figure *1,* to develop a drive-thru window fixture. It began with defining the problem, which necessitates critical, creative, and analytical thinking, as well as research skills. Engineering standards like ISO 9001 were followed, emphasizing customer-centricity. Research and information gathering were the next steps, involving critical thinking, analytical skills, research skills, and the use of software tools like Microsoft Forms, Excel, and Tableau. Local regulations and ergonomic concerns were considered. Design concept development followed, where AutoCAD was used to create designs and explore alternative solutions. This step required creative thinking, user-centered design thinking, collaboration, problem-solving skills, and AutoCAD expertise. Several engineering standards, including ASME Y14.5, ISO 128-1:2020, and ISO 6385:2016, guided the design process.

Iterative development broke down design tasks, allowing for multiple iterations to refine the fixture. This phase relied on creative thinking, user-centered design, collaboration, problem-solving, and AutoCAD. Evaluation of design concepts were done based on predefined criteria, considering factors such as cost, durability, simplicity, efficiency, and maintenance. The procurement of materials came next, requiring knowledge of materials, budgeting, logistics, and time management. Engineering standards such as ISO 45001 ensure materials' safety and compliance with regulations. Construction followed the selection of the optimal design and necessitates technical skills, project management, and problem-solving abilities. The testing phase ensured the fixture functions as intended, relying on product knowledge and analytical skills. Excel was used for testing data analysis, and ISO 6385:2016 standards were adhered to, aiming to reduce workplace injuries through the design. This comprehensive process ensured the development of a high-quality drive-thru window fixture while adhering to engineering standards and considering customer needs and safety.

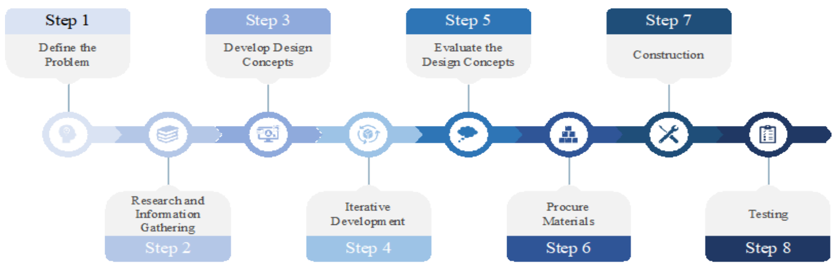


Figure 1: Design Approach

## 3.2 Ergonomic Design

Three proposed designs were created based on the constraints and results of the data analysis:

1. **Window Extension:** an extension to the existing window that will allow the drive-thru worker to slide orders on. It will reduce the amount of leaning required from the drive-thru worker.
2. **Mechanical Fixture:** a fixture that can move in multiple directions (up/down and forward/backward) using a combination of mechanisms such as a lever or push/pull that will help reduce the amount of leaning that the worker is required to do. The fixture will have an attached tray that has different depths to hold the drinks.
3. **Automatic Conveyer Belt:** a conveyer belt that is fully automated to move the order from the kitchen to the drive-thru window. This requires automation and technologies to be used. This solution will ultimately eliminate the need of a worker to stand at the drive-thru window.

In choosing the optimal fixture design, each proposed design was compared against the constraints, Figure 2, in which the window extension and mechanical fixture have the least compromises against the constraints defined; with the mechanical fixture being the preferred solution as it meets all constraints (two with limitations) while the window extension has two constraints that are not met. The automatic conveyor built is the least preferred solution as it only meets six out of the seventeen defined constraints.

| | Time | Cost | Relibility | Vehicle Height | Drink Spillage | Space Availability | Structural Requirement | Regulations Compliance | Aesthetics | Sustainable Materials | Energy Efficiency | Size Modification | User Guide | Reduce Leaning | Safety | Sanitation | Durability |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Window Extension | Possible within time constraint | Low cost | High reliability expected | Unable to move up and down | No depths | Does not take up too much space | Structurally sound and can be added to existing window | Will follow regulations | Able to blend in with existing building | Sustainable materials used | No energy used | Size is modifiable | User guide available in multiple languages | Reduces leaning | No safety concerns | Non-reactive | High durability expected |
| Mechanical Fixture | Possible within time constraint | Medium cost | High reliability expected | Able to move up and down | Depths available | Does not take up too much space | Structurally sound and can potentially be added to existing window | Will follow regulations | Able to blend in with existing building | Sustainable materials used | No energy used | Size is modifiable | User guide available in multiple languages | Reduces leaning | No safety concerns | Non-reactive | High durability expected |
| Automatic Conveyor Belt | Not possible within time constraint | High cost | Medium reliability expected | Unable to move up and down | No depths | Does not take up too much space | Structurally sound but cannot be added to existing window | Will follow regulations | Able to blend in with existing building | Partially uses sustainable materials | Energy highly used | Size is modifiable | User guide available in multiple languages | Reduces leaning | Safety concerns as it is automatic | Reactive as technology can be ruined when exposed to alcohol | Low durability expected |

Constraint met | Constraint partially met | Constraint not met

Figure 2: Design Solutions and Constraints Matrix

The three proposed designs were then measured against a defined criteria, cost, durability, simplicity, efficiency, and maintenance, Figure 3, in which the mechanical fixture scored the highest, 2.7 out of 3. The score of the mechanical fixture were as follows: the cost is relatively higher, compared to the window extension, as more pieces and mechanisms are required to be installed. It is highly durable as the pieces are mechanical and of high-quality material. It is simple as it is uses a push and pull mechanism in addition to a lever thus, it does not require any type of training to use. As for efficiency, the fixture is highly efficient as it meets our goal of eliminating leaning while using a low number of resources. Finally, the maintenance required on the fixture is low as the pieces are simple and should not break at any point.

| | Cost | Durability | Simplicity | Efficiency | Maintenance | |
|---|---|---|---|---|---|---|
| | 30% | 20% | 10% | 30% | 10% | |
| Window Extension | 3 | 3 | 3 | 1 | 3 | **2.4** |
| Mechanical Fixture | 2 | 3 | 3 | 3 | 3 | **2.7** |
| Automatic Conveyor Belt | 1 | 2 | 1 | 2 | 1 | **1.5** |

Figure 3: Optimal Solution Matrix

The mechanical fixture was implemented as it met all defined constraints, Figure 2, (two partially and fifteen fully) and scored the highest in the optimal solution matrix, *figure 3*. The fixture was then further developed and analyzed through RULA to ensure that it reduced the risk of musculoskeletal disorders on drive-thru workers.

## 4. Data Collection

Data was collected data from drive-thru workers at 45 companies - 23 distinct companies, to ensure a customer-centric design. We found that we could categorize these companies into restaurants (those who served food) or cafés (those who served drinks and light snacks). This categorization helped us understand the different needs and challenges in the subsequent analysis. Data was collected data from 25 cafés and 20 restaurants, Figure 4.

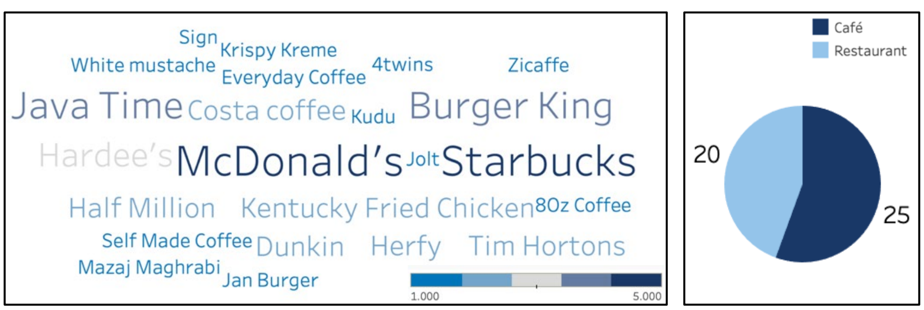


Figure 4: Companies Surveyed

All drive-thru workers, 100%, in both cafés and restaurants agreed that most of their orders came from the drive-thru window. Confirming our hypothesis that most customers prefer the convenience of not getting out of their cars to pick up their orders, Figure 5.

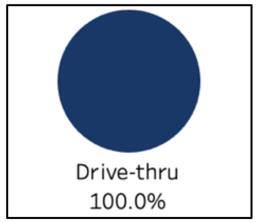


Figure 5: Order Method

In terms of injuries on drive-thru workers, it was found that 33 drive-thru workers, out of the 45 surveyed, have experienced some form of physical injury or discomfort, while only 12 have not. Most drive-thru workers, 13 out of the 33, experience these discomforts monthly, Figure 6, indicating a need for a redesigned workstation.

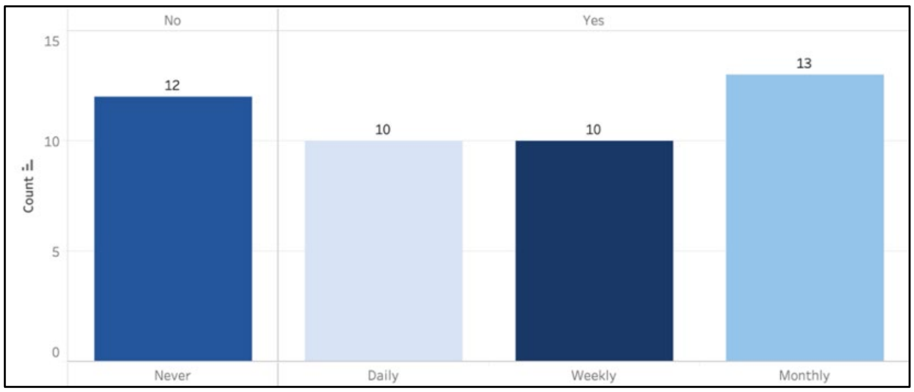


Figure 6: Drive-thru Workers' Injuries and Occurrences

Figure 7 depicts that out of the 33 workers that have experienced injuries and discomforts, 48.48% have sought medical treatment for their injuries and 54.55% have reported their injury to their employers. Only 42.42% have both sought medical treatment and reported their injuries to their employers.

| Reported injury to employer | Sought medical treatment or care for injuries: No | Sought medical treatment or care for injuries: Yes | Grand Total |
|---|---|---|---|
| No | 39.39% | 6.06% | **45.45%** |
| Yes | 12.12% | 42.42% | **54.55%** |
| Grand Total | **51.52%** | **48.48%** | **100.00%** |

Figure 7: Drive-thru Workers' that Reported and Sought Medical Treatment

Finally, the data in Figure 8 showed that, drive-thru workers at restaurants have dropped orders the most, 26.67%, while trying to give it to customers. On the other hand, drive-thru workers at cafés have dropped orders the least, with 31.11% of workers have not dropped an order. In general, it was found that 51.11% of drive-thru workers at both restaurants and cafés have dropped an order in the past while trying to give it to the customer; indicating a need for improvement in the delivery of the service.

| Dropped an order.. | Café | Restaurant | Grand Total |
|---|---|---|---|
| No | 31.11% | 17.78% | **48.89%** |
| Yes | 24.44% | 26.67% | **51.11%** |

Figure 8: Orders Dropped

# 5. Results and Discussion

## 5.1 Proposed Solution

The mechanical fixture is the proposed design solution that acts as an extension counter that can move in multiple directions (up/down and front/back). The following solution can be used on existing drive-thru windows that have already been built, Figure 9:

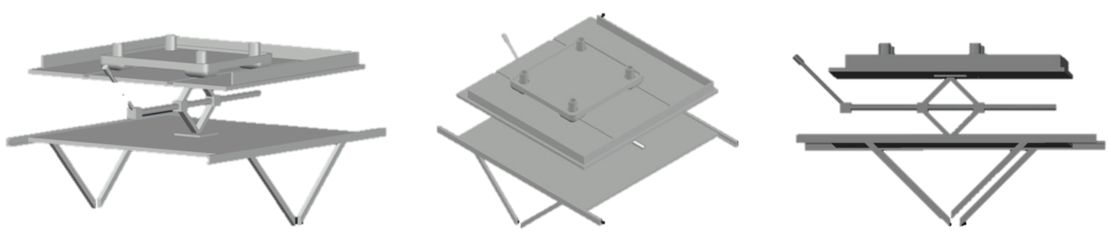

Figure 9: Mechanical Fixture Design

The order is placed on the plate of the fixture and different mechanisms are used to deliver the service. The fixture uses a screw jack mechanism to allow the upper fixture plate to move up (vertical movement) – controlled using the lever handle. The upper tray includes four depths to hold the cups – reducing the risk of drink spillage. The guides on the left and right of the fixture allows the lower plate to move back and forth (horizontal movement) – this movement uses a push and pull mechanism by the drive-thru worker.

## 5.2 Results of Rapid Upped Limb Assessment (RULA) Assessment

To accurately measure the improvements of the workstation using the fixture, a RULA assessment was first conducted on the drive-thru workers' movements at the current workstation (without using the fixture). The risk of injury on the neck, trunk, and legs scored 6 which indicated a very high risk that requires immediate change to the workstation. As for the upper limbs, it posed a negligible risk, with a score of 1. The overall score of the RULA assessment, Figure 10, was 5 which indicated that the workstation imposed an overall medium risk on the health of the workers.

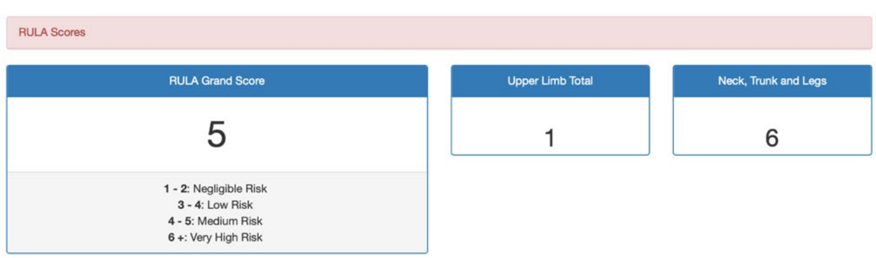


Figure 10: RULA Assessment of Current Workstations

A second RULA assessment was conducted by observing the movements of a person using a prototype of the mechanical drive-thru fixture, Figure 11. It was found that the risk of injury on the neck, trunk, and legs scored 1, greatly decreasing the risk of musculoskeletal disorders from the current workstation. However, the risk of injury on the upper limbs increased to 3, indicating a low risk versus the current workstation that scored 1 – this was expected as the load has been moved off the trunk of the worker to operating the fixture using his upper limbs. The overall score of the RULA assessment, Figure 12, decreased by 2 points reaching a final score of 3 which indicated low risk to the workers; versus the previous score of 5 which indicated medium risk. We can conclude that the drive-thru fixture is ergonomically safer for workers at drive-thru windows.

Figure 11: Mechanical Fixture Prototype

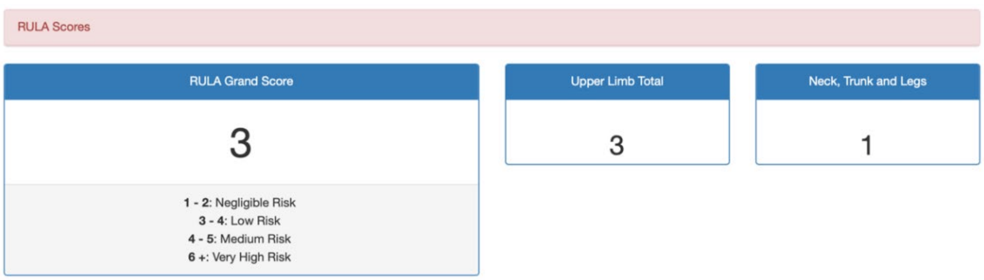


Figure 12: RULA Assessment of Future Workstations

## 5.3 Impact of Mechanical Fixture

The mechanical fixture has several positive impacts in various contexts. In terms of the global impact, the fixture has a significant impact as it directly affects the lives of drive-thru workers worldwide; the product was designed to be universally adaptable to enhance the well-being and job satisfaction of drive-thru employees on a global scale, effectively reducing injuries and boosting efficiency. The design of the fixture was meticulously crafted to be accessible, inclusive, and in compliance with international standards, ensuring a positive global impact. From an economic context, the fixture offers substantial cost savings by decreasing workplace injury-related expenses and reducing waste, such as dropped orders. The design not only promotes worker safety but also contributes to economic prosperity by minimizing the need for compensation in both waste and injury cases. Socially, the fixture could act as a pivotal force in preventing musculoskeletal injuries among drive-thru workers, thereby improving overall societal health. The design prioritized worker well-being through a customer-centered approach, making a positive impact on society.

## 5.4 Proposed Improvements

As the risk of injury to the upper limbs increased, the following improvements on the mechanical fixture have been recommended to further reduce the RULA score:

- Integrating sensors to automatically allow the fixture to detect the proximity and adjust based on the position of the drive-thru window and the customer, this will eliminate the need of the worker to push and pull the fixture tray; resulting in a lower risk to the upper limbs.
- Including automation features, in which buttons can be used instead of the levers to increase and decrease the height of the tray. This will eliminate the need of the worker to use the lever and will further reduce the risk of injuries to the upper limbs.

These recommendations aim to guide the effective implementation and continuous improvement of the drive-thru fixture, contributing to a safer and more ergonomic work environment for drive-thru workers.

## 6. Conclusion

In conclusion, the layout of a workstation plays a big role in the safety and health of the worker. As we explored, simple changes in the layout of the drive-thru workstation can drastically reduce the chances of a worker getting injured. We proposed three design solutions that can help decrease the amount of leaning required from each drive-thru worker: a window extension, a mechanical fixture, and an automatic conveyer belt. After analyzing these solutions against the design constraints and decision matrix criteria, we decided to implement the mechanical fixture as a response to the overall RULA assessment score of 5. The RULA assessment indicated that the current workstation imposes a high risk of injury and requires immediate change. The following conclusions can be derived:

1. Three solutions were proposed:
   - Window Extension: an extension to the existing window that will allow the drive-thru worker to slide orders on. It will reduce the amount of leaning required from the drive-thru worker.
   - Mechanical Fixture: a fixture that can move in multiple directions (up/down and forward/backward) using a combination of mechanisms such as a lever or push/pull that will help reduce the amount of leaning that the worker is required to do. The fixture will have an attached tray that has different depths to hold the drinks.
   - Automatic Conveyor Belt: a conveyer belt that is fully automated to move the order from the kitchen to the drive-thru window. This requires automation and technologies to be used. This solution will ultimately eliminate the need of a worker to stand at the drive-thru window.
2. Design Solution Selection:
   - Based on the criterion, the mechanical fixture scored the highest (best) in terms cost, durability, simplicity, efficiency, and maintenance.
   - The mechanical fixture was chosen to move forward to implementation, prototyping, and testing.
3. Design Solution Impact:
   - The project successfully addressed the ergonomic challenges faced by drive-thru workers, significantly reducing the risk of musculoskeletal disorders.
4. RULA Assessment:
   - The current workstation scored a 5 indicating a high risk of injury, specifically to the trunk area (scoring a 6).
   - The RULA assessment revealed a notable decrease in musculoskeletal risk, affirming that the drive-thru fixture can substantially improve the ergonomic safety of workers compared to traditional workstations. The use of the fixture decreased the risk of injury to 3, and drastically reduced the risk to the trunk areas (scoring a 1).
   - The RULA assessment validated that our mechanical drive-thru fixture effectively mitigates ergonomic risks, particularly in the neck, trunk, and legs, offering a marked improvement over existing workstations.

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## Biographies

**Fahad AlHadyan** is a candidate of the Bachelor of Industrial Engineering in the Department of Industrial Engineering, at Al Yamamah University. Fahad excels in time management, data analysis, and possesses proficient AutoCAD skills. Known for his precision in managing tasks and projects, Fahad is a detail-oriented problem solver with a keen eye for optimizing processes. His proficiency in AutoCAD adds a valuable dimension to his skill set, reflecting his commitment to mastering tools essential in industrial engineering.

**Faris AlMosa** is a candidate of the Bachelor of Industrial Engineering in the Department of Industrial Engineering, at Al Yamamah University. Faris stands out for his innovative approach to problem-solving, consistently generating unique solutions. His proficiency in AutoCAD further amplifies his ability to translate creative concepts into practical designs, showcasing a harmonious blend of creativity and technical expertise.

**Khalid AlKhateeb** is a candidate of the Bachelor of Industrial Engineering in the Department of Industrial Engineering, at Al Yamamah University. He possesses strengths in cost analysis and research skills. Known for his meticulous approach to financial assessments, Khalid's expertise in cost analysis is a valuable asset. His dedication to research reflects a commitment to staying at the forefront of industry trends and innovative solutions, making him a well-rounded and forward-thinking engineering professional.

**Musaad AlHobayb** is a candidate of the Bachelor of Industrial Engineering in the Department of Industrial Engineering, at Al Yamamah University. He excels in data analysis and problem-solving skills. Musaad's proficiency in data analysis allows him to extract meaningful insights, contributing to informed decision-making. A natural problem solver, Musaad approaches challenges with analytical precision, demonstrating a capacity for innovative problem resolution within industrial engineering contexts.

**Tariq AlMohawis** is a candidate of the Bachelor of Industrial Engineering in the Department of Industrial Engineering, at Al Yamamah University. He stands out for his strengths in creative thinking and communication skills. Tariq's ability to think outside the box ensures he approaches challenges with fresh perspectives, fostering innovation. His strong communication skills enable effective collaboration, ensuring ideas are conveyed clearly and facilitating seamless teamwork in the dynamic field of industrial engineering.

**Wasim AlShammary** is an Assistant Professor of Industrial Engineering Department at AlYamamah University, since 2019. He has a Doctor of Philosophy (Ph.D.) in industrial engineering from Wichita State University. As well, as a master's degree in engineering technology from Pittsburg State University, US.