Improving the Comfortability of Lineman's Pliers Using Customer-Centered Design

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Abstract

The design of the lineman's pliers was improved, with comfort as the primary consideration. An online survey was conducted to gather customer requirements and identify their needs. The data collected was analyzed using the House of Quality (HOQ) Matrix to determine the top features that might be improved based on the quantitative information gathered. The results of the HOQ matrix were then used in concept screening to finalize the concepts to be incorporated into the product design. The findings of this study provide valuable insights into the key factors that customers consider important in the design of lineman's pliers and can be used as a reference for future design and development efforts in this area, emphasizing the significance of comfort in the design of lineman's pliers and serving as a guide for future design and development efforts in the field.

Keywords
Lineman’s Pliers, House of Quality, Concept Development, Concept Screening, Concept Selection.

1. Introduction
Lineman's pliers, also called "linemen," play a crucial role in electrical line work (Kral n.d.). Originally invented by German immigrant Mathias Klein in 1857, these handheld tools have been widely used by electricians since the early 1900s to perform various tasks such as cutting, twisting, and bending wire (Kral n.d.). Despite their utility, poorly constructed lineman's pliers can result in workplace injuries, with over 10% of industrial employees getting injured annually (Carey and Gallwey, 2005). The ergonomic design of these tools, with a focus on wrist posture and grip, has been shown to reduce the risk of musculoskeletal disorders and increase productivity by 8% (Carey and Gallwey 2005).

In this paper, the researchers aim to improve the design of lineman's pliers by utilizing various design approaches and tools, such as the House of Quality (HOQ), to understand users’ needs and requirements. The HOQ analysis is used in concept screening to determine the top features to be incorporated into the design. The use of advanced materials and technologies, such as carbon fiber and titanium, has been shown to increase the durability and lifespan of the tools while reducing user fatigue (Wang et al. 2018). Furthermore, recent developments in ergonomic design principles, such as anti-slip grips and adjustable jaw configurations, aim to improve user comfort and reduce hand and wrist strain (Li et al. 2019). The use of computer-aided design and computer-aided manufacturing has revolutionized the design

and production process of lineman's pliers, resulting in more precise and customized designs, faster prototyping and testing, and improved accuracy and efficiency (Zhang et al. 2020).

Objectives

This study aims to identify a household or office product that the researchers determine to be problematic in terms of functionality, usability, safety, reliability, and aesthetics. The study also aims to assess and analyze user data using HOQ analysis to provide alternative designs for the identified product.

2. Literature Review

Pliers are hand-operated tools for holding and gripping small articles, or for bending and cutting wire. There are different types of pliers. Slip-joint pliers have grooved jaws and the pivot hole in one member is elongated so that the member can pivot in either of two positions in order to grasp objects of different size in the most effective way. On some pliers, the jaws have a portion that can cut soft wire and nails (Britannica n.d.). Pliers can be multifunctional as they can be used for bending and cutting. Combination pliers or lineman's pliers are one of the common tools found in the toolbox of any professional or homeowner. The main components of pliers are the jaw, pivot point, and handles. The jaw aids in bending, cutting, or holding; the pivot point connects the handle and the jaw; and the handles give the person the ability to use or hold the plier (Gray Tools 2018).

HOQ analysis is a theoretical framework that employs inter-functional ordering and communication. Individuals with various challenges and responsibilities may need to analyze plan aims while referencing to demonstrate designs on the HOQ's framework (Clausing and Hauser 1988). Moreover, according to Garvin (1987), there are numerous dimensions to what a customer means by quality, and it is a big problem to develop goods that meet all these specifications. Strategic quality management entails more than avoiding consumer repairs. Businesses must also learn from client feedback and balance what customers desire with what engineers can produce. In this study, the group aims to generate a Quality Function Deployment (QFD) questionnaire that will help them in constructing the first HOQ.

A study conducted by Serajul Haque and Abid Ali Khan (2009) states that in an industrial plant, poorly designed hand tools may injure more than 10% of workers each year. Poor design can lead to reduced productivity, as well as slower work and more errors. Increases in wrist, forearm, and shoulder injuries are also possible. In addition, illnesses may also become more common as a result of long-term damage. In this study, the researchers use the survey conducted from the QFD questionnaire to determine the requirements of people who use pliers.

According to Hessing (n.d.) the Pugh Analysis Matrix is a tool that provides one with a design that best fits a set criteria. The Pugh Matrix was developed by Stuart Pugh and is often called Pugh Analysis, Pugh Method, Decision Matrix Methods, or Decision Grid. The framework improves one's concept collection by employing a matrix-based strategy to weigh and compare conceptual designs. The matrix is very helpful in selecting the most plausible and practicable solution from a range of possibilities.

When new products are being developed, one of the important stages they go through before being sold to the public, is concept testing. Concept testing aids in avoiding costly errors and unexpected concerns. It also provides a better understanding on which audience the product would appeal to, giving manufacturers insights regarding the product (Muckersie 2021).

3. Methods

The House of Quality (HOQ) is used to integrate customer requirements into product specifications and to prioritize these in the product development process (Hessing n.d.). It is also utilized to aid in the collection and analysis customers' opinions.

In HOQ analysis, the significance of customer requirements and technical requirements must be recognized when deciding how to prioritize user demands and design components. Concept development, screening, and selection occur during the development of various concepts in the HOQ framework. Finally, in order to select the final product design, the product design team scores the designs using a variety of criteria.

4. Data Collection

A survey was conducted to gain a better understanding of clients' demands and to examine existing product satisfaction, allowing the researchers to produce a solution that meets clients' requirements. The survey helped determine how popular and important the current study's product characteristics were. The HOQ1 was then built based on the outcomes collected. The sample size of the survey was n = 31. The survey was done online and respondents were selected at random, with the respondents' age and employment not being restricted by any condition. The survey questionnaire was designed to collect information on (1) demographics of respondents, (2) product introduction, (3) customer requirements, and (4) satisfaction ratings.

5. Results and Discussion

5.1 Numerical Results

Based on survey results, the HOQ1 was constructed to depict the customer requirements as well as the lineman's pliers' technical requirements (Figure 1). It can be observed that the highest ratings for customer requirements are the following: comfortable to hold, grip reliability, great durability, and high build quality. Furthermore, based on the overall importance ratings, it is evident that material requirements, size/dimensions, and weight are the three vital technical requirements to improve on. These technical requirements must be prioritized while accommodating customer needs.

Project:	Pliers											
			Technical Requirements									
		Direction of Improvement	□	▲	▼	▼	□	□	▼	Customer Competitive Assessment		
Relative Weight	Customer Importance	Customer Requirements	Material Requirements	Size/Dimensions	Weight	Texture	Color	Shape	Product Cost	Our Product	Online shops (Shopee/Lazada/Instagram)	Certified distributors (ACE, Local Hardwa
16%	9	Comfortable to hold (Rubber Grips)	●	●	○	●	○	●	○	3	3	4
16%	9	Grip reliability (Textured Grips)	●	○	●	●		○		3	4	4
12%	7	Adjustable	○	●	▽			●		3	2	4
16%	9	Great durability	●	●	●	▽				3	5	4
16%	9	High build quality	●	○	●	○		○	▽	4	2	5
12%	7	Portability	●	●	○	○			●	4	1	5
12%	7	Aesthetically pleasing	○	○	○		○	○	▽	4	0	5

Importance Rating Sum (Importance x Relationship)	752.632	636.8	559.6	384.21	84.211	384.21	186
Relative Weight	25%	21%	19%	13%	3%	13%	6%
Our Product	3	4	4	3	5	5	4
Online shops (Shopee/Lazada/Instagram)	3	4	4	4	3	2	3
Certified distributors (ACE, Local Hardware)	5	5	4	4	2	3	2
Technical Competitive Assessment							

Figure 1. House of Quality 1

Material requirements (25%), size/dimensions (21%), and weight (19%) are the top three priorities in terms of technical criteria based on their performance. Enhancements in these categories may enable the researchers' lineman's pliers to compete more effectively against similar products.

5.2 Graphical Results

80.6 % of respondents were users and awareof pliers while the remaining 19.4% were not (Figure 2).

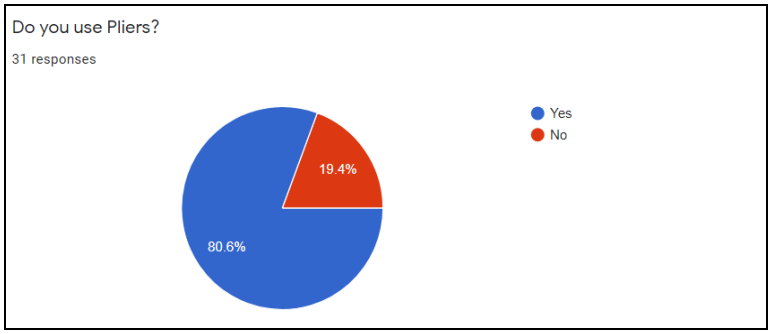

Figure 2. Pliers Usage

Survey respondents also believed that the pliers need some improvements with 74.2% agreeing and the remaining 25.8% disagreeing (Figure 3). Consequently, the researchers analyzed the survey to determine customer requirements with the highest ratings (Table 1).

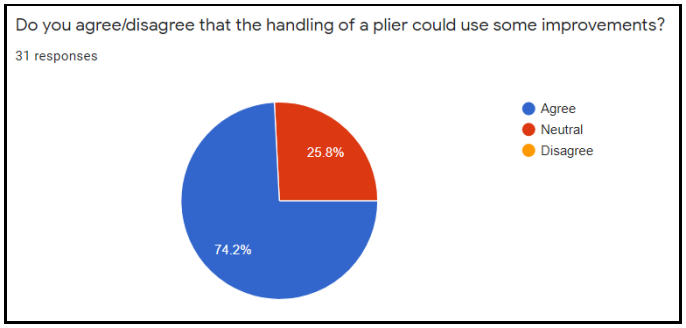

Figure 3. Improvement for Pliers

Table 1. Customer Requirements

Customer Requirements	Rating (in %)
Comfortable to Hold	16%
Grip Reliability	16%
Adjustable	12%
Great Durability	16%
High Build Quality	16%
Portability	12%
Aesthetically Pleasing	12%

The following are the most essential product attributes for customers: comfortable to hold, grip reliability, great durability, and high build quality.

5.3 Proposed Improvements

HOQ1 was utilized in order to determine the top product features that the lineman's pliers should have. The researchers were able to generate three alternative designs.

In the first design (Design 1), a spring was included to secure the wideness of the aperture of the pliers, avoiding instances of mishandling (Figure 4). A new design on the handle was also introduced to aid in fastening or holding the pliers since it fits closer to the comfort and grip of the hand. Another feature added was a lock mechanism on the handle's edge to aid in the handling of the pliers, contributing to its safe of usage, and reducing the danger of mishandling accidents such as undesired opening and loss of grip.

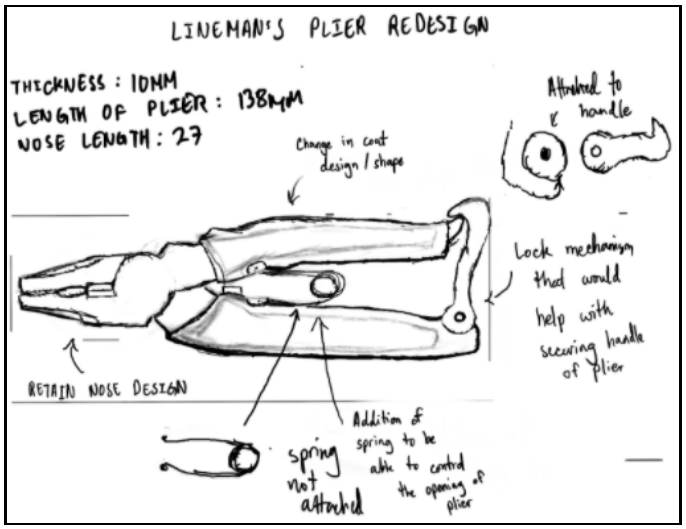

Figure 4. First Alternative Design

In the second alternative design (Design 2), the handle design was changed to prevent slippage and to provide the user a tighter grasp of the pliers (Figure 5). In order to increase leverage, the rivet was also positioned near the cutting edge. To prevent injuries, a spring was placed between the handles to limit the openings of the handles. A safety cover was also provided.

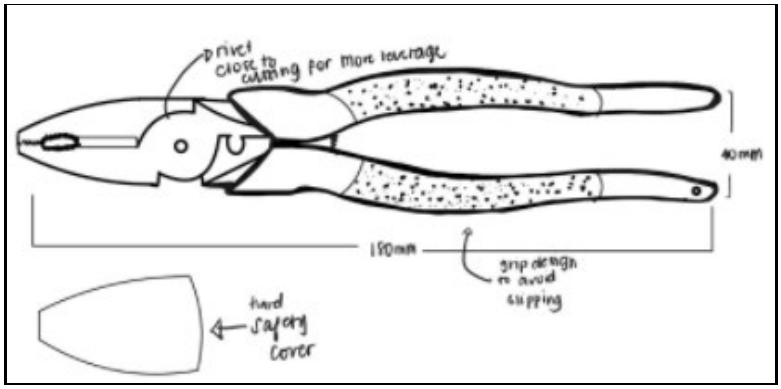

Figure 5. Second Alternative Design

As for the third alternative (Design 3), a new textured grip was added to the tool (Figure 6). The grip was made of rubber and was designed in such a way that the user could hold the tool with more cushion. Another improvement was a locking mechanism using a hook system that would close the pliers to prevent any sudden openings that could cause user discomfort.

Figure 6. Third Alternative Design

The concept selection approach was used to screen and choose the appropriate concepts to be included in the design. Table 2: Concept Screening Matrix illustrates the seven different criteria that the group determined to be helpful in the analysis: comfortable to hold, grip reliability, adjustability, great durability, high build quality, portability, and aesthetically pleasing. These criteria were based on the HOQ1 for customer requirements. The three proposed designs were used in the concept screening matrix to determine which design should be continued, combined, or discontinued. Each of the three designs was evaluated using symbols: (+) means better than, (-) worse than, and (0) same as. For the following criteria, all three designs had the same markings as all of them were able to satisfy the criteria equally: comfortable to hold, grip reliability, adjustability, great durability, portability, and aesthetically pleasing. However, for the high build quality criterion, Design 1 was better than the two alternative designs as it had a well-placed lock mechanism and an additional spring to aid the user in using the pliers. After the evaluation of each criterion, the net score was computed. The net scores obtained were 1, 0, and 0 for Design 1, Design 2, and Design 3, respectively. Based on the computed net scores, Design 1 was ranked first while Design 2 and Design 3 were tied at rank 2.

Table 2. Concept Screening Matrix

Criteria	Design 1	Design 2	Design 3 (Reference)
Comfortable to Hold	0	0	0
Grip Reliability	0	0	0
Adjustable	0	0	0
Great Durability	0	0	0
High Build Quality	+	0	0
Portability	0	0	0
Aesthetically Pleasing	0	0	0
Sum of +'s	1	0	0
Sum of -'s	0	0	0
Count of 0's	6	7	7
Net Score	1	0	0
Rank	1	2	2
Continue?	**Combine**	**Combine**	**Yes**

In order to identify the final concepts that would be the focus of the product redesign, concept selection matrices were constructed. As a result of the concept screening, the group was able to establish Design 3 as the reference design and Designs 1 and 2 were combined. Each criterion was assigned a weight based on the HOQ1. To construct a concept selection matrix, the researchers used a rating system (Table 3). Subsequently, a selection matrix was used to calculate the weighted score for each selection criterion (Table 4). Based on this matrix, the combined Design 1 and Design 2 had a weighted score of 3.44, higher than that for the reference design (3.00). As a result, the researchers decided that Design 1 and Design 2 should be developed, while Design 3 should be rejected.

Table 3. Rating System

Relative Performance	Rating
Much worse than reference	1
Worse than reference	2
Same as reference	3
Better than reference	4
Much better than reference	5

Table 4. Concept Selection Matrix

		CONCEPTS			
		Design 3 (Reference)		Design 1 & 2	
Selection Criteria	Weight	Rating	Weighted Score	Rating	Weighted Score
Comfortable to Hold	16%	3	0.48	3	0.48
Grip Reliability	16%	3	0.48	3	0.48
Adjustable	12%	3	0.36	3	0.36
Great Durability	16%	3	0.48	3	0.48
High Build Quality	16%	3	0.48	5	0.8
Portability	12%	3	0.36	3	0.36
Aesthetically Pleasing	12%	3	0.36	4	0.48
	Total Score	3		3.44	
	Rank	2		1	
	Continue?	No		Develop	

Table 5. House of Quality 2

		Direction of Improvement	▲	▲	▼	▼	□	▲	□	Customer Competitive Assessmen		
Relative Weight	Customer Importance	Technical Requirements	Cutting Performance	Material Thickness	Grip material	Handle Structure	Grip Design	Material Strength	Locking Mechnism	Our Product	Online shops (Shopee/Lazada/Instagram)	Certified distributors (ACE, Local Hard
20%	9	Material Requirements	•	•	▽	▽	○	•	○	4	3	4
18%	8	Size/Dimensions	•	○	▽	○		○	•	4	4	4
18%	8	Weight	•	•				▽	▽	3	2	4
14%	6	Texture	▽	▽	•	•	•		▽	3	5	4
7%	3	Color		▽	•	○	○		▽	2	2	5
14%	6	Shape	•	•	▽	•	○	○	•	5	1	5
9%	4	Product Cost	•	•	○		○	○	•	5	0	5
		Importance Rating Sum (Importance x Relationship)	729.5	627	264	341	273	325	468			
		Relative Weight	24%	21%	9%	11%	9%	11%	15%			
		Our Product	4	4	3	3	2	5	5			
		Online shops (Shopee/Lazada/Instagram)	3	4	4	4	3	2	3			
		Certified distributors (ACE, Local Hardware)	5	5	4	4	2	3	2			
		Technical Competitive Assessment										

A second HOQ (HOQ2) was constructed (Table 5). HOQ2 results showed that the researchers should maximize the cutting performance of the pliers, followed by its material thickness and strength. Additionally, the grip material and handle structure should be minimized to avoid any deviation from any design. Note that HOQ2 showed that cutting performance had the highest rating while grip material scored the least among the technical requirements.

5.4 Validation

In order to identify the final product design, alternative concepts on the different components of the pliers were acquired and evaluated during the concept selection procedure. To assess the marketability of the final product, two forms of prototyping were used (Figure 11, Figure 12).

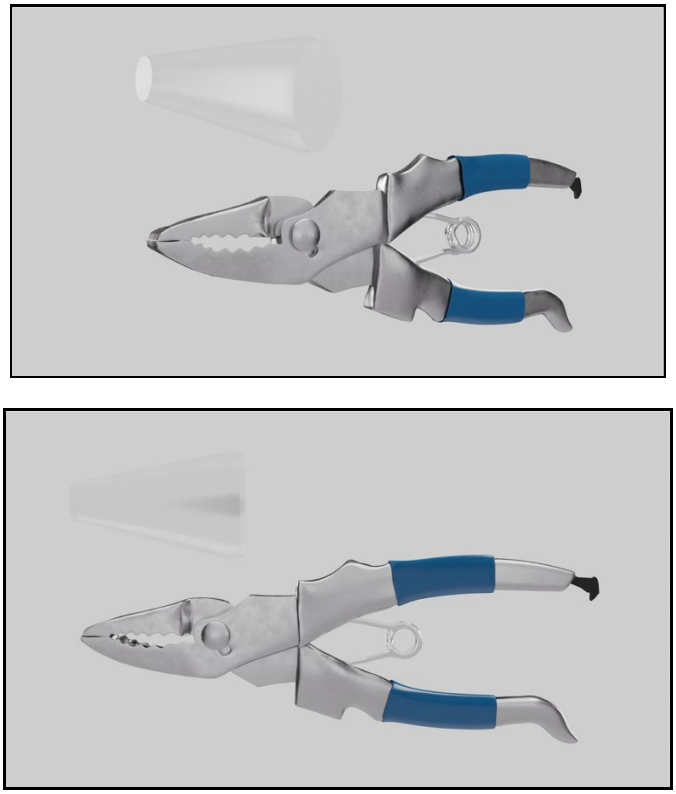

Figure 11. 3D Model

Figure 12. Actual drafted prototype of the plier

The actual drafted prototype was able to address the problems that were encountered by the survey respondents (Figure 12). The lock mechanism proved to be an effective way to improve the grip of the pliers on the object it is holding. It also provided safety when the pliers were not in use. Furthermore, the prototype showed that the added designs did not impede with the usual functions of the pliers. Overall, the improvements did not complicate the product but, in fact, addressed the concerns that respondents raised in the survey.

6. Conclusion

A new design for the lineman's plier was created after considering user concerns and developing concepts that were developed, evaluated, and tested. The final product design addressed the concerns of users, focusing on the pliers' handle, safety, and durability. It was not able to address all problems raised, but it prioritized the concerns that were very common and pressing to those who use lineman's pliers. This type of pliers is a tool that is useful to have, especially when it comes to maintenance tasks. The lineman's pliers may look simple, but there are still improvements that can be done to address issues that surface during the course of its use.

For further studies, the researchers recommend exploring materials that can be used to manufacture lineman's pliers without sacrificing any of the best qualities it already has. A study can also be done to evaluate the durability of the redesigned pliers, and potential fatigue associated with use of the new design.

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Biography

Benito P. Male VII is an undergraduate student of Industrial Engineering at De La Salle University. He has extensive experience working with the Industrial Management Engineering Society, starting as a Junior Officer in 2017-2018, then as an Assistant Vice President in 2018-2019 and finally as a Vice President in 2019-2021. He handled a variety of post-event paperwork and provided ideas for improving the organization's workflow for upcoming events. He had used photography to capture various occasions. In addition, Benito has experience working as an EISF intern at CEST Inc., where he cleaned financial records for assigned projects and carried out market research for key initiatives.

Joshua Wiglen D. Go is an undergraduate student of De La Salle University Manila in his final year of Industrial Engineering. He is familiar with concepts of production management, time study, systems study, and data science. He has strong project management skills, is proficient with MS Office, and has a talent for problem solving and creative critical thinking. Joshua has also developed strong communication skills. In 2022, Joshua was an intern at MERALCO where he created a research analysis on trends regarding the Net Metering program implemented by MERALCO and the financial performance of private companies and cooperatives in the power sector industry. He presented his findings to key stakeholders and executives within the company.

Shanne Tisha V. Caceres is an undergraduate student of Industrial Engineering at De La Salle University in her final year of Engineering. She has an internship experience in Melham Construction Company, where she handled various duties similar to HR as well as handling research based duties. She has gained experience in the field of construction and has been exposed to the human resources aspect of the industry. This experience will be beneficial as she has a glimpse of how the industry works and how the human resources department plays a crucial role in the company's operations.

Kyle Christian A. Ramos is an undergraduate student of Industrial Engineering at De La Salle University in his final year. During his studies, he has gained valuable experience as an intern research assistant in the IE Department of the University. He has been exposed to the research aspect of Industrial Engineering and has developed skills in research methods, analysis and data interpretation. This experience has provided him with a deeper understanding of the field of Industrial Engineering and the ability to conduct research independently.

Alek Sky R. Ronquillo is an undergraduate student of Industrial Engineering at De La Salle University, currently in his final year. He has gained industry experience through an internship under the operations department in the ITC Corp. This experience has exposed him to the day-to-day operations of a company and how Industrial Engineering principles are applied in real-world settings. He has developed skills in process improvement, time management and quality control. This experience has provided him with a deeper understanding of how Industrial Engineering can be used to improve efficiency and productivity within an organization. His skills and experience will be beneficial in his future endeavors, particularly in the field of operations management.

Ronald S. Mariano is an Assistant Professorial Lecturer in the Department of Industrial and Systems Engineering, Gokongwei College of Engineering at De La Salle University, Laguna Campus, Philippines. He earned his B.S. in Industrial Engineering and Master in Business Administration from the Colegio de San Juan de Letran, Calamba City, Laguna, Philippines. He was also pursuing Master of Science in Industrial Engineering at Mapua University, Intramuros, Manila, Philippines. He was also a Professional Industrial Engineer (PIE) certified by the Philippine Institute of Industrial Engineers – Industrial Engineering Certification Board. A member of the Philippine Institute of Industrial Engineers, Operations Research Society of the Philippines and Human Factors and Ergonomics Society of the Philippines. He has taught courses in Methods Engineering, Human Factors Engineering, and Systems Engineering. He was also an international consultant at Taiz University Master of Science in Engineering and Management. He was also a regular panelist in the industrial engineering research proposal and final oral defense.