Customer needs analysis towards back lumbar supportbelt design requirements for industrial workers

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Abstract. This study motivated by lack of design process in developing an industrial product. It introduces a method of developing lumbar support design goals and strategies that associated with industrial workers. The main point in the development of a product is required of customer needs towards the design and functionality. As we noticed, lumbar support is one of the cases of mediation strategy that been used in a way to reduce the back pain issues in the company. However, the criteria of current lumbar support do not achieve the requirement of users and a good quality was too expensive. The survey was distributed to analyse respondents knowledge and future criteria on new lumbar support based on their experiences. This method also investigates the feedback and experiences of current lumbar support design. Therefore, this factor suggested improving the framework of new lumbar support design based on factors of ergonomic design, human experiences, and psychophysical factors. This paper created to discuss the flow of redesigning the lumbar support by using a design and development research methods, strategies and issues. Besides, the effectiveness of this system needed to be focused and improved in this research. The recommended framework allowed the better path in the design process, management information system design and product development.

1. Introduction
Nowadays, most of working posture in many industries are repetitive with keeping a certain posture for a long time that contributes to uncomfortable and caused health issues to the workers. Generally, back lumbar support defines as a back supports that help to keep the spine to the natural and neutral position as well properly aligning the body posture and to avoid pain. In other words, the back belt or back supports used as a way to protect the lifting mechanisms in order to protect and reduce the back pain. Here, this study dedicates to measure the effect of using the lumbar support in improving the pain. Besides that, the study on the material of the back belt can be one of the reasons that effect the functionality of the lumbar support [1]. Meanwhile, from the previous study, the lower back pain (LBP) was better prevented by understanding the mechanisms and apply the prevention methods. The best prevention that highly recommended were physical exercise, training, furniture, shoe insoles, and manipulation treatment. Burton [2] concluded that with strong evidence, the lumbar support not effective in reducing LBP. From the regressions model analysed by Wassel [3], the belt back used also not associated with decreasing the incidences of back injury claimed among the workers. Support belts are effective in reducing the impact on the low back problem when the workers frequently lifting during work, however, there was no evidence that support belts can treat low back problem among the user [4].
There was an argument regarding belt supports and back injury among the workers. According to the research, airline employees’ faced the back pain issue because of the baggage and cargo handling. This study done by Reddell et al. [5], the risk of injury increased due to workers were not wearing a belt compared to the workers that follow the period of the wearing belt. Other than that, the whole-body vibration among forklift driver not preferred to use back belts because of invalid control measure in reducing the intensity of LBP [1]. For the driver, the lumbar support can reduce the discomfort of lumbar and can support the chest only. Hence, it will increase the discomfort of lumbar while not wearing the lumbar support [6].

Moreover, there is some related case in the usage of lumbar support with back pain issues. It was discovered that, most of the back pain issue faced by the workers mostly at the lumbar spine area that especially occurred at a trunk-thigh at an angle of 135°. Not only bend and awkward posture was contributed to the back pain, but prolonged standing also one of posture that can cause back pain. This posture could lead the lumbar curve that being exaggerated by the action of the anterior thigh muscles, which caused anterior tilting of the pelvis. The hip and knee flexion also influenced the spinal posture during standing [7].

The importance platform of the design was created to make a design that fulfilled the objectives and solve the problems that faced by the users. The previous lumbar support does not meet its functionality because of the poor design. Therefore, the lumbar support product should be reanalyses in proper design concept method. This framework of design and development can be used as a guide to developing a design and product. There are many tools been used as a platform for design and innovation. In this methodology, the tools that have been usedin this experiment was quality function deployment (QFD) [8]. Model product guided by the frameworks has the most flexible and effective methods in designing with the support of decision making. There are several of these frameworks been used which are system dynamic, planning, and modelling frameworks. The aim of this tool not only to smooth the decision making but also to differentiate the sample and problem that was faced [9]. QFD is one of decision method that listened to the voice of the customer and effectively responding those needs and expectation. From the Voice of Customer (VOC) indicated to create a product affected the satisfaction with customers’ needs, it contributed relationship of WHAT and HOW attributes [10].

2. Set up the material of QFD
A questionnaire survey was used as a medium to collect data onto the physical factors that contribute to the customers’ needs on the product. The following section describes the questionnaire used during the survey’s development, where the combination of scale level and survey data was the easy way to classify the needs to be improved [11]. Customer satisfaction and perceived risk can overcome the dependency on customer experiences and payback variables [12]. Therefore, the product will focus on customer needs, a fact based on justification, and no critical customer needs are missed. These questionnaires on current product or view can fulfill the needs of the customer for the future. The knowledge and experiences collected can describe the best product, properly classified the customer needs as well as providing the gaps between existing and new product for future improvement [13].

The designed questionnaire consists of five parts, which are personal information, knowledge of lumbar support, the experience of wearing lumbar support, experience use in lumbar support and future requirement of lumbar support. The type of this survey question was closed-ended. The survey better being asked person by person in a way to get input and closed suggestion. The survey from were distributed among 45 workers in production that eligible to wear the lumbar support. The survey being analyses using Excel software and the data are interpreted using graph and chart. This survey consists part of the body that feeling discomfort while wearing a current lumbar support, as shown in Figure 1. In this survey also have the suggestion for respondent in improving the current lumbar support as shown in Figure 2.
1. When wearing the current belt support, which part of the body do you feel discomfort? Tick scale of level of discomfort/pain. Side notes: remember belt support item.

| Part of body | Level of discomfort/pain |
|--------------|--------------------------|
| A            | 0 1 2 3 4 5              |
| B            | 0 1 2 3 4 5              |
| C            | 0 1 2 3 4 5              |
| D            | 0 1 2 3 4 5              |
| E            | 0 1 2 3 4 5              |

**Figure 1.** Likert scale question on the level of discomfort while wearing a current lumbar support.

2. Which part of current belt support need to be improved? Side notes: remember belt support item.

**Figure 2.** Open suggestion questions for user’s feedback on current lumbar support.
3. Methodology
In methodology, there is the step to achieve a customer’s needs in a way to develop the ergonomic and functional product design. This tool was channel directly into customers in targeting the market and development of the product. This process identified customer needs, which is the main point in the development of a product. Subsequently, the product concept was established and the related concept product was generated. After that, the best product that met the customer needs was selected and tested before introduced to the market.

The tool establishing the target specifications by preparing the list of needs-metrics matrices where this will show the relationship between customer needs and matrix correspond to the metrics. So from the VOC, the needs of customers are clarified and the relationship can develop in QFD [14]. QFD is used in identifying future customers’ requirement and as decision making in House of Quality (HOQ). This relationship indicates how a product affects the satisfaction from customers’ needs where it provided the relationship of WHAT and HOW attributes. WHATs is the question on the user interest in a product while HOWs stand to overcome the product solution. The ranking of those characters will produce the priority of product based on customers’ needs. Meanwhile, the correlation matrix represents the interdependencies among this matrix that affect the WHATs and HOWs [10].

This study was conducted in four steps: (1) closed-ended survey questions; (2) analysis of the survey data; (3) listed of needs-metrics; (4) built up HOQ. All customers’ requirements come from 45 workers in a production line of hand layup department that willing to share their ideas on lumbar support device improvement. The work conducted to all of the workers or respondents with the same type of department and type of work.

4. Result and discussion
For the priorities over customers, some of the respondents have higher priority than others. This customer’s priority has the impact on the decision making of QFD by classifying each of customers priorities using the interview. The priority will transform the user’s demands in implementing the functional design quality of the lumbar support. The customer needs is a description of their own view on their experiences of that product. Based on the data collection of the survey, most of the respondents have their own view on current lumbar support. The survey of design being created in the way to get information about the current design. There are many types of the survey can be distributed. In this research, the survey was distributed to respondent in the close way of answer and question. This method can help the designer to more understand the customer needs. There are five sections of question that can help in improving the current lumbar support.

From the survey, the highest discomfort percentage was at the back muscle with 33.33% and abdomen part with 20% with additional comments that plate supported at the back is small and does not support the lumbar. Meanwhile, for the abdomen, the material of the current lumbar support folded during handling works. In suggestion criteria, respondents suggested in improving an outer belt part (27%), support a waistband (37%), abdominal support belt (36%) and back support panel (27%) as the important consideration for future design. In addition, the results shown the majority of the respondents concerned on the back support as the previous design has few issues includes; the belt support does not fully support their back when using it, the panel thickness was 0.2mm, the quality and position in the design does not help the users. The important criteria of lumbar support that required by respondent are comfortable, easy to wear, support body and customize size.

One of the survey questions, point up the limitation of existing belt support are the moving belt during working, does not limit the movement, quality of belt support and the material does not absorb sweat. These factors can interpret the requirement of a user. The suggestion design and uncomfortable part in the body on current lumbar support, the behaviour of current lumbar support during working, criteria that needed by user and idea type of lumbar support that interest them. This comprehensive data from the survey will be used and to be identified in creating the QFD.

Figure 3 shows in detail the HOQ table that consists of six phase that complete the HOQ. Firstly, the customers’ requirements were identified and the weight rating was evaluated. The customers’
requirements were sorted from the questionnaire and have been evaluated in customer needs matrix. After that, the customer awareness of the service was compared. The third phase, the customer requirements were translated into technical design characteristics. Based on the questionnaire data, this requirement can help in design characteristic thus meet the customer requirements. Fourth, the relationship between WHATs and HOWs was defined in the relationship matrix. Fifth, the correlation between the various technical designs characteristics was determined. Finally, the target value of the technical was designed and this is absolutely important of each technical design characteristic. Based on Figure 4, the highest rank goes to the comfortable (16.20%) and followed by the supported back muscles (15.49%), customize size (15.49), no harm to user (12.05), easy to wear (11.47%), quality of material (7.89%), belt cover waist (7.03%), long lasting (6.87%), therapy the muscles (4.59%), and allow flow of air (2.87%).

![Figure 3. House of quality matrix](image)

| Customer Requirement | Priority | Comfortable while wearing | Easy to wear | Will support the back muscles | Customize body size | Able to move the air | Therapy the muscles | Belt cover fully waist | Quality of material | Long-lasting | Therapy the muscles | Allow flow of air |
|----------------------|----------|---------------------------|-------------|-------------------------------|--------------------|-------------------|-------------------|---------------------|-----------------|--------------|------------------|------------------|
| Light                | 4        | +                         | +           | +                             | -                  | -                 | +                 | +                   | +               | +            | +                | +                |
| Comfortable          | 8        | -                         | -           | -                             | -                  | -                 | +                 | +                   | -               | -            | -                | -                |
| Aesthetic            | 3        | -                         | -           | -                             | -                  | -                 | -                 | -                   | -               | -            | -                | -                |
| Easy to wear         | 8        | -                         | -           | -                             | -                  | -                 | -                 | -                   | -               | -            | -                | -                |
| Safety               | 7        | -                         | -           | -                             | -                  | -                 | -                 | -                   | -               | -            | -                | -                |
| Customize size       | 7        | -                         | -           | -                             | -                  | -                 | -                 | -                   | -               | -            | -                | -                |
| Cheap                | 5        | -                         | -           | -                             | -                  | -                 | -                 | -                   | -               | -            | -                | -                |
| Support body         | 8        | -                         | -           | -                             | -                  | -                 | -                 | -                   | -               | -            | -                | -                |
| Not hot              | 5        | -                         | -           | -                             | -                  | -                 | -                 | -                   | -               | -            | -                | -                |
| Functionality        | 7        | -                         | -           | -                             | -                  | -                 | -                 | -                   | -               | -            | -                | -                |

**Figure 3. House of quality matrix**
5. Conclusions
In order to complete the design requirement, the framework of design lumbar support successfully developed as a guide to designing the lumbar support that fulfilled the community needs and functionality. The survey was used to analyse the feedback on current design among the community that exposed to that work that required workers to wear a lumbar support. The needs were sorted to design the HOQ. The priority of each respondent was different since each person has their own benchmark in evaluating the functionality of lumbar support based on their experiences. Results reported that the limitation of current belt support is the moving belt during working, does not limit the movement, quality of belt support and the material does not absorb sweat. QFD output gives a possibility to integrate requirements of all parties and analyse joint priorities. This priority was analysed through HOQ and the result show comfortable high rank(16.20%) followed by the supported back muscles (15.49%), customize size (15.49), no harm to user (12.05), easy to wear (11.47%), quality of material (7.89%), belt cover waist (7.03%), long lasting (6.87%), therapy the muscles (4.59%), and allow flow of air (2.87%). The product that fulfilled the customer needs have potential in marketing and personal use. This QFD chart helps in setting the target on those issues, which are more important to the customer and how these technically can be achieved. Product concept can measure the best product that should be fabricated in the final selection. The concept being screening and scoring based on its characteristics and functionality. This can reduce the cost of wasting in fabrication and make the product more quality and functionality to the community. Based on this result, the improved should be highlighted in designing process are comfortable design and material, supported that function to straining and support the backbone, size of Malaysian anthropometry and no harm to the user in future.

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