



# FLUX: Design Education in a Changing World

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# The dilemma of technology acceptance from industrially developed countries to new emerging economies


## Abstract

*Industries from developed countries tend to overlook the fact that people in new emerging economies are different in terms of context, ergonomics, social and cultural dimensions. Evidence from the literature shows technical design problems involved in adapting technology and that it may require the development of new ergonomics principles because of the diverse nature of people. Users around the world are no longer willing to settle for one-size-fits-all products with standardised technology. Failure to consider users culture and ergonomics may result in unacceptable technology. This challenges designers to understand what cultural and ergonomics values they need to integrate in developing new technology. A case study was conducted at a knitting company in Botswana to determine sewing machines acceptance and usage behaviour using the Technology Acceptance Model Questionnaire. The research revealed that by becoming more mindful of the role played by culture and ergonomics in different contexts, this can enhance the relevance and acceptability of new technology.*



*Keywords: Technology transfer, new emerging economies, Industrially developed countries and technology acceptance*

## 1.0 Introduction

The dictates of globalisation, advancement of information technology as well as economic and social benefits associated with use of advanced technology, seem to continue to drive Industrially Developing Countries (IDC) to outsource technology from Industrially Developed Countries. Furthermore, profit driven technology producers and technology transfer agents from Industrially Developed Countries often scramble for market opportunities in New Emerging Economies (NEE) and customarily ignore the ergonomics, social and cultural factors that can influence acceptance and subsequent effective use of the transferred technology in the recipient country. However, numerous authors: Mansfield (1987), Manuaba (1997), Shahnavaz (2000) and Rao (2004) highlight the need to consider ergonomics and cultural factors in technology transfer. Their general view is that acceptance of technology that is transferred from Industrially Developed Countries to NEE entirely depends on consideration of ergonomics (anthropometrics) and social factors of users in the recipient country.

This paper is a culmination of a research exercise that was carried out to ascertain whether anthropometrics and cultural factors can indeed enhance acceptance of a technology. The research was carried out at one specific textile industry in Botswana where machine operators use sewing machines imported from Japan. To gather information, the technology Acceptance Model Questionnaire and The Corlett-Bishop body map questionnaire were used and relevant anthropometrics data were collected.

The aim of the research was to highlight the importance of anthropometrics and social factors in technology acceptance. Furthermore, the authors intended to draw the attention of the international community to injuries that can occur as a direct result of use of inappropriate technology from industrially developed countries. Finally, the authors proposed to emphasise how these injuries can be avoided by incorporating ergonomics and designing cultural-orientated technology. It is anticipated that such a research will serve as a baseline for workstations designs and design of machines and other consumer products destined for developing countries such as Botswana.

## 2.0 Technology acceptance

The Technology Acceptance Model (TAM) developed by Davies (1989) represents an important theoretical contribution towards understanding the concepts of perceived usefulness (PU) and perceived ease-of-use (PEOU). PU defines the degree to which a person believes that using a particular system would enhance his or her job performance within an organisational context whilst PEOU refers to the degree to which a person believes that using a particular system would be free from effect (Davies 1989). Based on the previous studies on the TAM e.g. Davies, Bagozzi & Warshaw (1989), Zankour (2004) and Venkatesh, Morris & Fred (2003), the authors are of the view that people will accept technology which they find to be useful to their lives and easy to use. However, it is further proposed that users will find a technology more usable if it is designed with users' physical and mental limitations in mind. However, usable technology generates pleasurable emotions which results in users cherishing that technology (Figure 1). Jordan (2000) argues that satisfaction is derived from technology that provides users with functionality, usability, interaction, experiences and pleasurability.

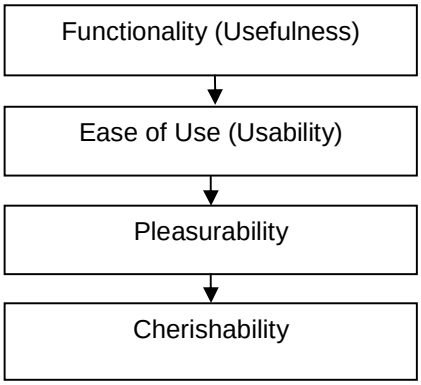

**Figure 1: Proposed technology acceptance model**

## 3.0 Ergonomic implications

Studies conducted elsewhere, e.g. Filipino Garment Industry indicate that safety and health problems of enterprises are compounded by the situations in workplaces including conditions of equipment and technology. With the creation of modernised industries, new technologies are imported indiscriminately from Industrially Developed Countries. This poses several problems and challenges. New technologies have been reported to cause new illness due to exposure to new hazards particularly in the field of ergonomics. Hendrikse & McKinney (2000) argues further that people from different countries have different mental models and population stereotypes and in most cases these factors may affect how they use technology. Ackerman & Tauber (1990) and Norman (1988) note that the designer's mental model and culture are usually built into the technology. In this regard such mental model and culture move with the same technology when it is transferred from one area to another. This suggest therefore that transferring technology without modification to suite local environment could lead to improper use of the technology which may lead to injuries such as musculoskeletal disorders thereby reducing the prospect of total acceptance and utilisation of the technology.

Technology imported from Industrially Developed Countries also poses a problem in the man-machine-fit dynamics. Although workers eventually get accustomed to new technologies, inconvenience, fatigue and discomfort due to inappropriate size of equipment, inefficiency are expected to be direct consequences of such designs.

It has been observed that sewing machines imported from Japan are based on the anthropometrics measurements of the Japanese. This population is obviously different from that of Botswana. At present, there is no systematic and scientific basis used in the design of technologies for the population of Botswana, highlighting the need to establish a database of anthropometric variables for Botswana such that these measurements will serve as a guide to designers who are involved in designing tools, equipment and workstations fitted for the local environment. This will evidently serve as a prerequisite to appropriate, comfortable and technology design.

Anthropometry is one of the disciplines of ergonomics dealing with measurements of human body measurements. Anthropometrics differences in various populations in New Emerging Economies (NEE) may pose serious obstacles in the standardisation of tools, equipment and workspaces that fit users from these economies, a prerequisite for efficient work performance and high productivity.

### 4.0 Cultural consideration

In spite of ergonomic differences from IDC to NEE, there are also cultural differences. Developers of new technology have to be more mindful of the role played by culture in creating new products. Taking consideration of user's culture can enhance the relevance and acceptance of new technology. By connecting meaningful with users cultural values can improve work effectiveness

and productivity. Studies by Samsung, Nokia indicate that designing meaningful technologies has become a platform for successful innovation initiatives around the world (Delaney et al., 2002). The basis for developing meaningful experiences comes from deep insights of user's culture. The use of a society's cultural values and norms in design not only makes technologies more appropriate for their social context, but makes better use of culture itself as a resource for innovation (Moalosi et al. 2005). Technology is an agent of change and it is important for designers to know how they can either undermine or support the indigenous cultural system of the society (Popovic, 2002). It is through technology that cultural values are communicated. Design and technology are, therefore, important medium of communication which expresses the values of the system within which they function.

Universality is a value that is reminiscent of the industrial era, but is no longer meaningful in a post-industrial world (Krippendorff, 2006). There are voices within design lamenting the loss of culture, traditions and ethnicity. For example, in a study conducted by Samsung Design, it is revealed that "users around the world are no longer willing to simply settle for one-size-fits-all products with standardised designs" (Delaney et al., 2002:46). They argue that individual users are demanding a wide range of sizes, shapes, colours, materials and features, and these have become important factors for creating successful products. That is, designers have to balance core shared values with local empowerment to best satisfy individual wants and needs. This means that users are demanding that specific needs be satisfied with more localised solutions (Aula et al., 2003). Electrolux and Whirlpool have started to show sensitivity to certain cultural specifics, demonstrating an understanding of the cultural diversity of their global users (Ono, 2002). It is posited that localisation of products must be viewed as a counter-balancing force for the maintenance and durability of national cultures facing globalisation as well as its potential capacity for holding, preserving and presenting cultural values to the respective product users. This can be translated as an act of globalisation starting to soften its approach towards the standardisation of products and services.

## 5.0 Methodology

### 5.1 Procedure and instruments

The Technology Acceptance Model Questionnaire (TAMQ) was administered to participants. The Corlett-Bishop body map questionnaire was then administered. Thereafter, anthropometric data were collected from participants using relevant tools. During this data collection exercise, anthropometric measurements on 18 body segments of sewing operators were collected using anthropometry measuring tapes. Thereafter, a stadiometer was used to take participants height. A digital bathroom scale was used to collect participant's body weight. These measurements were collected with the help of female research assistants as all participants were female. Three readings were taken for each body segment with the researcher positioned on the right side of each participant. The readings were later averaged to achieve a single reading for each body segment. Finally, participants were asked to fill in a seven point TAM questionnaire running from extremely likely to extremely unlikely. The questionnaire contained scales to measure the various constructs of perceived usefulness and perceived ease of use. The scales for PEOU and PU were adapted from prior studies, many of which have already established their reliability and validity (Davies 1989; Venkatesh & Davis 2000). Participants were finally asked to fill in a self administered Corlett and Bishop body map questionnaire. In this questionnaire participants were asked to rate their levels of pain on a five-point scale from no pain to extreme pain. All responses were coded and the final data inputs were loaded into a statistical package of SPSS for doing various statistical analyses.

### 5.2 Sample

A total of 157 female participants took part in the research. Participants had an average height of 1620mm. Their weight averaged 63.44kg. Participant's average age stood at 32.25 years. All could communicate in basic English but there were cases were help was provided. Operations performed were; sleeve hemming, shoulder attach, neck attach, two sides attach and bottom hemming. These operations were based on the production of a standard short sleeved T- Shirt to be exported to Germany. To carry out these tasks operators used the hemming machine, the

lockstitch machine and the straight machine. Operators were engaged in a 9hr shift (7.30am - 5pm) with the option for an additional one hour over-time. In each working day operators were allowed one 30 minutes lunch break.

## 6. 0 Results of the study

The results of the research reveal that machine operators' perceived that sewing machines are easy to use and useful in helping them achieve their daily targets. However, there was clear evidence to suggest that this acceptance came with a high cost. Participants reported to be suffering from musculoskeletal disorders particularly problems in the mid back, upper back, lower back, shoulders and neck. This may be attributed to the high repetitive tasks and operators prolonged sitting and bending postures characterising the sewing industry. Nevertheless, one cannot discard the mismatch between operators and sewing machines as another possible contributing factor. The most frequent complaint was extreme pain in the upper back as 32.5% of participants expressed extreme pain in this region, while 37.7% expressed a lot of pain and only 7.9% expressed no pain in this region. A total of 26.2 % of participants complained about extreme pain in the lower back and about 36.9% complained about a lot of pain in the lower back while only 10.1% expressed no pain in this region. A total of 26.4% of participants complained about extreme pain in the mid-back region while 34.5% complain about a lot of pain in the mid-back and only 8.8% had no mid-back complaints. A total of 21.7% of participants expressed extreme pain in the shoulders while 38.8% experienced a lot of pain in the same region. Table 1 below presents a summary in percentage form of recorded cases of musculoskeletal disorder prevalence in the same factory.

**Table 1: Musculoskeletal Disorder Prevalence Results**

| Pain | Neck % | Buttocks % | Upper arms % | Lower arms % | Mid-back % | Upper back % | Lower back % | Thighs % | Legs % | Shoulders % |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14.1 | 24.8 | 27.7 | 38.1 | 8.8 | 7.9 | 10.1 | 35.1 | 16.0 | 11.8 |
| 2 | 24.2 | 20.1 | 27.0 | 23.8 | 18.2 | 9.9 | 13.4 | 22.3 | 21.5 | 11.8 |
| 3 | 16.1 | 20.1 | 20.9 | 23.1 | 12.2 | 11.9 | 13.4 | 23.0 | 21.3 | 15.8 |
| 4 | 30.2 | 21.5 | 20.9 | 11.6 | 34.5 | 37.7 | 36.9 | 14.9 | 25.3 | 38.8 |
| 5 | 15.4 | 13.4 | 3.4 | 3.4 | 26.4 | 32.5 | 26.2 | 4.7 | 16.0 | 21.7 |

Key: 1. No pain 2. Little pain 3. Average pain 4. A lot of pain 5. Extreme pain

## 7.0 Discussion and conclusion

The strengthening of the globalisation process has intensified the international competitiveness strategies, and this has affected the development of new technologies. New technology is faced with impasses between catering for imperatives of standardisation of components and products, and the consideration of aspects of cultural identity. Elements from other cultures can be adopted while still ensuring localised identity. Fuhrer supports the latter viewpoint by saying, "in times where globalisation, rapid societal change, migration and multiculturalism are growing, the increasing hunger for identity is remarkable..." (2004:79). The basic principles of design should be grounded in the society's spiritual and cultural ideas (Buchanan & Margolin, 1995).

Papanek (1984:227) argues that "large scale design in developing countries by outsiders has never worked." Moreover, "design strategies that go against the ecological wisdom of a culture

are likely to fail" (Krippendorff, 2006:205). The observations made by these eminent authors demand a new approach to technology research and development especially from new emerging economies such as Botswana's. Cultural knowledge could enrich contemporary design theory and underpin creativity and innovation in technology practice.

In order to achieve technological innovation, design features can be borrowed from traditional symbols, forms, motifs, paradigms and ecosystems to come up with novel technological concepts. The use of these traditional elements not only makes design concepts innovative, but also adds emotional and aesthetic value. They evoke cultural association and spiritual attachment, and bond users to the technological concepts. Users over the years have moved from material affluence towards valuing spiritual fulfilment (Hirano, 2006). This enables technological concepts to appeal, excite, satisfy and induce some level of interest. The concepts become aesthetically acceptable and culturally appropriate, and ultimately lead to immersive experiences.

The research strives not only to create concepts that combine tradition with contemporary technology to satisfy the needs of the users, but also to achieve a new way of approaching the development of technology from the perspective of culture. The products that users own and employ daily are more than just objects; they are also a reflection of a microcosm of the users' broader culture. The ultimate aim is to create a framework under which modern Botswana products and ideas can be developed in the long term.

At present, there is no systematic and scientific basis used in the design of technologies for Batswana workers. In this research it was found that the average height of a Japanese woman stands at about 1520mm compared to 1620mm recorded for Batswana women. There is a difference of about 100mm between the two groups of women. This makes sense because Japanese belong to the Mongoloids race while Batswana belong to the Negroid race. According to Pheasant (1999) the limb ratios of these races are not the same therefore workbench table height designs based on either of these races anthropometrics, will obviously create a problem for the other during work.

Our research indicates further that the Japanese women Body Mass Index (BMI) stands at 23 while this research yielded BMI of 24. 23 amongst Batswana women, a difference of about 1.23. Interestingly in this context, both Japanese and Batswana women fall within the underweight BMI scale even though Batswana women are hovering on normal weight according to the BMI scales. Although the Botswana data is not that accurate based on the population size, this information can be used as the basis to suggest that sewing machines imported from Japan might need modification to match the physical and mental capabilities of Batswana. At the moment we conclude by suggesting that the risk of developing musculoskeletal disorders seem to be greater amongst sewing operators in Botswana textile industry. Given this scenario we emphasise the need to establish a database of anthropometric variables for Batswana workers such that these measurements will serve as a guide to designers who are involved in designing and modifications of tools, equipment and workstations fitted for Batswana workers. There is no doubt that these measurements will also serve as a prerequisite to appropriate, comfortable and technology design.

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## CURRICULUM VITAE

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Design Education Forum of Southern Africa

DEFSA International Design Education Conference 2007

# The Dilemma of technology acceptance from industrially developed countries to new emerging economies

Mr Oanthata Jester Sealetsa (University of Witwatersrand)
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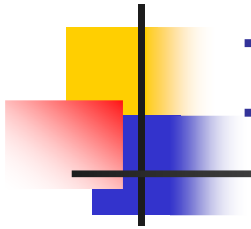
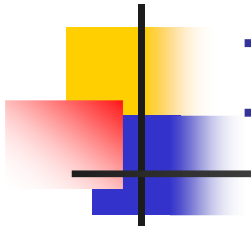


# Introduction

- Technology Acceptance model
- Ergonomic Implications
- Cultural consideration
- Research Methodology
- Results
- Discussion and Conclusion

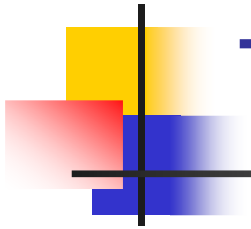


# Introduction

- Industrially Developed Countries (IDC) seek market opportunities in New Emerging Economies (NEE) for their technologies
- In the process they ignore ergonomics implications, social and cultural factors of recipient users
- Technology acceptance depends on ergonomics & socio-cultural factors of users in NEE

# Introduction

- Paper is a culmination of research carried out to ascertain whether anthropometric and cultural factors can indeed enhance technology acceptance
- Research investigated how sewing machines imported from Japan impact on  Botswana workers
- Aim was to draw attention to injuries that occur as a direct result of inappropriate technology from IDC
- Research serves as a baseline for workstations, machines design & other consumer products for NEE



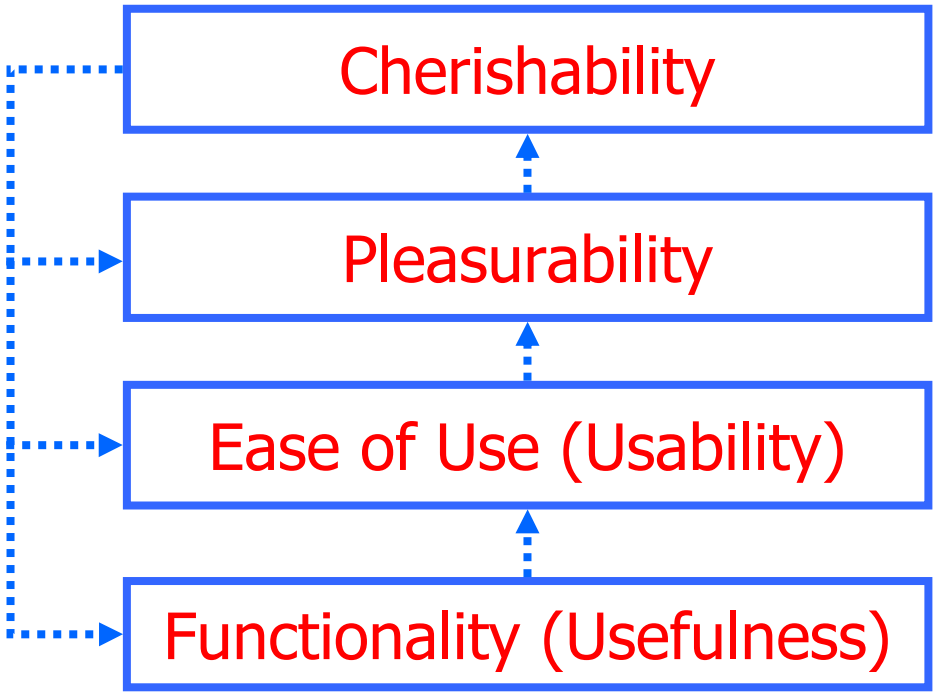
# Technology Acceptance

- Technology Acceptance Model (TAM) developed by Davies (1989) represents a vital contribution towards Understanding the concepts of perceived usefulness (PU) & perceived ease-of-use (PEOU).
- PU - the degree to which a user believes that using a particular system would enhance his/her job performance
- PEOU – the degree to which a person believes that using a particular system would be free from effect

# Technology Acceptance Cont…

- The literature indicate that users will find technology more useful if it is designed with users physical and mental limitations in mind.
- Usable technology generates pleasurable emotions which results in users cherishing that technology
- Satisfaction is derived from technology that provide users with functionality, usability, interaction and pleasurability (Jordan, 2000)

# Proposed Technology Acceptance Model



# Ergonomic Implications

- People from different cultures have different mental models and population stereotypes & this affect how they use technology
- Designer's mental model and culture are usually built into the technology
- This mental model move with the same technology when transferred to NEE
- Transferring technology without localising it may lead to injuries e.g. musculoskeletal disorder (MSD)
- This reduces the total acceptance and utilisation of technology

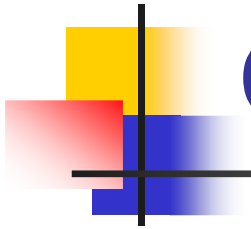
# Musculoskeletal disorder (MSD)

- MSDs are among the leading causes of:
  - Absenteeism
  - Low productivity
  - High medical bills
  - Law suits
  - High Insurance premiums

*Kormaz & Kirdi (2004), Higgs (2003), Delleman & Dul (2002)*

# Ergonomic Implications

- Observed that sewing machines imported from Japan are based on Japanese anthropometric data
- No systematic & scientific basis used in the design of technologies for Botswana
- Highlights the need to establish a database of anthropometric variables to guide the designing of localised technologies
- Such data is a prerequisite for efficient work performance and high productivity



# Cultural considerations

- Developers of technologies have to be mindful of the role played by culture
- Cultural consideration enhances the relevance and acceptance of new technology
- Studies by Samsung, Nokia indicate that designing meaningful products has become a platform for successful innovation
- Developing meaningful experiences comes from deep insights of users culture
- Thus culture has becomes a source of innovation
- Research shows that users no longer require one-size-fits-all products
- Users are demanding different sizes, shapes, colours, materials, features etc

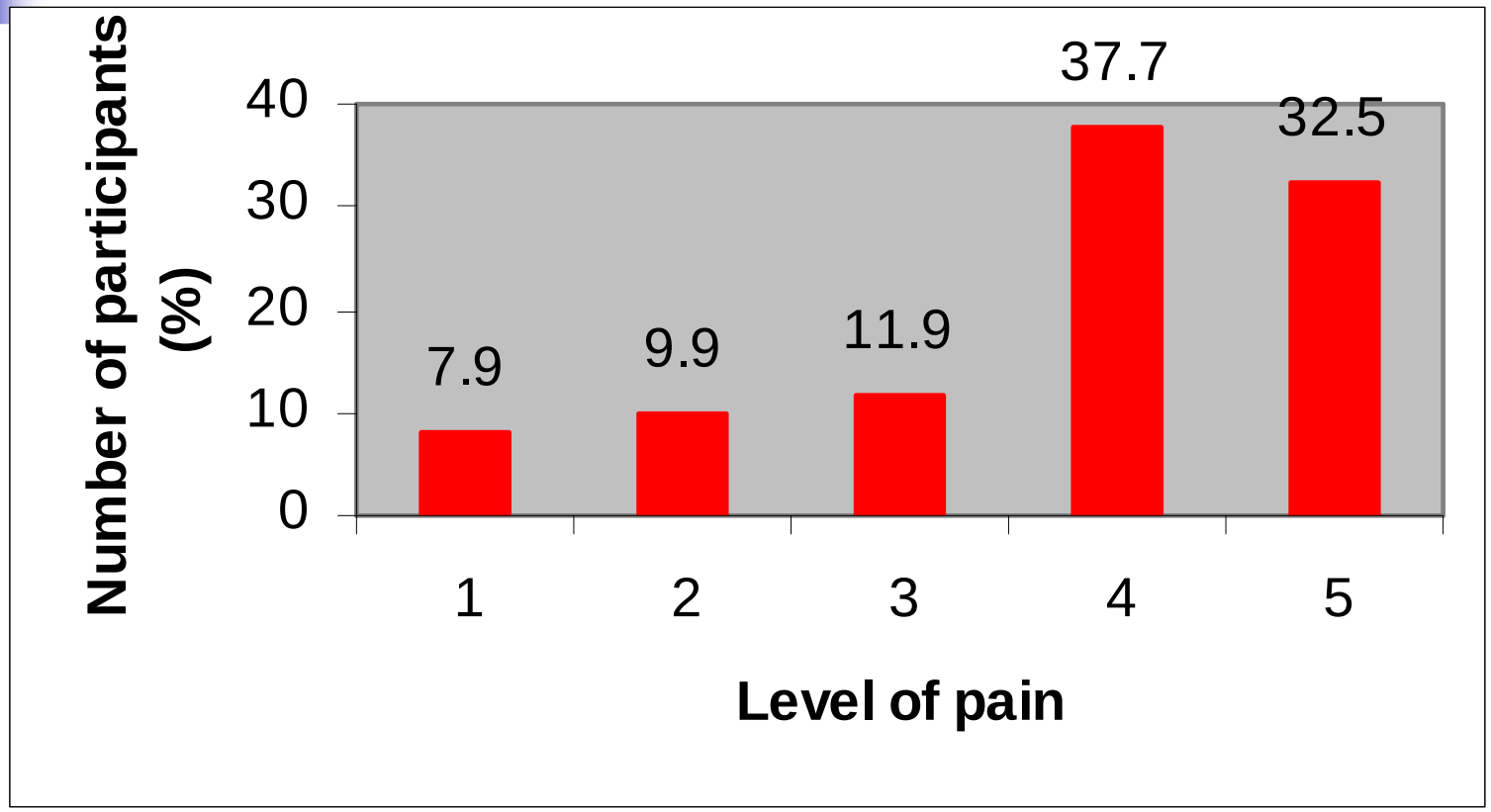
# Research Methodology

- A case study was conducted at a certain garments Textile company in Botswana – involved in Knitting, Dyeing, Cutting and Sewing)
- Questionnaires Administered:
  - Technology Acceptance Model Questionnaire (measures perceived usefulness & peceived ease-of-use
  - Self administered Corlett-Bishop Body Map Questionnaire (rates levels of pain on a 5-point scale)
- Anthropementric data of 18 body segments was collected from 157 females participants
- Their average age was 32, height – 1620mm & weight - 63.44kg

# Results

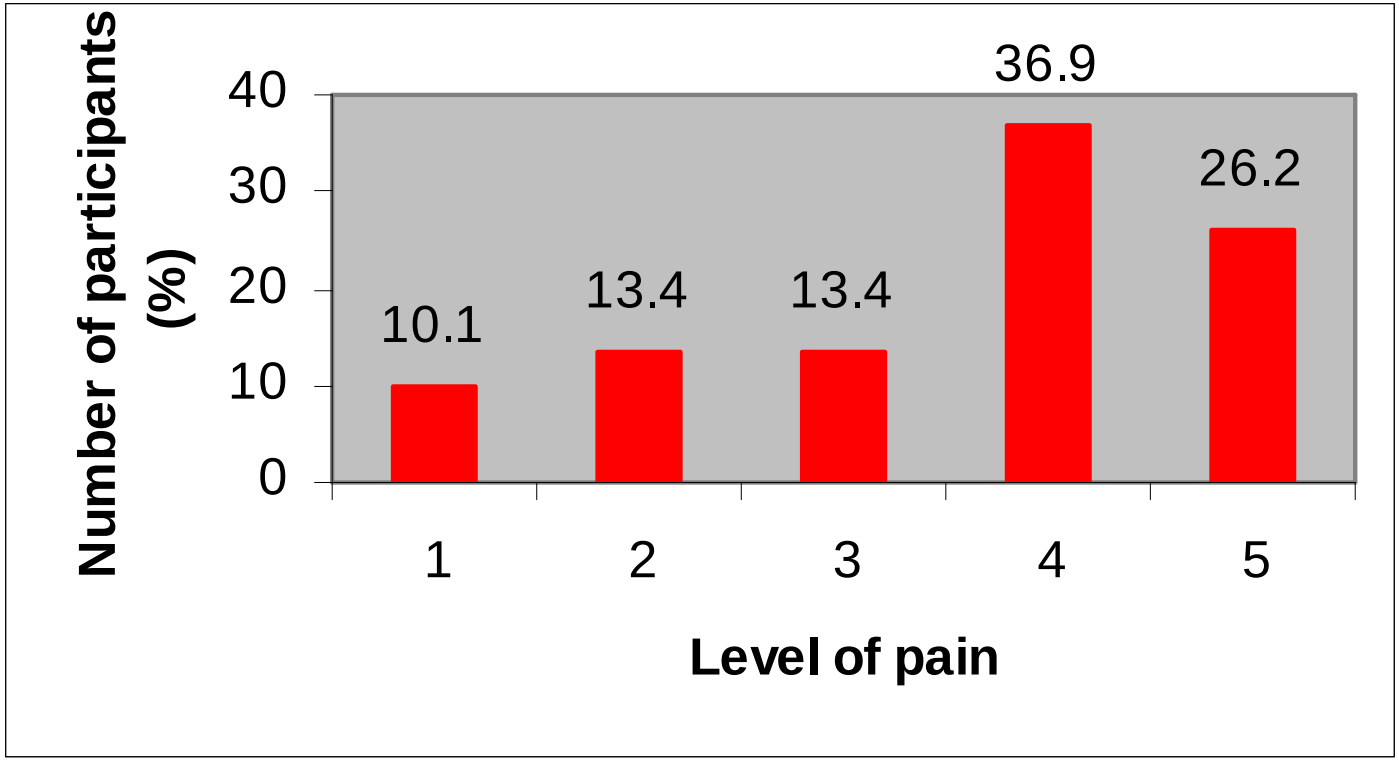
- Machine operators perceive that sewing machines are easy to use and useful
- This acceptance comes with a cost
- Participants reported suffering from musculoskeletal disorders, particularly:
- Mid back, upper back, lower back, shoulders and neck
- Could be attributed to high repetitive tasks, prolonged sitting and bending postures
- The mismatch between users and sewing machines is another contributing factor

# Level of Upper back pains



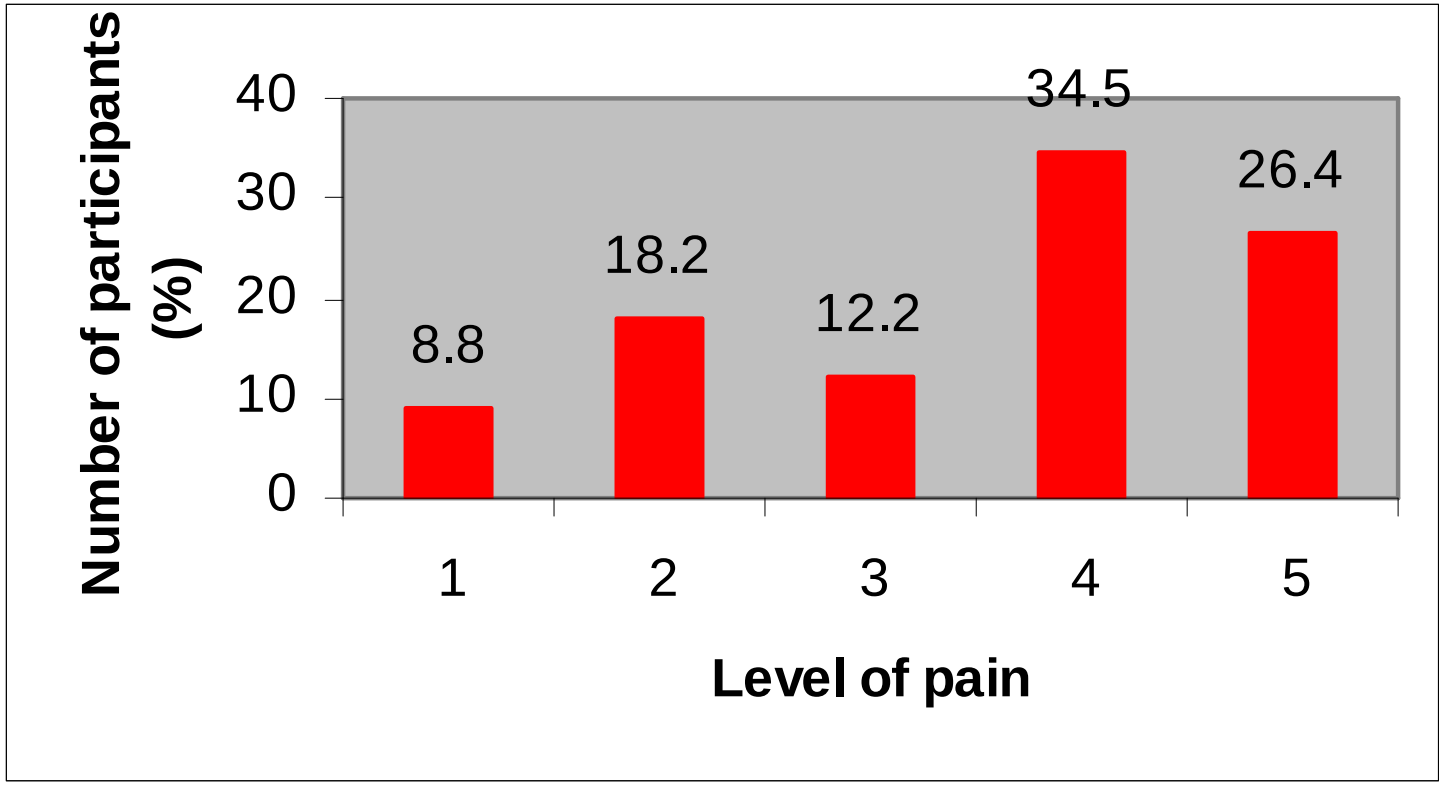

Key: 1. No pain 2. Little pain 3. Average pain 4. A lot of pain 5. Extreme pain

# Level of lower back pains



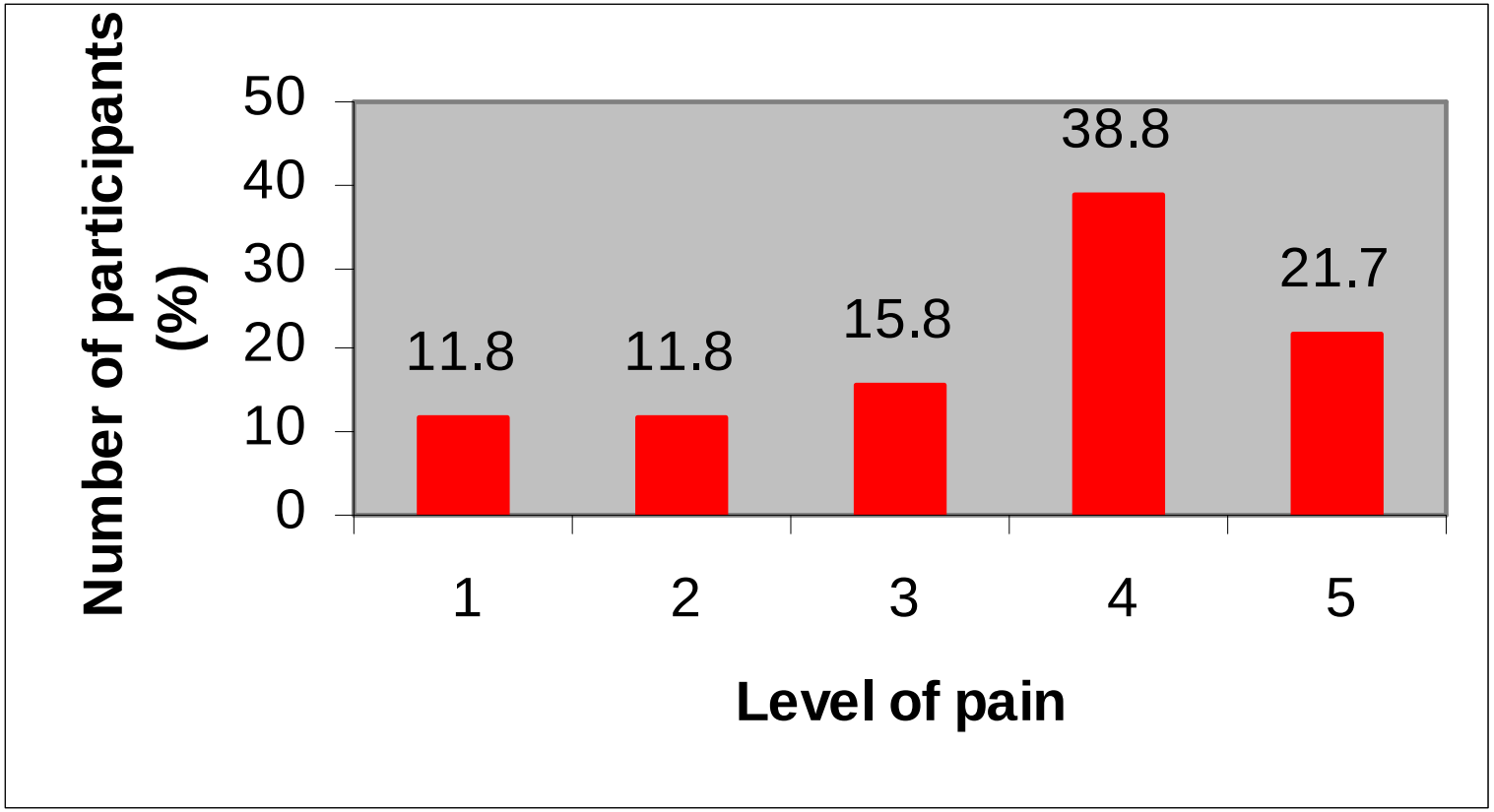

Key: 1. No pain 2. Little pain 3. Average pain 4. A lot of pain 5. Extreme pain

# Level of mid back pains




Key: 1. No pain 2. Little pain 3. Average pain 4. A lot of pain 5. Extreme pain

# Level of shoulder pains




Key: 1. No pain 2. Little pain 3. Average pain 4. A lot of pain 5. Extreme pain

# Summary of Results

## Areas of Body Discomfort Experienced by the Participants

| Pain | Neck % | Buttocks % | Upper arms % | Lower arms % | Mid back % | Upper back % | Lower back % | Thighs % | Legs % | Shoulders % |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 14.1 | 24.8 | 27.7 | 38.1 | 8.8 | 7.9 | 10.1 | 35.1 | 16.0 | 11.8 |
| 2 | 24.2 | 20.1 | 27.0 | 23.8 | 18.2 | 9.9 | 13.4 | 22.3 | 21.5 | 11.8 |
| 3 | 16.1 | 20.1 | 20.9 | 23.1 | 12.2 | 11.9 | 13.4 | 23.0 | 21.3 | 15.8 |
| 4 | 30.2 | 21.5 | 20.9 | 11.6 | 34.5 | 37.7 | 36.9 | 14.9 | 25.3 | 38.8 |
| 5 | 15.4 | 13.4 | 3.4 | 3.4 | 26.4 | 32.5 | 26.2 | 4.7 | 16.0 | 21.7 |

Key: 1. No pain 2. Little pain 3. Average pain 4. A lot of pain 5. Extreme pain

# Discussion and Conclusion

The results indicate that participants felt a:

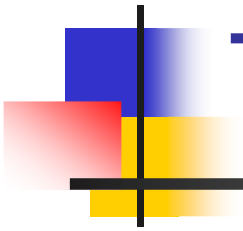
- High percentage of pains in the:
  - Upper back
  - Lower Back
  - Mid back
  - Shoulder
  - Neck
- Low percentage of pains in the:
  - Legs

# Discussion and Conclusion

- The research found out that the average height of Japanese women is 1520mm vs 1620mm of Batswana women
- Japanese and Batswana women Body Mass Index are 23 and 24 respectively
- These differences have implications on sewing machines design
- Modifications of these machines is needed to match the physical and mental capabilities of Batswana

# Discussion and Conclusion

- The findings suggest that the risk of developing musculoskeletal disorder seems to be greater amongst sewing machine operators in Botswana's textile industry
- There is need to establish a database of anthropometric variables for Batswana users
- The database to serve as a guide to designers developing new local technologies
- The database will serve as a prerequisite to designing useful, usable, pleasurable and cherishable technologies



# Thank you