

Design Science and Innovation

D. Bijulal · V. Regi Kumar ·  
Suresh Subramoniam · Rauf Iqbal ·  
Vivek Khanzode *Editors*

# Technology-Enabled Work-System Design

Select Proceedings of HWWE 2018

 Springer

# **Design Science and Innovation**

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Editors

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# Preface

We have a great pleasure to bring out the Proceedings of the 16th International Conference on Humanizing Work and Work Environment 2018 (HWWE 2018) with the theme “Technology Enabled Workplace Design” held during December 14–16, 2018 at College of Engineering, Trivandrum (CET), Kerala. This was organized jointly by the Department of Mechanical Engineering and CET School of Management, College of Engineering Trivandrum, Kerala. The HWWE series of Conferences is an annual flagship event of the Indian Society of Ergonomics (ISE) held in association with International Ergonomics Association (IEA). The Trivandrum Chapter of the Indian Institution of Industrial Engineering was the knowledge partner for HWWE 2018.

The 16th edition of HWWE aimed to bring together researchers from various countries working in different areas of Human Factors Engineering, to discuss the current developments, opportunities, and challenges in their respective fields. The HWWE 2018 received overwhelming response with nearly 185 submissions for presentation in the Conference and out of which only 145 submissions got selected after reviewing by renowned academicians and practitioners hailing from leading institutions from India and abroad.

The keynote speakers representing the International Ergonomics Association were Prof. Jose Orlando Gomes, Federal University of Rio de Janeiro and the Vice-President and Treasurer of IEA from Brazil, Prof. Eva Honeyman Vice Chairperson, Israel Ergonomics Association and Head of Ergonomics at Ergo group and Prof. Peter Honeyman from Israel. Other keynote speakers include Dr. Debkumar Chakrabarti IIT Guwahati and Vice-President of ISE, Dr. A. K. Ganguli, President, ISE, Prof. P. C. Dhara, Hon. General Secretary, ISE. Various lead lectures were presented by academicians and industry experts during the technical sessions. These lectures were delivered by Prof. Dibakar Sen, IISc. Bangalore, Dr. Anirudha Joshi, IIT Bombay, Mr. Guenter Fuhrmann, M/s. Ergoneers, Germany, Dr. Rauf Iqbal, NITIE, Prof. M. Muzammil, Aligarh Muslim University, Dr. Nandita Bhattacharyya, Assam Agricultural University, Dr. Ajita D. Singh, Punjab University, Dr. S. Mukherjee, University of Calcutta, Dr. Sudesh Gandhi, Haryana Agricultural University, Dr. Sougata Karmakar, IIT Guwahati, and Dr. Abid Ali Khan, Aligarh Muslim University.

The Organizing Secretary for the conference was Dr. D. Bijulal, Associate Professor, Department of Mechanical Engineering, CET and Vice Chairman, IIIE, Trivandrum Chapter. The conference was chaired by Dr. A. Samson, Head, Department of Mechanical Engineering and Dr. Suresh Subramoniam, Director, CET School of Management under the patronage of Dr. Jiji C. V., Principal, College of Engineering Trivandrum.

This Proceedings is the outcome of various contributors including the authors, the expert reviewers, the editors, and the publishers. This Proceedings contains 17 number of and outstanding selected papers from those presented at the conference. These manuscripts have undergone rigorous scrutiny in different stages of selection by experts in the field prior to publication. We hope that these papers will find good readership and will receive deserving attention from the Human Factors and Ergonomics fraternity across the world.

The editors wish to thank Dr. Usha Titus, Principal Secretary Higher Education and Former Vice Chancellor, APJ Abdul Kalam Technological University, Kerala and Dr. K. P. Indira Devi, Director of Technical Education for their constant encouragement. The financial support from Antrix Corporation, the Directorate of Technical Education, Kerala and the Centre for Engineering Research and Development (CERD) under the APJ Abdul Kalam Technological University are also greatly acknowledged. We thank all the authors for contributing and giving consent for their latest work to be published in this Proceedings. Special thanks go to reviewers for their critical review. We express our sincere gratitude to all the editorial staff of Springer for their immense support in bringing out this wonderful compendium of selected papers.

Trivandrum, India  
 Trivandrum, India  
 Trivandrum, India  
 Mumbai, India  
 Mumbai, India

D. Bijulal  
 V. Regi Kumar  
 Suresh Subramoniam  
 Rauf Iqbal  
 Vivek Khanzode

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The research interests of Prof. D. Bijulal include Industrial Engineering and Management, General Management, Intellectual Property Right, Behavioural Finance, System Modelling and Simulation, System Dynamics, etc. He is an approved guide under the APJ Abdul Kalam Technological University, Thiruvananthapuram and has five scholar doing their research under his guidance. Apart from the publications that he authored, he is a research contributor as reviewer for many international journals and conferences.

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**Rauf Iqbal** is a researcher, teacher and consultant in Ergonomics and Human Factors Engineering. He is an Associate Professor and In-Charge of Ergonomics Laboratory at the National Institute of Industrial Engineering (NITIE), Mumbai. He holds a Ph.D. degree in Ergonomics. He teaches Ergonomics and Human Factors, Layout and Facilities Planning and Worksystem design to the master's students of Industrial Engineering, and Manufacturing Management. and his research interest is Worksystem design, Engineering Anthropometry and workspace design, Biomechanics of human movement, Occupational ergonomics and Safety management.

Rauf Iqbal has publications of over 120 as journal articles, edited books, book chapters and conference proceedings. He has been regularly presenting and chairing sessions at International conferences over the last 15 years. He has guided several scholars for the Ph.D. degree as well as master's theses. He has reviewed articles for various International journals and also has examined Ph.D. thesis from national and international universities. He is member of various international and national committees like,—BRICS Plus Executive Committee for Human Factors and Ergonomics, Council member of Asian Council on Ergonomics and Design, Ergonomics sectional committee for Bureau of Indian Standards, Executive committee member of Indian Society of Ergonomics etc. He has carried out various projects funded by the Government as well as International Labour Organization. He has been conducting training and consultancy for numerous industries in the areas of ergonomics, work study, work systems design and Safety management.

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# Chapter 1

## A Changing World: Adapting to an Ageing Population in the Workplace



N. Bhattacharyya and Pubali Saikia

The world's population is ageing: most countries around the world are in the midst of demographic ageing; virtually every country in the world is experiencing growth in the number and proportion of older persons in their population (Kinsella and Gist 1998). Projected increase in both the absolute and relative size of the elderly population in many third world countries is a subject of growing concern for public policy (Kinsella and Velkoff 2001; World Bank 2001; United Nations 2002; Bordia and Bhardwaj 2003; Liebig and Irudaya 2003). By 2050, two billion people will be aged 60 or over, a proportion that brings with it many implications for society. The Organisation for Economic Co-operation and Development (OECD) estimates that over the next 50 years, its member countries will see a steep increase in the share of elderly persons in the population, as well as a steep decline in their prime working-age populations.

This has been especially true in case of developing countries like India, where the elderly population is increasing rapidly. In the forthcoming decades, there will be a tremendous increase in the number of elderly in India, with their rate of increase being faster than that of the total population (WHO 1984).

### 1 Ageing: The Indian Scenario

India, like many other developing countries in the world, is presently witnessing rapid ageing of its population. According to World Population Prospects, UN Revision, 2006, the population of aged in India is currently the second largest in the world. Even though the proportion of India's elderly is small compared with that of developed countries, the absolute number of elderly population is on the high. There has been

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tremendous increase in the number of elderly population since independence in India from 20.19 million in 1951 (5.5% of the total population) to 43.17 million in 1981 and 55 million in 1991. According to 2001 census, around 77 million population is above 60 years, which constitutes 7.5% of the total population of the country. This number is expected to increase to 177.4 million in 2025. (The growth rate of the population (1991–2001) of elderly has been higher (2.89) than overall growth rate (2.02) of the total population. India's older population will increase dramatically over the next four decades. According to World Population Data Sheet 2002, 4% of the Indian population are in the age group of 65 plus, which accounts for 41.9 million. This phenomenon of growing population of senior citizens has been the result of recent successes in the achievement of better health standards and a longer span of life for our citizens (UN 2011; Shakuntala 2013).

The impact of this transition means that there will also be a change in the labour supply. Many industries will have to adjust either by bringing more of the youth population into their workforce or by attracting more workers from the older population segment. People need to be working beyond traditional retirement ages.

## 2 Work Ability and Ageing Workforce

Globally, an ageing workforce has significant implications for developed as well as developing countries. As people age, they become more likely to acquire a disability or other age-related health condition that may reduce their functional capacity and affect their ability to remain in the workforce (Heidkamp et al. 2012).

Heidkamp et al. (2012) further reported that each individual ages differently, and the effects of ageing on physical changes may be:

- Reduced strength. With an increase in age on average, a person's physical strength decreases about 25% by 65 of age.
- Reduced aerobic capacity. An older person gets tired more easily under exertion than a younger, may be of 20 years of old.
- Reduced ability to handle shift work. Older people have less resistance to the stresses of night work and become more easily tired.
- Reduced ability to regulate body heat through sweat and water retention, making older workers more susceptible to heat stroke.
- Reduced reaction time. Indicates learning and remembering things for an older worker takes more time.
- Chronic health conditions. With an increase in age, chronic health conditions may also increase, affecting a worker's ability to do certain jobs. These include diabetes, irritable bowel syndrome, arthritis, high blood pressure, and obesity.
- Vision impairments. Change in vision power is very common as age increases. These changes may cause decreased ability to focus, see in conditions of low light, adjust to changes in light conditions, and distinguish colours in different regions.
- Hearing impairments. Hearing loss with age is well known.



The coming together of ageing, disability, and employment results in a complex set of issues for both older workers and their employers. Encouraging older workers to remain in the workforce will require strategies to accommodate their changing abilities. To do so interventions, facilitating the active performance of work until retirement age is required. According to Finnish researchers, Tuomi et al. (1998), ‘a comprehensive solution for the ageing challenge at the workplace is the promotion of work ability during ageing’. According to them, the concept of work ability comprehensively describes ‘the way to achieve a better correspondence between ageing and work, has been created in Finland as of the end of the twentieth century. It also includes an objective measurement of work ability based on the index of work ability’. This concept focuses on both human resources and working conditions. The core dimensions of human resources include health, physical and mental capacities and social functioning, competencies, as well as attitudes and values. The core dimensions of work cover the contents and demands of work, physical, ergonomic and psychosocial work environment, as well as management and leadership issues. Work ability is also connected to the microenvironment outside the workplace (family, relatives, friends, etc.) as well as with the macro-environment (infrastructure, services and other societal dimensions). The new core concept of work ability emphasizes the balance between human resources and work.

### 3 The Present Study (Tea Industry and the Workers)

The concept of work ability relates to the capacity a worker has to perform his work tasks, given his work demands, health status and physical and mental abilities. ‘Work ability’ is a complex construct reflecting the individual and occupational factors influencing a person’s ability to cope in working life. It reflects the interaction between mental and physical activities and worker’s functional capabilities, health and subjective assessment of their status in given organizational and social conditions (Tuomi et al. 1998). Generally, work ability is an individual quality, whereas maintaining work ability deals more with actions aiming at promoting an employee’s work ability (Julin et al. 2001). Work ability is largely based on individual qualities of physical, mental and social functional capacities, which all consist of various factors: physical functional capacity includes endurance (aerobic and anaerobic), muscle strength (endurance, speed and strength) and skills of the nervous system (flexibility, balance and agility). The improvement of work ability of workers is believed to be economically beneficial to the work place. Good work ability of workers improves the quality of work, resulting productivity and contributes to a better health-related quality of life. According to Ilmarinen et al. (1998), ‘being productive at work and being in good health are considered important determinants of prolonging working life and also of retirement in good health’.

Tea is consumed in about 100 countries, and India is the largest producer and consumer of tea in the world (Baroowah 2006). Assam is the largest tea producing state in India and contributes about 60% of the total production of India (Sen 2008).

The majority of workforce in tea fields are women workers (Bhattacharyya et al. 2013). 'Women workers are involved at every stages of production i.e., from nursery development to the packaging work' (Lama 1983). The tea planting industry is labour-intensive and workers being exposed to the vagaries of terrain and climate, in addition to exposure to chemicals in the form of pesticides and fertilizers, the possibility of safety and health hazards is very high. They are subjected to adverse working conditions inherent in the work process, viz., adopting awkward postures reaching for the new shoots to be plucked which involve long hours of standing, reaching or bending, repetitive movements and carrying heavy loads on back during plucking operation, etc. Moreover, workers need to travel long distance by carrying the plucked leaves on their head after completion of the entire shift to unload their daily plucked leaves to the place where plucked leaves are being weighed. The workers perform the works by following the same age-old traditional work practices without much awareness about its impact on health. Due to this backbreaking and drudgery-prone work, the work efficiency of the workers decreases, and health of the workers is also affected. Specifically, it aggravates when ageing workers are concerned because of physical effects of ageing. This category of workers has different types of work-related health problems leading to reduced work ability, early retirement, absenteeism and lowered productivity. As opined by Ilmarinen (2001), 'the improving work ability is one of the most effective ways to enhance the ability and preventing disability and early retirement'.

Thus, the assessment of work ability was considered as important tool as it would measure the ability of workers to perform their jobs, taking into account the specific psychosocial and physical work-related factors, mental and physical capabilities and health. Keeping it in view, the present study was undertaken in tea fields of Assam to assess the Work Ability Index (WAI) of workers of above 55 years age.

## 4 Materials and Methods

For the study, a total of 50 respondents belonging to the age group of above 55 years engaged in manual tea plucking activity were selected purposively from three randomly selected tea gardens of Jorhat district of Assam. The data were gathered from the respondents personally by the investigator.

Data on Work Ability Index (WAI) were collected by using the WAI questionnaire. The WAI scores were calculated according to the standard method provided by the Finnish Institute of Occupational Health (FIOH). According to the tool, 'the main part of the WAI consisted of 7 items, Including current work ability compared with the lifetime best (0–10), work ability in relation to the demands of the job (2–10), number of current diseases diagnosed by a physician (1–7), estimated work impairment due to diseases (1–6), sick leave during the past year (1–5), personal prognosis of work ability 2 years from now (1, 4 or 7) and mental resources, referring to the workers life in general, both at work and during leisure time (1–4). (The number in parentheses for each item indicates the scoring range).' The WAI Score ranges from 7 to 49