RIVISTA ITALIANA DI

ERGONOMIA

ORGANO UFFICIALE DELLA S.I.E. - SOCIETÀ ITALIANA DI ERGONOMIA

N.25 - 2022

- EDUCATION, SUSTAINABILITY, AND HUMAN FACTORS AND ERGONOMICS
- SUSTAINABLE WORKPLACE: AN INTEGRATED APPROACH TO INDUSTRIAL ERGONOMICS AND SERVICE DESIGN
- DEVELOPMENT OF A HELP COMMUNITY FOR THE CANCER PATIENT
- ERGONOMIC INTERFACES FOR SUSTAINABLE HUMAN-MACHINE-ENVIRONMENT SYSTEMS
- ERGONOMICS AND SUSTAINABILITY IN HIGHER EDUCATION
- SYSTEMIC LINK FROM (MICRO) ERGONOMICS TO SUSTAINABLE DEVELOPMENT

Poste Italiane S.p.A. – Sped. in Abbon. Post. DL 353/2003 conv. in L.27/02/2004, n.46, art.1 comma 1 DCB Milano – rivista quadrimestrale - anno 11 - n. 25, 2022

RIVISTA ITALIANA DI
ERGONOMIA

RIVISTA QUADRIMESTRALE
NUOVA EDIZIONE
NUMERO 25 - 2022

Organo ufficiale della
SOCIETÀ ITALIANA DI ERGONOMIA
www.societadiergonomia.it

SEDE LEGALE REDAZIONE, AMMINISTRAZIONE, ABBONAMENTI, PUBBLICITÀ
Segreteria SIE c/o R.M. Società di Congressi srl
Via Ciro Menotti 11, 20129 Milano
tel. +39 02 70.12.63.67 – segreteria@societadiergonomia.it

PROGETTO GRAFICO E IMPAGINAZIONE
Frush [Design sostenibile] – www.frush.it

PREZZO PER L'ITALIA € 10,00
ABBONAMENTO ANNUALE € 25,00
ABBONAMENTO STUDENTI € 20,00
ABBONAMENTO BIBILOTECHE E ISTITUZIONI € 30,00
L'abbonamento comprende 3 numeri della rivista

Autorizzazione del Tribunale di Milano n. 484 del 30 Ottobre 2009
Poste Italiane S.p.A. - Sped. in Abbon. Post. DL 353/2003 conv. in L.27/02/2004, n.46, art.1 comma 1 DCB Milano
ISSN 2531-8845, 2/12/2016, Rivista Italiana di Ergonomia

RIVISTA ITALIANA DI ERGONOMIA

THE RIVISTA ITALIANA DI ERGONOMIA, *of the S.I.E. - Italian Society of Ergonomics, is a scientific journal that operates nationally and internationally for the promotion and development of ergonomics and the study of human factors, and the dissemination and systematization of knowledge and experiences related to the ergonomic approach, in close relationship with the social, environmental and productive realities where human beings, operate and live, coherently with the goals of the SIE.*

Supported by an international scientific committee and using a double-blind reviewing process, the journal publishes original contributions from research and applications on ergonomic issues, in its various aspects and related to the different contexts and human activities.

The RIVISTA ITALIANA DI ERGONOMIA *is aimed at ergonomic professionals and all those interested in applying the principles and methods of ergonomics / human factors in the design, planning and management of technical and social systems, in work or in leisure.*

INDEX

EDITORIAL RULES FOR AUTHORS

GENERAL INFORMATION

- The articles must be sent in word-compatible format (.doc, .rtf) by e-mail to the following addresses: rivista.ergonomia@gmail.comand segreteria@societadiergonomia.it
- Each article must be submitted both in Italian and in English.
- Each version (ITA and ENG) has to include: title, author/s name, abstract and bibliography
- Each version must have a maximum of 25,000 characters includedspaces.
- In particular:

  - The abstract length shall range between 100 and 250 words

  - Provide complete names and affiliations of each author
- A short-bio of each author is required. Its maximum length is no more than 100 words each. They are excluded from the overall counting.
- Articles may be submitted for the section "Studies and research" or for the section "Profession and project". Articles submitted for the section "Studies and research" will be double-blind reviewed.

IMAGES AND TABLES

- The images should not be put in in the text, but separatelysent, attached to the email in .jpg or .tiff format
- The required resolution is 300 dpi.
- Images and tables should be numbered and positioned in the text as cross-references (e.g. [Figure 1])

REFERENCES IN THE TEXT

- References in the text include (name/s, date) as in the following examples:

  (Jones, 2001)

  (Robsen, Hudson, Hutchkins, Ru, &Selanis, 1989)

  (Smith et al., 2005)

REFERENCE LIST

- The reference list at the end of the text shall be in alphabetical order (per surname of the first author)
- References by the same author (or by the same group of authors in the same order) shall be arranged by year of publication with the earliest first.
- In case of multiple co-authors, separate the names with the comma and "&". Do not use the formula "et al."

Examples

Articles

Smith, L. V. (2000). Referencing articles in APA format. APA Format Weekly, 34, 4-10.

Journals

James, S. A. (2001, June 7). Magazine articles in APA-format. Newsweek, 20, 48-52.

Newspapers

Tensky, J. A. (2004, January 5). How to cite newspaperarticles. The New York Times, pp. 4-5.

Books

Rogers, C. R. (1961). *On becoming a person.* Boston: Houghton Mifflin.

Adler, A. (1956). *The individual psychology of Alfred Adler: A systematic presentation of selections from his writings.* (H. L. Ansbacher, Ed.). New York: Basic Books.

Online resources

Van Wagner, K. (2006). Guide to APA format. About Psychology. Retrieved November 16, 2006 accessibile online su http://psychology.about.com/od/apastyle/guide

REVIEWS

- Reviews shall be provided as follows:

  Title, reviewed by N. Surname and N. Surname, Publiser,City, Year, Pages, Price, Hardback (ISBNXXXXX), paperback (ISBN XXXXX).

EDITORIAL

ERMINIA ATTAIANESE AND EMILIO ROSSI

Sustainable Ergonomics and Ergonomics for Sustainability: Feeding the scientific discussion through international viewpoints

Sustainability and Ergonomics are two of the most important subjects to consider when it comes the creation of a wealthy, inclusive and productive modern society. Both are crucial for creating effective workplaces and solutions for finding ways to make people's lives better and healthier. Sustainability focuses on reducing environmental impacts while also considering economic and social factors to generate prosperity and wealth; therefore, one of the Sustainability's key aims is the creation of a balance between environmental impact and economic growth within a socially cohesive perspective. On the other hand, Ergonomics – or Human Factors – focuses on improving the design of artefacts (i.e., products, services, systems of solutions, built environments, etc.) fitting people's demands for comfort and health. Thus, Ergonomics looks at how people perform actions and interact with each other within given environments, in order to increase health, safety, comfort, usability, and user experience, and without missing systems and processes' efficacy and efficiency.

Since 2008, when the Human Factors and Sustainable Development Technical Committee was established by the International Ergonomics Association (IEA), the community working in the HFE field gradually increased the interest in this topic. But studies made in the last thirty years demonstrate that

there is a great interest in converging these disciplinary areas, to explore potential synergies and virtuous conditions able to support the creation of better living solutions that meet the contemporary trends of present and future society. For example, the efficiency of a workplace or the pleasantness of an industrial product becomes an important determinant of its success when placed in a sustainable perspective; also, the adequacy of products and environments with respect to the variability of the user and its context of use is an important driver for their sustainable life cycle. This means that the HFE research community is asked to fully embrace the new instances and issues expressed by Sustainability to conceive new conditions for prosperity and inclusion.

From the scientific point of view, the area of intersection between Sustainability and Ergonomics opens up an interesting and relatively less explored scenario of opportunities useful to rethink the current productive and living systems. This trend is also echoed by important organisations such as United Nations, which is putting significant efforts in stimulating cultural and scientific debates around the objectives to achieve in the near future, to mitigate the poverty, to contrast inequalities, and to advance a responsive growth while taking into account people, socio-economic conditions, and the ecological equilibrium of the planet. Accordingly, relevant issues to consider include, but not limited to: (i) digitalisation, innovation, competitiveness, culture and tourism, (ii) green revolution and ecological transition, (iii) sustainable mobility, including products, services and infrastructure, (iv) education and research for a sustainable transition, (v) inclusion and cohesion, (vi) health and wellbeing, and (vii) creative manufacturing and new working practices.

With the aim to start a first and solid discussion around these topics by contributing with cultural insights developed by scholars working in the field of Ergonomics, the number 25 of the Rivista Italiana di Ergonomia intends to reflect on the synergies and future opportunities for a common ground between Ergonomics and Sustainability: "*Sustainable Ergonomics – Ergonomics for Sustainability*". In doing so, for the first time in its history, the journal opens up at international debates by gathering high-quality contributions made by international experts in the field to feed a fruitful discussion on this topic. For the journal, this is a pivotal effort demonstrating the will of its editors to move form a local dimension to a global

one by offering a multidisciplinary contribution through a selection of high-quality international works.
Six contributions compose this first international volume.
The work proposed by Thatcher and entitled '*Education, sustainability, and human factors and ergonomics*' introduces interesting suggestions for the core skills and core contents that should be included in educational programmes to prepare future (and current) researchers and professionals to address the multiple crises referred to collectively as "Sustainability".
The article '*Sustainable workplace: An integrated approach to industrial ergonomics and service design*' proposed by Sadeghi Naeini et al. discusses the relationship between Ergonomics and Sustainability on the context of a holistic service system toward quality of working life; this is made through a bibliometric analysis of "Ergonomics" and "Sustainability" keywords searched among studies published in the last five years. Iacono et al. propose an interesting interdisciplinary study entitled '*New digital health challenges: Development of a help community for the cancer patient*' aimed at presenting a patient-centered, sustainable and innovative platform, a new digital solution respondent to the need of bringing people and treatments closer, bridging the physical and relational distance usually affecting cancer patients. With the study '*Ergonomic interventions for the design of sustainable work systems*', Rao discusses the transformation of work systems due to digitization and digitalization; in this work, considerations on the evolving role of ergonomic interventions aimed at designing the interfaces for ensuring the sustainability of human –machine interactions are made. The work proposed by Rodea Chávez et al. entitled '*Systemic link from (micro) ergonomics to sustainable development: Follow-up to common objectives*' discusses the need to develop an instrument to guide towards good sustainable practices that are connected with design cultures.
Finally, the work proposed by García Parra et al. and entitled '*Ergonomics and sustainability: A proposal for an integrated transversality in higher education*' introduces an interesting analysis on how a transversal approach linking "Sustainability" and "Ergonomics" could be incorporated into teaching curricula in HE.

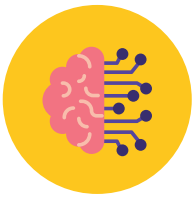
ERMINIA ATTAIANESE

Full time Associate Professor in Architecture Technology at the University of Naples Federico II, Italy. President of CREE Centre for Registration of European Ergonomist, she is also Chair of the Technical Committee "Ergonomics in Design for All", of International Ergonomics Association (IEA). Her research interest and areas of expertise relate to human-centred design of systems, particularly referred to ergonomics of the built environment, buildings and systems accessibility, safety and usability, human diversities, and social and environmental issues in sustainability perspective applied to the design of buildings, indoor and outdoor spaces.

EMILIO ROSSI

Tenure Track Assistant Professor in Design at the Department of Architecture, “Gabriele D’Annunzio” University of Chieti-Pescara, Italy. His research interests and areas of expertise relate to Design Research, Design for Social Inclusion and Design for Sustainability, with a focus on the development of methodological innovations for products and product-service systems, and the investigation of disciplinary and interdisciplinary relations between inclusive/human-centred domains and sustainable socio-technical systems. On these themes, he collaborates with important associations, societies, and technical committees such as AHFE, DRS, IEA, and LeNS.

Education, sustainability, and human factors and ergonomics



ANDREW THATCHER
Psychology Department, University of the Witwatersrand, Johannesburg, South Africa

Abstract

Humanity is facing multiple crises of its own making including the climate crisis, biodiversity loss, land degradation, and widespread social inequality. In this paper I make suggestions for the core skills and core content that I believe needs to be included in human factors and ergonomics educational programmes to prepare our future (and current) researchers and professionals to address the multiple crises referred to collectively as "sustainability". The core skills are complexity thinking, resilience, ethics and values, and transdisciplinarity. The core content areas in educational programmes need to emphasise the broad range of application areas (underpinned by human-eco-technology development) and existing theoretical frameworks such as green ergonomics, ergoecology, and sustainable and decent work design. I conclude by emphasising that human factors and ergonomics also needs to continue focusing on what it does best to provide invaluable contributions to multidisciplinary, interdisciplinary, and transdisciplinary teams.

Introduction

It is widely recognised that humanity's current activities are leading us on an unsustainable path (IPCC, 2022). Not only are we facing an anthropogenic climate crisis, but also significant biodiversity loss, unsustainable consumption of natural resources, degradation of land and ecosystems, rapid urbanisation without sufficient supportive infrastructure, massive social and economic inequalities, and a pandemic that severely disrupted our global economic and social systems (IPCC, 2022). We are not a world in equilibrium, but a world in denial about our negative impact on our life-supporting systems. This should not come as a surprise since the scientific community and civil society has been warning us about these crises for several decades (e.g., Brundlandt, 1987; Carson, 1962; UNCHE, 1972).

Globally, humanity has not completely ignored these crises and there have been several multinational attempts (although not always successful) to provide frameworks and agreements to address these challenges. The United Nations Development Programme's 17 sustainable development goals (SDGs) is one recent example trying to set international benchmarks. It is becoming increasing obvious though that we will not be able to successfully deal with these sustainability crises without the intensive contributions from multiple disciplines, including the behavioural sciences (van der Linden & Weber, 2021). Van der Linden and Weber (2021) acknowledge that while the behavioural sciences cannot address these crises on their own, the crises cannot be successfully addressed without the behavioural sciences and especially those disciplines that interact with engineering communities. Without explicitly mentioning our discipline, it is not difficult to see that van der Linden and Weber (2021) were referring specifically to human factors and ergonomics (HFE).

HFE has not simply ignored these crises either. Nearly three decades ago Moray (1995) urged HFE to address global sustainability challenges, although the International Ergonomics Association only established the Human Factors and Sustainable Development Technical Committee in 2008. In their seminal paper on the future of ergonomics Dul et al. (2012) recognised sustainability as a critical global trend for HFE to consider and that the strategy to achieve high quality HFE was through high-quality HFE education. So, how do we connect this critical global trend to the need for high quality

education in order to prepare our students, practitioners, and university programs for the challenges associated with sustainability? As a set of underpinning intervention strategies, it is useful to consider Monroe et al.'s (2019) three types of knowledge which are important for achieving behaviour change for sustainability: changing people's attitudes about the importance of sustainability and climate change; empowering action-taking by assessing the willingness to engage; and encouraging selected sustainable behaviours.

In this paper I consider two aspects for education in the HFE discipline to address sustainability challenges. First I look at what I consider to be the appropriate critical thinking and problem-solving skills required to enable thinking about sustainability. Second, I consider how much factual information about sustainability needs to be taught. I make some initial suggestions about what needs to be taught in all HFE programmes to prepare students to face the multiple crises encapsulated by sustainability.

Underlying critical-thinking skills for sustainability

Sterling (2001) provides an excellent overview of the underlying skills that should be taught to our students in order to prepare us for sustainability:

- Complex systemic thinking (i.e., the fuzzy borders between systems, the locality and provisionality of knowledge, and emergence).
- Designing for change and adaptation (resilience and the design of resilient systems).
- Participation (the value of inclusion, participatory designs, cooperation, collaboration, and trans/interdisciplinarity).

Sterling's (2001) outline forms the basis of my thinking for this section about how to prepare HFE educational programmes.

Complex systems-thinking

Systems thinking has always been one of the cornerstones of HFE with Dul et al. (2012) making systems-thinking a fundamental aspect of the HFE definition. Wilson (2014) even went so far as to state that any study, investigation, analysis, or development which did not take a whole system view was not HFE at all. Open-systems thinking that encourages HFE to consider the entirety of the human (i.e.,

our anatomy, physiology, and psychology) within their environmental and organisational context is the dominant systems-thinking paradigm. However, with the crises presented by sustainability, the type of simple open-systems thinking that is dominant in many HFE programmes is insufficient. What is required is a broader complex systems-thinking approach (Dekker et al., 2013; Thatcher, Nayak & Waterson, 2020; Thatcher et al., 2018) that takes multiple systems at much larger scales into account. But what are the characteristics of this complex systems thinking that need to be taught?

Dekker et al. (2013) outline these complex system characteristics as a high degree of interconnectedness between system components, they are dynamic, adaptive, and self-organising, which display characteristics of emergence (Dekker et al., 2013). There isn't enough space in this paper to talk about all the aspects of complex systems, but emergence requires a special mention because it is this quality that makes complex systems thinking so difficult. Emergence is a property of a complex system where novel characteristics and relationships are created that cannot be predicted a priori but can only be deduced after the fact (Damper, 2000).

Another important aspect of complex systems-thinking is the nature of feedback. Taking a traditional HFE perspective, feedback is about controllability; understanding what a system has done in response to a human action and then acting appropriately to keep the system in equilibrium. The traditional approach emphasises command-and-control mechanisms that typically emerge from teaching that the design of interfaces is simply an interplay between controls (human actions) and displays (machine interactions). However, feedback in complex systems may have outcomes that are physically or temporally distal from the initial inputs or entirely unpredictable (like emergence). HFE education requires an understanding of the various feedback mechanisms in complex systems, some of which may be impossible to determine from the outset. From an HFE design perspective, this also means teaching the precautionary principle (Johnston et al., 2007) which suggests that if we don't fully understand the systemic implications of our designs and interventions then we should rather err on the side of caution.
Several complex systems analysis tools already exist in HFE (e.g. Accimap, CWA, EAST, FRAM, STAMP, STPA) to help us diagnose and

find solutions within complex systems. However, Thatcher et al. (2020) noted that while these tools were fairly good at addressing issues of interconnectedness (for example Salmon et al. (2019) used a Work Domain Analysis to illustrate the interlinking nature of global problems), they were not suited to deal with dynamic, adaptive, and self-organising systems, or with issues of emergence inherent in socio-eco-technical systems. It is obvious that further work is required to develop the appropriate HFE complex systems-thinking tools. Nevertheless, I believe that an understanding of at least some of these complex systems analysis tools would be necessary to understand their value (and limits).

Resilience

Resilience refers to the system features that enable systems to maintain regular operations and to return to a "normal" state if they accidentally or temporarily deviate from stability. Systems displaying resilience are called 'resilient systems' and their qualities have already been considered extensively in HFE. Woods (2015), for example, divided the different understandings of resilience into four categories: resilience as rebound from trauma and return to equilibrium; resilience as a synonym for robustness; resilience as the opposite of brittleness; and resilience as network architectures that can sustain the ability to adapt to future surprises as conditions evolve. These various understandings of resilience still need to be applied in the context of sustainability, but it is likely that all four categories will prove useful.

Additionally, Thatcher and Yeow (2018a) identified five aspects that are important to consider in the design of sustainable, resilient HFE systems: persistence; functional diversity; adaptive capacity; sense of identity; and system efficiency. Once again, it is not possible to discuss all of these resilience concepts in this paper, but functional diversity and adaptive capacity bear special mention. Thatcher and Yeow (2018b) suggested that functional diversity is one of the key properties to make complex engineered systems resilient. More design options and different behaviour-types give systems a greater variety of pathways to recover from unusual disturbances. Functional diversity within the HFE discipline is often operationalised as cross-cultural design, but Lange-Morales et al. (2014) recommend that we need to go further and understand the diversity of place

(i.e., the geographical and cultural setting) and ecological diversity (i.e., our interactions with other biological entities). For example, one way to foster functional diversity to ensure sustainability is to understand local context and to emphasise local solutions for local problems. As Thatcher and Yeow (2018b) have noted, focusing on the local context not only increases the diversity of HFE approaches, but also contributes to distributed HFE expertise and local employment (addressing issues of social and economic inequity). Local solutions are more likely to be accepted (and sustained) by local users as they are the ones that have to live and work with the consequences of HFE interventions.

Paradoxically to the resilience property of persistence, one of the ways for a complex system to achieve resilience is by possessing adaptive capacity. Adaptive capacity doesn't mean that the whole system must adapt, but that the connections between elements in the system must have a high potential to adapt (Hoffman & Hancock, 2017). Ostensibly this means that the system has the capability to re-organise itself depending on the external pressures. Adaptive capacity means that some elements of a system may be repurposed or even "die off" to maintain the resilience of the entire system.

Ethics and values

Our ethics and values as an HFE discipline determine which problems or projects we address, which people are the targets/recipients of our efforts, and what sets of solutions can be considered. It is also obvious that some of HFE's existing (and unstated) ethics and values have contributed to (rather than ameliorated) sustainability crises. Dekker et al. (2013) initiated the discussion on the need to consider HFE's ethical stance with regards to sustainability and Lange-Morales et al. (2014) provided the first set of values for HFE and how we might seek to approach sustainability. The values identified by Lange-Morales et al. (2014) are: Respect for Earth; Respect for human rights; Respect for ethical decision making; Respect for transparency and openness; Appreciation of complexity; and Respect for diversity. It is not possible to discuss each of these values in depth, although it is useful to note that they overlap with concepts of complex systems thinking and functional diversity already discussed. These values have started to be incorporated into HFE design thinking but they are still a long way from being incorporated into main-

stream HFE education programmes. Thatcher, Lange-Morales, and García-Acosta (2020) extended these HFE values to propose an integrated stance towards ethicality and sustainability in HFE. Thatcher, Lange-Morales, and García-Acosta (2020) emphasised the necessity of developing education programmes that teach about these values by covering the goals of HFE, the underlying meaning of HFE, and the responsibilities of HFE towards individuals and society. In this way, future HFE researchers and practitioners can put the values into practice to guide ethical behaviour so that HFE plays a valuable role in society. However, it is also important to note that the framework for ethics that Thatcher, Lange-Morales, and García-Acosta (2020) presented is always provisional, meaning that it is always only temporarily valid, subject to change, and open to new descriptions or interpretations.

Transdisciplinarity

The nature of sustainability problems means that expert input is required from many different disciplinary perspectives and no single discipline possesses all the answers. In many ways, HFE is quite familiar with the multidisciplinarity since we already draw our core theories from a variety of disciplines including anatomy, physiology, psychology, design disciplines, and systems theory. When specifically considering sustainability, Dekker et al. (2013) suggested that we also need to add the humanities and social sciences to this repertoire, while Moray (2000) specifically suggested including cultural studies and politics. Whether or not HFE needs to integrate these additional disciplines into its core theoretical base is contentious. One could argue that HFE is already too broad and further additions may dilute its value or make educating HFE people overly complex.

Lang et al. (2012) argued that the challenges presented by sustainability require disciplines to move beyond a multidisciplinary approach towards interdisciplinary and transdisciplinary approaches. Interdisciplinarity involves cooperation to achieve a synthesis between the different theories and methods of individual disciplines. There are already many examples of interdisciplinarity in HFE. Transdisciplinarity, on the other hand, requires not just cooperation and synthesis, but an integration of disciplinary knowledge and methods to create new, unified theoretical frameworks not limited by their original disciplinary stances (Fiore et al., 2014). A critical aspect of transdisciplinary work is that translational partners are included as active participants. Translation-

al partners typically come from outside science and include people from the community, industry, or other relevant stakeholders. One might argue that HFE is already quite familiar with the translational partner aspect of transdisciplinarity, although we typically refer to this as participatory design (Martin et al., 2013). Transdisciplinarity means that we need to emphasise and expand on what we mean by participatory design in our educational curricula.

Specific content areas

There is now a substantial and growing corpus of theoretical and empirical research on HFE and sustainability appearing in the peer-reviewed literature (Bolis et al., 2022). Two recently published books (Thatcher & Yeow, 2018; Thatcher, Zink & Fischer, 2020) also provide a useful overview of the scope of work on HFE and sustainability. Still, it is difficult to be prescriptive about models and approaches to use, because they are all relatively new. Nevertheless, it is important to note that a substantial body of theoretical work already exists, including green ergonomics (Thatcher, 2013), ergoecology (Garcia-Acosta et al., 2012), and sustainable and decent work system design (Bolis et al., 2014; Zink, 2014).

Green ergonomics is defined as HFE with a pro-nature focus aimed at realising the reciprocal benefit between humans and the natural world. Green ergonomics already has several areas of application (e.g., Lumber et al., 2017). Ergoecology encourages HFE to take multiple perspectives when considering design interventions including the ecological, social, economic, technological, and political perspectives. Ergoecology calls for a balance between an anthropocentric and an ecospheric perspective in design (Garcia-Acosta et. al, 2012). Curricula would also benefit from including the discourse on decent and sustainable work systems. As the future of work around the world is constantly undergoing change it is important to ensure that the debates around the meaning and sustainability of decent work for all is covered (Bentley et al., 2021).
Thatcher and Yeow's (2016) Sustainable System-of-Systems (SSoS) approach also bears a mention here because it has the potential to connect complex systems thinking to sustainability interventions. SSoS isn't a theory or model, but rather a set of guidelines for enabling practitioners, researchers, and designers to characterise the problem to produce sustainable HFE interventions.

Discussion

It is important to note that the majority of suggestions that I have made in this paper do not recommend that we need to fundamentally change HFE's core curriculum content to educate students about the specific interconnected issues of the climate crisis, biodiversity loss, pollution, land degradation, forced migration, and inequality. While these content areas are obviously important (and for people in some parts of the World they represent existential crises), we can't expect HFE practitioners and researchers to be experts in all these areas. These are each complex problems that require multidisciplinary, interdisciplinary, and transdisciplinary teams to understand, intervene, and ultimately resolve. Instead, I would argue that we should focus on what HFE can contribute to these teams. This is fundamentally a deep understanding of human-system interactions, but will involve understanding issues of complexity and how complexity thinking is intertwined with HFE contributions and solutions that facilitate sustainability. As a final point I acknowledge that while some of the issues that I have raised are already part of the HFE discourse, they are not widely taught or part of the core curriculum. This needs to change.

References

- Bentley, T., Green, N., Tappin, D., & Haslam, R. (2021). *State of science: the future of work–ergonomics and human factors contributions to the field.* Ergonomics, 64, 427-439.

- Bolis, I., Brunoro, C. M., & Sznelwar, L. I. (2014). *Mapping the relationships between work and sustainability and the opportunities for ergonomic action.* Applied Ergonomics, 45, 1225-1239.

- Bolis, I., Sigahi, T. F. A. C., Thatcher, A., Saltorato, P., & Morioka, S. N. (2022). *Contribution of Ergonomics and Human Factors to Sustainable Development: A systematic literature review.* Ergonomics, in press, 1-19. https://doi.org/10.1080/00140139.2022.2079729.

- Carson, R. (1962). *Silent spring.* Houghton Mifflin.

- Damper, R. I. (2000). *Editorial for the special issue on 'Emergent properties of complex systems': Emergence and levels of abstraction.* International Journal of Systems Science, 31, 811-818.

- Dekker, S. W., Hancock, P. A., & Wilkin, P. (2013). *Ergonomics and sustainability: towards an embrace of complexity and emergence.* Ergonomics, 56, 357-364.

- Dul, J., Bruder, R., Buckle, P., Carayon, P., Falzon, P., Marras, W. S., Wilson, J. R., & van der Doelen, B. (2012). *A strategy for human factors/ergonomics: developing the discipline and profession.* Ergonomics, 55, 377-395.

- Fiore, S. M., Phillips, E., & Sellers, B. C. (2014). *A transdisciplinary perspective on hedonomic sustainability design.* Ergonomics in Design, 22, 22-29.

- García-Acosta, G., Saravia Pinilla, M. H., & Riba I Romeva, C. (2012). *Ergoecology: evolution and challenges.* Work, 41, 2133-2140.

- Hoffman, R. R., & Hancock, P. A. (2017). *Measuring resilience.* Human Factors, 59, 564-581.

- Johnston, P., Everard, M., Santillo, D. & Robèrt, K. (2007). *Reclaiming the definition of sustainability.* Environmental Science Pollution Research, 14, 60-66.

- IPCC (2022). *Summary for policymakers. In Climate Change 2022: Impacts, adaptation and vulnerability.* Contribution of working group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. doi:10.1017/9781009325844.001.

- Lang, D. J., Wiek, A., Bergmann, M., Stauffacher, M., Martens, P., Moll, P., Swilling, M., & Thomas, C. J. (2012). *Transdisciplinary research in sustainability science: practice, principles, and challenges.* Sustainability Science, 7, 25-43.

- Lange-Morales, K., Thatcher, A., & García-Acosta, G. (2014). *Towards a sustainable world through human factors and ergonomics: it is all about values.* Ergonomics, 57, 1603-1615.

- Lumber, R., Richardson, M., & Sheffield, D. (2017). *Beyond knowing nature: Contact, emotion, compassion, meaning, and beauty are pathways to nature connection.* PLoS one, 12(5), e0177186.

- Monroe, M. C., Plate, R. R., Oxarart, A., Bowers, A., & Chaves, W. A. (2019). *Identifying effective climate change education strategies: a systematic review of the research.* Environmental Education Research, 25, 791-812.

- Moray, N. (1995). *Ergonomics and the global problems of the twenty-first century.* Ergonomics, 38, 1691-1707.

- Moray, N. (2000). *Culture, politics and ergonomics.* Ergonomics, 43, 858-868.

- Sterling, S. (2001). *Sustainable education: Re-visioning learning and change.* Green Books.

- Thatcher, A. (2013). *Green ergonomics: definition and scope.* Ergonomics, 56, 389-398.

- Thatcher, A., Lange-Morales, K., & García-Acosta, G. (2020). *A future ethical stance for HFE toward sustainability* (Chpt. 3; pp. 51-73). In Thatcher, K.J. Zink & K. Fischer (Eds.). Human factors for sustainability: theoretical perspectives and global applications. CRC Press.

- Thatcher, A., Waterson, P., Todd, A., Moray, N. (2018). *State of science: ergonomics and global issues.* Ergonomics, 61, 1-33.

- Thatcher, A., & Yeow, P. H. P. (2016). *A sustainable system of systems approach: a new HFE paradigm.* Ergonomics, 59, 167-178.

- Thatcher, A., & Yeow, P. H. P. (2018a). *Sustainability and resilience: using the sustainable system-of-systems model for ergonomics interventions.* Ergonomics SA, 30 1-16.

- Thatcher, A. & Yeow, P. H. P. (2018b). *Ergonomics and human factors for a sustainable future: current research and future possibilities.* Palgrave-MacMillan.

- Thatcher, A. & Yeow, P. H. P. (2020). *Factors to consider in the application of the sustainable system-of-systems model for human factors and ergonomics interventions* (Chpt. 10; pp. 217-236). In A. Thatcher, K. J. Zink & K. Fischer (Eds.). Human factors for sustainability: theoretical perspectives and global applications. CRC Press.

- Thatcher, A., Nayak, R., & Waterson, P. (2020a). *Human factors and ergonomics systems-based tools for understanding and addressing global problems of the twenty-first century.* Ergonomics, 63, 367-387.

- Thatcher, A., Lange-Morales, K., & García-Acosta, G. (2020). *A future ethical stance for HFE toward sustainability* (Chpt. 3; pp. 51-73). In A. Thatcher, K. J. Zink & K. Fischer (Eds.). Human factors for sustainability: theoretical perspectives and global applications. CRC Press.

- Thatcher, A., Zink, K. J., & Fischer, K. (Eds.). (2019). *Human Factors for Sustainability: Theoretical Perspectives and Global Applications.* CRC Press.

- UNCHE (1972). *Declaration of the United Nations Conference on the Human Environment.* Stockholm: United Nations Conference on the Human Environment.

- Van der Linden, S., & Weber, E. U. (2021). *Editorial overview: can behavioral science solve the climate crisis.* Current Opinion in Behavioral Sciences, 42, iii-viii.

- Woods, D. D. (2015). *Four concepts for resilience and the implications for the future of resilience engineering.* Reliability Engineering & System Safety, 141, 5-9.

- Zink, K. J. (2014). *Designing sustainable work systems: The need for a systems approach.* Applied Ergonomics, 45, 126-132.

ANDREW THATCHER

Prof. Thatcher is chair of organisational/industrial psychology, past-president of the Ergonomics Society of South Africa, and past-chair of the Human Factors and Sustainable Development Technical Committee of the International Ergonomics Association (IEA). He is currently chair of the IEA's Future of Work Task Force. Prof. Thatcher developed the theory behind green ergonomics and the Sustainable System-of-Systems framework. He is an editor of the journal 'Ergonomics'. He is the author of three books (including two on HFE and sustainability) and more than 75 peer-reviewed journal articles.

Sustainable workplace: An integrated approach to industrial ergonomics and service design

HASSAN SADEGHI NAEINI[1,2], GIOVANNI MARI CONTI[1], MARTINA MOTTA[1], KARMEGAM KARUPPIAH[3], NASER KOLEINI MAMAGHANI[2], MAHDIEH JAFARNEJAD[2]

[1] Design Department, Politecnico di Milano (POLIMI), Milan, Italy
[2] School of Architecture and Environmental Design, Iran Univ. of Science & Tech. (IUST), Tehran, Iran
[3] Faculty of Medicine & Health Science, University Putra Malaysia (UPM), Serdang, Selangor, Malaysia

Abstract

Sustainable development has three main pillars including economic, ecological, and social aspects, in which "human" plays a prominent role, in this regard, people's health and safety interventions should be considered by employers and industrial sector managers toward working quality of life. Therefore, the role of some multidisciplinary science such as Ergonomics is so crucial. In this descriptive study aims to show the relationship between ergonomics and sustainability on the context of a holistic service system toward quality of working life. Two main keywords of ergonomics and sustainability were searched among the last five-year scientific works in the Web of Science, also to illustrate the figure out information, the VOS viewer was used. In the first screening in topics, 367 documents were extracted including 226 papers, 108 conferences' proceedings, 35 reviews, and six book chapters. Considering the exclusion criteria, the findings showed that 19 universities/organizations have the main role in publishing ergonomics and sustainability papers, in which, the Marche Polytechnic University and the University of

Witwatersrand are at the top list. According to our results, study and research in both fields of ergonomics and sustainability should be done more in the context of service design to make more effective outcomes.

Background

Sustainable development (SD), as a global pledge in which seventeen goals are introduced, is a practical strategy toward quality of life for current communities and the new generations. Sustainable development has three main pillars include economic, ecological, and social aspects, in which there isn't any boundary between them. All of these pillars make up the scope of SD.

Also, Sustainable development can be used in every community, society, industrial sector, and organization around the world. All of the sectors, based on their authorities and activities, are responsible for continuous improvement in sustainability. Though, industrial sectors, according to their characteristics, play a critical role in sustainability because they hire several sorts of human resources (which is related to social aspects of SD), run the production, develop some products and by-products (which is related to economic aspects of SD), using different materials and resources, different energy consumption (which is related to ecological aspects of SD), and so on (Sadeghi Naeini, 2020).

Besides, "human" has a prominent role in sustainable development, and according to the Rio Declaration on Environment and Development, the main core of sustainable development is human beings (Antrim, 2019); in this regard, health and safety interventions should be considered by employers and industrial sector managers (Sadeghi Naeini, 2020). This is a fact that human beings face problems in terms of overuse of resources and energy, environmental degradation, climate change, and so on. To overcome the mentioned wide challengeable circumstance, the science, knowledge, and disciplines that are related to human health and workers' quality of life should be deliberated; in this regard, ergonomics, based on its scopes and goals, is able to help employers to reach occupational health on the context of sustainability (Martin et al., 2013).

Although in the concept of ergonomics or human factors issues, humans are associated with other elements of systems toward quality of life, it means ergonomics are related to sustainability and plays a prominent role in achieving the outcomes of SD (Lin et al., 2019).

Furthermore, as sustainability and ergonomics are known as human-centered science, so the role of ergonomics is crucial (Hanson, 2013; Sadeghi Naeini, 2020).

Occupational Ergonomics and Sustainability

Ergonomics

Ergonomics as a multidisciplinary science concerns human being, work-related health and safety, and workstation, product and working system design based on quality of life (Karuppiah et al., 2020; Montoya-Reyes et al., 2020; Sadeghi Naeini, 2015).

has some sub-branches in which each part includes some specific fields. These branches are Micro-, Macro-, cognitive, cultural, and environmental ergonomics(Sadeghi Naeini, 2020) (Fig. 1).

- Micro-Ergonomics concerns anthropometry, physical workstation design, work physiology, and so on.
- Assessment of the relationship between technology and users' knowledge is done under Macro-Ergonomics. Macro-Ergonomics includes the Techno-social aspects of work systems,
- Cognitive ergonomics studies human perception and human-machine reciprocal communications. Also, the design characteristics of displays and controls are assessed in this part of ergonomics,
- Cultural or social ergonomics emphasize human attitudes, beliefs, and other aspects of users or customers,
- Environmental ergonomics concerns illumination, noise, radiations, heat stresses, and so on.

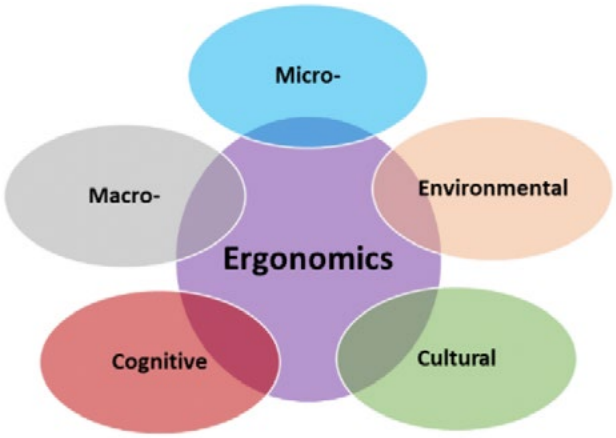


Figure 1. Ergonomics and its branches (Sadeghi Naeini, 2020).

All the mentioned subjects help the managers and employees and HSE experts to assess workplaces and workstations in terms of physical and mental workloads (Sadeghi Naeini, 2020). Occupational Ergonomics which focused on tasks and working duties introduces some sorts of interventions. These interventions and ergonomic improvements will be ended to more work-related quality of life for both white and blue-collar workers. However, the experts of ergonomics should take into account that needed to input at a macro level, as well as at a micro level with practical and innovative interventions (Martin et al., 2013).

One of the recent ergonomics-based interventions is known as green ergonomics, in which human sympathy with the natural world is concerned, in fact, when we talk about human beings and SD, natural environment and conservation of environment cannot be ignored (Thatcher, 2013).

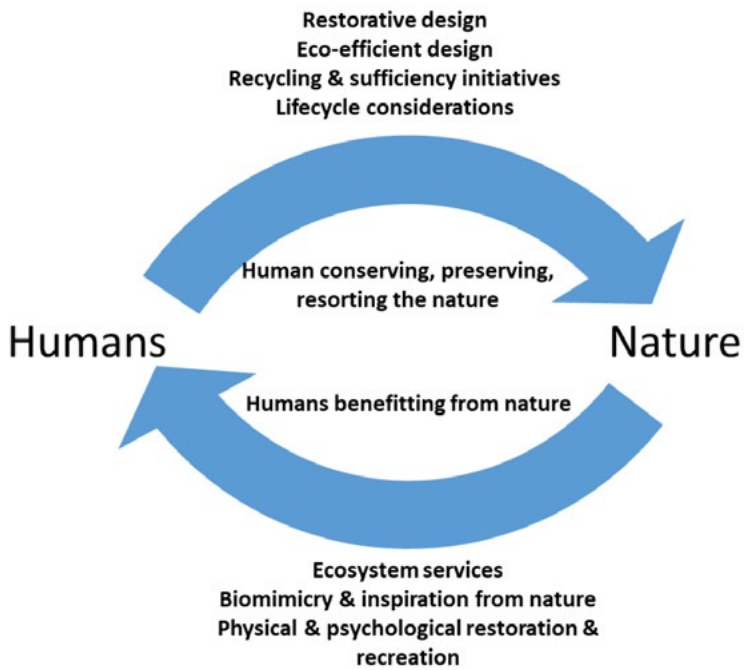


Figure 2. The relationship between humans & nature in the context of green ergonomics (Thatcher, 2013).

Sustainability

According to World Commission on Environment and Development (WCED) (Brundtland G.H, 1987), "sustainable development is a development that meets the needs of the present without compromising the ability of future generations to meet their own needs".

In addition, Sustainable development in industrial sectors concerns all aspects of economic, ecological and social aspects of working systems. Also eco-efficiency and Design for Sustainability concern the quality of life (Chapman, 2009; D'Anna & Cascini, 2016; Vezzoli et al., 2022). Natural resource protection and management are very important subjects toward sustainable development actions because of theses resource are not endless (Bolis et al., 2020).

All the mentioned sustainable development pillars are associated with quality of life not only for current communities but also for future generations (Corsini & Moultrie, 2021; Sadeghi Naeini, 2020), in this regard, industrial sectors' workers are involved too, therefore, there is no boundary between ergonomics issues and sustainability approaches. Surely, merging these two firms creates a synergetic theme for having a better working life for employees. Also, Work-related issues are known as one of the prominent items which is related to sustainability. Nonetheless, the essential of considering to firm association between work and sustainability is not good enough, therefore, activity-centered ergonomics and considering the work-related psychodynamics circumstance are important (Brunoro et al., 2020).

One of the recently introduced paradigms which explain the mentioned merging of sustainability and ergonomics is entitled *ErgoSustaiNomics* (Naeini, 2019). It is an integrated approach to both benefits of ergonomics interventions and sustainability (Appendix1).

Ergonomic Design for Workplaces

Workplaces as a general, and workstations as a specific term suffer some sorts of work-related hazardous agents (Benjamin O. Alli, 2002), therefore all of the workplaces should be assessed in terms of occupational health. Occupational health concerns some main objectives such as promoting the health of workers and their working capacity, improving the environmental conditions, and working cultures development toward workplaces safety and health (Jaiswal, 2022). In general, the most parts of work-related health and occupational disorders and work-related hazardous agents can be assessed by ergonomists. Indeed, each parts of ergonomics disciplines might be

used toward occupational health improvement, for instance *"fitting the workstation dimensions to the workers should be done by anthropometric measurement which is studied under micro-ergonomics, in fact in this case, workstation design will be done according to body dimensions of workers and calculation of percentiles make some guideline for workstation design. Labeling and clarifying some information about equipment and machines which are important in every working system are addressed by the human cognitive process. The mentioned side of the working systems is studied by cognitive ergonomics. Designing the lighting systems based on workers' needs should be done under environmental ergonomics aspects. Managing the system in terms of symbiosis between workers and technologies, shift working schedule, rotational planning among workers, and so on, are concentrated by Macro-Ergonomics approaches"*.

Considering the above-mentioned, Industrial ergonomics considerations should be reflected as a whole system. Indeed, ergonomics approaches and appropriate ergonomic interventions might be known as a "service design" beyond the product or workstation design.

Service Design

The word "service" meant different views and scopes, however, according to Oxford English Dictionary "Service is helping or doing work for another", Collins dictionary mentioned "service is "something that the public needs, such as transportation, communication facilities, hospitals, or energy resources, that is planned and organized by the government or an official institution are presented". Also, the Cambridge Dictionary defines a service as "a public system or private organization responsible for a specific type of activity, or for providing a specific thing that people need"(Morelli et al., 2021). Service also is known as an infrastructure of working systems in which rules, directions, and procedures are noticeable. It means serving as a systemic entity i.e., health system, scientific issues, or organizational knowledge organizes activities and processes. The term service design more or less is rooted in marketing issues (Morelli et al., 2021). A service blueprint can be used to depict each activity and stage of service production, to improve the service process and delivery. In particular, this scheme can represent the big picture of product development and design, in which the service concept, the service ecosystem (including customers and the service delivery system), and the service process are integrated (Gao et al., 2022).

Considering the above-mentioned scope for service design, it seems that most of the sustainability concerns, as the same as ergonomics, might be run in the context of service design. Furthermore, ergonomics as a multidisciplinary science that has a dual goal of health and productivity will be harmonized with service design issues.

Methodology

In this descriptive study, authors conducted to explore the reciprocal relationship between ergonomics and sustainability on the context of a holistic service system toward quality of working life. In this regard, the scientific and research works which were done during last five-year period were assessed in the Web of Science (WOS) search-engine. The criteria for selection the results were two words of "ergonomics" and "sustainability". In the first phase the VOS viewer was used for the WOS results. We assessed and selected the VOS results based on authors, organizations, and keywords distribution. However, to find the authors who published the related papers or book chapters, some criteria were chosen i.e., having at least three written work with at least 5 citations. To find the related organization, at least 4 the written works and citation were used to achieve the result. To find the related words, at least 10 repetition of words in the documents was selected and to find the clear data, some familiar words were merge together (clearing the data).

Results

Based on the WOS and searching two chosen words of ergonomics and sustainability, the 367 documents were extracted from the WOS database, based on the search terms of ergonomics and sustainability in the "topics" of the documents which were included papers (No. 226), conferences' proceedings (No. 108), 35 reviews, and the book-chapters (No. 6). The Fig. 5 showed the result of searched the related words in the documents. The related words were 2016, however after screen the words distribution based on at least 10 repetitions, the final extracted words changed to 22. As Fig. 5 shows the three words of "strategy, model, and industry" were mentioned in the most written works in last two years. These selected documents were written by 1228 main authors in which only the 26 cases were selected after applying the selection criteria (writing at least 3 documents with 5 or more citations). Our results showed that 585 organizations were involved, then after applying the selection criteria (having at least 4 documents with

at least 4 citations), this numbers were changed to 19 cases. Among the organizations which mostly were universities, the top two were Marche Polytechnic University, and University of Witwatersrand.

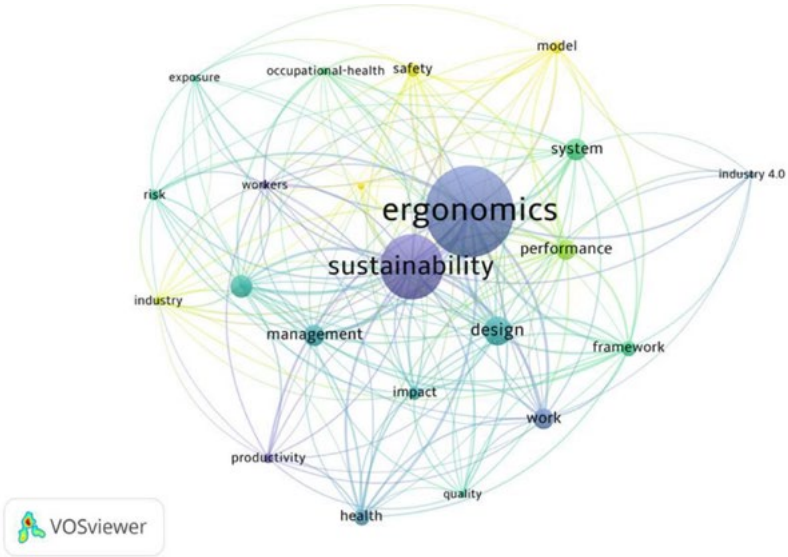


Figure 3. Map of selected words distribution during last 5 years.

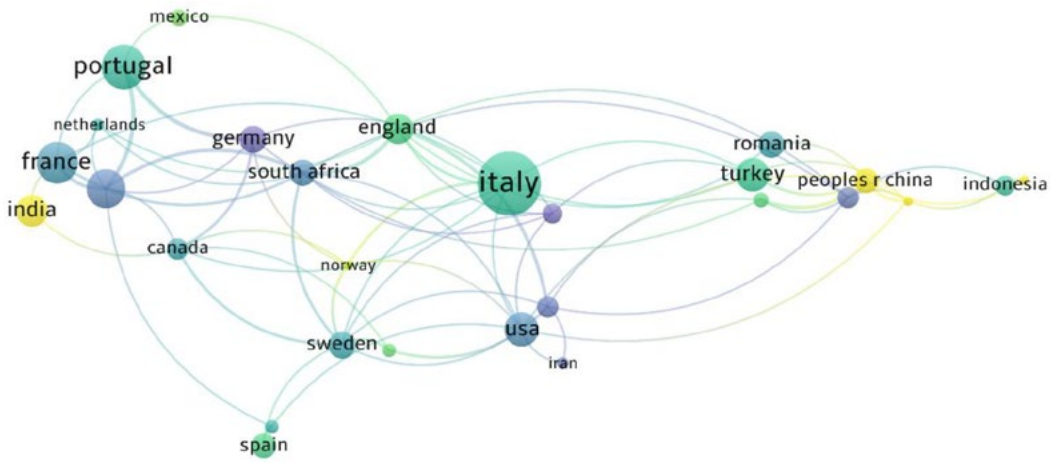


Figure 4. Map of country-based research (2018-2022).

As Fig. 4 shows the country distribution that are involved the research and study about ergonomics and sustainability during last 5 years. In the first step 68 countries were figure out, in which only 30 of them had at least 5 documents (with at least 5 citations), in which the first

rank belongs to the Italy (43) followed by Portugal (28), France (26) and so on. (Tab.1). Also some of the universities are more active in research and study about both ergonomics and sustainability (Tab.2)

Table 1. The countries and documents numbers.

COUNTRY	DOCUMENTS	COUNTRY	DOCUMENTS
Italy	43	Canada	12
Portugal	28	Malaysia	12
France	26	Indonesia	11
Brazil	24	Poland	11
USA	21	Mexico	9
Turkey	20	Singapore	8
India	19	Chile	7
England	18	Denmark	7
Germany	16	Slovakia	7
Sweden	16	Iran	6
Romania	15	Netherlands	6
South Africa	15	Greece	5
China	14	Japan	5
Spain	14	Norway	5
Australia	12	Taiwan	5

Table 2. The organizations (Universities) and their documents numbers.

ORGANIZATION	DOCUMENTS
Univ Politecn Marche	8
Univ Witwatersrand	8
Loughborough Univ	6
Univ Modena & Reggio Emilia	6
Ryerson Univ	5
Univ Minho	5
Univ Salerno	5
Univ Sao Paulo	5
Anadolu Univ	4
Natl Res Ctr Working Environm	4
Natl Taiwan Univ Sci & Technol	4
Natl Univ Singapore	4
Poznan Univ Tech	4
Transilvania Univ Brasov	4
Univ Appl Sci Emden Leer	4
Univ Fed Paraiba	4
Univ Nova Lisboa	4
Univ Padua	4
Univ Southern Denmark	4

Conclusion and Discussion

Ergonomics has an association with all aspects and efforts in sustainability (Dekker et al., 2013), otherwise, sustainability also has a health perspective on the context of user friendly products and environmentally friendly ones (Martin et al., 2013). Green ergonomics that concern natural capital and energy saving is not separate the social and economic aspects of SD (Hanson, 2013). Also, the green ergonomics the same as another ergonomics' sub-branches involves the systematic behaviour changes (Thatcher, 2013). Social aspects of SD include the different aspects of the quality of life (Naeini, 2019). Furthermore, two main fields of ecoefficiency' and 'ecoproductivity' in the context of ergoecology are recently considered. Ergoecology consists of three approaches to anthropocentric, sustainability and also systematic (Saravia-Pinilla et al., 2016) in which ecoefficiency and ecoproductivity are also considered (Sadeghi Naeini, 2020). Considering the mentioned fields are so important to approach sustainability, however, easy-to-use ecodesign tools in the preliminary phase of product and tools design shouldn't be ignore (Bernstein et al., 2010). Nowadays, meeting the customers and consumers' requirements and needs based on sustainability are considered by manufacturers(Lin et al., 2019). Practical methods in ergonomics covers both environmental design and user-oriented design (Sadeghi Naeini, 2020). Ergonomics makes a win-win state for both employers and employees (Dekker et al., 2013), and this benefit is related to all angles of sustainability. Basically, ergonomics is known as a empiricist and positivist field (Dekker et al., 2013). Also, product and service design are involved in the both process of ergonomics and sustainability (Naeini, 2019). Design assumes a human-centered approach in which users' requirements' and need should be met (Botta D., 2020). Product design strategies are related to industrial development and productivity (Sadeghi Naeini, 2015), in which ergonomics has an effective role(Sadeghi Naeini, 2020), besides, design for and Sustainability throughout ergonomics consideration is also shown the essential role of ergonomics, too (Nadadur & Parkinson, 2013; Tosi, 2012) otherwise sustainable product should be a user-friendly design (Ljungberg, 2007) therefore, essential role of ergonomics in both approach of sustainability and production can not be ignored. Furthermore, the side of economics in SD concerns costs of product development and production (Morelli et al., 2021). Both of ergonomics, and sustainability are known as human centered science

concern quality of life (Sarbat & Ozmehmet Tasan, 2022), however, each one has its own specific characteristic beyond the other, in this regard merging the benefits of these two firms make a synergetic new issue, and the new paradigm was coined by Sadeghi (2018) as "ErgoSustaiNomics" (Naeini, 2019). According to our results, ergonomics and sustainability should be considered in industrial ergonomics interventions simultaneously, and there are some experts in different country who are doing some research in the both fields, however, this sort of studies is not good enough, so more and more studies should be done to encourage the related authorities and even people to improve their actions on the context of sustainability and ergonomics considerations. Undoubtedly, to develop some effective actions in ergonomics and sustainability (or ergosustanabilty), deploying a service design might be an effective and feasible way map to proceed the appropriate outcomes. Finally, in the concept of sustainable development, human centrality plays a key role, therefore, workers are central to SD (Bolis et al., 2020). Undoubtedly, having some specific meetings by IEA in the national level and some of the national wide societies such as SIE to invite the researchers who are interesting in both ergonomics and sustainability for instance considering the above mentioned results may be ended to practical, effective and feasible action in both national and international levels.

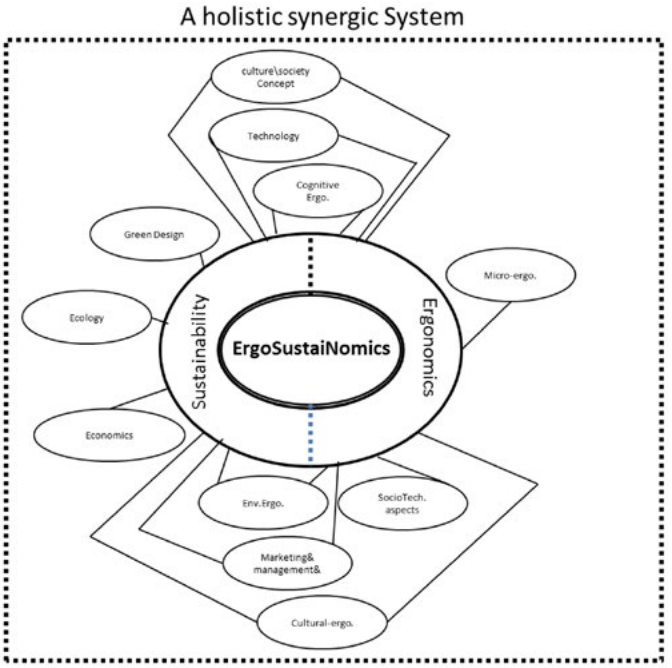


Figure 5. The concept of ErgoSustaiNomics as an integrate paradigm including ergonomics and sustainability (Sadeghi Naeini, 2020).

References

- Antrim, L. N. (2019). The United Nations Conference on Environment and Development. In A. E. Goodman (Ed.), *The Diplomatic Record* 1992-1993 (1st ed., pp. 189–210). Routledge. https://doi.org/10.4324/9780429310089-10

- Benjamin O. ALLI. (2002). Fundamental principles of occupational health and safety. *Choice Reviews Online*, 39(07), 39-3997-39–3997. https://doi.org/10.5860/CHOICE.39-3997

- Bernstein, W. Z., Ramanujan, D., Devanathan, S., Zhao, F., Sutherland, J., & Ramani, K. (2010). Function Impact Matrix for Sustainable Concept Generation: A Designer's Perspective. *Volume 6: 15th Design for Manufacturing and the Lifecycle Conference; 7th Symposium on International Design and Design* Education, 377–383. https://doi.org/10.1115/DETC2010-28340

- Bolis, I., Morioka, S. N., Brunoro, C. M., Zambroni-de-Souza, P. C., & Sznelwar, L. I. (2020). The centrality of workers to sustainability based on values: Exploring ergonomics to introduce new rationalities into decision-making processes. , 88, 103148. https://doi.org/10.1016/j.apergo.2020.103148

- Botta D. (2020). Designing artificial intelligence systems: A proposal for an ethical and responsible approach. SIE, 21, 10–17.

- Brundtland G.H. (1987). *Report of the World Commission on Environment and Development Our Common Future.* UN.

- Brunoro, C. M., Bolis, I., Sigahi, T. F. A. C., Kawasaki, B. C., & Sznelwar, L. I. (2020). Defining the meaning of "sustainable work" from activity-centered ergonomics and psychodynamics of Work's perspectives. *Applied Ergonomics*, 89, 103209. https://doi.org/10.1016/j.apergo.2020.103209

- Chapman, J. (2009). Design for (Emotional) Durability. *Design Issues*, 25(4), 29–35. https://doi.org/10.1162/desi.2009.25.4.29

- Corsini, L., & Moultrie, J. (2021). What Is Design for Social Sustainability? A Systematic Literature Review for Designers of Product-Service Systems. *Sustainability*, 13(11), 5963. https://doi.org/10.3390/su13115963

- D'Anna, W., & Cascini, G. (2016). Adding quality of life to design for Eco-Efficiency. *Journal of Cleaner Production*, 112, 3211–3221. https://doi.org/10.1016/j.jclepro.2015.09.109

- Dekker, S. W. A., Hancock, P. A., & Wilkin, P. (2013). Ergonomics and sustainability: Towards an embrace of complexity and emergence. *Ergonomics*, 56(3), 357–364. https://doi.org/10.1080/00140139.2012.718799

- Gao, Y., Zhang, Q., Xu, X., Jia, F., & Lin, Z. (2022). Service design for the destination tourism service ecosystem: A review and extension. *Asia Pacific Journal of Tourism Research*, 27(3), 225–245. https://doi.org/10.1080/10941665.2022.2046119

- Hanson, M. A. (2013). Green ergonomics: Challenges and opportunities. *Ergonomics*, 56(3), 399–408. https://doi.org/10.1080/00140139.2012.751457

- Jaiswal, A. (2022). *The Occupational Health And Safety*. 1, 261–269.

- Lin, C. J., Belis, T. T., & Kuo, T. C. (2019). Ergonomics-Based Factors or Criteria

for the Evaluation of Sustainable Product Manufacturing. *Sustainability*, 11(18), 4955. https://doi.org/10.3390/su11184955

- Ljungberg, L. Y. (2007). Materials selection and design for development of sustainable products. *Materials & Design*, 28(2), 466–479. https://doi.org/10.1016/j.matdes.2005.09.006

- Martin, K., Legg, S., & Brown, C. (2013). Designing for sustainability: Ergonomics – carpe diem . *Ergonomics*, 56(3), 365–388. https://doi.org/10.1080/00140139.2012.718368

- Nadadur, G., & Parkinson, M. B. (2013). The role of anthropometry in designing for sustainability. *Ergonomics*, 56(3), 422–439. https://doi.org/10.1080/00140139.2012.718801

- Naeini, H. S. (2019). Towards Quality of Life Through the "ErgoSustaiNomics" Approach. In S. Bagnara, R. Tartaglia, S. Albolino, T. Alexander, & Y. Fujita (Eds.), *Proceedings of the 20th Congress of the International Ergonomics Association* (IEA 2018) (Vol. 825, pp. 662–668). Springer International Publishing. https://doi.org/10.1007/978-3-319-96068-5_71

- Nicola Morelli, Amalia de Götzen & Luca Simeone. (n.d.). Service Design Capabilities.

- Sadeghi Naeini, H. (2015). *Occupational Health Promotion throughout an Interventional Ergonomic Design* (Case Study: An Ergonomic Cart Design at a Food Manufacturing Company in Iran). 5.

- Sadeghi Naeini, H. (2020). *Ergonomics on the Context of Sustainability: A New Approach on Quality of Life.* 30(2), 265–276.

- Saravia-Pinilla, M. H., Daza-Beltrán, C., & García-Acosta, G. (2016). A comprehensive approach to environmental and human factors into product/service design and development. A review from an ergoecological perspective. *Applied Ergonomics*, 57, 62–71. https://doi.org/10.1016/j.apergo.2015.11.007

- Sarbat, I., & Ozmehmet Tasan, S. (2022). Ergonomics indicators: A proposal for sustainable process performance measurement in ergonomics. *Ergonomics*, 65(1), 3–38. https://doi.org/10.1080/00140139.2021.1953614

- Thatcher, A. (2013). Green ergonomics: Definition and scope. *Ergonomics*, 56(3), 389–398. https://doi.org/10.1080/00140139.2012.718371

- Tosi, F. (2012). Ergonomics and sustainability in the design of everyday use products. *Work*, 41, 3878–3882. https://doi.org/10.3233/WOR-2012-0055-3878

- Vezzoli, C., Conti, G. M., Macrì, L., & Motta, M. (2022). Designing sustainable clothing systems: The design for environmentally sustainable textile clothes and its product-service systems. FrancoAngeli.

HASSAN SADEGHI NAEINI

Ph.D, is an Associate Professor at the Industrial Design Dept., Iran University of Science & Technology(IUST). His scientific field is Ergonomics in Design and most of his research and teaching are focusing on Ergonomics and sustainability. Journal papers publishing, books, book chapters writing, and attending several international conferences as a presenter or keynote speaker are some of his scientific works. He is a referee in some international journals and a referee team member in some national industrial design competitions and exhibitions. Recently, he is working at the School of Design, Politecnico di Milano (POLIMI), as a Visiting professor to conduct research in the field of Ergonomics and sustainability.

GIOVANNI MARI CONTI

Ph.D, Associate Professor, is currently the Coordinator of the Knitwear design Lab – Knitlab of the Fashion Design Degree at Politecnico di Milano. Founder and Scientific Coordinator of the website/blog www.knitlab.org, he is expert collaborator of the Instituto Italo-Latino Americano – IILA in the Pymes Forum for cooperation projects on textile and fashion. He is a member of the editorial board of “Lupetti. Editori di Comunicazione" and in 2020 he received the Honorable Mention at the XXVI Compasso d'Orofor the "DigiKnit" research. He is Director of the Master in Fashion Direction: Product Sustainability Management at MFI (Milano Fashion Institute Consortium) and a member of LeNS - International Learning Network on Sustainability.

MARTINA MOTTA

(Ph.D. cum laude in Design), is Research Fellow at the Design Department of Politecnico di Milano. As a faculty member she teaches at the School of Design of Politecnico di Milano, in the FIT in Milan program of the Fashion Institute of Technology (NY), and at Milano Fashion Institute. At MFI she is also vice-director of the Master in Product Sustainability Management. Her teaching and research activity on contemporary fashion have a particular focus on knitwear and textile design: on the convergence of traditional manual techniques with advanced technologies, on the evolution of digital representation of textile products, on the enhancement of sustainable design, processes and products within this specific industrial sector.

KARMEGAM KARUPPIAH

(PhD) is affiliated to Department of Environmental and Occupational Health, University Putra Malaysia. He is currently providing services as Associate Professor. He has authored and co-authored multiple peer-reviewed scientific papers and presented works at many national and international conferences. His research interests include Occupational safety and health engineering.

NASER KOLEINI MAMAGHANI

Received his PhD in Artifact Design Science, with a specialization in humanomics at Chiba University, Japan (2002). He is presently an Associate Professor of Industrial Design, School of Architecture and Environmental Design, at Iran University of Science and Technology. His research interest is in the field of applied ergonomics, with a focus on emotion research. He has published two books i.e. Kansei Engineering (in Persian). He has also presented papers at national and International Journals and conferences.

MAHDIEH JAFARNEJAD SHAHRI

Is an industrial design PhD student at Iran University of Science & Technology(IUST). She as a designer has already developed some conceptual designs in both product and service design. She also got some design awards. The main field of her research and study are ergonomics and aesthetics in design.

New Digital Health Challenges: development of a Help Community for the cancer patient

ESTER IACONO[1], VERONICA FRANCHINA[2], DARIO PIAZZA[3], VINCENZO ADAMO[4]

[1] Laboratory of Ergonomics and Design (LED), Department of Architecture, University of Florence, ITALY
[2] UOC Medical Oncology AO Papardo, Messina, ITALY
[3] GSTU Foundation for Cancer Research, Palermo, ITALY
[4] Scientific Director of Oncology A.O. Papardo, Messina, ITALY

Abstract

The crisis generated by the pandemic has made it clear the need to redefine the strategies relating to the fulfilment of goal 3 of Agenda 2030 (*Good Health and Well-being*) according to the new model of sustainable development. It considers the protection of environmental, social and economic resources, thanks also to the increase of digital societies. Within the healthcare context, to cope with the difficulties of carrying out healthcare services in the presence of and reducing hospital access, there has been a greater diffusion of new digital tools, accelerating the *digital health* race.

In a hospital-territory integration strategy, taking care of the patient is fundamental. He needs not only continuous monitoring but also a relational comparison with others.

Therefore, the work proposed in this article presents the results of a project developed by a multidisciplinary team within the Department of Medical Oncology of the Papardo hospital in Messina. The goal is to respond to the need to *bring treatments closer, bring people*

***together* and bridge the physical and relational distance through developing new digital solutions.**
In particular, the methodological approach of Ergonomics for Design and Human Centered Design, adopted in this work, has provided an effective strategy in allowing the development of a *patient-centered*, sustainable and innovative platform aimed at patients with breast cancer. The goal is to provide continuity between the hospital journey and the return home and to allow the patient, even at a distance, to feel supported in their needs, requests and expectations.

Introduction

The crisis generated by the pandemic has made it clear the need to redefine the strategies relating to the fulfilment of goal 3 of Agenda 2030 (*Good Health and Well-being*) according to the new model of sustainable development. The promotion of this model is based on an approach that considers the protection of environmental, social and economic resources, thanks also to the increase of digital societies (Collicelli & Cascelli, 2021).
In particular, the efficiency of the health service is often linked to digitisation. Today, the use of technology in the health sector is concretely translated into benefits for the patient but also for health facilities. As early as 2005, the 58th *World Health Assembly* in Geneva recognised the potential of e-Health to strengthen health systems and improve quality, safety and access to care and encouraged Member States to take action to introduce digitalisation into health systems and services.
With the onset of the Covid-19 emergency, to cope with the difficulties of providing healthcare services in the presence of and reducing hospital access, there has been a greater diffusion of new digital tools, which inevitably led to what is defined as "*digital health*".
Through apps, telemedicine and Industry 4.0, digitisation has firmly established itself in the healthcare sector. The new information and communication technologies (ICT) are revolutionising health systems and contributing to their future sustainability.
Focusing on a sustainable, resilient and equitable health system, the National Recovery and Resilience Plan (PNRR) provides for significant investments in the health sector. These investments make it possible to exploit digitisation's benefits to all users involved.
Rethinking services and processes by integrating them with digital technology, making them practical, efficient and centered on the

needs of the players operating in the health sector, becomes one of the main prerogatives for developing the "*Connected Care*" model. The latter represents the ecosystem that, through web-based digital platforms, guarantees the patient access and sharing of health information with all those involved in the treatment process (Sgarbossa & Locatelli, 2022).

However, in a strategy of hospital-territory integration, taking care of the patient is fundamental, who needs continuous monitoring and a relational comparison with others. The gap, created on both fronts, can be bridged by applying new technologies. Augmented reality, gamification, and technologies at the service of emotions and knowledge become helpful tools capable of guaranteeing more effective services.

Therefore, the work proposed in this article presents the results of a project developed by a multidisciplinary team within the Cracking Cancer Hackathon initiative to respond to the need to *bring treatments closer*, *bring people together* and fill physical and relational distance through the development of new digital solutions.

Breast cancer: between Breast Unit and post-hospital care

According to the latest survey carried out by the Italian Cancer Registries Association (AIRTUM), breast cancer is still the most frequently diagnosed cancer in women in Italy today. About 55,000 women get sick annually, one-third of the total cancers affecting the female population (AIRTUM-AIOM, 2021).

According to the Breast Cancer Research Foundation, two million women worldwide are diagnosed with breast cancer annually. It is estimated that one in eight women will develop the disease in their lifetime. However, thanks to increasingly sophisticated diagnostic tools and cutting-edge therapies, the chances of recovery are always higher. Today, breast cancer has an excellent average prognosis, with a survival of 88% five years after diagnosis (Gori, Miglietta & Modena, 2021).

The care of women affected by this disease deserves excellence. Therefore, establishing multidisciplinary breast cancer centres, or Breast Units, was fundamental. From diagnosis to follow-up, it provides for taking charge of all breast cancer patient's physical and psychological needs. As a model of assistance, specialised in the diagnosis, treatment and psychophysical rehabilitation of women, the

Breast Unit provides that the management is entrusted to a multidisciplinary group of experienced professionals in the breast and oncology field. They support the patient in the different phases of his path of care, from taking charge to managing the therapeutic assistance process, promoting clinical-experimental research activities with innovative drugs and at the same time guaranteeing information activities and specific initiatives through the involvement of patients' associations.

From 18 December 2014, through the approval of the "guidelines on the organisational and assistance methods of the network of breast care centres", the Italian Breast Units have a reference to offer women the best services and care (Europa Donna, 2020).

Breast cancer patients, therefore, by turning to individual centres that operate in synergy on the territory just like a network, can take advantage of services that guarantee prevention and continuity of care. In this context, the establishment of a network of breast centres in Sicily has seen the creation of as many as 17 Breast Units (Figure 1), which pursue the following goals:

- prevention and information on correct lifestyles;
- mammography screening and level II investigations with the most advanced technologies and highly specialised personnel;
- genetic counselling and psychological support;
- treatment with the most innovative surgical techniques and drugs;
- continuity of treatment and management of complications, as well as oncological nutrition.

Despite the support guaranteed by the Breast Units, the rapid spread of Covid-19 and the consequent restrictions on access to hospitals have inevitably conditioned the dynamics of the management of oncological diseases in all phases of the diagnostic and therapeutic process, as well as inevitably creating a distance physical and relational in post-hospitalisation.

Therefore, the need for patients to interface with health professionals has amplified the need to take advantage of remote patient-therapy monitoring systems (telemedicine), accelerating the *digital health* race.

In addition, following the spread of social media, a different patient approach emerges to information and comparison with other patients and healthcare personnel (Taylor et al., 2020).

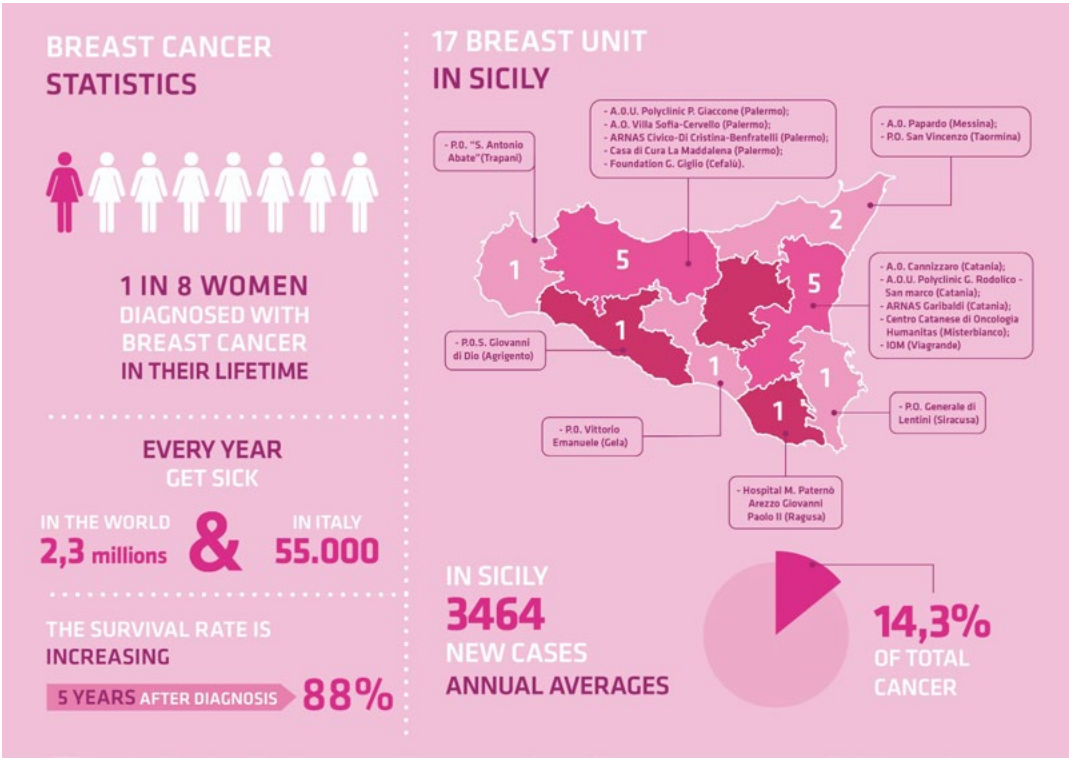


Figure 1. Graphical elaboration of data on breast cancer worldwide, in Italy and the Sicilian Breast Units. (Source: AIRTUM-AIOM, 2021; Europa Donna, 2020).

In particular, the so-called *Health Online Communities* have created new ways of remote interaction to overcome patients' loneliness. Indeed, scientific studies highlight how much patients approach communities initially in search of support and information. However, over time they also find gratification in providing support to others (Shaw et al., 2000).

Therefore, emotional support and respect for autonomy are fundamental elements for providing correct information to the patient (Piazza et al., 2021).

Membership in online cancer communities can eliminate the inhibitions deriving from face-to-face confrontations and foster equal relationships (Crook & Love, 2017). Furthermore, lower rates of depression and stress occur among patients included in these communities (Winzelberg et al., 2003).

Despite the numerous advantages, we should recognise the risks behind the communities, where it is possible to find information

that is only sometimes provided by professional and competent users on the subject.

Therefore, the present research aims to create new therapeutic tools and methods of remote interaction (support community) that allow for overcoming the patient's sense of loneliness and satisfying his needs and expectations alongside physicians, behavioural psychologists, and other experts supervised by a moderator. However, these forms of communication, resulting in the possibility of health improvement, require new measurement tools. Therefore, specific goals were:

1. investigate the criticalities and difficulties encountered by cancer patients in the post-hospital path;
2. develop innovative solutions capable of facilitating the post-hospital path, reducing the distance created when the patient leaves the hospital.

Methodology

The research used the theoretical and methodological tools of Ergonomics for Design (Tosi, 2020), specifically those of Human-Centered Design (ISO 9241-210: 2019) which, including data, information and knowledge collected on and with people in real life and work contexts allow the definition of design solutions.

The study, developed in stages, involved a multidisciplinary team of professionals (oncologists, nurses, computer scientists, communication and digital technology experts, designers, psychologists, data managers, case managers, trainees, project managers, designers and patients). With a participatory design approach, it was possible to encourage dialogue and comparison between the various parties involved. This involvement has made it possible to focus on the needs and expectations of cancer patients and the skills and points of view of the professionals involved in planning and managing services relating to care in the various Breast Units.

The research precisely developed the following operational phases:

i) phase 1: Literature analysis relating to digital technologies for healthcare (gamification, technologies at the service of emotions and knowledge, etc.);
ii) phase 2: Analysis of the critical issues in the post-hospital path;
iii) phase 3: Development of the design concept and scenarios;
iv) phase 4: Evaluation of the feasibility of the project.

Phase 1: Literature analysis relating to digital technologies for healthcare.

Through the review of the literature and state of the art, the first operational phase involved the analysis of the leading scientific contributions and the most recent experiments relating to the application of digital technologies within the world of healthcare.

Starting from the keywords "e-health" and "digital health", it was possible to select the research contributions that, nationally and internationally, were the most significant for research, especially about the experiments/studies of technologies used in the oncology field.

This phase allowed the collection of helpful material to identify reference models and start the subsequent analysis phases in the field.

Phase 2: Analysis of the critical issues in the post-hospital path.

The second phase of the research involved an "expert patient" and various professional figures to activate dialogue and participation processes that would allow the analysis of the context and, specifically, the analysis of the critical issues encountered during the post-hospital path.

For this purpose, the methodologies used in this phase were the following:

i) *focus group* with professionals who work within the medical oncology department (oncologists, nurses, trainees, psychologists, case managers, data managers, etc.), which allowed the collection of suggestions and information regarding the various hospital dynamics, activities and services offered within the departments, as well as indications regarding the functions to be implemented and included in the post-hospital care path;

ii) *semi-structured interview* (Wilson & Sharples, 2015) with an expert patient (PE) able to extrapolate, from his own health experience, the value of valuable knowledge for orienting decision-making and organisational choices both in the field of assistance, both research and social responsibility. What the interviewee reported made it possible to bring out critical issues and unexpressed needs common to many women who have cancer treatments.

The focus groups and interviews were crucial for defining the next phase, which involved developing the design concept and defining possible intervention scenarios.

Phase 3: Development of the design concept and scenarios.

The development of design concepts and the definition of intervention solutions in phase 3 were possible thanks to the application of the following methodologies:

i) *co-design workshop* with a graphic rendering of the results involved designers, project managers, IT experts, communication and digital technology experts and figures suitable for taking charge of the patient and professionals with experience in the breast and psychological field. Furthermore, the workshop, through brainstorming sessions (Nunnally & Farkas, 2017), concept maps (Wheeldon & Faubert, 2009) and the development of mockups, allowed to analyse of existing criticalities and encouraged the emergence of new ideas through discussion and creation of shared collective knowledge.

ii) *design-orienting scenarios* (Manzini & Jégou, 2004) have been useful for the development of "plausible" and "questionable" visions and proposals. For example, this tool made it possible to represent the team's strategic vision regarding developing an innovative and patient-centered community.

Overall, these methodologies were used to conduct activities aimed at:

- Analysis of the critical issues and difficulties encountered by cancer patients in the post-hospital path;
- Generation of ideas and definition of the platform's contents and the language used in the digital service.

Phase 4: Evaluation of the feasibility of the project.

For the project evaluation, elaborating a SWOT Analysis (von Kodolitsch et al., 2015) was fundamental. It is a methodology aimed at evaluating the opportunities and strengths, but also the criticalities and weaknesses, to determine the most appropriate management methods concerning the internal and external context in which the planning is developed (Figure 2). Furthermore, from an economic and sustainability point of view, it was possible to evaluate and calculate the costs of implementing the platform in the first year of life, analysing the expense items. In order to plan the implementation of the project and the necessary related resources, giving a consequentiality and timing to each phase, a chronogram of activities has also been developed, which extends for eight weeks and includes: the development of the project, the portal, of informative materials, the publication of contents, multidisciplinary meetings, shared interventions, activation of the toll-free number, fundraising, etc.

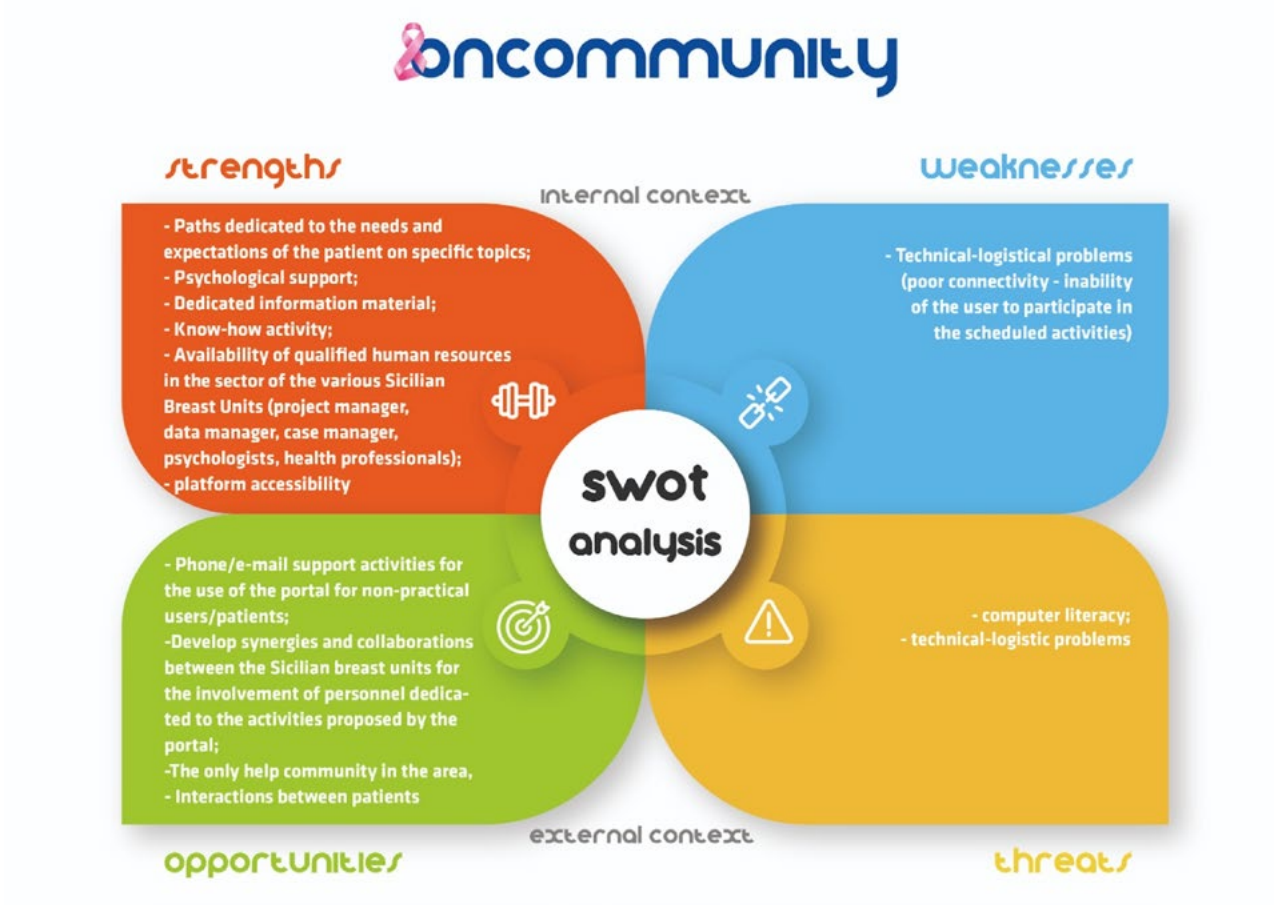


Figure 2. Processing of the Swot Analysis for the evaluation of the Oncommunity platform.

Results

During the processing of the collected data, it was possible to identify the following critical issues:

- Need for support, from a distance, of professionals such as doctors, psychologists, etc., able to alleviate the sense of fear, frustration and loneliness.
- Need for comparison, at a distance, between cancer patients who live the same situation/experience to be able to share and empathise with finding comfort, advice, etc.
- Need for more information on the part of the patient on the aspects concerning the therapy: symptoms, toxicity, duration, etc. and on his care path.

Therefore, based on the critical issues that emerged, it was possible to develop *Oncommunity*, a web-based platform entirely created in-house, with a responsive layout. Maximum compatibility with any computer system, accessibility from any device connected to the network, simultaneous access by multiple users to facilitate teamwork, centralised maintenance and updates of the platform, and reduction of management costs are all attributes that characterise this type of platform (Figure 3).

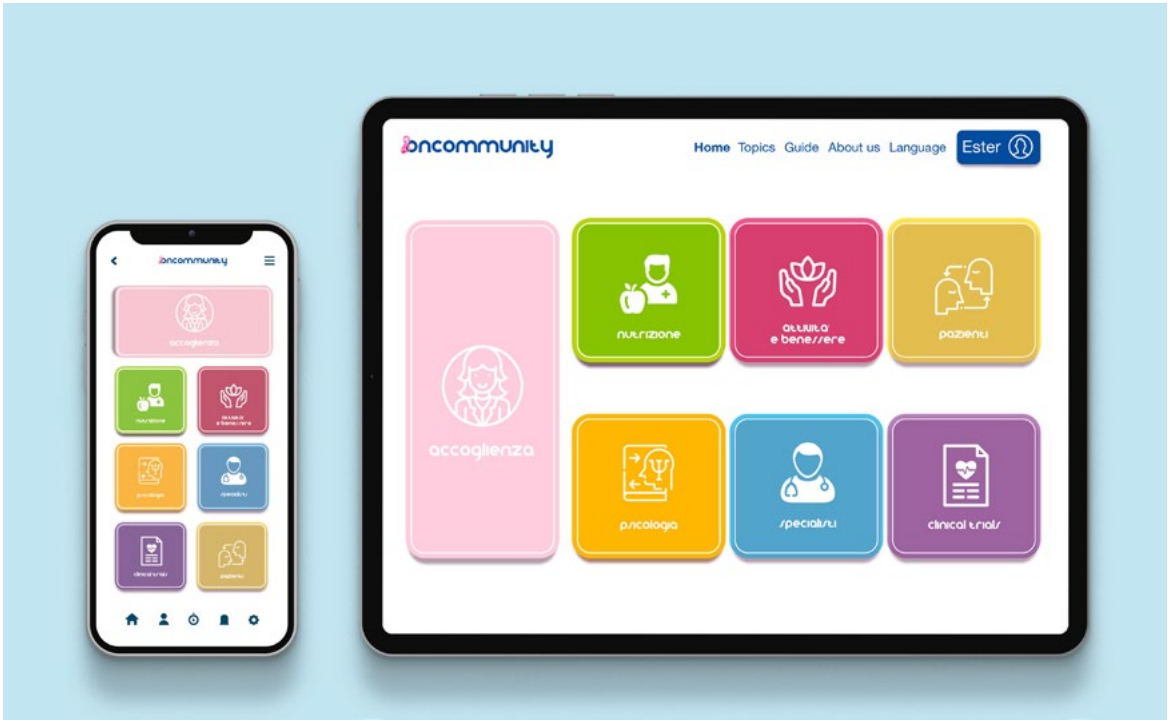


Figure 3. The graphic interface of the web-based platform is compatible with any computer system and accessible from any device connected to the network.

Specifically, it is a cloud-based web server platform with dedicated sub-tools and routines for each activity, i.e. tools made available to users and technologies tailored to the patient's needs. *Oncommunity* is a *patient-centered* platform aimed at patients diagnosed with breast cancer to provide continuity between the hospital path and the return home and to allow the patients, even at a distance, to feel supported in their needs, requests and expectations.

The platform aims to ensure that patients are cared for by professional figures in the post-hospital path to promote greater awareness in dealing with the disease from a medical, nutritional and bio-psycho-social point of view.
Therefore, it requires various human resources, such as Surgeons, Radiologists, Pathologists, Oncologists, Radiotherapists, Nurses, Case managers, Radiology technicians, Data managers, Psycho-oncologists, geneticists, Plastic surgeons, Nuclear doctors, and Data analysts. Conceptually, this *Help Community* is presented as a virtual tour consisting of 7 dedicated rooms (from reception to nourishment, trials, and specialists), which the patient can access, after registration, through his page (Figure 4). The latter requires indicating one's mutational status (for example, if the disease is in an early or advanced stage) in compliance with privacy and current regulations (GDPR). In this way, the user will be automatically redirected to the most relevant rooms/activities at the time of the illness.

Figure 4. *How to register and access the patient's page to take advantage of the services offered by Oncommunity.*

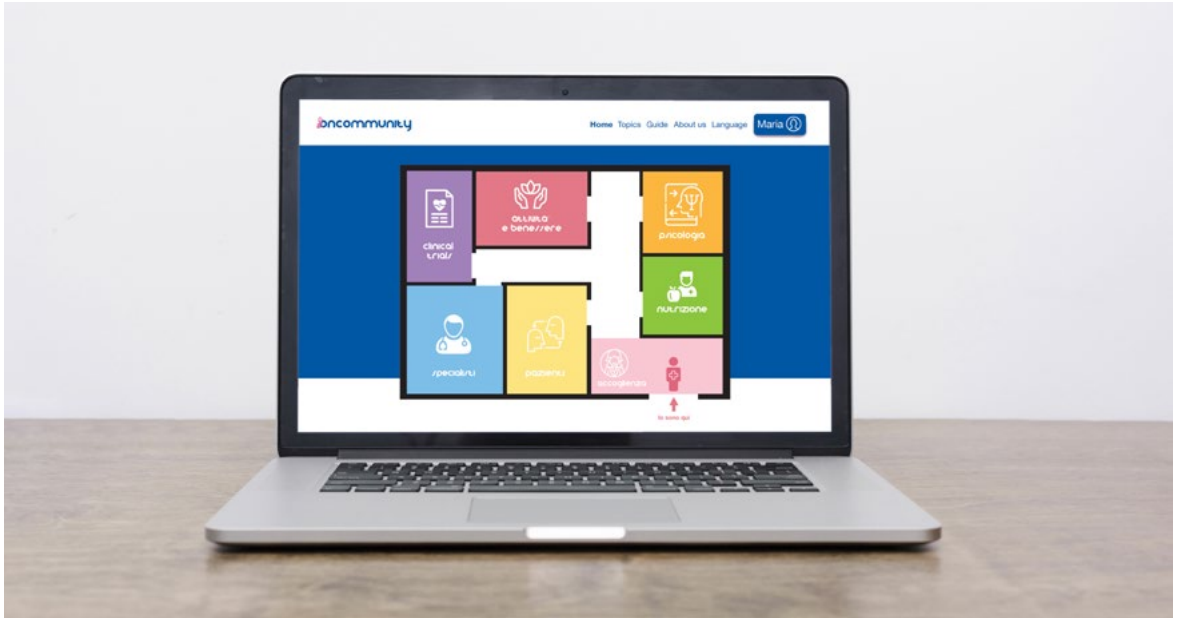


Figure 5. Graphical interface of the virtual tour with the possibility of accessing the various rooms (Nutrition, Activity and Wellness, Patient, Psychology, Specialists, Clinical Trials).

The virtual tour (Figure 5) begins in the first *Reception room*, where the patient is welcomed, taken by the hand and accompanied along the entire path, which includes the choice of the six subsequent rooms (*Nutrition*, *Activities and Wellness*, *Patient*, *Psychology*, *Specialists*, *Clinical Trials*).

Precisely, the *Nutrition room* satisfies the need for discussion; that is, it allows the patient to retrieve information on the correct diet to be followed during the treatment and participate in organised activities with chefs or experts in the sector.

On the other hand, the room regarding *Activities and Wellness* favours close collaboration with various associations, which, through meetings with professionals in the sector (hairdressers, make-up artists, etc.), respond to the patient's needs about lifestyles, physical well-being, and body care.

The need to share one's personal experience with other patients suffering from the same pathology is satisfied by switching on instead in the *Patient's room*. The discussion sessions are coordinated and moderated by a "guide patient" who has already experienced and overcome the disease.

The possibility of accessing the *Psychology room* is also fundamental, which allows greater awareness of what is being experienced through the support of psycho-oncologists and psycho-education laboratories. No less important is the Specialists' room, which guarantees effective communication between patients and healthcare professionals regarding the risks, and benefits of therapy, genetic tests and diagnostic tests to be performed.
Finally, the virtual tour allows access to the Clinical Trials room, which involves the patient in clinical-experimental activities, guaranteeing more information and discussion with the specialists in the sector.
Furthermore, to be more inclusive, the platform provides an email and a dedicated telephone number to contact if the patient needs to get used to technology.
Ultimately, Oncommunity:

1. Favours the creation of a remote multidisciplinary network for breast cancer patients.
2. Allows the patient to be taken in charge, supporting him in his care path.
3. Ensures human support to promote a better quality of life.
4. Guarantees a greater involvement of patients as actors and protagonists of their care path.

Conclusions

Although the research has allowed the identification of future and possible intervention scenarios within the oncology field, a further study that includes a larger sample of respondents would be desirable. Furthermore, this approach would allow us to understand the relational and emotional aspects of the patients. For this reason, further studies and analyses in the field (participatory and co-design processes) involving a diversified and enlarged user of patients and professionals in the sector should be launched to create an even more inclusive, sustainable and centered platform on the needs of the actors involved. Possible future steps of the research include the development of the platform and further usability testing phases that allow testing and improving the contents conceptualised in this survey. However, the results of this study highlighted the need for the following:

- create a new remote multidisciplinary network for the cancer patient who has breast cancer to provide continuity between the hospital path and the return home;

- have professionals who deal remotely with taking charge of the patient in his post-hospital path to promote greater awareness in dealing with the disease from a medical, nutritional and bio-psycho-social point of view;
- involve the patient more in clinical-experimental activities also through correct information and updates on the risks/benefits of the innovative treatments proposed;
- ensure adequate human support for the patient in his clinical path, a world unknown to him, to promote adherence to therapies and a better quality of life.

Therefore, the study highlighted the effectiveness of applying Ergonomics for Design, Human Centered Design and participatory design methodologies to identify sustainable and innovative intervention solutions within the hospital context. Specifically, the involvement of the Medical Oncology department of the Papardo hospital in Messina and a network of experts in different disciplines (psychology, medicine, computer science, etc.) has allowed underlining the importance of better combining the multidisciplinary dimension between multiple spheres of knowledge, to promote sustainability and well-being in the health sector.

Acknowledgements: We are grateful to all the professionals who have contributed to the realisation of this project: Giuseppina Rosaria Rita Ricciardi (Medical oncologist), Francesca Cacciola (case manager), Silvia Grano (psychologist), Massimiliano Spada and Lorena Incorvaia (oncologists), Giorgio Madonia and Giuseppe Mondello (oncology interns).

References

- AIRTUM – AIOM (2021). I *numeri del cancro in Italia 2021, Rapporto Airtum - Aiom*. Retrieved Ottobre 20, 2022, accessibile online su: https://www.salute.gov.it/imgs/C_17_notizie_5681_0_file.pdf

- Collicelli, C., & Cascelli, M. (2021). Salute e sviluppo sostenibile: dalle nuove esigenze sanitarie all'approccio One Health. In *Agenda 2030: un viaggio attraverso gli Obiettivi di sviluppo sostenibile.* Roma: ASviS e Santa Chiara Lab.

- Crook, B., & Love, B. (2017). Examining the light and dark of an online young adult cancer support community. *Qualitative health research*, 27(6), 938-948.

- Europa Donna (2020). *Il Tumore al seno.* Breast Unit. Retrieved Settembre 14, 2022, accessibile online su: https://europadonna.it/wp-content/uploads/2020/07/Manuale-Breast-Unit-2020.pdf

- Gori, S., Miglietta, F., & Modena, A. (2021). Neoplasie per singole sedi: Mammella. In *I numeri del cancro in Italia 2021, Rapporto Airtum - Aiom.* Retrieved Ottobre 20, 2022, accessibile online su: https://www.salute.gov.it/imgs/C_17_notizie_5681_0_file.pdf

- ISO 9241-210 (2019). *Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems.* Ginevra: International Standard Organization.

- Manzini, E., & Jégou, F. (2004). Design degli scenari. In: Bertola, P., Manzini, E. (eds.) Design Multiverso: appunti di fenomenologia del design, pp. 189–207. Milano: Polidesign.

- Nunnally, B., & Farkas, D. (2017). *UX Research, Practical Techniques for Designing Better Products.* Highway North, Sebastopol, CA: O'Reilly Media Inc.

- Piazza D., Borsellino N., Serretta, V., & Gebbia, V. (2021). Prostate cancer patients and their interactions with online oncology communities: a machine learning sentiment analysis. *J Cancer Rehabil* 2021, 4, 37-40.

- Sgarbossa, C., & Locatelli, P. (2022). Il PNRR per lo sviluppo del modello della Connected Care. In Pillole di Sanità Digitale, 147-152, ASSD.

- Shaw, B. R., McTavish, F., Hawkins, R., Gustafson, D. H., & Pingree, S. (2000). Experiences of women with breast cancer: exchanging social support over the CHESS computer network. *Journal of health communication*, 5(2), 135-159.

- Taylor, J., & Loeb, S. (2020). Guideline of guidelines: social media in urology. *BJU international*, 125(3), 379-382.

- Tosi, F. (2020). *Design for Ergonomics*. Cham: Springer.

- Von Kodolitsch, Y., Bernhardt, A. M., Robinson, P. N., Kölbel, T., Reichenspurner, H., Debus, S., & Detter, C. (2015). Analysis of strengths, weaknesses, opportunities, and threats as a tool for translating evidence into individualized medical strategies (I-SWOT). *Aorta*, 3(03), 98-107.

- Wheeldon, J., & Faubert, J. (2009). Framing experience: Concept maps, mind maps, and data collection in qualitative research. *International Journal of Qualitative Methods,* 8(3), 68–83.

- Winzelberg, A. J., Classen, C., Alpers, G. W., Roberts, H., Koopman, C., Adams, R. E., ... & Taylor, C. B. (2003). Evaluation of an internet support group for women with primary breast cancer. *Cancer: Interdisciplinary International Journal of the American Cancer Society*, 97(5), 1164-1173.

ESTER IACONO

Designer, Ph.D in Design and adjunct professor at Department of Architecture of University of Florence. She is currently a research fellow also. Researcher at laboratory of Ergonomics & Design (LED) in the fields of Emotional Design for healthcare, Human-Centered Design/User Experience, Ergonomics for Design and Design for inclusion. In 2019/20, she was lecturer of "Interaction Design" at AAP (Arts Abroad Project) at Overseas Study Center in Florence Teaching Program. She has also participated in national and international research projects and collaborated with public administrations and companies. She is also author of papers published in national and international scientific journals and conference proceedings.

VERONICA FRANCHINA

Study Coordinator & Data Manager. She began her professional experience in the oncology field in 2010 and since 2013 in clinical and experimental-translational research, at the U.O.C. of Medical Oncology of the A.O. Papardo di Messina, certified as a Clinical Trial Center. She obtained no. 4 master in: "Quality management in health services", University of Messina; "Pharmacovigilance, Pharmacoepidemiology, Pharmacoeconomics: Real World Data", University of Messina; "Assistant to clinical research", Faculty of Medicine and Surgery of the Catholic University of the Sacred Heart, "A. Gemelli ", Rome; "E-business and Information and Communication Technologies for Management", University of Messina. She has participated in numerous educational activities also as a speaker and teacher. She is the author of scientific publications and abstract.

DARIO PIAZZA

Lead Project Manager & Clinical Data Scientist at the GSTU Foundation for Cancer Research. He prevalently carries out real life scientific research design activities in oncology. He is co-creator and operations manager of the "Onconsensus Virtual Multidisciplinary Tumor Board" project, which in the depths of the pandemic crisis allowed the continuity of the multidisciplinary approach to oncology patient care by implementing its virtualization on a Sicilian regional multicenter network. He is a founding member of the scientific society Hospital & Clinical Risk Managers, where he promotes ICT expertise in support of modern clinical governance performance and measurement processes. He is the author of 63 scientific papers published in indexed, national and international journals.

VINCENZO ADAMO

Full Professor of Medical Oncology University of Messina. Scientific Director of the Oncology Project and coordinator of the Clinical Trial Center Papardo Hospital. Lead of the Breast Unit and contact person for the Sicilian Region Health Department. Coordinator of the Sicilian Oncological Network and the Molecular Tumor Board. Member of numerous scientific boards and scientific expert for training events. Principal Investigator of numerous clinical-experimental studies. The scientific activity, evidenced by over 200 publications in extenso and over 300 communications presented in national and international conferences, has been oriented towards the aspects of basic and clinical-experimental oncology research, the study of prognostic and predictive factors and integrated treatment of various solid neoplasms.

Ergonomic Interventions for the Design of Sustainable Work Systems

RAJESWARA RAO K. V. S.
Associate Professor, Department of Industrial Engineering and Management,
RV College of Engineering, Bengaluru, India

Abstract

Ergonomics considers the physical and cognitive human factors along with environmental aspects in the design of work systems. The work systems are expected to be organic and sustainable by understanding and aligning with the internal and external environment. Several factors are influencing the state of environment which is evolving over time. This necessitates integrated system designers to incorporate the ergonomic interventions in their design thereby resulting in sustainable systems. This work discusses transformation of work systems due to digitization and digitalization. Accordingly, the evolving role of ergonomic interventions aimed at designing the interfaces for ensuring the sustainability of human–machine interactions is deliberated.

Introduction

A typical integrated design of work system would involve considering human/worker, machine and environment as typical elements. The interactions amongst these elements include human-machine, hu-

man-environment and machine-environment. Over the years system designers have realized the need to incorporate human factors in the design to make the interaction experiences wholesome, comfortable and productive. In today's context, the central concepts of work are intensive work systems and sustainable work systems. The first one focuses on consumption of human resources in work systems and the latter highlights the vision for the future competitive work systems characterized with an environment for human regeneration and growth (Docherty P et al., 2009).The article highlights the need to dynamically focus on ergonomic interventions for transitioning the intensive work systems to sustainable work systems.

Evolution of Work System Design

Conventionally, the work system would comprise of a combination of workers, equipment and tools within a given space and environment and the interactions between these components within an organization. With rapid technological advancements, the component elements in work systems are evolving continuously. Today, a work system comprises of human participants and/or machines performing work using information, technology, and other resources to produce products and/or services for internal or external customers. The work systems have clearly transitioned from manual through semi automatic to automated and smart systems. Work systems as a result vary in complexity and characteristic features.

Work systems earlier were synonymous to a permanent workplace .However; today the ambit of Work system includes temporary/flexible work places. The concept of work system holds good at all levels in the organization and across all types of organizations including the residential spaces.

Ergonomics in Work System Design

Ergonomics as a discipline finds its origin during World War II. With all the able-bodied young men drafted to war, industrialists faced a need to suddenly adapt workplaces to the needs and limitations of a new, more diverse workforce consisting of women, physically disabled, and other previously overlooked groups of society (Berlin & Adams, 2017).

In the developed world, the word ergonomics connotes the comfort and safety associated with the work system design. Unfortunately, in developing parts of the world ergonomics is a luxury. Ergonom-

ics can signify anything from the physical activities and demands of the job, to how the human mind understands instructions and interfaces, to how work organization, teamwork and motivation influences human well-being and efficiency. Furthermore, it may include aspects of aging, working in extreme environments (such as fire fighting, working in freezer rooms or mines), working with protective gear (such as protection gloves, heavy jackets, helmets, etc.). In short, almost any aspect of work involving human activity can be approached from an HFE (Human Factors and Ergonomics) perspective (Berlin & Adams, 2017).

Ergonomics is the design of the workplace, equipment, machine, tool, product, environment, and system taking into consideration the human's physical, physiological, biomechanical, and psychological capabilities and optimizing the productivity and effectiveness of work systems while assuring the safety, health, and well-being of the workers (Fernandez J E, 1995). Ergonomics also consider users' individual differences and their different characteristics, such as gender, age, physical and mental conditions, etc. (Soares, M. M., & Rebelo, F., 2012) The scope of Ergonomics can be categorized into Physical Ergonomics, Cognitive Ergonomics and Organizational Ergonomics.

Physical ergonomics is concerned with human anatomical, anthropometric, physiological, and biomechanical characteristics as they relate to physical activity. It is concerned with the impact of anatomy, anthropometry, biomechanics, physiology, and the physical environment on physical activity. Areas of focus in physical ergonomics include the consequences of repetitive motion, materials handling, workplace safety, comfort in the use of portable devices, keyboard design, working postures, and the work environment (Nigel, B.,2022).

Cognitive ergonomics is concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system. Cognitive ergonomics is concerned with the human brain's ability to interact with and process information, and subsequently, the quality of a person's performance within a given system (Middlesworth, M., 2022). Organizational ergonomics is concerned with the optimization of sociotechnical systems, including their organizational structures, policies, and processes. Macro ergonomics, also referred to as organizational ergonomics, assesses how organizations and systems interact and how these systems of work are designed. It includes having the knowledge and ability to improve systems of work to

improve an organization's overall performance and effectiveness (Werezak, L., 2021).
Initial interventions had their focus on physical work in the industrial set up. Later stages, it was realized that there exists a great opportunity to improve the work place in relation to cognitive capability, teamwork and organizational policies and culture. This will lead to inclusive and sustainable work places.

Trans-disciplinary nature of Ergonomics

"Classical" Ergonomics can be considered essentially as "multidisciplinary" in its contents, availing itself of contribution by several disciplines, and as "interdisciplinary" in the approach to project through mutual exchange of approaches, methods and tools. This is a constructive and coordinated "confrontation" between different disciplines like Psychology, Physiology, Occupational Health, Sociology, Engineering, Architecture, and other ones that, at different levels, offer their own contribution to Ergonomic Design. This approach to project doesn't appear, however, to be able to respond in a sufficiently organic and coordinated way to complexity and novelty of the questions posed by Sustainability. Ergonomics would need to act in a "transversal" way, or better, in a "transdisciplinary" way respect to width of issues related to Sustainability (Di Bucchianico, G., Marano, A., & Rossi, E. 2012).
Ergonomics in a trans- disciplinary sense brings in knowledge from several disciplines as illustrated in Figure 1. The integrated knowledge is applied in the design of work systems.

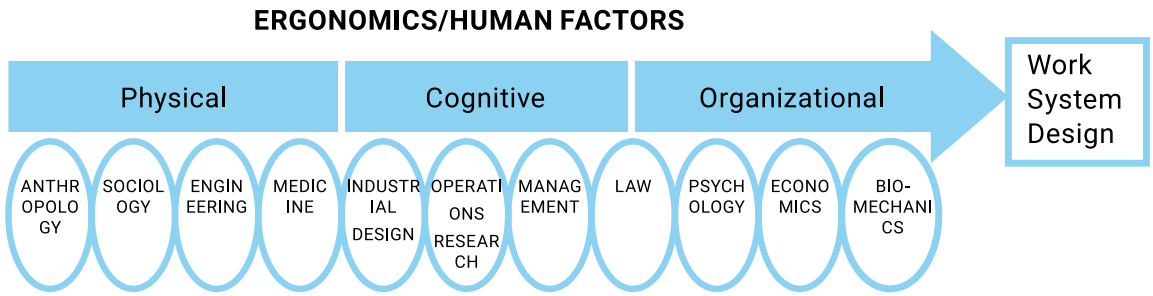


Figure 1. Ergonomics for Sustainable Systems.

Ergonomics and Sustainability

Sustainability can be seen as the dynamic state of resource regeneration and growth while sustainable development means those actions taken to reach and maintain this state (Docherty, Kira & Shani, 2008). The significance of sustainability has developed and spread during the past two decades, permeating widely through political, industrial, commercial, scientific and other channels. The meaning of the term 'sustainable' has shifted and evolved over the years. With earlier use, dating back to the middle ages, the meaning was of something capable of being maintained or likely to endure. More recently, the term has been adopted in connection with reducing consumption and a more active role for humans in protecting the environment. A sustainability agenda by various international agencies have led to wide ranging international action, seeking to make improvements in areas such as: consumption and production, built environment and resource utilization, land use and agriculture, transportation, energy generation and supply, waste and recycling. Human characteristics, behaviour and performance, and human interactions with technology are vital elements of these. A natural synergy exists between these areas and ergonomics, with its goal of understanding and optimizing the outcomes of human-system interactions. More recently, conceptions of sustainability have extended beyond concerns over the use and preservation of the planet's natural and physical resources, to include the sustainability of organizations and the sustainable use of human resources. Although ergonomics and human factors is of its very nature frequently concerned with achieving sustainable outcomes there has, until recently, been little direct connection made with the sustainability movement itself (Roger & Patrick, 2013). The definition of Ergonomics itself is embedded with sustainability as an outcome from human performance perspective (Zink, 2014). Envision 20230 document highlights the need to imagine a world fully inclusive of persons with disability. For this to happen, the human factors have to be considered in designing the work systems to suit the requirements of the workers. In fact, from systems perspective all the 17 sustainable development goals advocated by United Nations can be achieved by considering ergonomically designed work systems.

Ergonomics for Sustainable Work Systems

A sustainable work system is aimed at the regeneration of the resources it utilizes – human, social, material, and natural resources (Docherty, Kira & Shani, 2008).

The Work Systems have been evolving over time because of the technological advancements. What were purely Manual Systems have transformed to Semi-Automatic (Hybrid) and Automated Smart Systems. Ergonomics principles were considered by designers and engineers in designing jobs and workspaces with an objective of providing comfort and safety to the workers. During the early phases of Industrialization physical and physiological factors were considered in the design of work systems/spaces. However, with advancements in technology, the ICT is leveraged in the design of work systems.
Digitization and Digitalization of the processes and systems brings in hybrid systems requiring a new set of interfaces. As the work systems involve predominantly human-computer interfaces, considering Cognitive ergonomics in the design of Work systems becomes a necessity. The term cognitive ergonomics is synonymous to Human-Computer Interaction (HCI) in information technology space. As there is a proliferous introduction of computer systems in production and information technology work systems, there is an increasing focus on understanding the type of interactions and accordingly considering human factors in the design of interfaces for comfortable and safe interactions in the work spaces. Due to this the erstwhile man-machine interactions is getting replaced by human-computer interfaces. For sustenance of organizations, the design of interfaces and structures shall also consider cultural aspects. Designing work systems by leveraging the emerging technologies result in the sustainable work systems. Hence, the ergonomics principles considered for designing the systems have been evolving too.
Non-ergonomic postures and the resulting musculoskeletal disorders are key factors in worker disability and well-being. This underlines the importance of designing ergonomic work environments and educating workers in performing tasks ergonomically for sustainable work (van Deurzen et al., 2022). Social sustainability in work systems can be maintained by using several ergonomic assessment tools (Gajšek et al., 2022). Neglecting the ergonomic principles and practices at workplaces can lead to physical exhaustive, emotional depression and declining productivity (Sanil et al., 2013).

Conclusion

Sustainability is a global issue that has worldwide attention but the role of ergonomics in designing for sustainability is poorly understood and seldom considered. The contribution of ergonomics to

sustainability and sustainable design has been limited, even though the goals of sustainability and ergonomics are congruent. Ergonomists have not been at the forefront of research contributing to sustainability – and it is time for them to 'seize the day' – 'carpe diem' (Martin et al., 2013). Ergonomics as a multidisciplinary science is known as a human centered science that is concerned with human beings and their quality of life. In this regard, the integration between ergonomics and the concept of sustainability might culminate in higher levels of quality of life (Naeini, 2020). Ergonomics is the only factor that drives success and competitiveness in the business world; it focuses on the optimization of socio technical system, including their organizational structure, processes and policies. Ergonomics is not just about how an individual interacts with an object. Organizations need to be ergonomically designed to suit the workers (Thomas et al., 2022). Ergonomics by considering the hard and soft side of human factors can design, make and maintain sustainable work systems.

It is time for theorists, practioners and researchers in the field of ergonomics and human factors to put in place integrated action plans towards achieving the United Nations Sustainable Development Goal: 3 - Good Health and Well-being.

References

- Berlin, C., & Adams, C. (2017). *Production ergonomics: Designing work systems to support optimal human performance.* Ubiquity press.

- Bevan Nigel (2022), Usability Body of Knowledge, Retrieved on November 16,2022, accessible online via https://www.usabilitybok.org/physical-ergonomics

- Di Bucchianico, G., Marano, A., & Rossi, E. (2012). Toward a transdisciplinary approach of ergonomic design for sustainability. *Work*, 41(Supplement 1), 3874-3877.

- Docherty, P., Kira, M., & Shani, A. B. (2009). Creating sustainable work systems. *Abingdon: Routledge.*

- Docherty, P., Kira, M., & Shani, A. R. (2008). What the world needs now is sustainable work systems. In *Creating sustainable work systems* (pp. 27-48). Routledge.

- Fernandez, J. E. (1995). Ergonomics in the workplace. Facilities.

- Gajšek, B., Draghici, A., Boatca, M. E., Gaureanu, A., & Robescu, D. (2022). Linking the Use of Ergonomics Methods to Workplace Social Sustainability: The Ovako Working Posture Assessment System and Rapid Entire Body Assessment Method. *Sustainability*, 14(7), 4301.

- Middlesworth Matt.(2022). Ergonomics 101: The Definition, Domains, and Applications of Ergonomics , Retrieved on November 16,2022, accessible online via https://ergo-plus.com/ergonomics-definition-domains-applications/

- Martin, K., Legg, S., & Brown, C. (2013). Designing for sustainability: ergonomics–carpe diem. *Ergonomics*, 56(3), 365-388.

- Roger Haslam & Patrick Waterson (2013) Ergonomics and Sustainability, *Ergonomics*, 56:3, 343-347

- Sadeghi Naeini, H. (2020). Ergonomics on the context of sustainability: a new approach on quality of life. *Iran University of Science & Technology*, 30(2), 260-271.

- Sanil, S. K., Nair, V. K., & Ramanathan, H. N. (2013). Cognitive Ergonomics and Employee Well-Being in Financial Companies. *Journal of Strategic Human Resource Management*, 2(3), 48.

- Soares, M. M., & Rebelo, F. (2012). Ergonomics in design: solutions and proposals for a better interface with the user. *Theoretical Issues in Ergonomics Science*, 13(1), 1-3.

- Thomas, C. D., Eno, G. U., & Usoro, M. U. (2022). Ergonomics and Organizational Sustainability: A Study of Peacock Paint Limited, Ikot Ekan, Etinan LGA Akwa Ibom State. *International Journal of Business and Management Review*, 10(4), 75-94.

- Van Deurzen, B., Hendrikx, M., Vanacken, D., & Luyten, K. (2022). Work-a-Pose: Ergonomic Feedback and Posture Improvement Interfaces for Long-Term Sustainable Work.

- Werezak, L. (2021). Physical, Cognitive and Organizational Ergonomics. Retrieved on November 16,2022, accessible online via https://doubleblackimaging.com/2021/12/22/physical-cognitive-organizational-ergonomics/

- Zink, K. J. (2014). Designing sustainable work systems: The need for a systems approach. *Applied ergonomics*, 45(1), 126-132.

RAJESWARA RAO

Rajeswara Rao K.V.S. received the B.E in Industrial Production and Engineering from Bangalore University, India, Master's in Manufacturing Management from the BITS, Pilani, India, and the Doctoral degree in Business Administration from Kuvempu University, Shimoga, India. He is an Associate Professor with the Department of Industrial Engineering& Management, R V College of Engineering, Bengaluru, India. He has a total of 25 years of rich experience in the areas of industry, teaching, research, and consultancy and training. His research interests include Manufacturing and Industrial Engineering, Applied Ergonomics, and Functional areas of Management.
ORCID: 0000-0003-1592-5578

Ergonomics and Sustainability. A proposal for an integrated transversality in Higher Education

BRENDA GARCÍA PARRA, ALEJANDRO RODEA CHÁVEZ, LUCILA MERCADO COLIN
Universidad Autónoma Metropolitana. Unidad Cuajimalpa

Abstract

The relationship between Ergonomics and Sustainability is beginning to be widely recognized, particularly to identify the binding aspects that reveal the key components for achieving an approach as complex as the proposal of a (sustainable) development model that challenges a pre-existing vision of reality.

From the educational approach, various proposals have emerged to implement a sustainability vision, including "environmental curriculum", "education for sustainability", among others. These and other proposals agreed that the implementation of a sustainability approach should incorporate "transversality" of subjects and contents throughout study programs. That is, incorporating some subjects on sustainability in an academic program was not enough to strengthen and consolidate a reflective level and the student´s criteria for future decision making.

In this sense, the proposal issued by the United Nations "Decade of Education for Sustainable Development 2005 – 2014" also stands out that a transversal vision of sustainability should envision, not only

a curriculum and study plans, but also two additional and essential aspects in education: campus and community. (Müller-Christ, 2014) In this way, and taking up the existing link between Ergonomics and Sustainability to encourage paradigm changes, re-orient behaviors, or visualize different realities, this article aims to discuss how a transversal approach could be incorporated into the Curricular component of Higher Educational Institutions of both approaches jointly (Sustainability and Ergonomics).

Introduction

Inter-discipline, multi-discipline and trans-discipline, are among some of the strongest assets to provide a way of confirmation that a reasoning coming from a single point of view would led to a limited vision, bringing unfruitful solutions, especially for addressing complex problems.

Although Sustainability isn't awarded as a discipline, applying the same exchange and collaboration principle involving Ergonomics might be key for further understanding deeper root causes, factors and limitations regarding, not only the implementation, but the very comprehension of such an intricate concept as Sustainability.

As this conceptual bonding is being explored, a profound analysis and discussion would be necessary to further identify the possible delivery and implementation strategies, as Sustainability has proven to need diverse approaches, plans and policies in order to be implemented, at global and local levels.

Some of the known UN Strategies for addressing Sustainability, like Agenda 21, 2015 Millenium Development Goals, and current 2030 Agenda for Sustainable Development have revealed the importance of adopting a systemic perspective, while focusing on specific areas (or goals). In this sense, education has been identified as an essential conduit to approach Sustainability, not only as a means for increasing a person´s opportunities to improve a quality of life in general (rising the chance to reach other sustainability goals), but also as a path to integrate and channel knowledge, reflections, ethical postures and overall vision of people who might be decision-makers in the mid and long term.

Higher Education towards Sustainability

Education for Sustainability has been in the center of forums, debates and intergovernmental discussions, leading to the develop-

ment of important contributions in order to implement a sustainability vision.

One the first initiatives, regarding the educational perspective, was encouraged by UNEP (United Nations Environmental Program) and UNESCO (United Nations Educational, Scientific and Cultural Organization), at the Intergovernmental Conference of 1977 about Environmental Education. Even when the main focus was centered on the "natural environmental" in order to identify the necessary knowledge to integrate it at the different educational levels, the breadth of interconnected themes and principles was recognized, thus being considered as an antecedent of an education proposal towards sustainability.

Later on, and as the concept of Sustainability and Sustainable development was being discussed, it became evident the need to differentiate the conceptual integration at different educational levels. With particular emphasis on higher education, Tanguiane and Perevedentsev developed the manual *Pedagogical and scientific criteria to define the environmental content of university education* (1997), where three basic types of education were recommended, the first targeting the general public, the second specific occupational groups whose activity exerts an influence on the environment (architects, engineers, among others), and the third type aimed at training researchers and specialists in issues related to the environment.

The manual revealed in its conceptual framework the range of themes and the breadth of aspects that are contemplated for curricular planning at a higher level, which ranges from global environmental problems, to social aspects such as demographic growth and regional problems, reinforcement of ethical and moral criteria, human behavior, among others. Thus, the environmental education that was proposed, intended to develop a continuous learning process applicable to different contexts to integrate business sectors, and the community in general, weighing social, cultural and economic conflicts.

In addition to the previous recommendations and the different initiatives that have emerged in recent decades for the promotion of education as a basic strategy for achieving sustainable development, the promulgation of the United Nations Decade for Education for Development is distinguished (2005-2014) in which UNESCO's work is recognized to continue highlighting the relevance of *Education for Sustainable Development* (ESD) as an indispensable means to create

awareness, reinforce human commitment and form ethical values for the improvement of an environment at a global level.

One of the proposals issued during the Decade for Education for Development, stands out the importance of incorporating a transversal vision of sustainability, but not only at a curricular level, but also to consider two additional and essential aspects in education: campus and community (Müller-Christ, 2014).

In this sense, besides a curricular integration, it could be possible to continually reinforce essential Sustainability values, reflections, and principles through an articulated interaction with components surrounding the academic community throughout the same campus infrastructure, as well as through the development of activities.

Due to the thematic extension that would be required to address all three components in their entirety, this article will only explore the curricular integration.

Transversality as key factor for curricular integration

As it can be observed, the promotion of education towards Sustainability has evidenced the need to go beyond the incorporation of some subjects or topics related to sustainability in an academic program, but rather it is essential to rethink the curricular structure in order to establish the approach in which a way of thinking will be promoted, as well as the kind of values that should permeate both, the professional and personal lives of students, in the face of environmental, social and economic challenges. This way, curricular transversality in higher education has represented a critical strategy to encourage values that correspond to a long-term vision, due to its ability to promote the integration of contents that in a continuous, jointed, interrelated and evident way reflect common objectives, in order to achieve disciplinary (or better yet, interdisciplinary) training with a clear position in favour of sustainability.

That is, incorporating some subjects on sustainability in an academic program is not enough to strengthen and consolidate a reflective level and the student´s criteria for future decision making. Through a transversal strategy, it is possible to coordinate all curricular contents of a given academic program, in such a way that it results in an integrated consolidation of values, knowledge, attitudes and capacities of the future professional towards a strong compromise with sustainability.

Depending on the particular academic program, the transversal proposal of the curricular structure will clearly vary, and some confrontations will emerge regarding the integration of the "traditional" or general disciplinary knowledge and abilities, with a sustainability view. Especially since it will sometimes involve the confrontation or complete reformulation of the discipline or the academic program.
For example, the transversal integration of a sustainability perspective in an Industrial Design academic program, might need to tackle the very basic approach regarding industrial or mass production concepts, as well as the inherent consumption and production patterns and the scope of a development model it could promote.
Although the focus or depth in which Sustainability will pair with the objectives of the academic program (and the graduate profile) will depend on the Institution's own vision, revising existing studies and proposals, such as the current UN 2030 Sustainable Development Goals, could offer a complete guide on the type of urgent social, environmental and economic challenges, problems, and topics to address at a local and global levels.
Furthermore, specific educational and pedagogical methodologies could provide guidance on how to integrate theoretical and practical content in a totally interrelated manner with the different subjects that make up the curricular structure of the program, such as problem-based learning, among others. In this way, the projects, problems, discussion topics would always have a correlation with respect to those Sustainable Development Goals that are suitable to be addressed in the academic program, according to its profile, scope and objectives.

Ergonomics as a key factor for the activation of transversality

Having an integrated vision of Sustainability at a content-level in any academic program, even when all theoretical and practical aspects are considered, might not be enough to activate and consolidate a viewpoint change, re-direction of some behavior patterns or even a perspective of reality.
This way, Ergonomics could represent that key piece to consolidate a comprehensive transversality strategy, by identifying, anticipating and shaping all those components and factors behind the interpretation of a sustainability conceptualization during the academic program.

Visualizing and studying the student, and the academic community in general, at the center of an environment where interaction conditions can be identified (both from their environment and from the curricular content itself), could show how the curricular approach should be planned and verified, according to the relevance of a specific approach, messages conveyed and the signs involved.

A solid theoretical learning or identification of principles, concepts, causes and factors behind important sustainability problems does not ensure a change in behavior, leaving any effort to achieve Sustainability halfway.

This way, could the academic community (users) of an academic program be considered as part of a comprehensive analysis to identify (and later on, evaluate) the means of transversal curricular intervention of Sustainability as an ergonomic analysis? What kind of behavior change should be observed or anticipated throughout the different curricular levels in the program?

Should specific messages be reinforced through different perceptual and cognitive approaches by the Faculty staff according to UN Sustainable Development Goals transversaly paired with specific subjects?

Just as the United Nations Agenda 21 showed the need to act locally to achieve sustainable development, in the same way the "Locality" of a specific academic program in an institution becomes evident in order to develop a complete plan of analysis and action to achieve curricular transversality towards sustainability.

References

- Declaración mundial sobre la Educación Superior en el Siglo XXI: Visión y acción. UNESCO. 1998 http://www.unesco.org/education/educprog/wche/havdecs.html

- Aleixo, Ana M. Leal, S. Miranda, U. (2018). Conceptualization of sustainable higher education institutions, roles, barriers, and challenges for sustainability: An exploratory study in Portugal. *Journal of Cleaner Production*. 172, 1664–1673.

- Juárez-Nájera, M., Dieleman, H. (2006). Sustainability in Mexican Higher Education: towards a new academic and professional culture. *Journal of Cleaner Production*. 14, 1028-1038.

- Lo-Iacono, V., Torregrosa-López, J., Capuz-Rizo, S. (2016). Use of Life Cycle Assessment methodology in the analysis of Ecological Footprint Assessment results to evaluate the environmental performance of universities. *Journal of Cleaner Production*. 133, 43–53.

- Mc Intosh, M., Cacciola, K., Clermont, S., Keniry, J. (2001). *State of the campus environment: A national report card on environmental performance and sustainability in higher education.* National Wildlife Federation.

- Müller-Christ, G., Sterling, S., Van Dam-Mieras, R. (2014). The role of campus, curriculum and community in higher education for sustainable development – a conference report. *Journal of Cleaner Production.* 62, 134–137.

- Tanguiane, S. and Perevedentsev, V. Programa Internacional de Educación ambiental UNESCO – PNUMA. Serie de Educación Ambiental. Departamento de Ciencias, Educación Técnica y Medioambiental, número 19. UNESCO, 1997.

BRENDA GARCÍA PARRA

Professor and Researcher at UAM Cuajimalpa University. Department of Theory and Processes of Design.
Her research covers the theoretical and practical lines on Ecodesign, Sustainable Design, and Sustainable Product-Service Systems Design. She is currently co-coordinator of the LeNS Mexico network (Learning Network for Sustainability), and coordinator of the LeNS Laboratory at UAM Cuajimalpa Campus. Member of the Systemic Design, Ergonomics and Sustainability academic group.

ALEJANDRO RODEA CHÁVEZ

Professor and Researcher at UAM Cuajimalpa University, Department of Theory and Processes of Design. Industrial Designer and Master degree from UNAM. His research covers the theoretical and practical lines on Design issues, specially from ergonomics approach. Co-author of Ergonomics for Special Populations and User Experience and Perspectives books, as well as various specialized texts on ergonomics. Currently leads the Systemic Design, Ergonomics and Sustainability Academic Group.

LUCILA MERCADO COLIN

Professor and Researcher at UAM Cuajimalpa University. Department of Theory and Processes of Design. Graphic Communicator major and Industrial Design Master degree from UNAM. Her research covers the theoretical and practical lines on Ergonomics, Inquire and Evaluation in Design Process and UCD approach. Member of the Systemic Design, Ergonomics and Sustainability Academic Group.

Systemic Link from (micro) Ergonomics to Sustainable Development. Follow-up to Common Objectives

ALEJANDRO RODEA CHÁVEZ, LUCILA MERCADO COLIN, BRENDA GARCÍA PARRA
Universidad Autónoma Metropolitana. Unidad Cuajimalpa

Abstract

Ergonomics and Sustainable Development are two approaches with multiple points of coincidence. Their goals are synergistic. Although, from a systemic perspective at the highest level, Sustainability as a macro system, involves dynamic balances of all natural and artificial phenomena that promote their indeterminate temporal continuity, evidencing the importance of natural resources, but also social, economic and cultural issues.

Going down to the *meso* systemic level are disciplines such as macroergonomics, which correlates indicators of such objectives with economic effects when implementing macroergonomic interventions, facilitating both reactive and mostly proactive decision-making in the workplace or business.

Seen in this way, ergonomics is conceived more at a *micro* systemic level (not for that reason free of complexity), where the correlation of its User-Object-Activity-Environment components seeks a balance between the tasks assigned to the User and the other elements of the system, with health, safety and user satisfaction and system

efficiency objectives. However, as goals of microergonomics, they cannot be limited - and in fact are not - to the anthropocentric benefit of the user. They are linked to higher systemic levels in multiple ways, although their evidence is unclear.
There is a glimpse of the need to develop a filter or instrument that guides towards good sustainable practices (Conscious Design, Thakara) to, together with those of User-Centered Design, give methodological follow-up to the effects on multiple indicators of the SDGs 2030 observed from efficiency at the microergonomic system.

Introduction

There are many and varied aspects that need to be addressed, as a matter of urgency, when talking about human activities, the development of social groups and climate change. There are, of course, multiple people, groups and organizations that contribute in order to change to what is currently done. It is evident, both globally and temporarily weighted, that acceptable levels of performance are not being reached in accordance with said urgency.
Sustainable Development (SD) is conceptualized due to its enormous complexity as the problem of problems, whose magnitude continues to be elusive up to now "highlighting the dimensions that condition and define such complexity, fundamentally those of a systemic, global, ecological, demographical, local, cultural, political, moral and technological" (Colom, 2007).
This article raises the possibility, even the opportunity to link initiatives that have not often been combined, since they historically started from dissimilar objectives, perhaps disjointed, with different metrics, methods and approaches. Opportunities of blending ergonomics or human factors (HF/E) with Design for the Environment (DfE/ Ecodesign) can bring, as a broader concept, Design for Sustainable Development (DDS), can be glimpsed, methodologically promoting "...eco-efficient innovations of the system and therefore on a broader scale, beyond the individual product" (Vezzoli & Manzzini, 2007), which synergistically seek to have a clear and open impact on environmental sustainability indicators together with those pursued by ergonomics, framed perhaps in social sustainability, promoting health and efficiency of people.
Particularly from the project disciplines of Design and others such as health ones perhaps, it is feasible to find few points of convergence between objectives pursued and tools used to address ergonomic sys-

tems together with areas of environmental impact linked to human activities. The environmental impact (including carbon, water or ecological footprint), resource scarcity and other indicators of wear or use of resources, as well as the effects that human activities cause on their health, can be addressed to a greater or lesser extent from the ergonomic or environmental field. All of this without prejudice to the observance of economic benefits linked to performance or commercially viable outcomes.

"...little concern there is for working comprehensively on human and environmental aspects, and a trend towards segmentation of human and environmental aspects in the field of product/service design and development can be seen, at both concept and application/methodology levels. It was concluded from the above that comprehensive, simultaneous work is needed on human and environmental aspects, clarity and conceptual unity, in order to achieve sustainability in practical matters and ensure that ergoecology-compatible design methods are applied" (Sarabia, Daza & García, 2015).

From the Design field, particularly HF/E in Design, various authors differentiate into preventive and corrective actions, applicable when designing since its conception or through interventions, adaptations or redesigns (Daniellou, 1975, cited by Rodríguez, 2010); (Sarabia, 2006). This timing applies both if human characteristics are taken into account across interaction in an ergonomic system, promoting user's health, safety and satisfaction, fundamentals of User-Centered Design (UCD), as well as when focusing on task productivity and efficiency.

Seen in this way, it is evident that there are good practices (methods, instruments, metrics, and acceptable ranges) which, from the beginning can prevent problems when designing a new situation, system, or product. It also follows that, when diagnosing preexisting situations that are in conflict, it will be necessary to correct problems of highly variable severity, through ergonomic interventions, redesigning them. Rodríguez (2010) evince the opportune timing of the ergonomic action [design] has fewer restrictions of practical origin with more room for maneuver than in an intervention (pp. 87).

Parallel to the HF/E field, timing applies when considering possible environmental impacts. "Eighty percent of the environmental impact of the products, services, and infrastructures around us is determined at the design stage" (Thackara, 2005). From approaches such as ecodesign, or others of an environmental nature, there are also countless good practices and design guides that aids designers

to make decisions regarding the use of energy and materials, production processes or marketing systems for what they design, also linking toxic emissions to the environment that they could represent, in order to improve environmental indicators, and whose application a priori (thru DfE or an environmetally sensitive design) would result in avoiding or minimizing environmental impacts, while a posteriori (ecoRedesign existing consumer products), results in reducing or mitigating those already present. The sooner or later, would environmentally improve products with reduced impacts in the Product Life Cycle (PLC). The problem here was that a product had already been manufactured or procured, with environmental impacts designed in.

Systemic link from microergonomics to sustainable development

HF/E and DSD are two approaches with multiple points of agreement. Their goals are synergistic. Although, at the highest level from a systemic perspective SD, often described as sustainability, it is conceived as the macrosystem on the planet, which involves dynamic balances of all natural and artificial phenomena that promote planet indeterminate temporal continuity, evidencing the importance of having a healthy environment for all forms of life, while integrating social, economic, and cultural aspects, those ones directly linked to humanity.

Going down to a *meso* systemic level, the macroergonomic approach, sometime called Organizational Design and Management (ODAM), correlates indicators of specific objectives, (here primarily ergonomic, but perfectly appropriate and viable those of an environmental nature) with the economic effects that occur when implementing macroergonomic interventions. Evidencing such correlations facilitates decision-making, both reactive but more effective when proactive, in the workplace or business. Hendrick (1996) broadly abounds about it in his text Good Ergonomics is Good Economics.

HF/E as a system is seen in this scheme more as a micro systemic level (not for that reason free of complexity), and whose approaching strategy is based on the correlation of its components (subsystems themselves) User-Object-Activity-Environment, seeking to balance the tasks assigned to the User with those delegated to the other elements of said system to assist him, in the search for efficiency, health, safety and user satisfaction.

However, the objectives of (micro)ergonomics cannot be limited - and in fact they are not - to the anthropocentric benefit of users. They

are linked to a higher systemic levels in multiple ways, although their evidence is not always clear.
Reviewing how such links are visualized, why those are not obvious, how to tie or link them with others of interest to the DSD is a task that, from the methodological even ethical field, it is essential to address in order to integrate it into the logic of doing, designing and manufacturing or whatever human activity is, filtering possible negative effects, yes on users, but on societies, cultures, economy and on the local or global environment.
In general, Design Process Fig. 1 and methods are usually visualized as cyclical (non-linear), with curls or spirals that feed back into the process itself by investigating, proposing and evaluating what is proposed, to improve it to the point where it is considered acceptable.

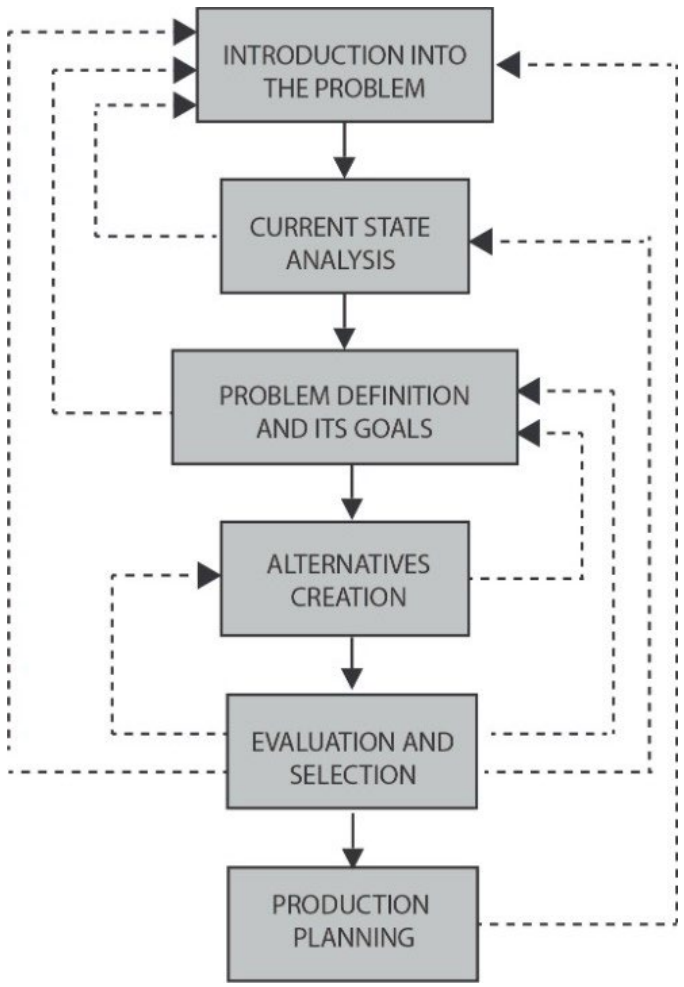


Figure 1. *Model of DP, according to Gugelot (quoted by Rodríguez, 2004) [Transl].*

Ergonomic design models Fig. 2 are also recursive (as all UCD ones), but they focus primarily on indicators related to users; people who will use what is designed and that the logical, dimensional, and perhaps aesthetic consistency of the elements of the designed system are consistent with the user's profile.

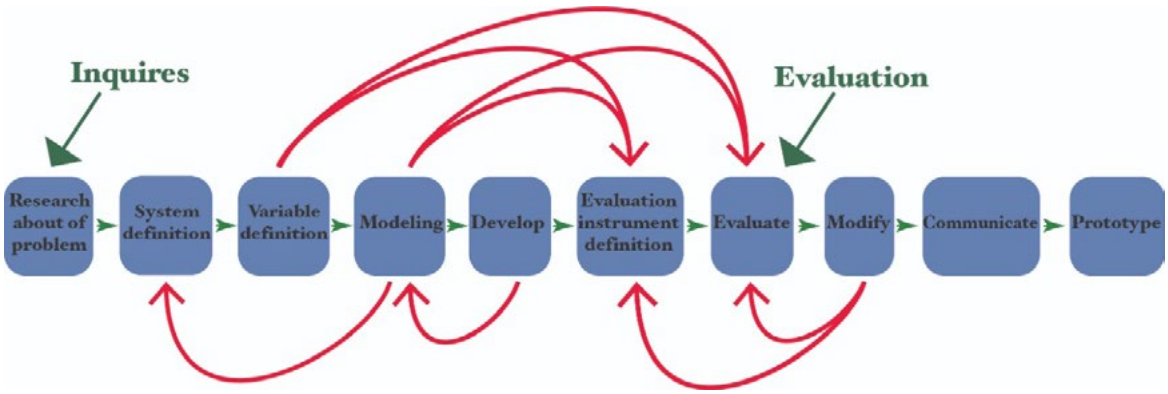


Figure 2. Stages of UCD (Mercado, 2015).

For their part, the instruments for (environmentally) sustainable design analyze "the way in which the product is used, distributed and discarded" (García, 2008); unfolding into aspects observed through various phases of the product life cycle (PLC) Fig. 3, the recyclability of materials, embodied energy, water use, etc., and through expanded diagrams of System Product (SPLC) Fig. 4.

Figure 3. Product Life Cycle. (García, 2008) [Transl].

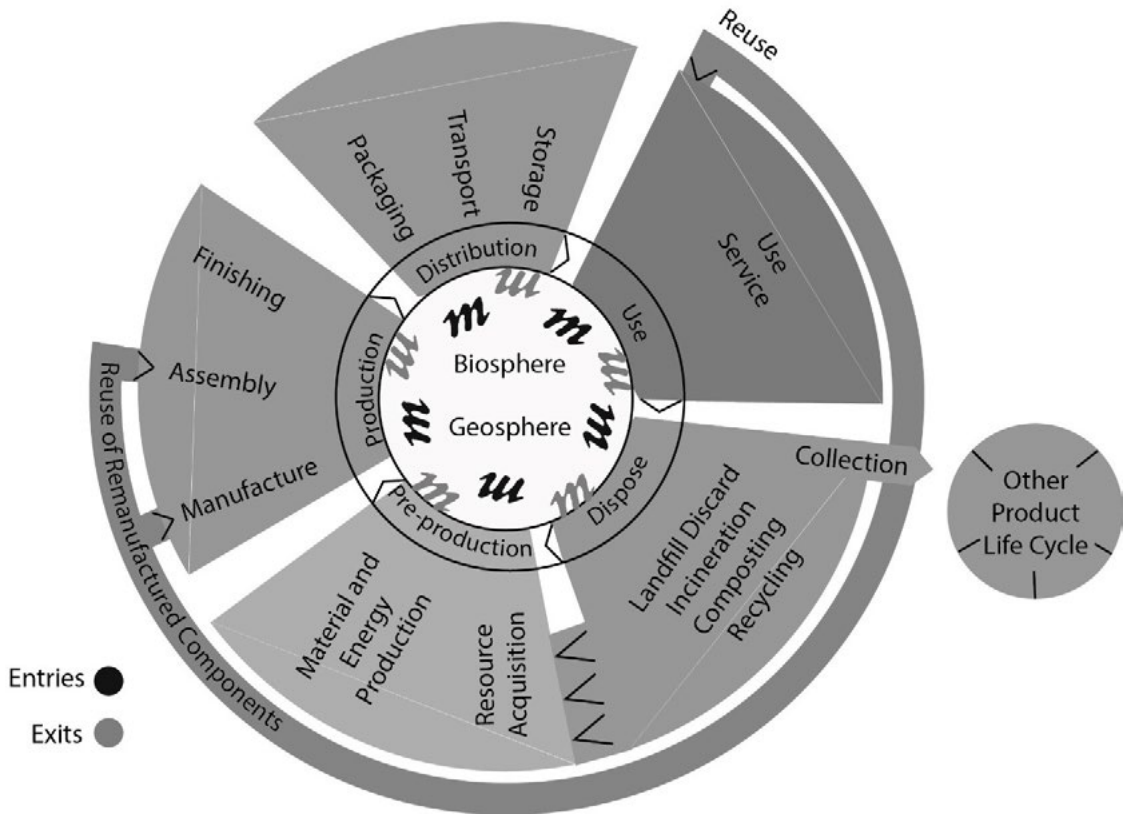


Figure 4. Life Cycle of the System Product, (Vezzoli & Manzini, 2015) [Transl].

Perhaps already in an incipient way, it is evident that the use phase of said LC has great links with the user's interactions seen from ergonomics, but the objectives or metrics are of a different nature. The former seek to minimize negative environmental impacts by observing maintenance, repair and replacement or reuse, while the latter pursue user safety and satisfaction, coupled of course with the efficiency of activities, understood as adequate results, with cost-benefit tolerable etc. However, the ergonomics-ecodesign link can also be followed in the *other LC phases*, and these may be room for ergonomic interventions that could add environmentally sound features, where surely the problems of *other users*, manufacturers, distributors, remanufacturers or operators in recycling and incineration are necessary to attend to both environmental and ergonomic issues.

It is worth highlighting here the scope that today has the application of the concepts of ergonomics (and related disciplines, in many cases

derivatives or evolutions of it, such as usability, experience design, inclusive design, Kansei engineering, etc.) applying in all areas of human activities, from sports, play or leisure, in home environments, on public roads, when being in the sky, sea or even in space. However, in some spheres it's still common to hear HF/E is observed in a very reduced way, only linked to the workplace (where the users are office or industrial workers, carrying out paid productive activities), and attending to a reduced complexity of the ergonomic system to only that of the user-object relationship. A reductionist approach will avoid finding the gaps in the proposed solutions to the ergonomic problem that, in addition, could promote improvements from an environmental approach (and in general SD, covering the pillars recognized by the UN (2011) Social, Economic and Environmental, and Political or Cultural perspectives).

It is also common to find incomplete conceptualizations of the phases that make up the (product) DP and of the PLC, two closely related concepts, but where the first focuses on *stages the designer deal with*, while the second encompasses the moments that the products live, in a symmetrical metaphor with the life cycle of biological entities.

This model Fig. 5 reflects a linear process, where important phases described in cradle to cradle models are not observed, such as reuse and recycling, nor destruction or *end of product life cycle*.

Stages	
1. Planning	Market research Potential users profiling Benchmark Use conditions Norms, legal and technical analysis Product prescription documents
2.. Design	Task assignment and product functions Analysis of user`s tasks Technical analysis Inconrporation of ergonomic specifications Computer Aided Design (CAD) Mockups, simulators, models Prototypes
3. Tests and verification	Prototype tests Modifications Verification
4. Production	Machines and tooling Instalate Documentation
5. Commercialization	Distribute and selling User analysis Reviews

Figure 5. *Stages in Ergonomic Design. (Page, 2001) quoted by Rosal (2011) [Transl].*

How is it that the user's activities in these phases of the LC (the way in which they unfold) affects the greater or lesser environmental impact? A possible answer would be in their efficiency and effectiveness. Errors or inefficient use of material and energy resources have a direct impact on production losses, overconsumption, negative effects on the quality of what is produced and, therefore, possible cascading effects, now on the user of the product.

Making efforts to extend the useful life of products through failed or suboptimal disassembly and repairing work on products, in general, can result in worse environmental impacts than if the product were recycled directly, and may even reflect economic losses or potential risks for those who use remanufactured products.

There is a glimpse of the need to develop a filter or instrument that guides towards good DSD practices, what Thackara (2005 pp.7), quoting Alain Findeli, would say mindfulness design. That approach should deal together with environmental as well as ergonomics issues, *macro and micro levels* at least, in order to give methodological follow-up to the effects on multiple indicators of the SDGs 2030.

Depending on the methodology used by the design team, at the procedural level, the synchronicity of its phases (inquiry, exploration, evaluation, delivery) can shed light on when each ergonomic or environmental objective operates. The initial thing in any process is to identify the problem, linked to the human needs (even if these are seen as global requirements, such as restoration of *their* environment, given the catastrophic conditions that have been reached) as well as requirements, needs or desires of people.

The participatory techniques, characteristical of the UCD and HF/E, have different degrees of integration, going from only involving users (and stakeholders) in the initial phases of inquiry or evaluation, to collaborative ones, where users contribute throughout the entire DP, since the very early stages of problematization, going to the generation and refinement of design ideas, till final evaluation and feeding back the hole DP. The benefit they bring to any always complex DP is evident. “Complex systems are shaped by all the people who use them, and in this new era of collaborative innovation, designers are having to evolve from being the individual authors of objects, or buildings, to being the facilitators of change among large groups of people” (Thackara 2005, pp. 7).

Thus, by identifying such requirements, a variety of possible solutions or satisfiers should emerge, either by brainstorming or by other cre-

ative means. However, that is where the first *sustainable* filter should enter, particularly the environmental one, which includes a broad review of the impacts that such proposals could cause, even in early stages of ideation. Such warnings must be followed up in order to avoid undesired results, and could lead to a rejection of the proposal.
From this analysis, a priori, good practices emerge from the literature, such as the preference of services over products, where the former imply zero or less use of materials, water or any natural resource compared to the latter. It should also be analyzed prospectively, but monitoring throughout the *development or maturation of ideas*, that related to the necessary energy to provide the products (or services if chosen, or their combination in product-service systems). Likewise, foreseeable toxic emissions throughout the LCA of said service or product. A MET matrix, (Materials, Energy and Toxic emission) could be good example of tools devoted for it.
It is known that such analyzes today turn out to be complex, expensive, or require very specific information to be accurate, and applied at so early stages in the DP could largely vary. However, it is of the utmost importance then that the design and development teams apply their knowledge (extensive use of engineering/design toolboxes, lists of good practices, to name some), to heuristically assess the possible environmental effects that the design proposals would entail, insisting on the need to follow up during the maturation of those proposals that continue to be considered as having a promising future.
Returning to the assessment of the needs and the possible satisfiers, it is also important to assess the ergonomics aspects (interaction/product interface) primary and secondary users of said product/service users would face (for example, the driver of a car or the passenger of a taxi service). Although, in these early DP stages, the definition such evaluations could yield would still be blurred, the expectations, emotions or motivations of users could play an important role in terms of the attachment or receptivity of the solution that would be provided or proposed to them; many products/services do not come to fruition due to failure to consider these aspects. “By proposing the creation of satisfiers based on no longer private consumer products but public ones, a concept closely linked to the service economy or functional economy, it emerge the need to assess the acceptance or perception of the user of such products in order to know the implications of this change of type of use of products, from private to public, and target opportunities for improvement

such design proposals refer, and simultaneously avoiding the possible reasons for rejection or detachment of such proposals". (Rodea & Mercado, 2012, pp. 1005).

Among the wide variety of *design guides* that have emerged, consolidating itself by promoting good practices, Fiksel (1996) explores those that seek an environmental upgraded level (DfE), such as the dematerialization or miniaturization, the creation of disassembled products, feasible to repair, and a large list of very specific effects. Meanwhile, good ergonomics practices in design embrace perspectives such as inclusive design, but also design *adjustable* to the specific human characteristics, in such a way that they enhance the result of activities to those that were created and the satisfaction and safety of those who use them.

From the HF/E approach, however, care should be taken when choosing an approaching focus to the user population. On the one hand, *Universal Design* concept conceptually proposes that what is designed should be usable by the entire population, *as far as possible*, without requiring any modification. A laudable question at first sight, but it is not discussed how efficiently will be for the entire population the use of said devices that *stretch* their qualities to cover such a wide range of users. For its part, there is the opposite or more specific vision, which advocates specialized design, which locates the specific characteristics of particular individuals or groups to design tailor-made for them. In this hypothesis, the effectiveness of the activities, as well as the receptivity, could have better performance than in the Universal Design, but effectively, multiple specialized designs would be required to include or satisfy the whole population.

Similar situations are faced from the field of ecodesign/DfE. Concepts such as manufacturing with materials from the area (close to where they will be used) base their logic on minimizing the transport of said materials, and with it the related costs, energy use or polluting emissions. This could be an excellent approach when users are concentrated in very determined or limited spaces and moments, but, in a similar way to the dilemma between Universal or Specialized Design, location of the *factory* or the place of origin of the material(s) could not always be *close* to that of the destination of use. Users could be spread over very large areas, on different continents so, possibly, a distributed production strategy should have better environmental results.

It will therefore depend on the design or development team, wheth-

er they should analyze HF/E or ecodesign/DfE approaches, choosing the best approach, the best practices among the many in their toolbox. It might be particularly helpful to focus on the phases of the PLC that are out of reach of the producing company, where the intended user of said product makes decisions of how and when to use, but also discard or reuse/recycle it, given that, by not being users a specialist in such concepts, they may incur in *bad or suboptimal practices* according to environmental logic. For example, after drinking bottled water, users could perform various actions with the container; save it until found a specialized deposit dedicated for recovering and then recycling it but, is it better to compact it or keep its shape intact? Should it be deposited along with its cap or separately? should it be rinsed and/or should be remove its label before disposing it? Which other good practices could he or she apply? What happens, on the other hand, if users choose to reuse said container?... Intervening by applying paint or decorations may give it a more attractive appearance but, will it be feasible to recycle/disassembly it later?

The best option designers can imagine should be promoted by enhancing it through an ergonomic approaching, i.e., designing the bottle to ease compact/carry with oneself; design easily removable labels without the need for tools.

These, like so many options, could occur with various products during the use and disposal phases, and through consideration of both ergonomics and potential environmental impacts, best user practices could be encouraged. This, of course, implies expanding the vision of the product as an individual entity, to Sustainable Product-Service Systems (SPSS), where the ergonomic vision of the interactions users will have with said system are in accordance with the objectives of SD.

References

- Colom C. (2007). *La Complejidad Del Desarrollo Sostenible.* Miscelánea Comillas. Vol. 65 Num. 126 , 511-534.

- Fiksel J. (1996). *Ingeniería de diseño medioambiental.* DfE. McGraw Hill/ Interamericana de España.

- Hendrick H. (1996) Good Ergonomics is Good Economics. Reprinted with adaptations from Proceedings of the Human Factors and Ergonomics Society 40th Annual Meeting. 1-15.

- Lockrey S., Verghese K., Pears A., Taylor P. & Fennessey L. (2016) Ecoredesign: Methods and Products for Environmental Change. In *RMIT Design Archives Journal* vol. 6 Num. 1, 42-50.

- Page A., Porcar R., Such M.J., Solaz J. & Blasco V. (2001) N*uevas técnicas para el desarrollo de productos innovadores orientados al usuario*, IBV, Valencia.

- Rodea A. & Mercado L. (2012). A methodology for connecting User Centered Design UCD with Ecodesign. The possibility of migration of products to services based on user acceptance. *Work. A Journal of Prevention, Assessment & Rehabilitation* 41, 1004-1007.

- Rodríguez M. Luis. (2004) *Diseño: estrategia y tácticas*. S. XXI. CDMX.

- Rodríguez V. Mario. (2010) *Principios para un abordaje macroergonómico; útil, práctico y aplicado.* U. Nacional de Colombia. Bogotá.

- Rosales López, G. (2011). *Elaboración de metodología basada en la ergonomía de producto y ecodiseño aplicada a mobiliario escolar. Validación Metodológica del producto.* Tesis Doctoral. U. de Oviedo.

- Saravia-Pinilla M., Daza-Beltán C & García-Acosta G. (2015) A comprehensive approach to environmental and human factors into product/service design and development. A review from an ergoecological perspective. *Applied Ergonomics* 57, 62-71.

- Thackara J. (2005). *In the Bubble. Designing in a Complex World.* MIT, Massachussets.

- United Nations. Equilibrar los pilares para el desarrollo sostenible. https:// www.un.org/es/desa/desarrollo-sostenible Last seen Dec.17th2022

- Vezzoli C., & Manzini E. (2015). *Diseño de productos ambientalmente sustentables.* Designio, CDMX.

ALEJANDRO RODEA CHÁVEZ

Professor and Researcher at UAM Cuajimalpa University, Department of Theory and Processes of Design. Industrial Designer and Master degree from UNAM. His research covers the theoretical and practical lines on Design issues, specially from ergonomics approach. Co-author of Ergonomics for Special Populations and User Experience and Perspectives books, as well as various specialized texts on ergonomics. Currently leads the Systemic Design, Ergonomics and Sustainability Academic Group.

LUCILA MERCADO COLIN

Professor and Researcher at UAM Cuajimalpa University. Department of Theory and Processes of Design. Graphic Communicator major and Industrial Design Master degree from UNAM. Her research covers the theoretical and practical lines on Ergonomics, Inquire and Evaluation in Design Process and UCD approach. Member of the Systemic Design, Ergonomics and Sustainability Academic Group.

BRENDA GARCÍA PARRA

Professor and Researcher at UAM Cuajimalpa University. Department of Theory and Processes of Design. Her research covers the theoretical and practical lines of Ecodesign, Sustainable Design, and Sustainable Product-Service Systems Design. She is currently co-coordinator of the LeNS Mexico network (Learning Network for Sustainability), and coordinator of the LeNS Laboratory at UAM Cuajimalpa Campus. Member of the Systemic Design, Ergonomics and Sustainability Academic Group.