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► To cite this version:

Maxence Denu, Aurélie Landry, Pierre David, Fabien Mangione. How to study human skills development in a complex industrial environment: feedback on the use of digital simulation in a multidisciplinary project. Better Life Ergonomics for Future Humans, International Ergonomics Association, Aug 2024, Jeju City, South Korea. halshs-04731364

HAL Id: halshs-04731364

<https://shs.hal.science/halshs-04731364v1>

Submitted on 10 Oct 2024

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How to study human skills development in a complex industrial environment: feedback on the use of digital simulation in a multidisciplinary project.

SUMMATIVE STATEMENT:

In the context of a remanufacturing company seeking to improve its training process, the intervention carried out proposes a multidisciplinary approach including digital simulation making it possible to link the operational performance to the operator health and the skills acquisition.

KEYWORDS: training, digital simulation, circular production systems, ergonomic intervention, multidisciplinary

PROBLEM STATEMENT:

The current environmental emergency is prompting some companies to make the transition to a circular economy, requiring a complete overhaul of their current manufacturing systems to make them more capable of meeting the challenges of circularity. In a context of great uncertainty and high demand for human to perform complex tasks with a high degree of variability, the training of operators is a crucial factor in ensuring the performance of the production system, as well as protecting their health. In this context, a company remanufacturing electronic materials is questioning its training process to allow operators to be more quickly operational at their workstations with complex tasks specific to circular manufacturing systems (CMS).

OBJECTIVE/QUESTION:

The aim of this article is threefold.

Firstly, this article proposes to study the question of the skills acquisition and the preservation of the health of operators faced with complex and physically demanding tasks such as those found in production systems practicing the reworking of second-hand products. Indeed, the intricacy of the activities at hand necessitates a great deal of manual operation, which drives up work costs (Kurilova-Palisaitiene, Sundin, & Poksinska, 2018) and requires a customized process flow for each product (Klein, Wurster, Stricker, Lanza, & Furmans, 2021). Furthermore, to complete the intricate CMS duties, circular activities call for a greater degree of training and a broad range of abilities (Giutini & Gaudette, 2003). Operators must acquire special skills to replicate unique items (Guelle, Caroly, & Landry, 2023). The aim of the ergonomic intervention is to test whether an increase in skills by dividing up the process would be relevant from the point of view of operators' health and the development of expertise.

Secondly, to investigate the intervention question, the multi-disciplinary team is proposing to test training solutions using digital simulation at lower cost and easier than by implementing it in the

field. This proposal has made it possible to test the relevance of digital simulation tools commonly used in the design and improvement of production systems in engineering, which generally incorporate little or no human aspects in the modelling of a real system. Indeed, the human is not systematically taken into account in the engineering literature. In fact, human models are still criticised, and their integration into simulation models does not allow them to faithfully represent humans (Widok & Wohlgemuth, 2016). Another approach, based on the collection of data on fields, has been developed in conjunction with the engineering research team. After digital simulation, a physical simulation made on a technological platform is also presented to retrieve insights of possible improvements in the systems.

Thirdly, feedback on the conduct of multidisciplinary project is provided.

METHODOLOGY:

The increase in skills, as well as the link between health and skills, led to an ergonomic analysis being carried out within this company. A multidisciplinary team in ergonomics and engineering has made it possible to study the situation of skills development.

Observations were carried out over 14 days on the site to carry out an ergonomic diagnosis of the company. In parallel, a three-stage multidisciplinary methodology combining physical and numerical simulation is proposed. (1) Firstly, a CMS was created on a technological platform with similar production phases (such as the disassembly of a product, for example) to that of the company. Students were recruited to simulate the operation of this circular production workshop in conditions close to those observed in the company. This physically simulated case makes it possible to test small-scale configurations for potential improvements. These improvements may be technological or organisational in nature. (2) Secondly, a digital simulation reproducing a CMS is created and initialised with the values from the physical simulation and from the case study. Capitalising on this advantage, the simulation is used to test the observations of the physical simulation and generalise them to several workstations in the workshop to test their usefulness and relevance. (3) Thirdly, the results of the simulations are analysed and proposals based on these elements are put forward to the company.

RESULTS & DISCUSSION

The methodology used will be presented, along with the preliminary results of the ongoing study. Moreover, feedbacks on the conduct of a multidisciplinary project are proposed. It returned to the need for a common operating reference framework that has been to be developed in this kind of collaboration (Caroly & Barcellini, 2013)

The methodology studied also provide insights into the transferability of results between the real case, physical and digital simulation and. One of the novelties of this proposal lies in the inclusion of human factors in a digital simulation of a production system, which has rarely been studied in the literature.

CONCLUSIONS:

This paper is based on an intervention in an industrial company which raised the issue of training their operators in a complex production system carrying out circular economy operations. The intervention was multidisciplinary, combining engineering, ergonomics and occupational psychology. As part of this project, a digital simulation linking the operational performance of a circular production system to the health of operators and skills acquisition has been developed. This paper looks back at this intervention and capitalizes on the sharing and transferability of knowledge between several scientific disciplines.

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