Work 73 (2022) S141–S152
DOI:10.3233/WOR-211267

Ergonomic work analysis and training: Past, present and future

Catherine Delgoulet[a,*] and Marta Santos[b]
[a]*Centre de Recherche sur le Travail et le Développement (CRTD), Conservatoire National des Arts et Metiers, Paris, France*
[b]*Centro de Psicologia da Universidade do Porto, Universidade do Porto, Porto, Portugal*

Received 3 October 2021
Accepted 1 June 2022

Abstract.
BACKGROUND: The Ergonomic Work Analysis and Training (EWAT) network celebrated its 30th anniversary in 2021.
OBJECTIVE: THE EWAT focuses mainly on how activity analysis in real work can contribute to the training situations. Over the years, two lines of thought evolved: i) training in ergonomic work analysis, and ii) the use of the work analysis for the improvement or design of training interventions. Both share a common theoretical and methodological background based on three pillars: the focus on real work, the adoption of a systemic and participatory approach, and the intentional emphasis on a multidisciplinary approach.
METHODS: The design of training courses that are adequate both for workers and for supervisors who are concerned with the development of the worker's skills and health at work is challenged by major changes at work. Such challenges were the driving force behind the discussion within this network at the IEA 2021 congress.
RESULTS: The authors who contributed to this congress maintain the network's characterizing principles. At the same time, they introduce research updates and new intervention methodologies. In addition, the authors have been called upon to provide novel answers to the issues of organizational transformation and digitalization of work and training.
CONCLUSION: The permanence of this network involves leveraging its 30 years of collective expert experience to continue to respond to present and emerging challenges, concerning work and training sustainability. The network's research contributes to growing evidence about how training can impact on healthier workplaces where individual and group development is improved.

Keywords: Activity, description, transformation, design, evaluation

1. Introduction

The Ergonomic Work Analysis and Training (EWAT) research-intervention network celebrated its 30th anniversary at the International Ergonomics Association - IEA congress organized by experts from the Canadian Association of Ergonomics in Vancouver in 2021 (especially Ian Noy, Nancy Black and Patrick Neuman). By focusing on the contributions of ergonomics, and with particular attention to the contributions of activity analysis in real work or in training situations, the research of this network has explored various facets of research-intervention in ergonomics in the field of training. This research work thus contributed to understanding and to designing critical links between work and training.

This article is therefore an opportunity to: i) recall the milestones in the development of this international research network; ii) present recent productions and orientations discussed during the 2021 congress; iii) outline perspectives for the future.

*Address for correspondence: Catherine Delgoulet, CRTD, Conservatoire National des Arts et Metiers, Paris, France. E-mail: catherine.delgoulet@lecnam.net.

ISSN 1051-9815/$35.00

2. EWAT network over the last decades

2.1. Historical elements: an informal network that lasts

The EWAT network has its roots in the organization of a first roundtable during the IEA congress in 1991 in Paris [1]. The field of training had been relatively absent from the publications of ergonomics researchers until Canadian-Québécois, French and Swiss experts started a reflection on the contribution of ergonomic work analysis to professional training. Questioning the relationship of ergonomics of work and professional training was not commonplace. Such a research question required a solid theoretical explanation to justify that addressing training issues when discussing ergonomics was in line with the initial project of ergonomics. Therefore, the researchers assured theoretical consistency by stating the conditions when the association between training and ergonomics contributes to theory and practice. Those conditions are condensed in two lines of contribution. Both research avenues respected and enhanced the principles of ergonomics of work. The first axis aimed at training occupational health and safety actors (and in particular trade unionists) in ergonomic work analysis for the transformation of work situations considered problematic due to health, safety, quality, and/or productivity issues. The second axis addressed the mobilization of ergonomic work analysis for the design of learning objectives and/or training programs that meet the realities of work and performance conditions. The purpose was the transformation-conception of work for all, using training as the means to adjust the socio-technical systems to the workers. Consequently, training is not centered on the prescribed tasks alone, it also considers context or interplay of contributing factors. In spite of its informal nature, the network was able to continue within the international ergonomics community by: i) successfully proposing to the organizers of each IEA congress (except in 2015) one or more communication sessions or symposiums; and ii) regularly publishing outstanding contributions in special issues of scientific journals (Safety Science, 1996 [2]; Industrial Relations, 2001 [3]; Pistes, 2004 [4], 2014 [5]; Work, 2012 [6]; Laboreal, 2014 [7]) or chapters [8, 9]. Over the years, the network activities were numerous and impactful. The EWAT network included researchers from eleven countries from two main continents (North and South America and Europe). This influence was even broader at the IEA 2021 congress with the participation of colleagues from Africa (Nigeria) and Asia (Japan and Taiwan). Hence, it is clear that concerns about work analysis and training converge beyond cultural and geographical boundaries.

Over the last three decades, the two lines of thought have taken different directions. In the field of training in ergonomic work analysis, the emphasis was placed, for example, on:

- specific populations, trade unionists and staff representatives, occupational physicians and nurses, engineers-designers, employees, and ergonomists-to-be (e.g., [10–12]);
- specific approaches and methodologies for designing or conducting such training courses, from training-action to self-analysis of one's work activity through practice exchange groups (e.g., [13, 14]);
- the approaches and criteria for evaluating the impact of such training programs in the construction of a new representation of health-work relations, the development of skills for action and, above all, the evaluation of the effective transformations of work situations (e.g., [15, 16]);

In the field of work analysis for the improvement or design of training, research has also focused on a detail-oriented analysis during network meetings. In particular, the focus was on:

- specific populations: first of all experienced employees who already have the skills to be transposed into training, followed by employees who are going to be trained and finally, trainers or teachers and their working conditions, including tutors engaged in the task of transmitting knowledge and know-how (e.g., [17–19]);
- the role of gender, experience or work teams in professional learning or work and their involvement in training design (e.g., [20, 21]);
- the evaluation of training or learning systems from the point of view of 1) the learners, 2) the work to be done or 3) the trainers (e.g., [22]);
- approaches and methodologies in training design with a view to transforming work situations (e.g., [23–25]).

From the intersection of the two lines of thought emerged a broader reflection on the role played by the ergonomist - trainer - designer in the training model. This model stands for major principles of adult learning in professional environments which

aims at emancipating people through and in their work [26].

The informality of this research network has not prevented it from enduring over time, thus testifying to the relevance and renewed relevancy of its framework proposed at the time of its creation.

2.2. *Three pillars for a common background: Real work, system and participation, multi-disciplinary approach*

Literature review shows the network shares three theoretical and methodological pillars.

The first pillar is the concern for real work (i.e. the work as it is actually done). Far from the approaches that think and design training objectives, programs and evaluations based on tasks prescribed by managers or organizations, the work carried out by this network's ergonomists demonstrates the interest of describing work as it is understood, preserved and done by workers themselves [27]. The advantages of detailed real work knowledge are fourfold: i) to diagnose the existing situation and to determine if the context-related questions are indeed related to employee training and not to the design of the work; ii) to define the knowledge and know-how necessary for the performance of the real work in its individual and collective dimensions in order to design training systems that contribute to building that knowledge and know-how; iii) to build the links between the training situation and the work situation necessary for the continuation of learning after the formal training period is completed and for the appropriation of knowledge and know-how in daily work through experience; iv) to build evaluation-improvement approaches for learning systems based on a realistic representation of the intangible resources (knowledge and skills) to be transferred for the work ahead.

The understanding of real work played a major role in the researchers' decision to use the concept of activity in its multiple approaches and according to different theoretical models (e.g. Faverge's proposal on the work analysis in terms of regulation [28]; Leplat's model of the double regulation of the activity [29]; Engeström's cultural-historical theory of the activity system [30]; Theureau's course of action [31]; Schwartz's ergology [32]; the Rabardel's instrumental approach of activity [33]; etc.), in particular inspired by the work from constructivist approaches. These are notably the two major schools of thought: Russian psychology from the beginning of the 20th century [34] and Piagetian psychology [35]. Both theories consider that the activity deployed by a person, in order to carry out his/her task, is: a) singular, because it is situated in space and time as a result of a given professional history, b) finalized, according to the individual, collective or organizational goals pursued, c) mediated, by the material, organizational and intangible resources which orient the capacities and practices of people, and d) invested in, by the significance each person gives to his/her work [36]. Approaching real work through the concept of activity presents a fifth advantage, by making it possible: v) to propose an approach to health-work relations that is not unique or deterministic, since a person's activity in a given situation mediates these relations by positioning the person as a potential actor, considering the resources allocated and his or her capacities. This approach takes into account dysfunctions, variabilities, collective work, what is not foreseen, or prescribed [37].

The second pillar shared within the network is based on a systemic and participatory approach to research and intervention in workplaces. Systemic, because it is about understanding the relationship between work and training as a potential professional development system for trainee-employees, trainers or tutors and not about learning processes or pedagogical devices in isolation. This scientific position builds links between work and training. Therefore, it sheds broader light on the systemic approach defended in ergonomics, which more frequently focuses on the work as a sociotechnical system only (e.g. [38, 39]). Participatory, because each person is in turn an expert and an ignorant person (including ergonomists) and it is a question of combining the knowledge and know-how of different stakeholders to describe, understand, design, transform and evaluate work and/or training, to develop the agency of the participants (i.e. their intelligence and creativity in action) and thus to reinforce the sustainability of the action [40].

The third pillar lies in a deliberately broad opening to a multidisciplinary approach. Over the years, the network has welcomed research from sociological, managerial, psychological, medical, educational or training science approaches, and evaluation research. Two arguments justify the pertinence of a multidisciplinary approach. On the one hand, the complexity of the systems studied and the issues addressed cannot be solved by ergonomists alone. In addition, ergonomists are equipped to lead projects, to build synergies, and to mobilize stakeholders (decision-makers, engineers, employees-trainees,

trainers, designers, etc.) [41, 42]. On the other hand, scientific improvements and innovations are developed through cooperation and scientific controversy around common projects. The multidisciplinary approach indicates an expansive scientific strategy.

The informality of the network has allowed these three theoretical and methodological pillars to consolidate over time. The informal nature of the network has also given the successive coordinators freedom to emphasize one particular pillar, according to the themes of the congresses and the proposals made by the network authors.

3. Capitalization from the past and new horizons

The global organization of the Vancouver IEA 2021 conference favored questions related to the interconnected world. In the EWAT network, the topic of an interconnected world was explored by working on the links between the transformations of work and the repercussions on training. The major changes happening in the world of work (ageing populations, massive data work, cobotics, environmental transformations, artificial intelligence, etc.) are indeed challenges for the conception of adequate training courses for workers and for supervisors concerned with the development of workers' skills and health.

A symposium and 16 communications contributed significantly to the 2021 event. The topics central to the research network were reinforced through existing themes, and through the acceptance of new horizons. Therefore, the first axis encompassed contributions that incorporate and highlight ergonomic work analysis for the design of training. In the second axis we find works that emphasize technological issues and digitalization of activities, including the impacts that digitalization has on the work of trainers (see Table 1). The benefits and limitations of this research are developed in sections 3.1 and 3.2, respectively.

3.1. Building the links between work as it is done and training: Reasons and ways

Under this axis, which is part of the continuous reflection carried out over the last 30 years, nine contributions were identified. In all of them, the work analysis was performed before training, hence supporting the subsequent interventions. What is hereafter discussed are: i) the different reasons that supported this analysis and; ii) the way this analysis was performed, challenging, at times, the most accepted methods that are part of the heritage shared by the EWAT network members.

As far as the **reasons** are concerned, the symposium organized by Chambel and colleagues [43] shows how the analysis of activity performed by ergonomists at the beginning of their career (in France but also in Peru) can be useful for nourish the spaces of debate. Junior ergonomists invest in such moments to reflect upon the practice of the profession. Various intermediary objects [44] (e.g. intervention maps) that expects ergonomists' activity through simulation and games, are influenced by new shared knowledge (e.g. on intervention strategies) that emerges to enrich the practice of each individual.

From another perspective, research used work analysis as the moment prior to the definition of training plans and as a way to identify intervention clues that enable the improvement of working conditions. An example thereto is the work developed by Juns and Gomez [45], Nepomuceno and colleagues [46] and Oliveira and Rotenberg [47], where the work analysis made it possible to identify context-related intervention clues, anchored in the workers' activity, whether they were healthcare professionals or industrial operators. All three studies try to intersect the purpose of transforming the conditions and ways the work is organized with the workers' development through the training debate about the conditions in which their activity is performed.

However, the authors' findings did not yet include elements that could illustrate such development. Two studies mention something that is expected to happen as a result of the collective debate and of the training performed with the decision makers [45, 47]. Nevertheless, the third study found evidence that a change in the representations of work did not necessarily lead to the implementation of the measures reported in research-action-training [46].

A last group of communications used work analysis mainly to reflect upon training design and implementation work performed by trainers. For example, Munoz, Parage and Simonet [48] analyzed care assistants' activity, aiming at understanding how the "clandestine activity", resulting from cognitive and ethical suffering, is taken into consideration by the trainers and can update training itself. Similarly, Ketelaars and colleagues [49] started from the analysis of the work performed by the Covid-19 Humanitarian First Responders to question how

Table 1
Characterization of the 17 contributions to the EWAT Track at IEA 2021 (authors, country, participant and thematic area) according to two axes of analysis: Link between Work and Training (LWT; $N = 9$) and Digitalization of Activities and Training (DAT; $N = 8$)

Authors	Country	Participants	Thematic area	Contributions
Chambel and colleagues [43]	France and Peru	Junior ergonomists	Analysis of the activity of junior ergonomists mobilized in spaces of debate to reflect about the practice of the profession	LWT: work analysis to enrich the debate about practice
Juns and Gomez [45]	Brazil	Healthcare professionals	Transforming working conditions by discussing the conditions in which the activity is carried out.	LWT: - work analysis to identify context-related intervention clues, anchored in the workers' real activity, - the use of questionnaires to obtain information about the work and its conditions - design of a training action to promote work debate spaces
Nepomuceno and colleagues [46]	Brazil	Industrial operators	Transforming working conditions by discussing the conditions in which the activity is carried out.	LWT: - work analysis to identify context-related intervention clues, anchored in the workers' real activity, - design of a training action to promote work debate spaces - limits of voluntary participation
Oliveira and Rotenberg [47]	Brazil	Healthcare professionals	Transforming working conditions by discussing the conditions in which the activity is carried out.	LWT: - work analysis to identify context-related intervention clues, anchored in the workers' real activity, - the use of questionnaires to obtain information about the work and its conditions - design of a training action to promote work debate spaces
Munoz, Parage and Simonet [48]	France	Care assistants	Analyze to what extent trainers take some activities into consideration to update their own training	LWT: work analysis to reflect upon training design and trainers' work implementation
Ketelaars and colleagues [49]	Switzerland	Covid-19 Humanitarian First Responders	Developing formative practices in unpredictable and unanticipated situations	LWT: work analysis to reflect upon training design and trainers' work implementation
Rodrigues and colleagues [50]	Portugal	Primary teachers	Reflect on what extent primary teachers can address "work" as a topic and place it as one of the children's study objectives.	LWT: - work analysis to reflect upon training design and trainers' work implementation - design of a training action to promote work debate spaces
Pereira, Delgoulet and Santos [51]	Portugal	Industrial operators	Analyze the process of knowledge transmission in situations of high production demands in pull flow organizations	LWT: work analysis to reflect upon training design and trainers' work implementation
Atueyi and colleagues [52]	Nigeria	Lecturers	Identify knowledge and practices associated with ergonomics and work analysis by lecturers	LWT: the use of questionnaires to obtain information about the work and its conditions
Boccara and Toralla [54]	France	–	Literature review, discussing the concept of "scenario"	DAT: identification of the prerequisites in the design of digital pedagogical tools
Ketelaars and Flandin [55]	Switzerland	Civil protection officials	The characteristics required for learning in role play situations	DAT: identification of the prerequisites of training
Person and colleagues [56]	France	Computer scientists and teachers.	Conditions for the co-design of a learning analytics tool by computer scientists and teachers.	DAT: identification of the prerequisites in the design of digital pedagogical tools

(*Continued*)

Table 1
(*Continued*)

Authors	Country	Participants	Thematic area	Contributions
Morélot, N'Kaoua and Garrigou [57]	France	Fire Intervention Trainers	Learning in highly complex situations using virtual training environments	DAT: - the use of digital technologies in training - lack of flexibility of digital tools
Praetorius, Mallam and Nazir [58]	Norway	Maritime and lignite workers	Use of simulators to recreate real-work situations	DAT: the use of digital technologies in training
Aoki and his colleagues [59]	Japan	Radiology Doctors	Use of eye tracking systems to facilitate the explanation of experts' knowledge	DAT: the use of digital technologies in training
Lin, Su, Chou and Chou [60]	Taiwan	–	Training design using videogames	DAT: the use of digital technologies in training
Cusanno, Vidal-Gomel and Le Bellu [62]	France	Drivers of automated vehicles	Design of a learning tool that considers the sensitive situations introduced by technology	DAT: the use of digital technologies to support users' learning

to develop training when the work situation is unpredicted, unanticipated and, for those reasons, unregulated. Rodrigues and colleagues [50] analyzed how primary teachers can make work itself the object of children's study. In line with these previous works, Pereira, Delgoulet and Santos [51] questioned to what extent the working conditions in situations of high production demands in pull flow organizations can impact the way knowledge transmission occurs among workers. The work analysis allows the research to be at the heart of the work or learning, as close as possible to invariant factors that characterize them, but also to their situational specificities. Work analysis clarifies what is at stake for learners, trainers, and tutors, and thus to design training programs that take this into account.

Though the reasons are distinct, because they are in line with the objectives of each research study, it is understandable that work analysis remains a key element of the reflection and intervention in different contexts.

Regarding the way work analysis was developed, several works chose on-the-job observation and workers' verbalizations in order to understand the workers' motivations and their decision-making process on how to perform their job. However, fewer contributions used other tools to know the real work, including for instance, questionnaires. Research from Juns and Gomez [45] and from Oliveira and Rotenberg [47] are examples thereto, that used questionnaires to collect information from a broader group of workers about the conditions in which they perform their work and about the perceived impacts on health. In these studies, the findings were subsequently discussed with the workers, and as such, the authors debate the content of the training sessions to reflect on the constraints imposed by the real work and the strategies developed in the activity.

Research by Atueyi and colleagues [52] also used questionnaires. This study's objective is to accomplish a first approach to knowledge awareness and practices about ergonomics from lecturers of two distinct fields (Engineering and Medicine). The authors' conclusions reinforce the idea that having knowledge of ergonomics does not make it automatically possible to apply ergonomics principles in daily work; consequently, the authors point to the need to implement a training action where reflection upon the working conditions is the actual training subject.

The option for uncommon instruments within the network is included in the acknowledgement of potential data triangulation [53], from different sources and under the scope of multi-methodologies, which provide in-depth knowledge of situations. However, that option also results from the need to find alternatives to continue the research and intervention on work, even during a health crisis. Ketelaars and colleagues [49] proved this need in a different way: when the observation of the work execution was forbidden due to pandemic restrictions, the solution encompassed recorded video diaries and video call interviews.

The network gives priority to the field, to the direct and live contact with the workers, recognized as pivotal to access a perspective on the real work; notwithstanding, restrictions imposed by the context, physical or temporal, are leading

researchers to implement more or less creative solutions/instruments to perform work analysis, to get around the obstacles and, above all, to assure the interventions never stop. The use of questionnaires (and other instruments) also seems to result from the integration of new lenses, complementary perspectives introduced by different fields of study, though equally concerned about the relationships that may be established between work and training, as both can contribute to the transformation of working conditions and the activity performance conditions.

Two additional observations emerge as relevant. The first observation addresses an adjustment noticed when the type of training designed using work analysis is presented. More than the design of a training action in order to solve a problem, different contributions highlight the importance of having spaces for debating work among workers and, for instance, developing an activity sector [45], strengthening the groups [47], building analysis tools [50], or changing representations of work [46]. Consequently, the relevance of the debate within professional groups and between professional groups seems to assume relevance in training, mainly in situations when problems are not yet acknowledged by the different stakeholders. In such cases, it is essential to share at least a common framework to help define intervention commitments.

The second observation addresses the importance of the discussion triggered by the work from Nepomuceno and colleagues [46] about the limits of voluntary participation in research. Some stakeholders in the work situation were absent from the intervention and for that reason no decisions were made that would guarantee the implementation of certain measures, collectively designed. The importance of the collective in the scientific tradition assumed by this research network, together with the wakeup call established in this text, endorse the continuity of the reflection about the constitution of debate/training/intervention groups and about the conditions the researchers must meet to assure their involvement in research-action-training.

The different reasons and ways that work analysis is present in these studies do not minimize the focus work analysis still gets in this network's project. In fact, it is evident that researchers update how they perform work analysis, bearing in mind the constraints they face, but protecting the ethical principles that guide research within this network, that is, the effective participation of the stakeholders directly involved in research.

3.2. Digitalization of activities and training consequences

The eight contributions included in this section, without neglecting the theoretical-methodological principles this network holds dear, stand out from the previous ones due to the focus on technology issues. In fact, when facing the challenge of reflection upon the major changes that the world of work is undergoing, technological changes posed the most questions to the network's authors. Two approaches emerge from these contributions. The first approach, less common, is concerned with the prerequisites of training when introducing changes in technology at work or in training. The second approach, more widely discussed by the authors, focuses on the use of digital technologies in training.

In the first axis, more than just a reflection about the role played by training in situations when the work is undergoing a technological transformation, three manuscripts invite a reflection on the prerequisites that precede the introduction of such tools in training: Boccara and Toralla [54], based on a literature review, discussed the concept of "scenario"; Ketelaars and Flandin [55] studied the necessary characteristics to learn in role play situations and Person and colleagues [56] focused on the conditions necessary for the co-design of a learning analytics tool by computer scientists and teachers.

Boccara and Toralla [54] stated that regardless of the technological tools to be used in training, it will always be necessary to build scenarios for simulated situations. They led a systematic revision in the field of vocational training aiming at identifying the characteristics associated with the definition of a "good scenario". While this research made it clear that "realism" is the most commonly referenced characteristic in scientific papers, the research from Ketelaars and Flandin [55], in a study conducted with civil protection officials, drew attention to the fact that it is not always necessary to insist on the most realistic high-fidelity simulations. Choosing "good enough" simulations, whose focus is on consistency with ordinary work, seems to meet the purposes of activity learning, particularly for the least experienced workers. The study of Person and his colleagues [56] is based on the observation of co-design sessions between computer scientists and teachers involving a dashboard using Learning Analytics (LA). The observation was complemented by individual interviews. The authors noticed the first stage of co-design is the definition of concepts, objectives and modalities.

Failing to do so, LA and the dashboard only fit into the world of computer scientists and the co-design sessions do not fulfil their function of bridging the two professional modes of designers and users. Computer scientists are too far from the professional activity of teachers who fail to project themselves into the potential use of this new tool. These three studies emphasize that beyond technology itself, it is the way objectives and contents are used in the learning activity or in the teachers' work activity that are of primary importance.

Concerning the second axis centered on the use of technological tools in training, the presentations concerned virtual training environments [57], simulators [58], eye tracking system [59] and videogames [60].

Literature in this field emphasizes [61] the value of using these tools in training. This value is particularly evident in three configurations: i) in highly complex learning situations, thus avoiding the constraints imposed by the real as is the case for firefighting, studied by Morélot, N'Kaoua and Garrigou [57]; ii) when the knowledge held by experts is embedded and is difficult to put into words, as is the case with the radiology doctors studied by Aoki and his colleagues [59]; iii) and, when trainees themselves can use such tools to recreate situations from their work, as the workers of lignite power domain in the study from Praetorius, Mallam and Nazir [58]. However, these technological training tools may also bring difficulties, namely for the trainers' work: certain tools lack flexibility, which may hinder the adjustments trainers usually do throughout the learning process, hence transforming trainers' activity [57].

Finally, Cusanno, Vidal-Gomel and Le Bellu [62] describe the analysis of a situation deeply transformed by the introduction of technology – driving automated vehicles – to think about the design of a learning tool that takes into account the sensitive situations identified by the analysis of the drivers' work. The drivers need to adapt their "traditional" driving schemes since trust in the technological device is an essential aspect in learning about automated driving. Such a situation will not be reached if the functioning of the automated systems is kept opaque.

It seems indisputable that technology is deeply changing human activity and learning practices. What these studies reveal is the acknowledgement that there is still a major debate to be held to fully consider the real work's point of view, considering the users' activity from the process of tool design, the learning processes and paces and the construction of new experiences based on the past, but providing clues for the future, strengthening work collectives.

4. Which ways for the future?

The studies presented at the IEA 2021 congress in Vancouver attest to the continuation of reflections around the two main research axes (training in the ergonomic work analysis activity and mobilizing the ergonomic work analysis activity to design training). However, the studies also question some methodological fundamentals, in particular the role of observation in real work situations to analyze the activity of workers, trainees or trainers. Indeed, research based on debate spaces, on simulations, or on remote interviews due to the Covid pandemic, question the way in which real work can be described in these conditions to feed professional learning at work or in training. The studies presented challenge whether it is indeed possible to build links between work and training, a dimension that is essential to the primary prevention of health and safety at work [63, 64].

The EWAT presentations also testify to the vitality of the general framework shared around the three EWAT pillars: real work, systemic approach and participation, and contributions from various disciplines. Within this framework, the presentations propose new methodological or thematic perspectives with: i) the spaces of debate as training devices for actors of work situations or their representatives; and ii) the significant development of works dedicated to the contribution of ergonomic activity analysis to the design of technological tools (virtual reality devices, learning analytics tools, autonomous systems) for learners and trainers.

The decision between which of the two research avenues to explore further is based on two premises: the future of the scientific network and the future orientations and research themes.

4.1. The EWAT scientific network configuration

This scientific network, although informal, celebrated its thirtieth anniversary in 2021, which attests to its durability and to the acuity of the questions it addresses in the field of ergonomics. The diversity of the researchers who contribute to the network indicates shared scientific concerns beyond cultural specificities of training and learning formats (laws, funding mechanisms, training organizations,

commonly shared adult learning models, etc.) that can be observed in the teaching practices of different countries.

In the years to come, the stabilization, or even the reinforcement, of the network's visibility at an international level can take two paths that remain to be discussed within the EWAT network. The first path would be to seek a form of flexible institutionalization of the network which would ensure the evolution from an informal, discreet research network to an identified and agile network in its configuration and organization. The IEA provides the means to implement this evolution because committees are formal organizations (e.g. Technical and Scientific committees – TCs and SCs). The constitution of a new committee would then solve the need for formality and recognition. The second path would be to pursue cooperation with the members of the IEA's Gender and Work Technical Committee, and with other TCs. These two horizons could enrich the network's work on an international scale.

4.2. Challenge for the future

For 30 years, this network has developed an original view of the contribution of ergonomics to training. Based on the primacy of real work, to understand learning situations and design training situations, programs or tools, the network shows today how much the deep transformations of work (e.g. digitalization, robotization, and automation) depend on these approaches to place the human being at the heart of these transformations. However, there are still many challenges to be met in a world where technological and environmental changes will reexamine work and professions. In particular, it is necessary to:

- demonstrate how sustainable work and training systems are sources of development and resources for building health at work;
- qualify the sustainability conditions and criteria of learning situations in training and at work (from the point of view of health and performance);
- identify the necessary conditions for the design of training courses that allow all workers and organizations to adapt to the transformations in the workplace, ensuring their participation in the process, their development, and the preservation of their health.

Ergonomists, researchers and practitioners must address these questions to contribute to the design of work and training situations that are favorable to the emancipation of women and men at work [65]. These questions seem fundamental for ergonomists and the EWAT network to contribute to the future of training and work.

Acknowledgements

The authors would like to thank all the members of the EWAT network who have been involved in highlighting work in the field, developing symposia and coordinating publication projects since 1991. The EWAT network owes them a special tribute.

Conflict of interest

None to report.

References

[1] Rabardel P, Teiger C, Laville A, Rey P, Desnoyers L. Ergonomic work analysis and training. Exposé introductif à la session "Ergonomic and training". In Quéinnec Y, Daniellou F, editors. Designing for everyone, Proceedings of the 11 th Congress of the IEA; 1991. pp. 1738-40.

[2] Teiger C, Montreuil S. Introduction. Ergonomists training and occupational health and safety. Guest editorial, Saf Sci. 1996;23(2-3). Available from: https://www.sciencedirect.com/journal/safety-science/vol/23/issue/2

[3] Montreuil S, Bellemare M, Ergonomie, formation et transformation des milieux de travail : introduction. Relations industrielles/Industrial relations. 2001;56(3). Available from : https://www.jstor.org/stable/i23077675

[4] Bellemare M, Montreuil S, Formation, ergonomie et transformation des situations de travail : trajectoires croisées, PISTES (http://www.pistes.uqam.ca), 2004;6(2).

[5] Chatigny C, Santos M, Cau-Bareille D, Delgoulet C, Larberge M, Ouellet S. Editorial, présentation des contributions. PISTES [Internet]. 2014 [cited 2021 Sep 1];16(4). Available from: http://journals.openedition.org/pistes/4317 DOI : 10.4000/pistes.4317

[6] Delgoulet C, Cau-Bareille D, Chatigny C, Gaudart C, Santos M, Vidal-Gomel C. Ergonomic Analysis on Work Activity and Training. Guest editorial. Work. 2012;41(1):111-5.

[7] Chatigny C. Introdução ao dossiê temático "A análise ergonómica do trabalho e da formação para um desenvolvimento sustentável". Laboreal [Internet]. 2014 Jul [cited 2021 Sep 1];10(1). Available from: http://journals.openedition.org/laboreal/5125 DOI: 10.4000/laboreal.5125

[8] Lacomblez M, Bellemare M, Chatigny C, Delgoulet C, Re A, Trudel L, et al.Ergonomic Analysis of Work Activity and Training: Basic Paradigm, Evolutions and Challenges. In Pikaar R, Koningsveld E, Settels P, editors. Meeting diversity in ergonomics. Elsevier; 2007. pp. 129-42.

[9] Delgoulet C, Santos M, editors. Part III: Ergonomic Work Analysis and Training (EWAT). In Black NL, Neumann WP, Noy I, editors. Proceedings of the 21st congress of the Inter-

national Ergonomics Association (IEA 2021) - Volume I: Systems and Macroergonomics. Springer; 2021.
[10] Montreuil S. Ergonomics training for managers, employees and designers involved in the design and organization of work systems, Saf Sci. 1996;23(2-3):97-106.
[11] Valverde C, Lacomblez M. Contributions of the "safe coordinators" training to promote building sector prevention contextualization. In Pikaar R, Koningsveld E, Settels P, editors. Meeting diversity in ergonomics. Proceedings IEA 2006 Congress. Elsevier; 2006.
[12] Gaudart C, Petit J, Dugué B, Daniellou F, Davezies P, Théry L. Impacting working conditions through trade union training, Work. 2012;41(2):165-75.
[13] Jackson JM, Dischinger M. Ergonomic work analysis as a tool for reflective practice. In Pikaar R, Koningsveld E, Settels P, editors. Meeting diversity in ergonomics. Proceedings IEA 2006 Congress. Elsevier; 2006.
[14] Ledoux E, Cloutier E, Fournier PS. The Influence of Flexible Management Practices on the Sharing of Experiential Knowledge in the Workplace: a Case Study of Food Service Helpers. Work [Internet]. 2012 [cited 2021 Sep 1];41(supl. 1):5172-6. Available from: https://content.iospress.com/download/work/wor0805?id=work%2Fwor0805 DOI: 10.3233/WOR-2012-0805-5172
[15] Berthelette D. Evaluation of ergonomic training programs. Saf Sci. 1996;23(2-3):133-43.
[16] Duwelz M, Thibault, JF, Josse P. Long term impact assessment of ergonomic traing courses on professional practices. In Pikaar R, Koningsveld E, Settels P, editors. Meeting diversity in ergonomics. Proceedings IEA 2006 Congress. Elsevier; 2006.
[17] Chatigny C, Lévesque S, Riel J. Training while training: the challenge of vocational training (VT) teachers. Proceedings of the 17th IEA Congress. Beijing, 9-14 August 2009.
[18] Delgoulet C. Being a Trainer in the French Vocational Training System: a Case Study of Job Status and Working Conditions in Relation to Perceived Health. Work [Internet]. 2012 [cited 2021 Sep 1];41(supl. 1):5203-9. Available from: https://content.iospress.com/download/work/wor0810?id=work%2Fwor0810 DOI: 10.3233/WOR-2012-0810-5203
[19] Santos M, Ferreira A. Conditions, demands and constraints on trainers activity: a case study in the Portuguese context. Work [Internet]. 2012 [cited 2021 Sep 1];41(supl. 1):5210-7. Available from: https://content.iospress.com/download/work/wor0811?id=work%2Fwor0811 DOI 10.3233/WOR-2012-0811-5210
[20] Chatigny C, Riel J, Nadon L. Health and Safety of Students in Vocational Training in Quebec: a Gender Issue? Work [Internet]. 2012 [cited 2021 Sep 1]; 41(supl 1):4653-60. Available from: https://content.iospress.com/download/work/wor0104?id=work%2Fwor0104 DOI 10.3233/WOR-2012-0104-4653
[21] Nogueira S, Lacomblez M, Santos M, Cunha L, Castelhano J. The entry of women in predominantly male professions: when training supports the search of alternative ways of organizing work time. Work [Internet]. 2012 [cited 2021 Sep 1];41(supl 1):4650-2. Available from: https://content.iospress.com/download/work/wor0103?id=work%2Fwor0103 DOI 10.3233/WOR-2012-0103-4650
[22] Santos M, Vicente T, Monteiro A, Lacomblez M. What is not assessed in continuous training in companies? Two case studies in Portugal. Proceedings of the 17th IEA Congress. Beijing, 9-14 August 2009.
[23] Lacomblez M, Montreuil S, Teiger C. Ergonomic Work Analysis, Training and Action: New Paths Opened by the Interconnection of Approaches Proceedings of IEA Ergonomics. Proceedings of the Human Factors and Ergonomics Society Annual Meeting [Internet]. 2000 Jul [cited 2021 Sep 1];44(12): 2-647-2-650. Available from: https://journals.sagepub.com/doi/10.1177/154193120004401255 DOI 10.1177/154193120004401255
[24] Ouellet S. Ergonomic Analysis of Work Activity for the Purpose of Developing Training Programs: The Contribution of Ergonomics to Vocational Didactics. Work [Internet]. 2012 [cited 2021 Sep 1];41(supl.1):4572-6. Available from: https://content.iospress.com/download/work/wor0753?id=work%2Fwor0753 DOI: 10.3233/WOR-2012-0753-4572
[25] Vidal-Gomel Ch, Boccara V, Cau-Bareille D, Delgoulet C. How Holistic Approaches of Activity Analysis in Ergonomics Renew Training Design? In Bagnara S, Tartaglia R, Albolino S, Alexander T, Fujita, Y, editors. Proceedings of the 20th Congress of the International Ergonomics Association. Springer Nature. 2019;4:233-41.
[26] Delgoulet C, Boccara V, Santos M, editors. Les formateurs au travail: conditions d'exercice, activités, interventions. Toulouse: Octarès Editions; 2019, pp. 245.
[27] Delgoulet C, Cau-Bareille D, Chatigny C, Goudart C, Santos M, Vidal-Gomel Ch. Ergonomic analysis on work activity and training. Work [Internet]. 2012 [cited 2021 Sep 1];41(2):111-4. Available from: https://content.iospress.com/download/work/wor01286?id=work%2Fwor01286 DOI: 10.3233/WOR-2012-1286
[28] Faverge J M. L'analyse du travail en termes de régulation. In Faverge JM et al, editors, L'ergonomie des processus industriels. Bruxelles : Ed. de l'Université Libre de Bruxelles – Institut de Sociologie; 1966;33-60.
[29] Leplat J. La notion de régulation dans l'analyse de l'activité. PISTES [Internet]. 2006 [cited 2021 Sep 1];8(1):1-25. Available from: https://journals.openedition.org/pistes/3101 DOI 10.4000/pistes.3101
[30] Engeström Y. Learning by expanding: an activity-theoretical approach to developmental research. Helsink: Orienta-Konsultit; 1987.
[31] Theureau J. Le cours d'action: Méthode élémentaire. Toulouse: Octarès; 1992.
[32] Schwartz Y. Le paradigme ergologique ou un métier de philosophe. Toulouse, Octarès; 2000.
[33] Rabardel P, Béguin P. Instrument mediated activity: from subject development to anthropocentric design. Theor Issues Ergon Sci [Internet]. 2005 [cited 2021 Sep 1];6(5):429-61. Available from: https://www.tandfonline.com/doi/full/10.1080/14639220500078179 DOI: 10.1080/14639220500078179
[34] Vygotsky LS. Mind in Society, the Development of Higher Psychological Processes. Cambridge, MA: Harvard University Press; 1978, pp. 176.
[35] Piaget, J. Success and understanding. London: Routledge & K. Paul London; 1978, pp. 236.
[36] Daniellou F, Rabardel P. Activity-oriented approaches to ergonomics: some traditions and communities. Theor Issues Ergon Sci [Internet]. 2005 [cited 2021 Sep 1];6(5):353-7. Available from: https://www.tandfonline.com/doi/full/10.1080/14639220500078351 DOI: 10.1080/14639220500078351

[37] Daniellou, F. The French-speaking ergonomists' approach to work activity: cross-influences of field intervention and conceptual models. Theor Issues Ergon Sci [Internet]. 2005 [cited 2021 Sep 1];6(5):409-27. Available from: https://www.tandfonline.com/doi/full/10.1080/14639220500078252 DOI: 10.1080/14639220500078252

[38] Wilson JR. Fundamentals of ergonomics in theory and practice. Appl Ergon [Internet]. 2000 Dec [cited 2021 Sep 1];31(6):557-67. Available fromfile:///C:/Users/marta/AppData/Local/Temp/1-s2.0-S000368700000034X-main.pdf

[39] Dul J, Bruder R, Buckle P, Carayon P, Falzon P, Marras WS, et al. A strategy for human factors/ ergonomics: developing the discipline and profession, Ergonomics [Internet]. 2012 Feb [cited 2021 Sep 1];55(4):377-95. Available from: https://www.tandfonline.com/doi/full/10.1080/00140139.2012.661087 DOI: 10.1080/00140139.2012.661087

[40] Bolis I, Brunoro CM, Sznelwar LI. Mapping the relationships between work and sustainability and the opportunities for ergonomic action. Appl Ergon [Internet]. 2014 Jul [cited 2021 Sep 1];45:1225-39. Available from: https://www.sciencedirect.com/science/article/pii/S0003687014000325 DOI: 10.1016/j.apergo.2014.02.011

[41] Daniellou F, Garrigou A. Human factors in design: sociotechnics or ergonomics. In Helander M, Nagamachi M, Editors. Design for Manufacturability, a Systems Approach to Concurrent Engineering and Ergonomics. London: Taylor & Francis; 1992. pp. 55-63.

[42] Eerd D, Cole D, Irvin E, Mahood Q, Keown K, Theberge N, et al. Process and implementation of participatory ergonomic interventions: a systematic review. Ergonomics [Internet]. 2010 Sep [cited 2021 Sep 1];53(10):1153-66. Available from: https://www.tandfonline.com/doi/full/10.1080/00140139.2010.513452 DOI: 10.1080/00140139.2010.513452

[43] Chambel A, Jon D, Bachellerie C, Toulisse C. Creation of the Junior Practices in Reflection Committee of the French Speaking Ergonomics Society: Historical Genesis and Theoretical Foundation of the Exchange on Practice. In Black NL, Neumann WP, Noy I, editors. Proceedings of the 21st congress of the International Ergonomics Association (IEA 2021) - Volume I: Systems and Macroergonomics [Internet]. Springer; 2021. pp. 454-61. Available from: https://doi.org/10.1007/978-3-030-74602-5_64

[44] Vinck D. Taking intermediary objects and equipping work into account in the study of engineering practices. Engineering Studies [Internet]. 2010 Sep [cited 2021 Sep 1];3(1):25-44. Available from: https://www.tandfonline.com/doi/full/10.1080/19378629.2010.547989 DOI: 10.1080/19378629.2010.547989

[45] Juns AG, Gomez JPS. Ergonomic Analysis of the Material and Sterilization Center in a Private Brazilian Hospital. In Black NL, Neumann WP, Noy I, Editors. Proceedings of the 21st congress of the International Ergonomics Association (IEA 2021) - Volume I: Systems and Macroergonomics [Internet]. Springer; 2021. pp. 485-91. Available from: https://doi.org/10.1007/978-3-030-74602-5_68

[46] Nepomuceno V, Alvarez D, Araújo F, Figueiredo M. Steering Group: An Action-Training Tool in the Ergonomic Work Analysis. In Black NL, Neumann WP, Noy I, editors. Proceedings of the 21st congress of the International Ergonomics Association (IEA 2021) - Volume I: Systems and Macroergonomics [Internet]. Springer; 2021. pp. 417-424. Available from: https://doi.org/10.1007/978-3-030-74602-5_59

[47] Oliveira S, Rotenberg L. Dialogues with Health Workers in a Hospital to Combat the Covid-19 Pandemic. In Black NL, Neumann WP, Noy I, editors. Proceedings of the 21st congress of the International Ergonomics Association (IEA 2021) - Volume I: Systems and Macroergonomics [Internet]. Springer; 2021. pp. 508-15. Available from: https://doi.org/10.1007/978-3-030-74602-5_71

[48] Munoz G, Parage P, Simonet P. Clandestine Activity Among Care Assistants in France: Questions for Training? In Black NL, Neumann WP, Noy I, editors. Proceedings of the 21st congress of the International Ergonomics Association (IEA 2021) - Volume I: Systems and Macroergonomics [Internet]. Springer; 2021. pp. 500-7. Available from: https://doi.org/10.1007/978-3-030-74602-5_70

[49] Ketelaars E, Flandin S, Scannell O, Poizat G. Covid-19 Humanitarian First Responders' Experience: Insights for the Design of Preparedness Training. Extended Abstract from 21st Triennial Congress of the International Ergonomics Association, Vancouver, June 13–18, 2021.

[50] Rodrigues A, Cadilhe M, Ferreira F, Pereira C, Santos M. Developing a training action for primary school teachers by doubly considering (their) work. In Black NL, Neumann WP, Noy I, editors. Proceedings of the 21st congress of the International Ergonomics Association (IEA 2021) - Volume V: Methods & Approaches [Internet]. Springer; 2022. pp. 758-63. Available from: https://doi.org/10.1007/978-3-030-74614-8_93

[51] Pereira C, Delgoulet C, Santos M. Impact of high production demands in knowledge transmission and learning: contributions of work activity analysis. In Black NL, Neumann WP, Noy I, editors. Proceedings of the 21st congress of the International Ergonomics Association (IEA 2021) - Volume I: Systems and Macroergonomics [Internet]. Springer; 2021. pp. 516-23. Available from: https://doi.org/10.1007/978-3-030-74602-5_72

[52] Atueyi BC, Nwanya SC, Ekechukwu END, Madu OT, Aguwa EN, Ekechukwu OV. A Comparison of the Knowledge, Awareness and Practice of Ergonomics Between Lecturers in the Faculty of Engineering and College of Medicine in a Nigerian University. In Black NL, Neumann WP, Noy I, editors. Proceedings of the 21st congress of the International Ergonomics Association (IEA 2021) - Volume I: Systems and Macroergonomics [Internet]. Springer; 2021. pp. 432-37. Available from: https://doi.org/10.1007/978-3-030-74602-5_61

[53] Volkoff S. Statistiques « ouvertes » et ergonomie « myope »: combiner les niveaux d'analyse en santé au travail. Sci Soc Sante [Internet]. 2010 Jun [cited 2021 Sep 1];2(28):11-30. Available from : https://www.cairn.info/revue-sciences-sociales-et-sante-2010-2-page-11.htm DOI: 10.3917/sss.282.0011

[54] Boccara V, Toralla MSP. What is a Good Scenario in Vocational Training Design? Considerations Based on a Literature Review. In Black NL, Neumann WP, Noy I, editors. Proceedings of the 21st congress of the International Ergonomics Association (IEA 2021) - Volume I: Systems and Macroergonomics [Internet]. Springer; 2021. pp. 446-53. Available from: https://doi.org/10.1007/978-3-030-74602-5_63

[55] Ketelaars E, Flandin S. Four Principles for the Design and Support of "Good Enough" Simulations for Crisis Management Novices. Extended Abstract from 21st Triennial

Congress of the International Ergonomics Association, Vancouver, June 13–18, 2021.

[56] Person J, Vidal-Gomel Ch, Cottier P, Lecomte C. Co-design of a Learning Analytics Tool by Computer Scientists and Teachers: The Difficult Emergence of a CommonWorld. In Black NL, Neumann WP, Noy I, editors. Proceedings of the 21st congress of the International Ergonomics Association (IEA 2021) - Volume I: Systems and Macroergonomics [Internet]. Springer; 2021. pp. 524-33. Available from: https://doi.org/10.1007/978-3-030-74602-5_73

[57] Morélot S, N'Kaoua B, Garrigou, A. Feedback on the use of virtual reality in training: the case of fire intervention trainers. Extended Abstract from 21st Triennial Congress of the International Ergonomics Association, Vancouver, June 13 – 18, 2021.

[58] Praetorius G, Mallam SM, Nazir S. How to Train for Everyday Work - A Comparative Study of Non-technical Skill Training. In Black N L, Neumann WP, Noy I, editors. Proceedings of the 21st congress of the International Ergonomics Association (IEA 2021) - Volume I: Systems and Macroergonomics [Internet]. Springer; 2021, pp. 534-42. Available from: https://doi.org/10.1007/978-3-030-74602-5_74

[59] Aoki H, Morishita K, Takahashi M, Machida R, Kudoh A, Kishino M, et al. Analysis of Clinical Reasoning Processes During Scanning Chest X-Rays Based on Visual Perception Patterns. In Black NL, Neumann WP, Noy I, editors. Proceedings of the 21st congress of the International Ergonomics Association (IEA 2021) - Volume I: Systems and Macroergonomics [Internet]. Springer; 2021, pp. 425-31 Available from: https://doi.org/10.1007/978-3-030-74602-5_60

[60] Lin PH, Su KW, Chou Ch, Chou ShY. The Investigation of Positive and Negative Affect Schedule on Double-person Kinect Training. Extended Abstract from 21st Triennial Congress of the International Ergonomics Association, Vancouver, June 13–18, 2021.

[61] Sipiyaruk K, Gallagher JE, Hatzipanagos S, Reynolds PA. A rapid review of serious games: from healthcare education to dental education. Eur J Dent Educ [Internet]. 2018 Mar [cited 2021 Sep 1];22(4):243-57. Available from: https://onlinelibrary.wiley.com/doi/10.1111/eje.12338 DOI 10.1111/eje.12338

[62] Cusanno H, Vidal-Gomel Ch, Le Bellu S. Identification of Sensitive Driving Situations to Guide the Design of a Learning Tool for Automated Vehicle Drivers. Proceedings of the 21st congress of the International Ergonomics Association (IEA 2021) - Volume I: Systems and Macroergonomics [Internet]. Springer; 2021, pp. 462-70. Available from: https://doi.org/10.1007/978-3-030-74602-5_65

[63] Ouellet S, Vézina N. Activity Analysis and Workplace Training: An Ergonomic Perspective. In: Filliettaz L, Billett S, editors. Francophone perspectives of learning through work. Springer; 2015, pp. 241-256.

[64] Vidal-Gomel C, Delgoulet C. Analysing relationships between work and training in order to prevent psychosocial risks. Saf Sci. [Internet], 2022 Jan [cited 2022 May 2];145:105517. Available from: https://www.sciencedirect.com/science/article/pii/S092575352100360X DOI 10.1016/j.ssci.2021.105517

[65] Béguin P. Emancipation and Work: An Outmoded Ambition? In Black NL, Neumann WP, Noy I, editors. Proceedings of the 21st congress of the International Ergonomics Association (IEA 2021) - Volume I: Systems and Macroergonomics. Springer; 2021. pp. 425-31.