<http://www.diva-portal.org>

Postprint

This is the accepted version of a paper presented at *20th Congress of the International Ergonomics Association, IEA 2018; Florence; Italy; 26 - 30 August 2018.*

Citation for the original published paper:

Karltun, A., Karltun, J. (2018)

Benefits of the Human-Technology-Organization Concept in Teaching Ergonomics – Students Perspective

In: Sebastiano Bagnara, Riccardo Tartaglia, Sara Albolino, Thomas Alexander, Yushi Fujita (ed.), *Advances in Intelligent Systems and Computing* (pp. 627-636). Springer

https://doi.org/10.1007/978-3-319-96080-7_75

N.B. When citing this work, cite the original published paper.

Permanent link to this version:

<http://urn.kb.se/resolve?urn=urn:nbn:se:hj:diva-41501>

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/326850456>

Benefits of the Human–Technology–Organization Concept in Teaching Ergonomics – Students Perspective: Volume IV: Organizational Design and Management (ODAM), Professional Affairs, F...

Chapter · January 2019

DOI: 10.1007/978-3-319-96080-7_75

CITATIONS

0

READS

8

2 authors:

Anette Karlton

Jönköping University

21 PUBLICATIONS 31 CITATIONS

[SEE PROFILE](#)

Johan Karlton

Jönköping University

32 PUBLICATIONS 188 CITATIONS

[SEE PROFILE](#)

Some of the authors of this publication are also working on these related projects:

Production Ergonomics [View project](#)

1 Resilient Action Strategies of First Line Managers (ReActS) [View project](#)

Benefits of the Human-Technology-Organization concept in teaching ergonomics – students perspective

Anette Karlton^[0000-0003-4853-3140] and Johan Karlton^[0000-0002-0109-5246]

¹ Industrial Engineering and Management, Jönköping University, Sweden

anette.karlton@ju.se

Abstract. The human-technology-organization (HTO) concept has been used for creating systems understanding of ergonomics in three engineering educations at the School of Engineering in Jönköping. Students from courses given in two undergraduate and one graduate program (n=122) participated in the study, which involved a course evaluation questionnaire to assess the understanding of ergonomics as discipline and HTO as a means for creating systems understanding. The questionnaire included both ranking and personal comments to the questions. The results show that the students in general considered knowledge of ergonomics and HTO as beneficial for their future work and that the HTO concept did contribute to their understanding of workplace ergonomics. However, there was a significant difference between undergraduate and graduate students in all these aspects where undergraduates ranked all these aspects lower than graduates. This was also reflected in personal comments on the questions. Conclusions that can be drawn are that understanding systems is generally difficult and the HTO concept can assist in helping students to overcome these difficulties. However, the differences between the student groups must be explicitly considered as well as increasing students' awareness of the relevance of ergonomics for engineers.

Keywords: HTO concept, engineering education, systems understanding

1 Background

In engineering education, providing courses in ergonomics is one way of trying to meet the demands for understanding and improving future workplaces. The increasing technological complexity also make it more obvious that to understand, manage and develop technical systems, understanding the workplace as a system becomes more and more important. The systems character of ergonomics/human factors was for example described by Wilson (2014) where he concluded that the view should be holistic and complemented by concerns for context, interactions, complexity, emergence and embedding of professional effort.

One of the systems' approaches within ergonomics is HTO, where this acronym stands for considering a work activity to be an interaction between three separate sub-systems, the human (H), the technology (T) and the organization (O) (Karlton et al., 2017). By focusing the interaction between these three major interdependent sub-

systems, rather than the sub-systems themselves, the reasons for system performance becomes more obvious. In addition, the interaction indicates a dynamic system with ongoing activities, which implies that the understanding of the relationship between activities and organizational processes and system performance as a whole is facilitated (Karlton et al., 2017).

The authors have worked for a long period of time (>10 years) with developing and applying the HTO concept in research and education, inspired by developments in safety critical businesses like nuclear power plants and hospitals (Karlton et al., 2017; Karlton, 2014). We have found that this concept brings advantages also outside such specific businesses. Main advantages are a more explicit emphasis on systems understanding, on interactions between identified sub-systems and stressing the human as a sub-system of equal importance as technology and organization.

Ergonomics as subject is very wide and encompasses parts from for example psychology, medicine, engineering and sociology (Daniellou, 2001), which is needed to reflect the complexity in working activities as well as in businesses where these activities take place. It thus puts large demands on the teaching of the subject. There are also challenges involved in teaching a systems perspective for workplace understanding and design. To emphasize such a perspective during the ergonomics courses, students are encouraged to reflect on the facets of each HTO sub-system, their interactions and their relevance to different cases.

Students may also find it difficult to realize why they should engage in systems' thinking as it is demanding, and ergonomics is often not a focus in engineering students' mental models of their future work. Their future employers (The Confederation of Swedish Enterprise) however, consider that knowledge in ergonomics and work environment development is what engineering students in Sweden often lack (Jeppsson, 2018).

There are as far as we know, few studies presented about how we reach the students with teaching ergonomics as a systems discipline, except for the ones we previously published (Berglund & Karlton, 2015; Karlton et al., 2017).

The aim with this paper is to present the students' experiences from participating in courses where the HTO concept was used to explain and develop the systems' character of ergonomics to undergraduate as well as to graduate students.

2 Method

The study was based on a course evaluation questionnaire specifically devoted to assessing the perceived relevance of ergonomics as subject and the impact of using the HTO concept as a method for creating understanding of the systems' perspective inherited in workplace ergonomics.

The students participating in the investigation came from educations in logistics and management (undergraduate), sustainable supply chain management (undergraduate), about 10 % exchange students not following a program (undergraduate) and production development and management (graduate) respectively, in total 122 students distributed as 87 undergraduates and 35 graduate students.

The questionnaire had some introducing questions related the students background regarding which program the students were engaged in, if they were Swedish students, non-paying exchange students or tuition fee paying students from outside Europe.

The three main questions used to assess students' experienced impact of using the HTO concept as a method for creating understanding of the systems perspective inherited in workplace ergonomics were:

- A. Do you think you will benefit from your knowledge of ergonomics in your future work?
- B. How much do you think the HTO concept contributed to your understanding of workplace ergonomics?
- C. Do you think you will benefit from your knowledge of the HTO concept in your future work?

These questions were designed with a five alternative response scale rated from 'to a low extent' (1) to 'to a high extent' (5). Each of the questions were followed by a space where the students were asked to give a text comment to motivate their scaled answer. A majority of the students also gave such answers.

The five scale questions were analyzed quantitatively using descriptive and inferential statistics. The comments were then analyzed question by question and the rationale for the examples chosen in the paper was to show representative answers and give a picture of the span in the answers as well.

3 Results

The results of the three questions used are presented below. Each question is presented sequentially, first the quantitative results on the five-scaled questions and then the motivations for the quantitative answer as a representative sample.

3.1 Question A: Do you think you will benefit from your knowledge of ergonomics in your future work?

Both student groups regarded the benefits of ergonomics knowledge in future work important but to somewhat different degrees as shown in Table 1.

Table 1. Students' perceived benefits from ergonomics in their future work.
Answers scale 1-5 (to a low extent - to a high extent). n = 122

Question A: Do you think you will benefit from your knowledge of ergonomics in your future work?			
	Undergraduate students (87)	Graduate students (35)	Students T-test on difference
Average	3,65	4,71	$p < .001$
Median	4	5	

The answers in Table 2 and 3 below gives a more substantial understanding of the benefits perceived in relation to question A.

Table 2. A representative sample of undergraduate students' comments regarding perceived benefits from ergonomics in their future work related to Question A. The programs were logistics and management (L&M) and sustainable supply chain management (SSCM).

Undergraduate students' comments	Program	Previous work experience Time; type of work; country
<i>In the past, I personally didn't understand the reasons and problems concerning ergonomics but after taking this informative course I have learned a lot.</i>	SSCM	> 3 years; sales, administration, customer service industry; India, Sweden, UK
<i>It will be good to have in the back of my head regarding potential issues but no more.</i>	SSCM	> 3 years; industrial, carpenting, logistics; Sweden
<i>I think we will benefit from it because much of the future work will probably be about improvements of different kinds.</i>	L&M	1-3 years; production work; Sweden
<i>Partly, I will probably have theories in mind, but much focus and time I think will be given priority on value-adding, etc.</i>	L&M	1-3 years; grocery store mostly; Sweden
<i>The importance of how you sit and stand and so on.</i>	SSCM	1-3 years; car rental, office; Sweden
<i>I can use the HTO modules to increase efficiency in work.</i>	*	< 6 months; amusement park; USA

*Exchange student from Singapore

Table 3. A representative sample of graduate students' comments regarding perceived benefits from ergonomics in their future work related to Question A. The program was production development and management.

Graduate students' comments	Previous work experience Time; type of work; country
<i>It is an inevitable topic that we need to include in the production system. This can make drastically changes and can make profit in any organization.</i>	1-3 years; production engineer; India
<i>This course helped me understand how to develop a systems perspective and broadened my perspective of the ergonomics field. I earlier used to think ergonomics is only related to design and mental process at the most. Now I have a better view about ergonomics and how Human, Technology and Organizational aspects interact.</i>	1-3 years; mechanical industry; India
<i>I think this course provided a good overview on areas, which I have not (unfortunately) reckoned in engineering education. Also, the way of the exam enabled us to store the information deeper and it has become more natural for me to think about and consider ergonomics.</i>	6 months - 3 years; production engineer; England
<i>I think ergonomics could be applied to a lot extent in a production, its performance and the relationship to HTO.</i>	< 6 months; café, healthcare; Sweden

3.2 Question B: How much do you think the HTO concept contributed to your understanding of workplace ergonomics?

The answers on this question show that the students think the HTO concept contributed to their understanding of workplace ergonomics but to a different degree in the undergraduate and graduate group related to the quantitative responses shown in Table 5.

Table 4. Student's experience of benefits of the HTO concept in workplace ergonomics. Answers scale 1-5 (to a low extent - to a high extent). n = 122

Question B: How much do you think the HTO concept contributed to your understanding of workplace ergonomics?			
	Undergraduate students (87)	Graduate students (35)	Students T-test on difference $p < .001$
Average	3,16	4,49	
Median	3	5	

The comments show however, that many of the undergraduate students actually think that the HTO concept has contributed to understanding workplace ergonomics but not as deeply as the master students' comments show (Table 5 and 6).

Table 5. A representative sample of undergraduate students' comments regarding the HTO concepts contribution to their understanding of workplace ergonomics (Question B). The programs were logistics and management (L&M) and sustainable supply chain management (SSCM).

Undergraduate students' comments	Program	Previous work experience Time; type of work; country
<i>The HTO concept contributed enormously as one must think of all parts of HTO to evaluate a work place.</i>	SSCM	> 3 years; sales, administration, customer service industry; India, Sweden, UK
<i>The HTO concept contributed a lot, if something is wrong with the ergonomics, the HTO simplifies and gives us a broad understanding of the reasons.</i>	SSCM	< 6 months; production line; Sweden
<i>The need for a holistic view is immanent and HTO allows you to easily understand workplace ergonomics.</i>	L&M	> 3 years; construction industry, hospital, manufacturing; Australia, Germany
<i>Good way to understand the parts and how these interact with each other's and also easy to educate others to understand it.</i>	L&M	> 3 years; logistics; Sweden
<i>The HTO concept is very important to understand in our job.</i>	L&M	< 6 months; warehouse; Sweden

Table 6. A representative sample of graduate students' comments regarding the HTO concepts contribution to their understanding of workplace ergonomics (Question B). The program was production development and management.

Graduate students' comments	Previous work experience Time; type of work; country
<i>The HTO concept helped me to understand how workplace ergonomics can be viewed in various ways.</i>	1-3 years; mechanical industry; India.
<i>The HTO concept gave a whole new perspective to the ergonomics and how it actually affects all parts.</i>	< 6 months; café, healthcare; Sweden
<i>The HTO concept gives me a good mental model of where to look and how it can help.</i>	6 months - 1 year; McDonalds, transport planning; Sweden
<i>The HTO concept gave me a wider perspective on how important workplace ergonomics is and how the HTO-factors affect each other.</i>	1-3 years; process consultant/engineer; Germany
<i>Understanding of each of the HTO sub-systems is very important in order to design a suitable workplace for all.</i>	< 6 months

3.3 Question C: Do you think you will benefit from your knowledge of the HTO concept in your future work?

Table 7 shows the quantitative results of question C, illustrating that the students think that they will benefit from their knowledge of the HTO concept in their future work. As in the answers on question A and B we can also here see a difference between undergraduate and graduate students as groups considered.

Table 7. Student's experience of benefits from their knowledge of HTO in their future work. Answers scale 1-5 (to a low extent - to a high extent). n = 122

Question C: Do you think you will benefit from your knowledge of the HTO concept in your future work?			
	Undergraduate students (87)	Graduate students (35)	Students T-test on difference $p < .001$
Average	3,27	4,43	
Median	3	5	

Regarding the comments below we found that the undergraduate students were more superficial in their comments to question C and there was a larger span in opinions compared to the graduate students. However, both groups show benefits from the HTO concept in many comments regarding their future work (Table 8 and 9).

Table 8. A representative sample of undergraduate students' comments regarding perceived benefits from their knowledge of HTO in their future work (Question C). The programs were logistics and management (L&M) and sustainable supply chain management (SSCM).

Comment	Program	Previous work experience Time; type of work; country
<i>Of course, I will benefit from the HTO concept in my future work and it will help me a lot.</i>	SSCM	> 3 years; sales, administration, customer service; India, Sweden, UK
<i>Yeah, you can not only blame the human (H), you have to consider the other aspects T and O.</i>	L&M	6 months - 1 year; carpentering, logistics; Sweden
<i>I can't say where I will work but definitely not with ergonomics and HTO.</i>	SSCM	> 3 years; warehouse, assembly line, customer support; Sweden
<i>Yes, because it is tool of analysis that can be adaptable to any situations.</i>	*	< 6 months
<i>As studying industrial engineering with focus on production it will be definitely beneficial to have it in mind!</i>	#	> 3 years; construction industry, hospital, manufacturing; Australia, Germany

*Exchange student from Italy

Exchange student from Germany

Table 9. A representative sample of graduate students' comments regarding perceived benefits from their knowledge of HTO in their future work (Question C). The program was production development and management or follow the course as exchange students.

Comment	Previous work experience Time; type of work; country
<i>Yes, in designing, work load distribution, work place, error analysis and better decision making.</i>	-
<i>Yes, for better workplace design and help industries work differently.</i>	1-3 years; mechanical industry; India
<i>The HTO perspective is very helpful when understanding a system holistically + OD (an organization development model we also used in the course) as support in planning organizational change (this is what I want to do – help improve companies).</i>	1-3 years; process consultant/engineer; Germany
<i>I will definitely see that there are interactions and that they can be used in analysis, development, design etc. I am very grateful for this knowledge!</i>	< 6 months; café, healthcare; Sweden

4 Discussion

The students' experiences from participating in courses where the HTO concept was used to explain and develop the systems' character of ergonomics show that undergraduate students in logistics and management and sustainable supply chain management as well as graduate students in production development and management perceived knowledge about ergonomics and the HTO concept beneficial.

Both undergraduate and graduate students regarded the benefits of ergonomics knowledge (Question A) in future work important but to different degrees. These differences were statistically significant according to the Students T- test. In the motivations, we could recognize a difference in the characteristics and spread of the answers between the groups. There was a greater span in the answers given by undergraduate students regarding their perceived benefits of ergonomics in future work compared with graduate students. The depth of understanding of the application and benefits of workplace ergonomics were also identified in the comments. These illustrated that some undergraduates had less interest in ergonomics as well as a different view of it.

How much the students thought the HTO concept contributed to their understanding of workplace ergonomics according to Question B differed somewhat more between the groups in the scaled answers, also statistically significant differences according to the Students T- test. The comments show however, that many of the undergraduate students actually thought that the HTO concept had contributed to understanding workplace ergonomics, but they don't seem to have grasped it as well as the master students.

Undergraduate and graduate students thought they would benefit from their knowledge of the HTO concept in their future work (Question C). Similar to the

answers in question A and B, there was a statistically significant difference according to the Students T- test. Moreover, the undergraduate students were more superficial in their comments to this question and there was a larger span in opinions compared to the graduate students' comments.

The result gap between the two groups indicates that the undergraduate students did not grasp the subject as deeply as the graduate students. This is reasonable as they had less study maturity and generally had less work place experience. Another reason for the differences could be due to program focus and what they perceive to be their responsibility in their future work.

A further reason may be the bigger group and spread of students in the undergraduate group which inevitably changed the pedagogic conditions. Another pedagogic aspect referred to by a graduate student in Table 3, was the benefits of the examination method used in the graduate course. The experience of this oral exam method was proven successful in contribution to a more active learning (Karlton & Karlton, 2014).

Ergonomics is a discipline that is very broad in theory and application. The HTO concept has provided a useful tool to help the students to relate to overall systems performance associated with interactions between the sub-systems Human, Technology and Organization. It has also shown to be useful as an entry to system's thinking in education on undergraduate as well as graduate level (Karlton et al., 2017).

However, systems knowledge includes the understanding of dynamic changes and is challenging to achieve. It involves a 'development capacity' that requires a deeper kind of learning as double loop learning and second order learning (Kjellström & Andersson, 2017). Double-loop learning requires a shift in understanding, from simple and static to broader and more dynamic, such as taking into account the changes in the surroundings and the need for expressing changes in mental models (Argyris, 2002). First-order learning refers to people learning something within their current understanding. But change at the system level often requires transformational or second-order learning, which means that persons need to change their way of understanding (Mezirow, 1991). This takes time and it is also related to workplace experiences to be applied within workplace ergonomics. We consider the differences in the perceived benefits between undergraduate and graduate students also relate to these aspects.

5 Conclusions

One conclusion that can be drawn from this study is that to improve the teaching of ergonomics as a systems topic, using the HTO concept is a way of doing so. The difficulty in moving the understanding of work systems, from simple linear models of cause and effect to system models illustrating the complexity of work and organizations' operations, must be acknowledged. By further analysis and development of appropriate actions there are possibilities of moving a larger portion of the students towards more elaborate systems understanding of ergonomics. Moreover, differences between student groups must be explicitly considered and the relevance of ergonomics within the engineering educations should be further motivated for the students.

6 References

Argyris, C. (1999), *On Organizational Learning*, Blackwell, Oxford.

Berglund, M., Karlton, A. (2015). *Emphasizing the interactive systems view in a master's programme in Ergonomics and HTO*. Proceedings 19th Triennial Congress of the IEA, Melbourne 9-14 August.

Daniellou, F. (2001). Epistemological issues about ergonomics and human factors. *International Encyclopedia of Ergonomics and Human Factors*, Part 1. W. Karwowski. London, Taylor & Francis: 43-46.

Jeppsson, P. (2018) Speech (in Swedish) presented at AFoU dialogue seminar 180130, <https://www.youtube.com/watch?v=og1HOFrS4eQ>, Deputy CEO The Confederation of Swedish Enterprise, Stockholm.

Karlton, A. (2014). *A novel approach to understand nested layers in quality improvement*. Proceedings of Human Factors in Organizational Design and Management – xi Nordic Ergonomics Society Annual Conference – 46, Copenhagen, August 17-20, pp. 343-360.

Karlton, A., Karlton, J. (2014) *Interactive oral assessment supporting active learning*. Proceedings of the 10th International CDIO Conference, Universitat Politècnica de Catalunya, Barcelona, Spain, June 16-19.

Karlton, A., Karlton, J., Eklund, J. and Berglund, M. (2017). HTO - A Complementary Ergonomics Approach, *Applied Ergonomics*, 59, 182-190.

Kjellström, S., Andersson, A-C. (2017). Applying adult development theories to improvement science. *International Journal of Health Care Quality Assurance*, 30:7, 617-627. DOI 10.1108/IJHCQA-09-2016-0124.

Mezirow, J. (1991), *Transformative Dimensions of Adult Learning*, Jossey-Bass, San Francisco, CA.

Wilson, J. R. (2014). Fundamentals of systems ergonomics/human factors. *Applied Ergonomics* 45(1), 5-13.