

11th Conference on Learning Factories, CLF2021

Conceptualising transfer of wicked industry 4.0 opportunities through Learning Factories

Lene Buhl^a, Lasse Christiansen^b, Flemming P. Knudsen^{a*}, Esben Skov Laursen^b

^aUCL Erhvervsakademi og Professionshøjskole, Boulevarden 25, 7100 Vejle

^bUniversity College Northern Denmark, Sofiendalsvej 60, 9200 Aalborg SV, Denmark

Abstract

Industry 4.0 (I4.0) implies significant wicked opportunities for manufacturing. However, manufacturing companies lack competencies to innovate their processes to transfer these wicked opportunities quickly and thoroughly. Process innovation can support the utilisation of a new or significantly improved method for production or distribution, with the intention to decrease unit costs of production or distribution, to increase quality, or to produce or distribute new or significantly improved products. However, transfer of I4.0 related methods often requires significant changes in the manufacture's technology, software, tasks, structures, and employees' competencies. To advance the development of employee's competencies to transfer wicked opportunities of I4.0, the concept of Learning Factories can help employers in transfer, learning, and training. A Learning Factory that facilitates transfer, learning and training can be organised and facilitated as either a personal or collective in situ experimental learning process that networks industry participants, faculty, and students. Learning Factories offers opportunities to improve the learning and transfer processes; however a stronger conceptual frame for the innovation of learning and transfer processes could aid the development of Learning Factories. Consequently, this study unites and synthesises existing research on transfer to advance theory building, to strengthen process innovation in Learning Factory settings. Based on the findings, the initial work of an operational model for knowledge transfer of I4.0 wicked opportunities in Learning Factories is discussed.

© 2021 The Authors. This is an open access article.

Peer Review statement: Peer-review statement: Peer-review under responsibility of the scientific committee of the 11th Conference on Learning Factories 2021.

Keywords: Knowledge transfer; cognitive; situated; sociocultural; Learning Factory

1. Introduction

A beneficial and profitable learning process is a process that leads to better practical actions and thus leads to the application of what the learner has learned as new knowledge, skills, and competencies [1]. However, how much of what is learned in a training program is applied in practice? How many of those who have learned something in a training program apply any of what they have learned? The answer seems to be both less than one would think and than one might wish.

Practical experience and evaluations, and research indicate that only a limited part of what is learned in a traditional training program is applied subsequently. Some studies suggest that only around 10% of what is taught during a course is applied by the attending students later [2]. Therefore, training programs needs to be designed to enable learners to transfer what they learn to new situations. This notion leads to the research question of this paper: "How can Learning Factories promote transfer in continuing education?"

Transfer, presented by Årkrog and Wahlgreen [3], as part of the learning processes in continuing education has been on the agenda for a long period of time. The applied research into knowledge transfer, and numerous contributions in regards to the Learning Factory, is mainly characterised by its focus on *how* to transfer, and less on conceptualising *what* transfer is.

To assist in the development of a focus on *what* transfer is, inspiration can be found internationally, where educational researchers point out that transfer presupposes a theoretical understanding of learning and that the concept of transfer is changing – when there is no ‘what’ it makes it difficult to imbue the discussion with meaning

* Corresponding author. Tel.: +4592434988
E-mail address: fpkn@ucl.dk

of a 'how'. By focusing on the 'what', it is possible to gain new insights into, and design better, Learning Factories. This can be seen as process innovation, as it is an improved delivery method based on new techniques [4].

According to one of the leading researchers in the field, transfer means "transfer of knowledge and skills from one situation to another" [3]. However, the understanding of the term is intensely debated within the research field, and consequently several understandings can be found in the literature. The debate of transfer raises key questions for our understanding of transferring and the ways in which it makes sense to work with transfer – also in the context of Learning Factory settings.

The Learning Factory is defined as a learning environment with a teaching or training purpose, authentic and multistage from a technological perspective [5]. It is changeable, either virtual or physical, and concerns either a service or a physical product. Furthermore, the learning approaches rely on formal and informal learning that enables reflection [5]. Supplementing this, the concept of teaching factors has emerged; learning processes based on industrial factories and operations focus on lab-to-factory and factory-to-classroom interactions [6], [7]. Prospectively, no distinction between these concepts will be made in this article, as the transfer process is a key output from both the Learning and the Teaching Factory.

Judith Enke names three parameters on which the Learning Factory's maturity should be assessed: operating method, purpose, and didactics. In a well developed Learning Factory, reflection is a central part of the setup as a step for competency development [8]. This implies that the reflection should be the vessel in which the transfer of knowledge from the Learning Factory provider to the worker's everyday work life should occur.

This article investigates the need for transfer in dynamic settings with a fast expiration of knowledge and skills, like the I4.0-setting. First, the term transfer is introduced. Furthermore three different perspectives for the work with transfer are unfolded and related to the conceptualisation of knowledge transfer through Learning Factories in the continuing education system.

2. Transfer

The interest in transfer has been linked to fundamental societal changes since the emergence of the concept of transfer in the early 20th century [9]. Whether society is described as late modern [10], fluid modern [11] or complex [12], a common perception is that society is continually characterised by processes of change that take place at increasing speed. In 1996 Anthony Giddens wrote: "Not only is the rate of social change far higher, its extent and the depth with which it affects previously existing practices and behaviours is also far greater" [10]. This also applies to job profiles, where both core and contextual competencies change as new technology and trends emerge [13]–[15]. These core and contextual skills have different gaps and impacts depending on job profile, and as job profiles change and emerge due to new technology and trends, the gaps expand and multiply [16]. American education researchers estimated, almost 15 years ago, that approx. 50% of all employees' concrete knowledge and skills become obsolete within 3-5 years [17]. The expiration date has not been extended since and is not likely to be so within the domain of I4.0. Therefore, new knowledge must be translated and transferred quickly and efficiently in the workplace. Educational institutions today are in no way able to teach employees and students everything they need to know in working life [9], and therefore leaders and educators are preoccupied with lifelong Learning and transfer to competencies.

2.1. Scope and density of transfers

The processes and results we use to describe transfer have both a quantitative and a qualitative aspect. The quantitative aspect covers the fact that transfer has a greater scope and density in societies, characterised by social change, than in societies, characterised by stability. A profound societal change is differentiation or specialisation [10]. New tasks, challenges and wicked opportunities arise in working life due to the I4.0, and the handling requires employees to exchange information and collaborate across professional boundaries, regardless of previous divisions of tasks and organisations. Learning in working life is about becoming an expert in a minimal field and about crossing boundaries and working with transfer [12], [18]. Yrjö Engeström points out that expertise today consists of building up knowledge within an area and committing to and negotiating between many parallel contexts. Expertise means that one can combine elements from different contexts to arrive at hybrid solutions [9].

The Learning Factory's transfer scope is mostly rooted in technological skills, where the learner is expected to gain knowledge, skills, and competencies within certain technologies [5]. The underlying assumption is that the multistage environment's interconnection will form a basis for transfer. Here, the resemblance between the Learning Factory's value chain and the real-life value chain can form a basis for chunking [19]. Hence, the transfer can take place by building on activation of existing experiences, and a demonstration of knew content within the Learning Factory. Afterwards, the new content can be applied within the Learning Factory, before it can be implemented within the everyday worklife of the learner once again [20].

2.2. Transfer quality

The question is whether the more intensive and dynamic requirements for learning and transfer also mean that the transfer quality has changed? Transfer can be divided into different ways of performing the transfer. An applied division is in *specific* and *general* transfer types. According to Wahlgren & Aarkrog, 2012, *specific* transfer is linked to learning and applying skills and techniques, while *general* transfer includes learning and applying general knowledge and skills [3].

The *specific* transfer requires that industry participants and students can do the same thing in a new context. The *specific* transfer has been suggested as a transfer mechanism for I4.0-approaches to small and medium-sized enterprises through Learning Factory concepts [21]. On the other hand, the *general* transfer requires that learners see how abstract knowledge, such as theories and general skills, can be used in a few different concrete situations that are not necessarily similar to each other [3].

Although transfer play a central role in working life, developments indicate that the *general* transfer has become relatively more important in the labor market compared to the *specific* transfer [22]. As researchers and educators in the field of continuing and further education, our combined experience tells us that we typically observe a focus on *specific* competence development in the collaboration between educational institutions and municipal workplaces. Simultaneously, the underlying thought patterns, which do not age with the same pace, also require a transfer where the explicit skills required today are linked to new skills and existing knowledge for the formation of e.g. system thinking or mathematical thinking [23].

As a result, the specific competencies are in focus as a result of current political and professional priorities. While the general focus on both digital and general skills have been highlighted in many actions in the recent years, the interconnection between these have also been investigated [13]. It is argued that these domain specific competences does not fade in relevance, but new requirements have been added [24]. Accordingly, it is our collective experience that the need for general competence development continues to emerge in the specific training and education courses. For example, general competencies can be to create an overview, know where and when to seek new knowledge, work analytically, and create relationships with partners and end users.

In this way, the general competencies seem to play a central role in the field of continuing education, although they are not necessarily prioritised.

Table 1 - Process of specific and general transfer

Specific Transfer	General Transfer
<i>Specific</i> transfer requires that learners can do the same in a new context.	<i>General</i> transfer requires that learners see how abstract knowledge, such as theories and general competencies, can be used in different concrete situations that are not necessarily much alike.
<i>Specific</i> competence development, e.g., knowledge of new legislation or new technology, software, or methods. Transfer where the explicit competencies required today are linked to new competencies.	<i>General</i> competence development can be to create an overview, know where and when to seek knowledge, work analytically, and create relationships with partners and end users.
<i>Specific</i> competencies are in focus as a result of current political and professional priorities.	<i>General</i> competencies seem to play a central role in the field of continuing education, although they are not necessarily prioritised.

3. Discussion

An intense debate has taken place about transfer among educational researchers internationally in relation to new and changing requirements for transfer between educational institutions and workplaces. The debate revolves around well-established educational research positions; a cognitive approach, a situated approach, and a sociocultural approach. Below, the disagreements are presented, emphasising the importance of the work with transfer in the continuing education system.

3.1. A cognitive approach: Can content and context be separated?

The cognitive approach has for long been present in the transfer discussion. Transfer is understood as a transfer of knowledge and competencies from one task solution to another, where cognition is the active element [25].

Behaviourists believe that transfer happens almost by itself in the right environment; supporters of a cognitive approach emphasise an active interpretation, modification, and reconstruction of what is learned in a new context. This is done by structuring knowledge in mental schemas within the individual's interior.

The understanding based on a situated perspective has been criticised for separating learning from the social contexts in which it takes place. Critics point out that knowledge is tied to the situations in which it is created [12]:

knowledge changes depending on the situation. This is not a simple reproduction. In other words, knowledge and skills cannot be de-contextualised.

The author of the situated perspective, Jean Lave, deny the possibility of transfer because every situation must be understood as unique [9]. The critique from a sociocultural position is an extension of this, that it is far from only cognition that is transferred from one context to another, but also especially social and affective elements.

The difference in conceptual understanding is important for the expectations that teachers, company participants and students may have in regard to transfer in a Learning Factory setting. Can teachers achieve transfer by organising learning based on similarities between the teaching situation and practice with a focus on cognition or should they at the same time work with active emotional and social participation of course learners? Does transfer only mean that learning is recognising elements and structures in problem understanding and handling in the workplace from previously at the educational institution (*specific* transfer), or does transfer also mean that learners actively relate to positions and roles in the workplace when new learning is put into play? (*general* transfer)

3.2. A situated perspective: Cognition or participation?

According to a situated perspective, transfer can be understood as the transfer of participation processes and patterns from situation to situation. It is not only mental schemas that are transmitted, but also schemas of action. The key here is to understand how learning to participate in one context affects the ability to participate in a similar activity in another context. With a situated perspective, participatory processes in working and everyday life are central and thus the focus is also shifted to areas outside the education system.

The elements that, in addition to the classical knowledge and skills, are included in the concept of transfer from a situated perspective are participation paths, participation patterns and identity of different types [25]. Transfer is not only about what we know and what we can do, but also about who we are and who we become when we interact with other people in different social communities. Consequences of the different perceptions are extensive for the educational institutions. Is it important to focus on individual cognitive growth, or should teachers, company participants and students in Learning Factories also work with activating, developing and democratic teaching methods? Are social identities in the form of professional affiliation also included in the teachers' work or perhaps even collective action options and problem solutions?

3.3. A sociocultural perspective: Identical elements or border crossings?

The critique of the situated approach comes primarily from a sociocultural perspective. Engeström points out that situated approaches present communities of practice as being in a stable state and do not take into account the radical changes and shifts that characterise working life in complex societies [9].

It is a break in the transfer discussion when the banner bearers from a sociocultural perspective suggest attention to similarities and differences in different contexts [25]. According to Henningsen & Mogensen, 2013, the classic and most prominent transfer concept in the literature is based on an idea of transfer via identical elements [26]. But in a sociocultural perspective is not necessarily about working with similarity between learning in different contexts, but about being aware of what types of boundaries are crossed, creating intertextuality between them and working with the degree to which dominant forms of knowledge, rules, social interaction patterns, etc. are complementary or in conflict. The consequence of this learning understanding is far-reaching, and the question is how teachers in continuing education and organisers of Learning Factories can set the framework for learning about crossing borders between fields in working life?

Several perspectives point to different factors that influence how participants in competence development can transfer what they have learned in practice in the previous sections. In a more general summarising perspective, the various factors could be related to: a) the learner, b) the teaching/learning, and c) the practice. In the table below, 12 generic transfer factors are briefly described.

Table 2. 12 generic transfer factors [27].

Factors related to the learner
1. The more clearly the learner can see the need to learn - the more transfer
2. The more clearly the learner has formulated the goal for learning - the more transfer
3. The more the learner believes that s/he can apply what he/she learns - the greater the probability for that s/he actually uses it
Factors related to the teaching/learning
4. The better one masters what one have learned - the greater the probability of using it
5. The more identical elements there are between learning situation and application situation - the more transfer
6. The better reflection on the relationship between theoretical knowledge and practical application situation - the more transfer

7. The more you train transfer in teaching - the more transfer
8. The more credible the teacher is - the more transfer
Factors related to the practice
9. The better the situation of use is organised in relation to the testing and application of what has been learned - the more transfer
10. The more socially supportive the situation of use is - the more transfer
11. The more systematic follow-up on learning - the more transfer
12. The greater advantage the learner can see in the application of what is learned - the greater the transfer

3.4. Towards a new understanding of transfer

In recent years, there have been discussions internationally about transfer, which have grasped the significance of complex societal changes and which can qualify the work with transfer in the continuing and further education system. A main point in the international transfer debate is that transfer tasks presuppose a clarification of which learning understanding one is working with.

Is it a cognitive approach, where the task is to support the development of understanding and overview in the individual? Is it a situated approach where communities of practice and the workplace context are central and educational institutions are assigned a less important role? Or is it a sociocultural approach where educational institutions and collaborative workplaces prioritise learning by crossing borders between different contexts?

The general societal specialisation and differentiation points to an increased need for transfer at the same time as the increasing speed of the changes may mean that the general transfer in the form of e.g. abstract knowledge and skills become relatively more important than the specific transfer in the form of concrete knowledge and skills.

The phenomenon of transfer depends on the type of learning to be translated and on the current societal, cultural, and working life contexts. In the late modern, complex society, transfer can be seen as a joint project between educational institutions and workplaces with the aim of creating new knowledge and new practices [12]. Transfer takes place through a diversity of processes that unfold in both educational institutions and workplaces.

Rather than a division of labor where educational institutions are responsible for theoretical knowledge and workplaces to develop and maintain practices, it is advantageous to work with theory and practice elements in both contexts [22]. This points to a more organisational perception of transfer [28] and a strategic collaboration between educational institutions and workplaces on competence development courses.

And it also points to new roles. Continuing education professionals must be able to identify and discuss learning with company workers and transfer needs in the workplace. Teachers and students must be able to disseminate knowledge and be involved as change agents in collaboration with actors in the field of practice. In the workplace, managers, workers, and consultants must be able to work strategically with competence development and be involved in planning, participating in, and following up on specific learnings through factories

The general societal specialisation and differentiation points to an increased need for knowledge transfer. At the same time, the increasing speed of changes may mean that general transfer in the form of e.g. abstract knowledge and skills become relatively more important than the specific transfer in the form of concrete knowledge and skills.

In other words, the phenomenon of transfer depends on the type of learning to be translated and on the current societal, cultural, and working life contexts. In the late modern, complex society, transfer can be seen as a joint project between educational institutions and workplaces with the aim of creating new knowledge and new practices [7]. Transfer takes place through a diversity of processes that unfold in both educational institutions and workplaces in a learning environment that can be characterised as a Learning Factory.

4. Conclusion

To answer the research question of this paper: How can Learning Factories promote transfer? – we have discussed at least three generic conceptualising factors that promote transfer - personal factors, teaching factors, and factors that relate to the situation and context where learners are going to apply what they have learned. Transfer and application of what is learned can thus be promoted if the learning process emphasises what the learner must do differently and better.

Simultaneously learners transfer and application of what is learned is promoted when teaching and learning is organised in relation to how processes needs to be done differently. As the final concluding remark, this paper has highlighted that training programmes that are beneficial and profitable; recognise that knowledge transfer is promoted by an "extend focus", because the process of transfer, happens before teaching and continue after teaching, just as much as during the actual learning situation.

If Learning Factories should support transfer processes, this would require tasks and learning processes which encourage the participants to experiment and be creative on how to learn, implement and train the different transfer factors. A learning factory for transfer, distinguishes itself from existing Learning Factories because of its focus being to create environments that support both specific and general transfer in an industry setting.

Consequently, with an offset in the findings of this research we can describe the characteristics of a transfer Learning Factory which stand out from existing use of Learning Factories. A transfer Learning Factory can, therefore, be described as a Learning Factory which supports efficient transfer in an industry setting through tasks that may be experimental and encourage creativity compared to existing Learning Factory approaches. Furthermore, to succeed, these Learning Factories should support the long-term and visionary implementation and exploitation of wicked I4.0 manufacturing technologies and systems, and thus focus on development of a conceptual understanding of transfer processes in I4.0 besides focus on individual I4.0 technologies and methods which are already used in Learning Factories today.

References

- [1] E. Commission, *The European Qualifications Framework*. 2012.
- [2] D. L. Georgenson, "The problem of transfer calls for partnership," *Train. Dev. J.*, vol. 36, no. 10, pp. 75–78, 1982.
- [3] V. Aarkrog and B. Wahlgren, *Transfer: Kompetence i en professionel sammenhæng*. ISD LLC, 2012.
- [4] *Oslo Manual*. OECD, 2005.
- [5] E. Abele, J. Metternich, and M. Tisch, "Learning Factories," in *Concepts, Guidelines, Best-Practice Examples*, Springer, 2019.
- [6] D. Mavrikios, K. Georgoulas, and G. Chryssolouris, "The Teaching Factory Paradigm: Developments and Outlook," in *Procedia Manufacturing*, 2018, vol. 23, pp. 1–6.
- [7] P. Stavropoulos, H. Bikas, and D. Mourtzis, "Collaborative Machine Tool design: The Teaching Factory paradigm," in *Procedia Manufacturing*, 2018, vol. 23, pp. 123–128.
- [8] J. Enke, R. Glass, and J. Metternich, "Introducing a Maturity Model for Learning Factories," *Procedia Manuf.*, vol. 9, pp. 1–8, Jan. 2017.
- [9] T. Tuomi-Grohn, Y. Engestrom, and M. Young, "From Transfer to Boundary -crossing Between School and Work as a Tool for Developing Vocational Education: An Introduction," in *Between School and Work: New Perspectives on Transfer and Boundary Crossing*, Pergamon Press, 2003, pp. 1–18.
- [10] A. Giddens, *Modernity and self-identity: Self and society in the late modern age*. Stanford university press, 1991.
- [11] Z. Bauman, *Liquid modernity*. John Wiley & Sons, 2013.
- [12] R. Konkola, T. Tuomi-Gröhn, P. Lambert, and S. Ludvigsen, "Promoting learning and transfer between school and workplace," *J. Educ. Work*, vol. 20, no. 3, pp. 211–228, 2007.
- [13] E. van Laar, A. J. A. M. van Deursen, J. A. G. M. van Dijk, and J. de Haan, "The relation between 21st-century skills and digital skills: A systematic literature review," *Comput. Human Behav.*, vol. 72, pp. 577–588, Jul. 2017.
- [14] S. Fareri, G. Fantoni, F. Chiarello, E. Coli, and A. Binda, "Estimating Industry 4.0 impact on job profiles and skills using text mining," *Comput. Ind.*, vol. 118, p. 103222, Jun. 2020.
- [15] A. Khan and K. Turowski, "A survey of current challenges in manufacturing industry and preparation for industry 4.0," in *Advances in Intelligent Systems and Computing*, 2016, vol. 450, pp. 15–26.
- [16] J. Pontes et al., "Relationship between Trends, Job Profiles, Skills and Training Programs in the Factory of the Future," in *The 9th International Conference on Information Technology: IoT and Smart City*, pp. 1–6.
- [17] T. F. Hawk, *Learning in Adulthood: A Comprehensive Guide.*, vol. 10, no. 1. John Wiley & Sons, 2011.
- [18] S. F. Akkerman and A. Bakker, "Boundary crossing and boundary objects," *Rev. Educ. Res.*, vol. 81, no. 2, pp. 132–169, 2011.
- [19] B. Oakley, "Learning How We Learn: In an unlikely confluence, bioengineers are finding fertile ground in research and teaching about learning," *IEEE Pulse*, vol. 6, no. 2. Institute of Electrical and Electronics Engineers Inc., pp. 37–41, 01-Mar-2015.
- [20] M. D. Merrill, "A Pebble-in-the-Pond Model For Instructional Design," *Perform. Improv.*, vol. 54, no. 1, pp. 42–48, Jan. 2015.
- [21] A. Wank, S. Adolph, O. Anokhin, A. Arndt, R. Anderl, and J. Metternich, "Using a Learning Factory Approach to Transfer Industrie 4.0 Approaches to Small- and Medium-sized Enterprises," in *Procedia CIRP*, 2016, vol. 54, pp. 89–94.
- [22] C. Macaulay and V. E. Cree, "Transfer of learning: Concept and process," *Soc. Work Educ.*, vol. 18, no. 2, pp. 183–194, 1999.
- [23] M. Prensky, "The World Needs a New Curriculum.," *Educ. Technol.*, vol. 54, no. 4, pp. 3–15, 2014.
- [24] L. Büth, S. Blume, G. Posselt, and C. Herrmann, "Training concept for and with digitalization in learning factories: An energy efficiency training case," in *Procedia Manufacturing*, 2018, vol. 23, pp. 171–176.
- [25] J. Lobato, "Alternative perspectives on the transfer of learning: History, issues, and challenges for future research," *J. Learn. Sci.*, vol. 15, no. 4, pp. 431–449, 2006.
- [26] S. E. Henningsen and F. Mogensen, *Mellem teori og praksis: Om transfer i professionsuddannelser*. VIA-systeme, 2013.
- [27] B. Wahlgren, "Transfer i VEU: Tolv faktorer der sikrer, at man anvender det, man lærer," *København NCK/Nationalt Cent. Kompet.*, 2013.
- [28] U. Brandi, "Transfer dybt afhængig af arbejdspladsen," *Efter-og Videreuddann. af udsatte børn og unge*, vol. 5, 2016.