Lean European Action-learning Network utilizing Industry 4.0

WP 2 – Mapping learning practices in Smart Operations and Lean Manufacturing

D2.2 A taxonomy of Network Action Learning

Version: Final Report

Date: 28-08-2019

Project Reference: 601227-EPP-1-2018-1-NO-EPPKA2-KA

Co-funded by the Erasmus+ Programme of the European Union

LEAN 4.0 Version Control Table

Deliverable Title	WP2 D2.2 A taxonomy of Network Action Learning
Prepared by	HSOS
Evaluating Partner	SINTEF
Version date	28.08.2019
Contact	Dennis Konusch (dennis.konusch@hs-osnabrueck.de)

Revision History:

Date	**Version**	Summary of Changes	Initials
15.06.2019	Draft version		DKO
06.07.2019	New draft after review with NTNU	Modified according to NTNU comments	DKO
12.08.2019	Draft ready for review (internal)	Modified according to Rosen suggestions	DKO
20.08.2019	Draft ready for review (external)	Modified according to SINTEF suggestions	DKO
28.08.2019	Approved		

Contents of WP2

List of Figures

List of Tables

1 Introduction: LEAN 4.0

1.1 LEAN 4.0

LEAN 4.0 is a collaborative initiative between four leading Higher Education Institutions (HEI) and four industrial enterprises that aims to integrate Industry 4.0 smart technologies within the proven Lean Manufacturing paradigm in order to improve factory performances. Besides their necessity in order to face in an efficient way the continuous market changes and needs, knowledges and experiences regarding both the continuous improvement activities associated with Lean Manufacturing and the disruptive technological innovations of Industry 4.0 are still lacking.

Together, the partners of LEAN 4.0 will address this significant gap in knowledge and practical experience, anticipating the European manufacturing industry's contemporary need for development of new skills brought along by "Industry 4.0". By acting as a conceptual framework, LEAN 4.0 will inspire the operation managers of the future and will prepare European Manufacturing for the challenges that lie ahead.

1.2 Work Package 2 – Mapping learning practices in Smart Operations and Lean Manufacturing

This work package include a map of learning practices in industry, academic environment regarding the scholarly state of the art on Network Action learning based on literature. The focus will be on the specific practices for Network Action Learning, open process innovation, and other collaborative methods as they relate to Lean manufacturing and Smart technologies and the synergy between the two. Further types of learning can be identified and corresponding practices can be addressed. The map consisting of learning types and practices should provide the information basis for the following WP2 tools.

1.3 Deliverable 2.1 – Taxonomy of Learning Practices for LEAN 4.0

Furthermore, a taxonomy will be addressed to classify identified learning types in order to better understand the evolution of Network Action Learning. This task will develop a continuously updated taxonomy that brings together knowledge on Network Action Learning, open innovation and other learning/innovation processes specific for learning and research about Smart technologies and Lean methods. All the partner organizations shall update and quality assure the content. The taxonomy will draw on the findings from the two previous tasks (map of learning practices and the assessment-tool) and provide a coherent taxonomy for Network Action Learning.

2 WP 2 Research for learning practices

2.1 Theoretical background

To build a “continuous improvement” culture in the company´s business processes it has been proven many times that different tools in the context of lean management can help. Continuous Improvement primarily promotes the improvement of the general performance of an organization (Middel, Boer, & Fisscher, 2006). The further development of the large variety of methods of "continues improvement" could help many organizations to handle today's challenges within the company. 5S or Kanban are well known lean methods, that help to reduce waste, analyze and optimize processes, and can be applied along the value chain. Often continuous improvement is associated with “innovation” and especially with the famous PDCA-Circle (Plan-Do-Check-Act). For others, it implies a preoccupation with sustained incremental change, quality improvement and costumer services (Bessant and Caffyn, 1997).
There are already concepts that are "collaborative improvement" –oriented. It can be meant as a continues improvement - concept in an international collaboration context (Middel et al., 2006). “CO-IMPROVED” (Collaborative Improvement Tool for the Extended Manufacturing Enterprise) is a research project with a similar methodology. It is also associated with “Organizational Learning” (OL), from which it can be deduced that these concepts can be linked (Savolainen and Haikonen 2007).
OL implements success factors that supports continuous improvement and the ability to fundamentally renew and revitalize the different forms of learning. It includes different actions that can help to classify learning types and, above all, draws on existing experience (Coughlan, P, Coghlan D., 2011). OL appears in various forms in literature and practice. That is why it is necessary to find out how the individual learning practices differ in practice and whether there are classifications of types of learning. Collaboration between companies and academic organizations in OL can establish valuable progress. Especially in inter-organizational learning, new scientific findings can often be exchanged and tested in practice (Holmqvist 2003). The exchange of researchers and students can particularly boost the progress of companies processes.
An existing project consortium of academic and practical partners (LEAN 4.0) has a useful starting position to deal more intensively with the change from inter-organizational to intra-organizational networks. A literature review on the subject of learning practices and types of learning should provide an overview of already existing learning structures and help LEAN 4.0 to develop its own learning methodology.

2.2 Research Model

The own learning methodology of LEAN 4.0 should help operations managers to learn in networks and use advantages of inter-organizational collaborations within the age of Industry 4.0. For this purpose, research is oriented towards **Blended learning**, **Action learning** and the **Network Action Learning** of Coughlan in order to develop the LEAN 4.0 - **Blended Network Action Learning** Methodology. The following research question can be raised:

What are the Network Action Learning best practices for international collaboration within and between universities, companies and supply chains for implementing Lean methods or Industry 4.0 technologies?

To be able to work out specific results from this review, a superordinate research question was raised:

What types of learning can be practiced in the organizations?

Furthermore, results from a literature review, experiences from past projects of the LEAN 4.0 project consortium and currently used learning practices of corporate partners will be analysed and used to perform answers for the research questions.

The following Research model shows what can be expected.

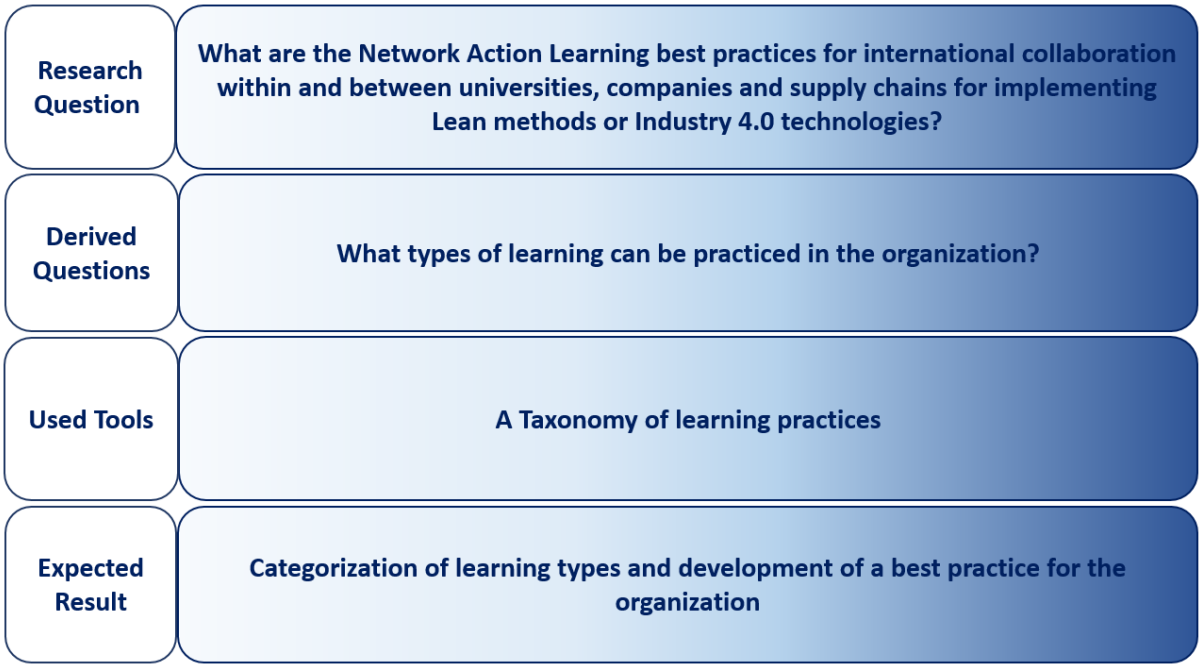


Figure 1: Research Model: Research questions, tools and expected results

Figure 1 shows that LEAN 4.0 operates with a specific tool to answer the derived questions.

The derived question in the research model includes a specific question: *What types of learning can be practices in the organization?* To answer specific questions certain tools can be helpful. Since in this case different types of learning are searched for, a tool that classifies objects according to their characteristics can be useful. In this research project the method of a taxonomy was used to classify and evaluate the learning types that are listed in a pre-step. If the research effort includes the elementary components of a method, self-organizing maps and inputs and outputs of practices, a taxonomy can be created (Aziz and Salleh 2011). In LEAN 4.0, the taxonomy can be seen as a categorization and serves as guideline on how to develop or apply a suitable (best) practice for the organization.

2.3 Literature review

The research question was used to identify keywords so that search terms can be formed for searching in databases. Systematically constructed search terms reduce the search hits to the most essential (table 1).

Table 1: Literature review – Keywords

Keywords / relevant wording regarding the topic „learning“ and „smart technologies“	Learning, practice, blended, network, action, method, model, maturity, lean, industry 4.0, industry, 4.0, technology, factory, problem, type, characteristic, solving, framework, case, smart, learning, game-based, concept, knowledge management, knowledge transfer, learning environment, network learning, network, action learning, virtual environment, e-learning, distance learning, collaboration, skill, collaboration environment, teaching factory, learning factory, traditional learning, innovative learning, synchronous learning, asynchronous learning, learning management

Based on several keywords a search term was created and entered into relevant databases. The results of the literature review are listed below.

Table 2: Results of the first Literature review (by Webster and Wattson)

Literature review according to Webster and Watson							
Searching-term 1	(„Network Action Learning“ OR „Action Learning Research“ OR „Blended Learning“ OR „Learning Factory“) AND („Practice” OR “Method” OR Modell” OR “Maturity” OR “Framework”) AND (“Industry” OR “4.0” OR “Lean”) AND (“problem” OR “solving” OR “Type” OR “Characteristics”)						
Data bases	**Review**	**Emerald**	**Science Direct**	**Springer Link**	**Wiley Online**	**EBSCO host**	**Total**
All Results	First review	376	2744	1337	503	270	**5230**
Results after title-review	First review	339	2501	1314	482	263	**4899**
Results after abstract-review	First review	80	453	125	46	11	**715**

Results after full text-review	First review	5	11	20	0	0	**36**

After the first literature review was carried out, it was realised that the found sources often did not provide enough concrete information about certain types of learning practices, so a second review was carried out. In the second round the search for “problem orientation” was reduced and the “cooperation” and “practice” keywords was increased. It can be noted that the second review per database produced considerably fewer hits.

Table 3: Results of the second Literature review (by Webster and Wattson)

Literature review according to Webster and Watson							
Searching -term 2	(„Network Action Learning“ OR „Action Learning “ OR „Blended Learning“ AND („Practice” OR “Best” “Method” OR “Modell” OR “Framework”) AND (“Industry” OR “4.0” OR “Lean” OR “Smart”) AND (“collaboration” OR “inter” OR “Cooperation” OR “Network”)						
Data bases	**Review**	**Emerald**	**Science Direct**	**Springer Link**	**Wiley Online**	**EBSCOhost**	**Total**
All Results	Second review	-	603	451	51	-	**1105**
Results after title-review	Second review	-	352	286	26	-	**664**
Results after abstract-review	Second review	-	30	25	9	-	**64**
Results after full text-review	Second review	-	18	5	4	-	**27**

According to the approach of Webstar and Watson all search hits are reduced to the most relevant ones. Here a step-by-step process is recommended by first carrying out a title and abstract examination. The prerequisite is the use of a systematic search term. Before the sorting process starts, the settings of the databases are standardized, such as a "without preview-only sources” setting (Webster and Watson 2002). The process and the results can be seen on Table 2. After the title and abstract investigation has been completed, a reduced number of search hits can be expected. These can be analysed with a full text analysis. In most cases the mainresult of the literature as a main figure or a table explains the research result. Furthermore, the research

methodology and the conclusion are examined more closely. By using the search function for keywords the search can often be accelerated.
The first review also revealed that databases such as *Emerald*, *Wiley* and *ESBCOhost* produced just a few relevant results after closer examination of the search hits. They were therefore not further considered in the second review.
Further information was obtained from the above-mentioned sources such as research projects like "CO-IMPROVE" and Societies like "SoloOnline" (The Society for Organizational Learning North America).

3 WP 2 – Results

3.1 Types of Learning

In order to effectively implement the method of a taxonomy, the identified learning types must be questioned. For this purpose, the context of the LEAN 4.0 project is examined and the research question is examined in detail. This raises the question which of the 10 learning types identified are relevant for this research. The following table lists the identified learning types.

Table 4: Types of learning by literature

Blended Learning (Kaur, 2013)
Network Action Learning (Coughlan, P, Coghlan D., 2011)
Action Learning (Revans 1982)
Organizational Learning (Steiner & Hartmann, 2006)
Problem-based Learning (Lehmann, Christensen, Du, & Thrane, 2008)
Project-based Learning (Thomas, 2000)
Research-based Learning (Abele, Metternich, & Tisch, 2019)
Experiential Learning (Abele et al., 2019)
Game-based Learning / Gamification (Schuldt & Friedemann, 2017)
Challenge-based Learning (Garay-Rondero, Rodríguez Calvo, & Salinas-Navarro, 2019)

Before taking a closer look at the learning types, the core idea of the project will be addressed. In the LEAN 4.0 project, the focus is mainly on **blended-oriented, network-oriented and action-oriented learning types**. One of the other work packages in the project addresses the development of an own blended network action learning methodology and hopes to concentrate on the very relevant core characteristics. After an internal review by the project consortium of the literature and the given learning types lead to a selection of **four** relevant learning types,

which can be related to an effective approach of inter-organizational learning. This can be seen as a basis to develop an own LEAN 4.0 – Blended Network Action Learning Methodology.

The following learning types can be seen as relevant (1. – 5.).

Alternative learning types (A. – F.) can be exclude.

1. The name of this learning type already indicates that it is a holistic learning behaviour. **Organizational Learning** refers to learning within an organisation and is not limited to the learning behaviour of a single individual. The characteristics often show elements of the behaviour of an organisation towards learning activities. Furthermore OL show ways of creating new solutions and sharing knowledge with other members of an organization (Sugarman 2012). Thus, success factors can be derived and OL can be presented as a starting point for any learning type.

2. **Action Learning** takes into account the current processes of an organisation, focuses on changes in specific actions and improves by trying things out in practice (Olsson et al. 2010). The learning by doing – behaviour is often connected to an Action Learning approach and includes group work where members come together to form an action learning set. Learning occurs through a continues process of reflecting and acting by the members on a defined problem in this set (Graaf and Kolmos 2015).

3. **Blended Learning** provides effective combinations of different methods of teaching and how to deliver exercises in an interactively meaningful learning environment. It includes a mix of offline- and online and synchronies and asynchronies learning tools (Kaur 2013).

4. **Network Action Learning** is known as a learning type what provides a valuable mechanism for building sustainability by building networks. Network Action Learning – Networks allow conducting both, intra- and inter-organizational action learning and can make the transition from strategic to learning and transformational networks. As in the action learning approach, the set what is a group of people with defined tasks addresses complex problems. A facilitator just for this network will facilitate the actions of this set (Coughlan P., Coghlan 2011).

The following section explains why other learning types are **not** taken into account in the research of an own LEAN 4.0 – Blended Network Action Learning Methodology.

A. An *experiential learning* model can imply a reflective practice proposed. It implies types of actions like 'reflexion in action', on-the-spot surfacing, criticizing, restructuring and testing (Matsuo 2014). This argument leads to the suggestion that methods within experiential learning are covered in the area of Action learning.

B. *Problem-based learning* can be regarded as a preliminary stage for Network Action Learning. Also in this type of learning a group of people comes together as a team who seek to achieve tasks collaboratively and there is usually a facilitator who is a member of staff (Graaf and Kolmos 2015). Similar conditions therefore also exist in the Network Action Learning context.

C. *Challenge-based learning* involves existing operating constraints defined in the experiential work space and leads to taking actions like continues improvement tools (Garay-Rondero et al. 2019). From the perspective of the project this learning type is therefore also an explicit part of Action Learning. Similar conditions therefore also prevail in the Network Action Learning context.

D. Furthermore, *Game-based Learning and Gamification* can be relevant at a later stage of the project. A Learning Platform, which can be found in another work package of LEAN 4.0 (WP5), could be a suitable condition for the application of this method. One of the tasks of the platform includes the use of interactive learning videos with game-based content to boost a learning effect for the users.

E. *Research-based learning* returned the fewest results in the literature review and will probably not continue to be relevant, since LEAN 4.0 is oriented to a practice- and action-oriented or a pilot project-driven methodology. On the contrary, this learning type can be considered if learning subjects or pilot projects are picked in research findings (Abele et al. 2019).

F. According to the literature review, *project -based learning* is one of the best known learning types and occur in both **collaborative and blended approaches**, most of time with similar approaches and practical orientation (Lehmann et al. 2008). Therefore, the practices of these learning can be assigned in blended-, action- or network action learning practices.

The following Table 5 will define the selected types of learning in detail. In addition, the objective of an own LEAN 4.0 learning type is defined.

Table 5: Definition - Types of learning for LEAN 4.0

LEAN 4.0 relevant types of learning
1.0 Organizational Learning
By (Fiol, C. M.; Lyles 1985) organizational learning can be seen as the growing insights and successful restructurings of organizational problems by individuals reflected in the structural elements and outcomes of the organization. This is intended to promote the recognition of errors and solving skills (Argyris, 1977). An organization must have the potential to learn, unlearn, or relearn based on its past behaviors – then organizational learning is the essence of strategic management / key activity for dealing with changes occurring in the environment and involves the continuous of making strategic choices. Inter-organizational learning involves collaborating approaches across national borders. It reveals combinations and builds on expertise of several individual organizations (Steiner and Hartmann 2006).
2.0 Action Learning
In this literature review Action Research is combined with keywords regarding the Action Learning process, which is characterized by a activity-based learning environment like face-to-face learning or the method of a learning / teaching factory (Abele et al. 2017). In addition, (Revan 1993) points out, that Action Learning follows the following learning model: 70% of experiential learning in tough jobs and assignments, 20% of learning from others in a "social" context, usually from the boss in which coaching and mentoring styles predominate and 10% of acquiring knowledge and skills from courses and reading. Learners act independently, focused and performance-oriented. The teaching persons should stay in the background and rather assume a moderating role (Cachay et al. 2012).
3.0 Blended Learning
In a strategy of blended learning, traditional learning methods will be adopted together with online learning. Therefore, a mix of active and interactive communication- and learning tools and virtual / traditional classrooms will be used to enhance the learner's participation and exchange of knowledge (Güzer and Caner 2014), (Siew-Eng and Muuk 2015), (Collis and Margaryan 2004).
4.0 Network Action Learning
Network Action Learning is characterized by a learning behavior with active participation in networks. In a collaboration environment, Network Action Learning presents a learning mechanism, which, in combination with strategic improvement enables the achievement of sustainable strategic improvement (Paul 2012).
Expected outcome of LEAN 4.0: Blended Network Action Learning
A very LEAN 4.0-own learning type created in a pilot project-driven research project in an inter-organizational setting in the context of Industry 4.0. The methodology will be used to solve actual and relevant challenges in the field of Smart Lean Operations through the development and operation of networks (consisting of enterprise and HEI staff). The Blended NAL approach combines concepts from Network Action Learning and Blended Learning.

3.2 A Map of learning practices

As a result of the literature search a map of learning practices can be presented. This should serve to visualise the corresponding results. The identified learning practices could be assigned to **four** classifications:

1) Blended-oriented learning practices
2) Action-oriented learning practices
3) Network oriented learning practices and
4) Organizational Learning practices.

Blended-oriented learning practices (1) include all learning methods that are associated in literature with creative communication models. Outstanding keywords are virtual classrooms, synchronous and asynchronous learning, offline and online learning, mix of different communication and teaching methods. In Action-oriented learning practices (2) the focus is on the action, so that all learning methods which follow a learning-by-doing method, implement learning and teaching factories or always work with experiments and tests will be selected. The Network-oriented part (3) covers all methods that are carried out in different types of networks or groups of people. The focus is especially on international networks and networks between academic and business organizations.
Since it is not unusual for a learning practice to implement more than one of these categories, the map of learning practices in Figure 2 shows overlaps that contain particularly interesting practices.
During the review of OL practices it was discovered that OL is often not a concrete learning practice, what means it often doesn´t shows guidelines how to improve by learning in the context of Industry 4.0. More often, it explains the necessary characteristics of an organization to involve a learning behaviour environment. Sometimes case studies are mentioned or well-known methods such as single-loop and double-loop learning are pointed out. The characteristics were classified in the appendix 8.2
The result of the review regarding the learning practices includes **35 found learning practices + 20 Organizational Learning approaches**, which have been identified as relevant.
All procedures and characteristics of the learning practices are described in the appendix 8.3.

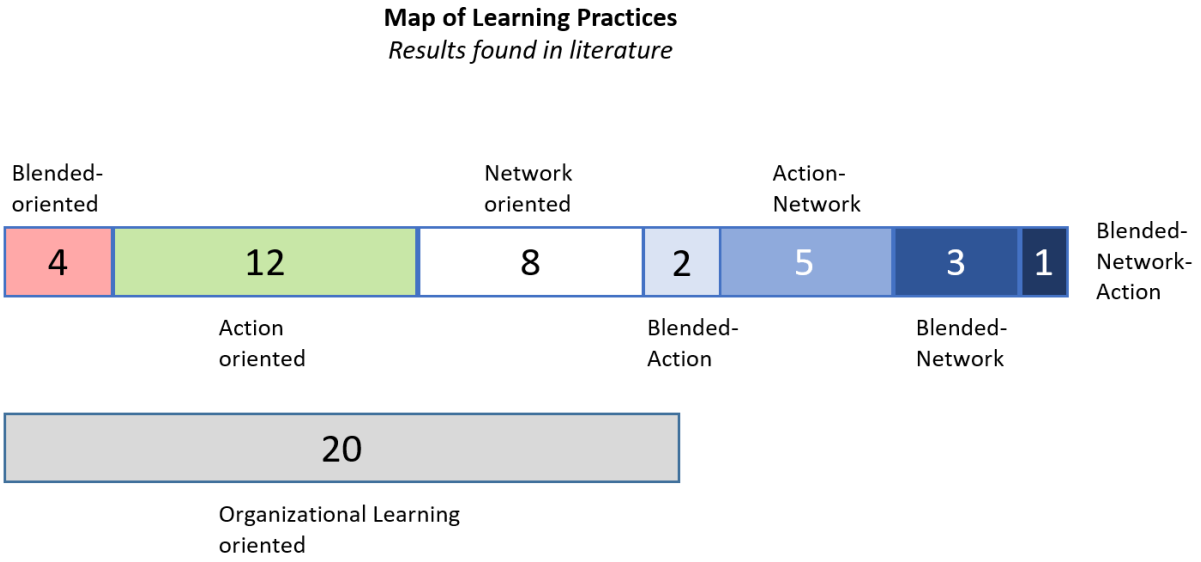


Figure 2: Map of Learning Practices (LEAN 4.0 Illustration)

The map of the learning practices, which differentiates between the types of learning, shows the actual result of the literature review. Based on the selected literature in Table 1 practices were selected that contain characteristics for relevant learning types. As explained, the problem- and project-orientated learning practices fall under action learning what leads to a depiction of three categories on the map: Action-oriented, Blended-oriented and Network-oriented learning practices. The learning practices usually include approaches of organisational learning. The review for OL-Practices established 20 cases which are linked to OL characteristics or success factors. This is the most comprehensive result and suggests that most learning types can include OL characteristics. Furthermore, OL means that individuals do not learn as own units, but rather the entire organisation drives learning progress and can address any organization (Coughlan P., Coghlan 2011).

3.3 Deliverable 2.2: Taxonomy of Learning Practices for LEAN 4.0

3.3.1 Expected and actual outcome

The LEAN 4.0 project consortium decided to develop a taxonomy that brings together knowledge on NAL, open innovation and other learning processes. The content of the taxonomy should support the use or implementation of learning practices in the context of Industry 4.0 or in relation to lean methods. The focus should be on NAL, as this is one of the basis of LEAN 4.0´s research project. One of the main literatures to which LEAN 4.0 was oriented is "Collaborative Strategic Improvement through Network Action Learning - The Path to sustainability" from P. Coughlan and D. Coghlan, 2011. The research interests of the authors includes continues improvement of manufacturing, product development practices, services innovation, action learning, action research and organizational development. The profile of the authors and the theme of the book, which focuses on NAL and identifies Organizational Learning as one of the key elements for successful learning, can provide an excellent basis for developing the foundation of a taxonomy. So far, that is the expected outcome.

Table 6: Expected and actual results: Research components of the Taxonomy

Expected and actual results: Research components of the assessment tool		Sources
Expected Results	i) A Taxonomy which is focusing on NAL ii) A Taxonomy which address practices and processes related to: 1. How do enterprises and HEIs bring together employees? 2. How do enterprises and HEIs bring together in an network of suppliers and clients? 3. How do enterprises and HEIs use students and research staff and employees? 4. How to collaboratively testing out new Lean methods and technologies? 5. Best practices for extended network academia-industry collaboration across national borders?	i) Project Application ii) Project Application
Learnings during the research process	i) NAL is not an established type of learning (not many references) ii) To address all the 5 questions, different and more than just NAL-practices has to be reviewed. How can NAL be created and enhanced for addressing all five questions?	i) Literature review ii) Past project-experiences, Coughlan OL/NAL Book, WP3 of LEAN 4.0
Actual Results	i) Presentation of the development of NAL and a best practice (BNAL - WP3) ii) The questions are transformed into hypotheses and assigned to learning practices from the Map of Learning Practices by using the taxonomy.	i) Literature review ii) Literature review, Coughlan OL/NAL Book, WP3 of LEAN 4.0

Two main results are addressed during the development of the taxonomy.
On the one hand, **i)** the Taxonomy should focus on NAL. This involves a classification of all learning practices or types of learning that involve an action-oriented learning method and operate in a network across international borders. However, it emerged during the literature review and in discussions with industry partners that there are just few references to NAL and it may is an unestablished or rather unknown learning method. Thus, the basics of NAL were researched in more detail in regard to Coghlan and Coughlan, 2011. As a result, e. g. the first step should differentiate between puzzles which can be easily solved, and problems that are more complex before a NAL approach is taken. This approach can be seen as a typ of learning named “puzzle solving” and will be classify by the taxonomy as a pre-step to NAL. Further research was done in this form until the taxonomy can define the steps that are necessary to perform a NAL best practice.

On the other hand, **ii)** the taxonomy should especially address practices and processes related to five questions, which can be seen in the table above. However, since it has already been established that there are not many references to NAL knowledge, it can be assumed that not all five questions can be answered properly. A separate research question can be adapted:
How can NAL be created and enhanced for addressing all five questions?
The Map of Learning Practices can be used to assign learning practices to the five individual questions. The steps or classes defined in i) can be used to derive the most appropriate or the best practices from the large number of learning practices.

3.3.2 Phases

The taxonomy can be used by looking at five defined steps that a visualized in the following figure 3:

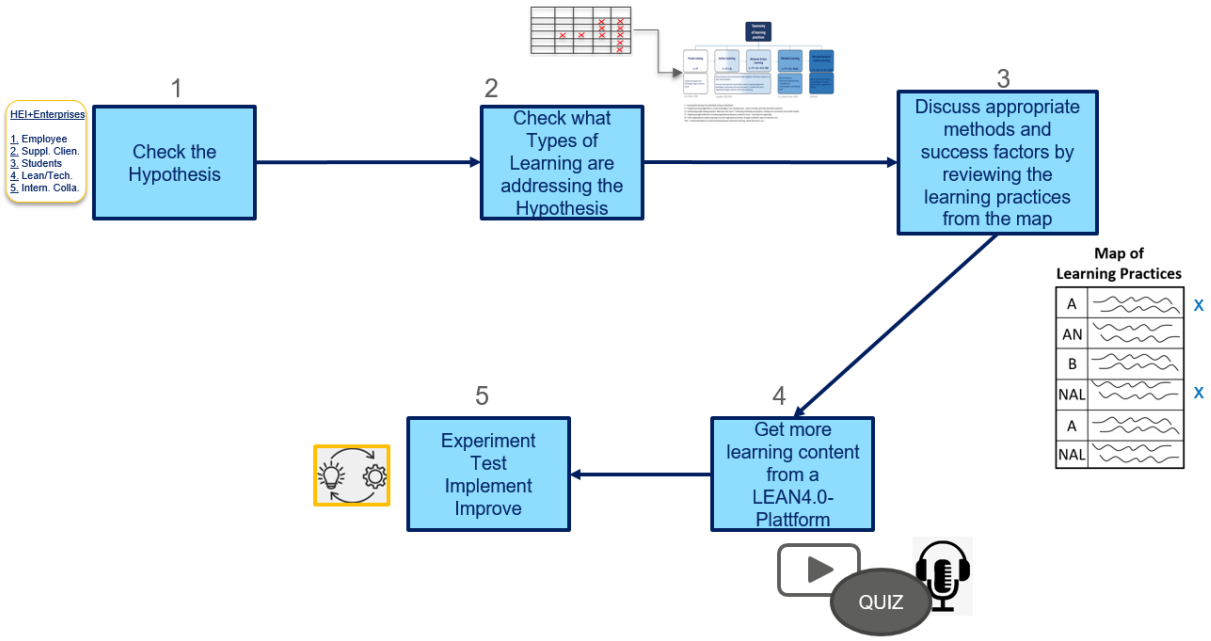


Figure 3: Step-by-Step Process: Taxonomy

In the **first** step five specific hypotheses are reviewed by an organization. These include all necessary criteria that the taxonomy and a best learning practice should address. The five hypotheses are examined in more detail in the following chapter 3.3.3. This can additionally be defined as a guide to provide an organisation with an overview of necessary characteristics of relevant learning practices and learning behaviour.

The **second** step includes a review of the taxonomy and a link to the five hypotheses. Here, an assignment of a learning type that can address the five hypotheses can be shown. In addition, the taxonomy serves to visualize the story of NAL and, for the first time, to present the Blended Network Action Learning (BNAL) method as a best practice method.

Step **three** is the link to the learning practices from the map of learning practices, what is the result of the literature review. The cases, methods, characteristics and success factors contained, can help to find out how to address a situation for an organization that is similar to one of the five hypothesis. An organization can review a learning practice for an applicable starting situation and assess what level in the taxonomy it is and what needs to be done to improve. All found learning practices are listed in the appendix. Here, too, further discussions are to be held with LEAN 4.0 partners or experts from the respective fields to analyze the content.

Steps **four and five** only serve as an guideline for further activities. In other work packages, for example, a learning platform or a toolset is developed, which combines many learning contents and is ideally connected to the BNAL methodology. The learning content will contain diverse and detailed information. Above all, standardized and creative methods will be used to

convey this information effectively. This includes common tools such as reports on pilot projects, interviews with experts, students-work and recommended literature. Furthermore, podcasts, interactive learning videos, quizzes and digital "Gemba Walks" through production and storage lines of LEAN 4.0 Partner can be helpful to experiment with new practices.

This corresponds the **transfer** of research findings to components for creating an own taxonomy / LEAN 4.0 classification of learning types. This will be explained in more detail in the following chapter.

3.3.3 The Taxonomy of Learning Practices

The taxonomy has the task to adapt the knowledge gained in the literature review to the requirements of LEAN 4.0. After OL was identified as a separate learning type in the research process, OL could be defined as a prerequisite for NAL approaches in the LEAN 4.0 context by using selected relevant literature and expert interviews. This means that OL is no longer considered as a learning type, but is used as a term (= O) component of the composition of a formula for certain learning types, as shown later in Figure 4. This can be defined as one of the main research results of LEAN 4.0.

Furthermore, the goal of the taxonomy for the project concludes future collaborations within or outside of the project consortium. In particular, the taxonomy will especially address learning practices and processes related to the following hypotheses:

1. Enterprises and HEIs bring together employees of several companies in an open exchange of problems and ideas.
2. Enterprises and HEIs bring together in a network of suppliers and clients an open exchange of problems and ideas.
3. Enterprises and HEIs use students, research staff and employees in an open exchange of problems and ideas.
4. Established mechanisms for collaboratively are testing out new Lean methods and technologies in practice and learn continuously from them.
5. Best practices for innovative extended network academia-industry collaboration across national borders.

In the following table the three main learning practices reported in Secton 3.1 (i.e., Action Learning, Network Action Learning and Blended Learning) and the Blended Network Action Learning methodology developed within this project are assessed with respect to the five above-mentioned hypotheses. The use of these learning practices is required only when the problem cannot be solved with already existing solutions. For such situations, there is no need of using complex learning methods but **Puzzle-solving** can be used. An example of puzzle would be equipment failure while under warranty. In response, the technician may diagnose the failure mode, replace the defective component and restart the equipment (Coughlan P., Coghlan 2011).

Table 7: Hypotheses (Taxonomy) and Types of Learning

Learning Types / Hypo-theses	Action Learning	Network Action Learning	Blended Learning	Blended Network Action Learning
1.		X	X	X
2.		X	X	X
3.		X	X	X
4.	X	X		X
5.				X

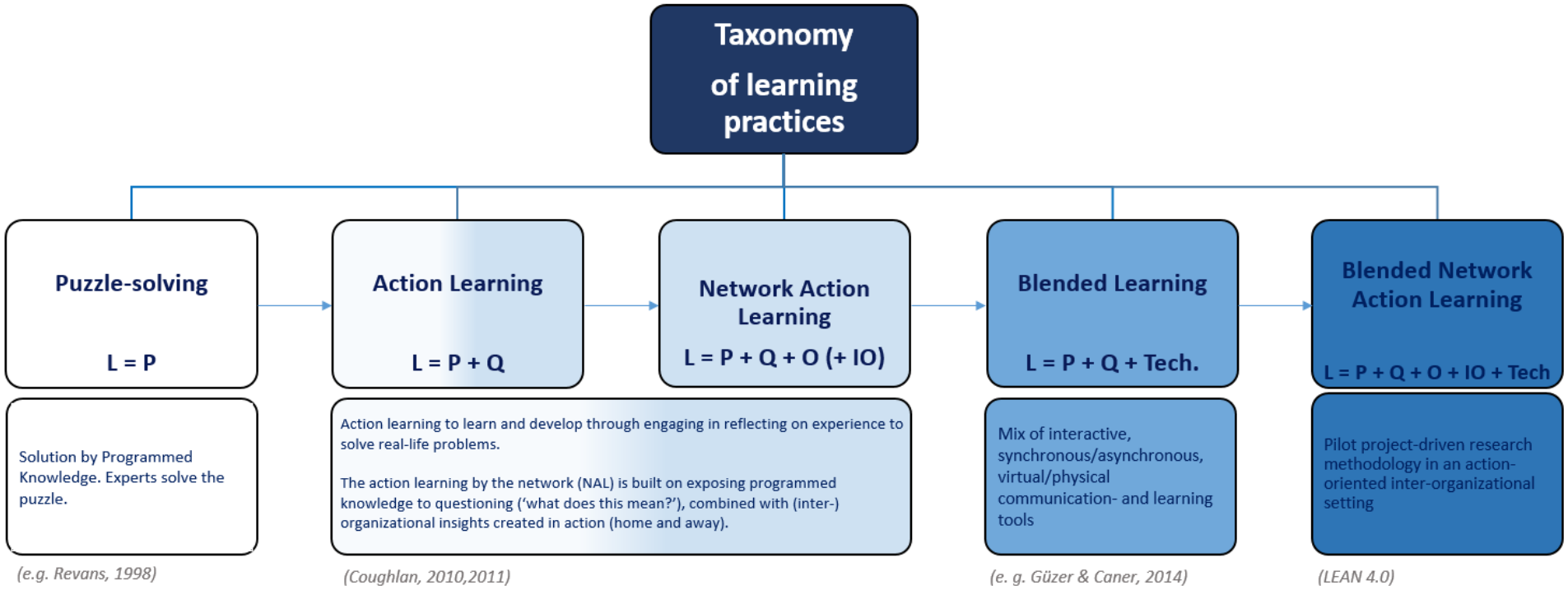
For more complex problems that cannot be solved with already existing solutions, the Action Learning, Network Action Learning, Blended Learning and the Blended Network Action Learning methodology can be used.

The Action Learning topic can often be seen as an extension of the puzzle-solving approach. As soon as actions are introduced, the learning really begins (Revans 1982). Hence, LEAN 4.0 assumes that the very well-known problem-based learning can be applied in action learning practices and helps to implement new lean methods or technologies in practice. Since Action Learning is not based on cooperation across national borders is not aiming for collaborations, these learning practices address more the testing of new methods in practice – Hypotheses No. 4.

The Network Action Learning not only includes learning by individuals. First, the individual's experience of action learning included not only questioning insight for the individual, but also for the (inter-) organizational insights. Second, Network Action learning provides a "home and away" mechanism for helping networks to transition from strategic to learning-transformational networks. Aiming for the "home and away" approach, characteristics include organisational and inter-organisational learning, where learning first takes place at home and then moves on to learning at another organization. Home and away learning can build new competencies and include challenges such as creating a safe learning environment, research-based learning orientation or rethinking the role of managers and consultants (Shani and Mitki 2000). NAL builds on cooperating partnerships and benefits through the development of networks and addresses specific goals or problems. These learning practices can bring together company employees as well as suppliers and customers in an action learning approach. As partnerships between academy and companies are also in focus, as well as cooperation across national borders, this type of learning can meet - Hypotheses No. 1 / 2 / 3 and 4.

The blended learning approach addresses a variety of communication and teaching/learning methods. The added value is generated by the mix of synchronous or asynchronous and online or offline methods. The focus is on the implementation of IT (information technologies). The creative transfer of learning content via, for example, an online learning platform as well as the actual action in practice in hands-on workshops could be an example - Hypotheses No. 1 / 2 and 3.

Blended Network Action Learning is a product of LEAN 4.0. It is intended to become the basis for best practices and to unite the best approaches of all other types of learning. Learning practices from literature and existing practice from project partners can be adapted. The focus, however, is on the development of a pilot project driven method, which is created by using both, experts and students in an inter-organizational setting. A framework will be derived and a "Blended Network Action Learning (BNAL)" learning practice will be visualized as a template for an innovative learning type. This type of learning also serves as a best practice and combines all the strengths of the other types of learning – Hypotheses 1 / 2 / 3 / 4 and 5.



L = Learning (the learning is by individuals acting as individuals)
P = Programmed knowledge (that is current knowledge in use, already known, what is in books, and what prescribes solutions)
Q = Questioning insight (Asking question: What does this mean? / unfreezing underlying assumptions, creating new connections and mental models)
O = Organizing insight (reflection of existing organizational dynamics created in action – learning from organizing)
IO = Inter-organizational context (Learning in an inter-organizational setting - through a facilitator, types of networks, etc.)
Tech. = Using technologies for virtual learning approaches (interactive-learning, virtual classrooms, etc.)

Figure 4: Taxonomy of Learning Practices (LEAN 4.0 Illustration)

The formulas that appear among the learning types in the taxonomy in Figure 4 are intended to represent the contents or characteristics of the learning practices that can be found in a corresponding learning practice. The following chapter explains the individual formulas. For sake of clarity, Puzzle-Solving has also been considered since the search for already existing solutions is typically the first step to solve a problem.
Revans, a well-known author for the Action learning approach, has developed an Action Learning formula. However, before action learning can take place, it is necessary to clarify what are the addressed learnings by an organisation. Maybe it is only a puzzle that can be solved with existing knowledge. The learning happens by using expert opinions (L = P).
If the problems are complex and cannot be solved easily, the use of Action Learning is often a good learning methodology: L = P + Q

The L stands for learning. Usually the learning of an individual (employee or manager) is represented here. The learning of an entire organisation (holistic learning) would be the opposite.
P stands Programmed knowledge which represents the current state of knowledge of such individuals. This can be the knowledge that has acquired the learning content from books or from experts.
The Q is the special thing about the formula, because it stands for Questioning insight and means questioning the already existing solutions. This can create the motivation to solve outdated models that may already be inefficient and to integrate new, smarter solutions into an organisation.
The author Vince (2004) has reflected on the contents of this formula of Revan and has established the connection between Action Learning and Organizational Learning. The organizing insight = O should not continue to rely on the experiences and learning of individuals, but should consider the organizational dynamics in action learning (Learning from organizing) (L = P + Q + O).
The IO can be interpreted here as Inter-organizational insight / context and stands for the organisational development across national borders by forming networks or using facilitators across several offices of an organisation (L = P + Q + O + IO).
The LEAN 4.0 consortium has also added technology = tech., which stands for the use of communication technologies and methods. Here, the degree of innovation and digitization has to be increased and a blended approach introduced (L = P + Q + O + IO + Tech). This model should combine a NAL approach with innovative learning methods and thus represent a LEAN 4.0 Best Learning Practice.

4 Summary of D2.2 and Added value for LEAN 4.0

With the help of the information gathered from the literature review, a Taxonomy of Learning Practices for the LEAN 4.0 project could be developed. The taxonomy shows an overview about types of learning and classified them as very relevant for an own LEAN 4.0 learning methodology. Furthermore, it shows which prerequisites have to be considered and how the method of a Blended Network Action Learning approach is derived. As a pre-step, the Map of Learning Practices is used here to take a closer look at common learning practices from practice and to identify them as references. Thus, WP 2 with D2.2 was able to provide an overview and

classification of creative and innovative learning practices and enabled the development of an own learning method consisting of established learning types. This task takes into account if international- and Industry 4.0 setting is included for supporting pilot projects in an international and collaborative context.
To wrap this work up, the given input serves also for implementing the Blended Network Action Learning methodology in practice and to use tools and practices in the rightful way to implement smart technologies.

5 References

Abele E, Chryssolouris G, Sihn W, et al (2017) Learning factories for future oriented research and education in manufacturing. CIRP Ann 66:803–826. https://doi.org/https://doi.org/10.1016/j.cirp.2017.05.005

Abele E, Metternich J, Tisch M (2019) Learning Factories

Alexander A, Martin DP, Manolchev C, Miller K (2018) University–industry collaboration: using meta-rules to overcome barriers to knowledge transfer. J Technol Transf 1–22. https://doi.org/10.1007/s10961-018-9685-1

Argyris C (1977) Organizational learning and management information systems. Soc Sci Med 11:582. https://doi.org/10.1016/0037-7856(77)90186-x

Aziz NM, Salleh H (2011) A readiness model for IT investment in the construction industry. African J Bus Manag 5:2524–2530. https://doi.org/10.5897/AJBM10.1025

Cachay J, Wennemer J, Abele E, Tenberg R (2012) Study on Action-Oriented Learning with a Learning Factory Approach. Procedia - Soc Behav Sci 55:1144–1153. https://doi.org/10.1016/j.sbspro.2012.09.608

Collis B, Margaryan A (2004) Applying activity theory to computer-supported collaborative learning and work-based activities in corporate settings. Educ Technol Res Dev 52:38–52. https://doi.org/10.1007/BF02504717

Coughlan P., Coghlan D (2011) Collaborative Strategic Improvement through Network Action Learning. Edward Elgar Publishing Limited / Inc., Cheltenham

Elbestawi M, Centea D, Singh I, Wanyama T (2018) SEPT Learning Factory for Industry 4.0 Education and Applied Research. Procedia Manuf 23:249–254. https://doi.org/https://doi.org/10.1016/j.promfg.2018.04.025

Fiol, C. M.; Lyles NA (1985) Organizational Learning. Fac Work Pap NO 1110 Coll Commer Bus Adm Univ Illinois Urbana-Champaign

Garay-Rondero CL, Rodríguez Calvo EZ, Salinas-Navarro DE (2019) Experiential learning at Lean-Thinking-Learning Space. Int J Interact Des Manuf. https://doi.org/10.1007/s12008-019-00578-3

Goyena R (2019) Handbook of Principles of Organizational Behavior

Graaf E, Kolmos A (2015) Management of change

Güzer B, Caner H (2014) The Past, Present and Future of Blended Learning: An in Depth Analysis of Literature. Procedia - Soc Behav Sci 116:4596–4603. https://doi.org/https://doi.org/10.1016/j.sbspro.2014.01.992

Hartley J, Allison M (2002) Good, better, best?: Inter-organizational learning in a network of local authorities. Public Manag Rev 4:101–118. https://doi.org/10.1080/14616670110117332

Holmqvist M (2003) A dynamic model of intra- and interorganizational learning. Organ Stud 24:95–123. https://doi.org/10.1177/0170840603024001684

Kaur M (2013) Blended Learning - Its Challenges and Future. Procedia - Soc Behav Sci

93:612–617. https://doi.org/https://doi.org/10.1016/j.sbspro.2013.09.248

Lehmann M, Christensen P, Du X, Thrane M (2008) Problem-oriented and project-based learning (POPBL) as an innovative learning strategy for sustainable development in engineering education. Eur J Eng Educ 33:283–295. https://doi.org/10.1080/03043790802088566

Locke EA (2013) Handbook of Principles of Organizational Behavior

Matsuo M (2014) Instructional skills for on-the-job training and experiential learning: An empirical study of Japanese firms. Int J Train Dev 18:225–240. https://doi.org/10.1111/ijtd.12035

Middel R, Boer H, Fisscher O (2006a) Continuous Improvement and Collaborative Improvement: Similarities and Differences. Creat Innov Manag 15:338–347. https://doi.org/10.1111/j.1467-8691.2006.00407.x

Middel R, Boer H, Fisscher O (2006b) Continuous Improvement and Collaborative Improvement: Similarities and Differences. Creat Innov Manag 15:338–347. https://doi.org/10.1111/j.1467-8691.2006.00407.x

Olsson A, Wadell C, Odenrick P, Bergendahl MN (2010) An action learning method for increased innovation capability in organizations. Action Learn Res Pract 7:167–179. https://doi.org/10.1080/14767333.2010.488328

Paul C (2012) Collaborative Strategic Improvement through Network Action Learning. Hum Resour Manag Int Dig 20:. https://doi.org/10.1108/hrmid.2012.04420baa.015

Pearn M (1994) Tools for a Learning Organization. Manag Dev Rev 7:9–13. https://doi.org/10.1108/09622519410771600

Revans RW (1998) ABC of Action Learning. Lemos and Crane, London

Revans RW (1982) The Origins and Growth of Action learning. Chantwell Bratt, Bromley

Savolainen T, Haikonen A (2007) Dynamics of organizational learning and continuous improvement in six sigma implementation. TQM Mag 19:6–17. https://doi.org/10.1108/09544780710720808

Shani AB, Mitki Y (2000) Beyond the learning organization: beyond mechanisms. Marcell Dekker, Ney York

Shrivastava P (1983) a Typology of Organizational Learning Systems. J Manag Stud 20:7–28. https://doi.org/10.1111/j.1467-6486.1983.tb00195.x

Siew-Eng L, Muuk MA (2015) Blended Learning in Teaching Secondary Schools' English: A Preparation for Tertiary Science Education in Malaysia. Procedia - Soc Behav Sci 167:293–300. https://doi.org/https://doi.org/10.1016/j.sbspro.2014.12.677

Sobek DK, Jimmerson C (2006) A3 reports: Tool for organizational transformation. 2006 IIE Annu Conf Exhib

Sommer L (2015) Industrial revolution - Industry 4.0: Are German manufacturing SMEs the first victims of this revolution? J Ind Eng Manag 8:1512–1532. https://doi.org/10.3926/jiem.1470

Steensma HK (1996) Acquiring technological competencies through inter-organizational

collaboration: An organizational learning perspective. J Eng Technol Manag - JET-M 12:267–286. https://doi.org/10.1016/0923-4748(95)00013-5

Steiner M, Hartmann C (2006) Organizational learning in clusters: A case study on material and immaterial dimensions of cooperation. Reg Stud 40:493–506. https://doi.org/10.1080/00343400600757494

Sugarman B (2012) A learning-based approach to organizational change: Five case studies of guided change initiatives. Soc Organ Learn 1–33

Triste L, Marchand F, Debruyne L, et al (2014) Reflection on the development process of a sustainability assessment tool: Learning from a Flemish case. Ecol Soc 19:. https://doi.org/10.5751/ES-06789-190347

Webster J, Watson RT (2002) Analyzing the Past to Prepare for the Future: Writing a Literature Review. MIS Q 26:xiii–xxiii. https://doi.org/10.1.1.104.6570

6 Appendix

Organizational Learning findings

Table 8: Methods and Key-Elements regarding OL

Methods regarding OL	Key-Elements	References
Single-Loop Learning Double-Loop Learning Triple-Loop Learning	Nature: licensing agreements, research contracts, joint development Use of Continuous Improvement Tools / Six sigma Improve by understanding by considering results and revisiting assumptions	(Easterby-Smith, 2002) (Savolainen & Haikonen, 2007) (Steensma, 1996) (Bennet & Tomblin, 2006)
4I Model: Intuiting (through experience) Interpreting (same language) Integrating (shared understandings) Institutionalizing (routines)	Tension between exploitation and exploration	(Crossan, Lane, White, & White, 2011) (Bennet & Tomblin, 2006)
Three learning levels: Individual Learning Group Learning Organizational Learning	Communication (internal/external) Use of IT technology Problem-solving orientation Team-based partnerships Stored in organizational memory Communication opportunities outside the Organization	(Crossan, Lane, White, & White, 2011) (Hendriks, 2000)
Four contextual Factors: Corporate culture Flexibility-Strategy Innovative structure Environment	Matrix structure Project-Teams Flat hierarchy Innovative capability Decentralization	(Ellström, 2010)
Development: Lower development Higher development Behavioural development Cognitive development	New insights or knowledge New structures New	(Ellström, 2010) (Steensma, 1996)
Higher Level learning Lower level learning	Higher: Heuristics and insights, non-routine, differentiated Lower: Repetition, routine, control over immediate task, rules	(Ellström, 2010)

OL Industry 4.0 Approach: OL structure (matrix structure) HR practices (like training, staffing, …) Willingness to abandon investment/knowledge Short term innovation / long term capabilities	More than one authority line Flat hierarchy, / span of control is wide Decision-making is transferred to lower level of organizations Knowledge oriented leadership	(Ellström, 2010) (Shamim, S. 2017)
OL – Subprocess: Information Acquision Information Dissemination Shared Interpretation Development of organizational memory	Examples in Learning Factory approaches	(Nardello, M., 2017)
Four Level Model: Maintenance (improving through experience) Adaptive (changing procedures/rules) Transitional (radical environment changes) Creative learning (inter-functional cooperation's, openness in decision making)	External acquisition – inter-OL Blended Learning approach (face-to-face vs. non-direct communication) Use of Software (facilitate)	(Steensma, 1996)
Informal learning systems: Corporate culture in clusters and networks Info-channels as vehicles of learning	Value-chain approach Corporate stories: One-man institutes and collaboration as knowledgebase Formal management systems: strategic planning, information systems Bureaucratic learning systems: rules and procedures, exact advice for specific situations/problems	(Steiner & Hartmann, 2006) (Steensma, 1996)
Framework: KM + OL + ICT (Information communication technology)	CI/ Lean given tools OL for rapid learning in organizations Investigation of the application to both CI and OL	(Bennet & Tomblin, 2006)
1. Management Practice 2. Organizational structure 3. Leadership-Style 4. HR Practice 5. Long-Term capabilities vs. Short term innovation	Attention to training. Learning, KM, CPS, Industry 4.0 From organic to mechanistic organization, centralized authority, top down communication, team-based structure Transformational and transactional leadership Staffing, Training, Job design Willingness to abandon current investment/knowledge	(Shamim, S. 2017)

Detailed Learning Practices

Table 9: Learning Practices regarding literature

Target-Group	Numbering	Titel/Description	Keywords and Comment	Reference	Addressing Hypothesis 1-5
Academia + Industry	B-1	Promoting open educational resources-based blended learning: An open educational resource-based blended learning model is using a moodle to support an online-source with guidelines for LEAN 4.0. Setting: Innovative learning environment, technical enhancement (moodle, LMS) Practices used: • 5R Concept of OER (Open Educational Resources: Retain (the right to make), Reuse (in many ways), Revise (adaptation), Remix (combinations with the original content), Redistribute (sharing with others) • Use of a moodle • Teleconferencing, Brainstorming, Warm-up sessions for learners, high interactivity between teachers and learners, sustainable models, LMS, Quick feedback rounds	Teaching practice, open-educational resource-based blended learning adaption, moodle, online course Comment: Ideas how to perform the moodle – no learning concept	(Sandanayake, 2019)	5
Academia	B - 3	Web-based blended e-learning for adults; a case study: With this study that will emphasize applications and the effect of internal and external evaluations over success and sustainability of a project that differs from it's a like for being multinational and multi partner. Listed strengths and weaknesses of a project with blended learning approaches. Setting: Collaboration/Relationships (European cooperation Projects) Practices used: • E-learning methods (blended larning methodology) • How To´s: New learning and teaching methods and diactics • Provide blended learning courses to target groups: e. g. adults, youth • Creating learning resources /- Open source platform • Prepare a booklet for those methods regarding the target groups	Blended learning, strengths, weaknesses, distance education, sustainable project outcomes, multinational, multi partner Comment: Case Study about BL – Project, no practice described	(Ari & Taplamacioglu, 2012)	5
Academia +	B - 4	PBL – Problem Based Learning for Companies and Clusters: Learning methods been developed with	ICT, Clusters, joint action plan, pbl, SME,	(Hamburg & Vladut, 2016)	5

Industry		potential of innovation and research in four a case of four European Regions Setting: Collaboration/Relationships (Clusters), Competitiveness Industry, Innovative Industry, Changing environment, SMEs Practices used: • Problem-based learning: Efficient form for SMEs and their work in clusters • Clusters vs. Networks Analyses • Application: Info processing - Students use their knowledge to generate learning objectives, Collaborative learning – Tutorial groups and self-learning, Control – defined timetable, Behaviorism and social cognitive • Step-by-step process how to teach PBL	e-learning, international, research		
Academia + Industry	A-1	Experiential learning at Lean-Thinking-Learning Space: This practice demonstrates how to integrate knowledge manage. And e-learning in enterprises with defined needed competencies and phases. A combination of several models is used. Setting: Reconfigurable manufacturing • Experimentally • Competency-based education • Involvement of students in challenge-experimentally- and project-based settings • Involvement of students into manufacturing process • Students face socio-technical problems	Develop training-skills, professional competencies, improvement tools, learning model, challenge-/competency-based education Comment: Example for a best practice	(Judrups, 2015)	4
Academia	A – 2	Design Training Systematically and Follow the Science of Training: A practice for experiential learning at „Lean-Thinking-Learning“ – Competency- / Challenge- based and experiential learning with two case studies: Volvo and Toyota Setting: Reconfigurable manufacturing • Problem-based learning • Involving participants (superiors and subordinates) • Smaller group learning • Differences in task complexity • Laboratory experiment • Two-person laboratory with supervisors	Designing training, ksa (=knowledge/skills/attitude), learning architecture, performance tool, collaborative partnership, key stakeholders, assessment-tools, instructional experiences Comment: Case Study about OL/CI – Volvo and Toyota, no learning practice described	(Salas & Stagl, 2012)	4
Academia + Industry	A – 3	Knowledge Flow in Supply Chain Manufacturing: Case Study in Food Manufacturing Firm: This paper discusses the knowledge acquisition problems faced in the Supply Chain Management (SCM) when acquiring knowledge among Supply Chain (SC) members, and it	Supply chain knowledge, modelling knowledge types, SCM problems, case	(Almuiet & Salim, 2013)	4

		subsequently shows how modelling of knowledge types can be used as knowledge base to assist in solving SCM problems. This paper justifies the types of knowledge are useful in order to build knowledge bases to help decision makers and more importantly to help making decisions at the right time. Setting: Reconfigurable Supply Chain • Problem-based learning • Model: Knowledge in SC Food Manufacturing • Literature review: Knowledge-Classification	study, knowledge acquisition Comment: Types of Supply Chains / Knowledge sharing – no learning practice		
Industry	A – 4	Learning Factories for Research, Education, and Training: Knowledge Flow in supply chain manufacturing – A case study which includes a model for knowledge flow in SCM with the help of knowledge classification (taxonomy) Setting: Changing environment • Action Learning: Learning Factory • Morphology and Network of Innovative learning factories (NIL): How learning factories working in networks (Academic Partner – Nonacademic Partner – Profit oriented partner	competency development; education; learning factory; morphology; vocational training, industry and academia, collaborative working group, scenarios Comment: Example for a best practice (Guru Paper of Learning Factories/Teaching Factories	(Abele et al., 2015)	4
Academia + Industry	A – 5	Procedure for Experiential Learning to Conduct Material Flow Simulation Projects, Enabled by Learning Factories: Learning factories for research, education and training – important LF examples and characteristics/features has to be considered. Setting: University classes • Problem-based learning • Action Learning: Learning Factory • Building up simulation model • Case Study: Vietnamese-German University • Students decision making • Course of the exercise with students	Experience, learning; learning factory; simulation, projects, experiment-based Comment: Very student-oriented pracitce	(Müller, Menn, & Seliger, 2017)	4
Academia	A – 6	The multi-layered nature of small-group learning: Productive interactions in object-oriented collaboration: A study of small-group interaction in the context of collaborative learning in undergraduate education. The implications for the educational practice and further research point towards the need for a better understanding of the way groups function when challenged to address complex problems and to participate in knowledge production, how these	Small-group interaction, collaborative projects, research studies, co-construct knowledge, complex problems, developing knowledge, discourse-based/object-oriented	(Damșa, 2014)	4

		processes can benefit learning, and what is needed in terms of pedagogical and technological support. Setting: Collaboration/Relationship • Small-Group learning / Student-Groups, Face-to-Face discussions • Problem-based learning • Theoretical and empirical perspectives • Exploratory talk, Constructive interaction, conversational interaction	Comment: Analysis and a guide for small-group learning, not a best practice for AL		
4Industry + Industry / Industry + Academia	A – 7	Center of Excellence for Lean Enterprise 4.0: Using action research and action learning for entrepreneurial network capability development and to develop fully integrated practical learning environments- concept in the whole value chain. Setting: Innovative environment, changing environment • Process-oriented value-adding network model: LEAN Enterprise 4.0 • Problem-based learning: Employees ned to have high problem-solving skills • People need to have knowledge and expertise in entirely different topics (e.g. robotics or big data • Analyzed learning, target-actual comparison and the subsequent determination of learning content/objectives have to carried out • Teaching-learning environment with cooperation with industry	industry 4.0, lean enterprise, learning environment, changed competency, theoretical presentation Comment: Example for a best practice	(Dombrowski, Wullbrandt, & Fochler, 2019)	4
Industry	A – 8	Industry 4.0 - Competencies for a modern production system: A curriculum for Learning Factories: Required competencies to enable a successful integration of lean management and Industry 4.0 by using a Learning Factory Setting: Innovative environment, changing environment • Action Learning: Learning Factory • Problem-based learning • Differentiates Technology-based and methods-based approaches • Example of a learning module: Basics Lean 4.0 - concept	industry 4.0, competency, lean management, learning factory, complex, comprehensive Lean 4.0 curriculum Comment: Good combination of LEAN and Industry 4.0, but not regarding a network collaboration	(Enke et al., 2018)	4
Academia + Industry	A – 9	SEPT Learning Factory for Industry 4.0: Education and Applied research: Using a learning/teaching paradigm based on cooperation between Industry and Academia to the needs of modern industrial practice. Setting: Innovative environment, changing environment • Action Learning: Learning Factory (for I 4.0 educataion and applied research), Fokus: IoT	cyber-physical systems, Industry 4.0, learning factory, hands-on Comment: Mentioned collaborating approaches, but integrated	(Elbestawi et al., 2018)	4

		• Vertical networking of production systems, horizontal integration of global value chain networks, end-to-end engineering, high-impact disruptive technologies • Complement students abilities by providing new technical skills • Applied research: Additive manufacturing research and Problem solving			
Academia + Industry	A – 10	Learning Factory Modules for Smart Factories in Industry 4.0 Mapping workplace scenarios and learning modules for enabling participants to transfer learned knowledge directly to the own workplace in the context of a smart factory. Setting: Small and medium-sized enterprises, Implementation of Industry 4.0, High amounts of data, new human role in production processes • Learning factory in a real-world manufacturing environment • Simulation of as many use cases of real production systems as possible • An Assembly line will focus only on possible improvements within the process • Different learning moduls (MTM, lean management, assistant systems) • Digital learning scenarios on the shopfloor • Learning framework Applied research: Additive manufacturing research and Problem solving	Industry 4.0, learning factory, operating figures, variety of learning modules Comment: Action oriented, no networks	(Prinz et al., 2016)	4
Industry	A – 11	Evolution of SMEs towards Industry 4.0 through a scenario based learning factory Training: A concept how enterprises can be trained with the realm of a learning factory based on scenarios of different Industry 4.0 evolutionary steps. Setting: Learning Factory concept, SME´s, socio-technical solutions through Industry 4.0 • Maturity model • Learning concepts • Scenario based • Industry 4.0 maturity model during different evolutionary steps • Decision making – support • Adaption-model of existing learning factory-concept • Allocation of participants during an audit phase in the learning factory • Socio-technical developments in Industry 4.0	Industry 4.0, learning concepts, learning factory, maturity model, scenario-based, research-project adaption Comment: Evaluation about E-learning, no practice	(Wienbruch, Leineweber, Kreimeier, & Kuhlenkötter, 2018)	4
Industry	A – 12	Tangible Industry 4.0 - A scenario-based approach to learning for the future of production: Using required skills and competencies to link Industry 4.0 to learning	Industry 4.0, learning factory, problem-oriented, scenarios,	(Erol, Jäger, Hold, Ott, & Sihn, 2016)	4

		factory approaches in a learning environment (scenario-/project based learning). Setting: Scenario-based Industry 4.0 Factory concept, Digitalization and intelligentization of manufacturing processes, realistic concepts such as the Internet of Things, Industrial Internet, Cloud-based Manufacturing and Smart Manufacturing as drivers, SMEs, Assembly planning and control-system • Different types of competencies • Creative activities in a distributed social setting, involve heterogeneous interdisciplinary and interorganizational teams • Require the ability to communicate complex problems in different languages • Action-related, domain-related • Scenario-based learning factory	develop skills and competencies, complex problems Comment: Best Practice for a learning factory approach in Industry 4.0		
Industry	N - 1	Continuous Improvement and Collaborative Improvement - Similarities and Differences: A practice to clarify the additional aspects of collaborative practices to Lean managements and continuous improvements. Setting: CO-IMPROVE project, Extended concept of continuous improvement, existing theories about continuous innovation, study of collaborative improvement, • Inter-company interactive processes for EME (extended manufacturing processes) • Key-behaviors of continuous improvement and continuous collaborations • Short-term orientation vs. long-term orientation • Small improvements, trust and decision making • Key-abilities of collaborative improvement setting • Defined project human roles for CO-IMPROVE	Collaboration, working together, research, relationship between factors, collaborative improvement, partner characteristics Comment: Good basics and knowledge	(Middel et al., 2006a)	1 2 3
Academia + Industry	N - 2	Creating and Managing A high performance knowledge-sharing network – A Toyota Case: / Setting: A case how Toyota used collaborative improvement to solve problems within own production line. A case as a guideline for LEAN 4.0. Enhancement of continuous improvement and small-group learning. Comparison of US- and Japanese Automobil productivity. • Motivation members to participate and openly share valuable knowledge • Prevent free riders	knowledge management; learning; networks, black box of knowledge sharing, effectively create and manage network-level, suppliers, motivate members to participate, reduce costs	(Dyer & Nobeoka, 2000)	1 2 3

		• Reduction of costs associated with finding and accessing different types of valuable knowledge • Organizational + Inter-organizational literature • Arising questions like how learning networks are created, what are such structures and processes on interorganizational learning, … • Defined reasons, how Toyotas practices increased through continuous learning/improvement by the time	Comment: Client+Supplier, OL + Network learning, small-group learning, Example of a best practice		
Academia + Industry	N - 3	Five principles for the practice of knowledge exchange in environmental management: Five principles for effective practice of knowledge exchange, which when applied, have the potential to significantly enhance the impact of environmental management research, policy and practice. Setting: CO-IMPROVE project, Extended concept of continuous improvement, existing theories about continuous innovation, study of collaborative improvement, • Inter-company interactive processes for EME (extended manufacturing processes) • Key-behaviors of continuous improvement and continuous collaborations	Environmental management; Knowledge exchange; Knowledge management; Knowledge transfer; Knowledge translation; Research; Stakeholder engagement; Stakeholder participation Comment: Good elements of knowledge exchange, no practice	(Reed, Stringer, Fazey, Evely, & Kruijsen, 2014)	1 2 3
Industry	N - 4	Global Engineering Services: Shedding Light on Network Capabilities: Global concept of network capabilities for GES, highlighting the centrality that (i) network resources - accessing and deploying dispersed resources, (ii) network coordination - coordinating and integrating network activities, and (iii) network learning - collective learning and knowledge management, all play in enabling the successful operational management Setting: Six different case studies to explore the operations management challenges of delivering global engineering services • Concept of network capabilities like: • Network coordination • Network resources • Network learning • Analysis of cases like: Network learning leads to knowledge reuse, knowledge creation, digital learning • Global platform of knowledge creation is mentioned in a case	Global engineering services (GES); Network capabilities; Professional service operations management (PSOM), network resources, network coordination, operational management Comment: Examples of good practices	(Zhang, Gregory, & Neely, 2016)	1 2 3
Academia+	N - 5	Innovative Tools Used by Business Networks and Clusters in Communication: Innovative tools used by business networks and clusters in communication with	best practices; business communication;	(Negruşa, Rus, & Sofică, 2014)	1 2

Industry		a shown case study – where different approaches of **social media** tools are revealed. Setting: Case study about the communication in networks and clustersm, Enterprises in Romania, particularly SME • Different approaches of social media tools used for networking propose which can be adopted by other networks and clusters • Innovation and know-how exchange • Mentioned Moodle • Advantages and Disadvantages of Facebook pages etc.	clusters; innovation; networks; social media Comment: Too strong focus on social media		3
Industry	N - 6	Methods for developing innovative SME Networks: With the aim to build trustful relationships and define phases of the process. Setting: Facilitation of creation of new networks for SME • Methods that initiate knowledge mobility and support the development of trustful relationships • Individual- Group –Plenary Reflection (IGP) as a hybrid dialog method • Theoretical, methodological and practical implication of innovative networks	Develop innovative SME networks, trustful relationships, network individual group Comment: Good Practice – missing framework	(Gausdal, 2015)	1 2 3
Industry	N - 7	Networked Innovation in Innovation Networks: A Home Appliances Case Study BT - Leveraging Knowledge for Innovation in Collaborative Networks: A home appliances case study with six focus areas, the use of innovation factory and a innovation network scorecard. Setting: Interorganizational collaboration to increase internal competences and resources and to better respond to dynamic market requirements; Virtual Breeding environments (VBE´s), Virtual Organizations (VO´s),Collaborative Networked Organizations (CNO´s) • TALAI-SAREA Methodology • Vase study about FAGOR Electrodoméstecis, Poland • Basics of Innovation Networks (Strategy definition among partners, Effective orchestration of activities, enhanced innovation collaboration culture	Types of collaborative networked organizations, innovation network, characteristics, effective network, reference model, set of analysis tools Comment: Hard to follow	(Berasategi, Arana, & Castellano, 2009)	1 2 3
Industry	N – 8	Critical competencies for the Innovativeness of Value Creation Champions: Identifying challenges and Work-integrated Solutions: Creating Value-creation-champion by improve the innovativeness based on the	critical competencies, implicit knowledge, industry 4.0, knowledge transfer, networked competence	(Kinkel, Schemmann, & Lichtner, 2017)	1 2 3

		competencies of individual employees with work-integrated learning and knowledge exchange Setting: Value creation through knowledge transfer and industry 4.0 in SME • Four clusters of competencies: • E.g. Creative problem-solving competences • Five-step process that enables companies to identify possible critical competencies	development, work-integrated learning, creative problem-solving Comment: Good Basics for international borders and supplier + clients		
Academia	NB - 1	Design of Collaborative Learning with Creative Problem-solving Process Learning Activities in a Ubiquitous Learning Environment to Develop Creative Thinking Skills: A design of collaborative learning with creative problem-solving process learning activities in a ubiquitous learning environment to develop creative thinking skills. Setting: Conceptual framework, theoretical research • Design of a collaborative learning with creative problem solving process (ubiquitous learning environment) • Evaluate such learning activities • Five stages of collaborative learning in such ways	Collaborative Learning; Creative Problem-Solving Process; Creative Thinking Skills; U-Learning Comment: Example for a best practice	(Wannapiroon, 2014) (Laisema & Wannapiroon, 2014)	1 2 3 5
Academia	NB - 2	Development of Research-based Blended Learning Model to Enhance Graduate Students' Research Competency and Critical Thinking Skills A practice how CO-IMPROVE used project-based workshop-approaches for identifying factors which affecting the developments of collaborative improvement. Setting: Enhance of students research competency and critical thinking skills, including 10 experts and experiment with 28 graduate students • A model should include 8 components and 9 procedures to develop research competency and critical thinking skills • Components like: Virtual learning envorinemnt, cloud learning management system, learning courseware, etc. • Procedures like: Introduction, Storyboard, keynote lecutres, resources for information and communication, etc.	Research-Based Learning Blended Learning Research Competency Critical Thinking Skills Cloud Learning Management System Comment: NAL – Practice from popular project: CO-IMPROVE	(Panlumlers & Wannapiroon, 2015)	1 2 3 5
Academia	NB - 3	Design of Cooperative Problem-based Learning Activities to Enhance Cooperation Skill in Online Environment: In a strategy of blended learning, traditional education will be adopted together with online learning technologies, e.g. learning management	Cooperative Learning; Cooperative Skill; Learning Activity; Online Environment; Problem-Based Learning	(Wannapiroon, 2014)	1 2 3

		system, video broadcasting, desktop video conference, and interactive communication tools. Enhance students' participation and exchange of knowledge, while valuable class time will be used for developing thinking skills and necessary attitude toward learning of students. Setting: Focus on the National ICT Policy Framework 2011-2020 in Thailands education "smart learning" • Design cooperative problem-based learning activities to enhance cooperation skill in online environment • To evaluate the designed cooperative problem-based learning actitiviteis • Characteristics of cooperative learning • Framework of all activities	Comment: Area of students, many examples of blended learning		5
Academia + Industry	AN - 1	Collaborative Improvement – Interplay but not a Game: Identified factors which affecting the developments of collaborative improvement are list and methods how projects like CO-IMPROVE worked in such approaches – as if they shared knowledge – Characteristics and Relationships are explained. Setting: CO-IMPROVE Research project with focus on the inter-firm collaboration / Extended Manufacturing Enterprises • Indentification of factors which influence the collaborative improvement progress like: • E.g. Culture, partner characteristics, vision, trust, etc. • Case of a danish extended manufacturing enterprise • Interplay between influences	Working together, collaboration, continuous improvement, research, relationships between factors, interplay of factors, competences Comment: NAL – Practice from popular project: CO-IMPROVE	(Kaltoft, Boer, Chapman, Gertsen, & Nielsen, 2006)	1 2 3 4
Academia + Industry	AN - 2	Action Learning for increased innovation capabilities: Using learning network setup involving several organizations for inter-organizational action learning	Innovation capability, action learning, learning network, inter-organizational learning, trust-building, complex, learning network sessions, action research, experiential learning Comment: Example of a NAL approach	(Olsson, Wadell, Odenrick, & Norell Bergendahl, 2010)	1 2 3 4
Academia + Industry	AN – 3	Coughlans NAL Book: Collaborative Strategic improvement through network action learning – the path to sustainability: This practice presents a collaborative strategic improvement as a cycle of	Action learning, network, collaborative strategic improvement, actual	(Coughlan, P., 2012)	1 2 3

		activities in which firms in a network can engage together.	cases, operations management, knowledge-generation Comment: Famous book about NAL-Author, basis for taxonomy		4
Academia + Industry	AN - 4	A new stimulus to enhance international collaboration: Using Learning Factory and an academic research program comprising a double degree to enhance international collaboration between partner universities	Horizontal integration, international collaboration, learning factory, star network, vertical collaboration, innovation level, complex challenges Comment: Example of a best practice	(Darun, Palm, Athinarayanan, Hummel, & von Leipzig, 2019)	1 2 3 4
Academia + Industry	AN – 5	Operations and supply chain management – Academics and Practitioners: Identify, how research, practice and theory can learn from each other	Research competences, successfully solve practical problems, engage with O&SCM SCHOLAR, world around us Comment: Suppliers and customers cooperation	(Coughlan, Draaijer, Godsell, & Boer, 2016)	1 2 3 4
Academia	AB - 1	Development of blended learning model with virtual science laboratory for secondary students: Design of collaborative learning with creative problem-solving process learning activities in a ubiquitous learning environment to develop creative thinking skills	Blended Learning, Science, Virtual Science Laboratory, project-based learning, experiments, face-to-face online network, combination, learning model Comment: Too strong focus on students / secondary school	(Klentien & Wannasawade, 2016)	1 2 3 4
Academia + Industry	AB - 2	State-of-the-art Analysis on the Knowledge and Skills Gaps on the Topic of Industry 4.0 and the Requirements for Work-based Learning: Work-based learning in the topic of Industry 4.0 and the state of the art analysis on the knowledge and kills gaps	Industry 4.0 skills; factory of the future; manufacturing; work-based learning Comment: Industry 4.0 approaches	(Moldovan, 2019)	1 2 3 4
Industry	AN B - 1	Engineering Education in Changeable and Reconfigurable Manufacturing - Using Problem-Based	Changeable manufacturing,	(Andersen, Brunoe, &	1

		Learning in a Learning Factory Environment: Problem-based learning in a learning factory environment what should add a highly blended learning environment and Guidelines for Industry Partner – How to cooperate in LEAN 4.0 with blended learning factory approaches.	reconfigurable manufacturing, engineering education, problem-based learning, learning factory Comment: A mix of different learning types, good example to follow how to mix different approaches	Nielsen, 2019)	2 3 4 5
OL = Organizational Learning Practice (in general)					
Academia + Industry	OL – 1	Organizational Learning – The key to management Innovation: This practice blends theoretical thinking with real-time problem solving and focuses more on management innovation than on product or technology innovation. For this, organizational learning is used to integrate a broader range of management tools and methods to facilitate organizational change, improvement and helps to better appreciate the power of system dynamics. An umbrella is shared to unify an approach to systems thinking, planning, quality improvement, organizational behavior and information systems. Setting: Competitiveness Industry, Innovative Industry Practices used: • Problem-based learning: Blending theoretical thinking with real-life problems • Developing management tools together: Propose how Research can help companies ideas and concepts into practice • Suggested Management Tools and System principals as guide for OL	Problem-solving, complex organizations, theoretical thinking, real-time problems, systems thinking, planning, quality improvement, organizational behavior, information systems, delays and instabilities	(Stata, 1989)	1 2
Academia + Industry	OL – 2	Disciplines of Organizational Learning: Contributions and Critiques: Psychology and OD; management science, sociology and organizational theory; strategy, production management and cultural anthropology. This practice shows how to better consider organizational learning as a multidisciplinary field containing complementary contributions and research agendas. It also shows the main disciplinary perspectives in the literature on organizational learning and demonstrates the contributions and problematic features from each perspective. Furthermore, it analyzes the contribution of the disciplines to the conceptualization and practice of the learning organization. Between and within organizations	Organizational learning, learning organizations, knowledge creation Comment: Between and within organizations	(Grandgirard, Poinsot, Krespi, Nénon, & Cortesero, 2002)	1 2

		Setting: Competitiveness Industry, Innovative Industry Practices used: • Levels of OL: Single- Double- and Triple-Loop • Theoretical Disciplines of OL with Ontology, range of contributions/ideas and associated problems			
Academia + Industry	OL – 3	An Organizational learning Framework: From Intuition to Institution: Although interest in organizational learning has grown dramatically in recent years, a general theory of organizational learning has remained elusive. We identify re-newal of the overall enterprise as the underlying phenomenon of interest and organ-izational learning as a principal means to this end. With this perspective we develop a framework for the process of organizational learning, presenting organizational learning as four processes-intuiting, interpreting, integrating, and institutionaliz-ing-linking the individual, group, and organizational levels. Setting: Feed-forward and feedback processes, from individual- to group- to organization, for researchers and managers Practices used: • Theoretical Framework: OL as a dynamic process • Relation between new learning (feed forward) and what has already been learned (feedback)	Organizational Learning, $I model, framework, four processes, three levels, individual, group, and organizational levels. Comment: Between and within organizations	(Crossan, Lane, White, & White, 2008)	1 2
Academia + Industry	OL - 4	Organizational Learning: This practice clarifies the distinction between organizational learning and organizational adaptation and shews that change does not necessarily imply learning. There are different levels of learning, each having a different impact on the strategic management of the firm. After pointing out a learning concept, the "Lower-level learning" (Single-Loop) as a more repetition of past behaviors and "Higher-level learning" which includes more new actions (Double-Loop), "Learning" will be differentiated from "Adaption". Setting: Strategic management of a firm Practices used: • Literature research to compare terms of OL and develop a learning concept • Using learning level for identifying a hierarchy based o the level of insight and association building (higher- and lower level learning)	Organizational learning, adaption, higher level, lower level, double loop, single loop, alignment, learning concept, learning behavior Between and within organizations	(Fiol, C. M.; Lyles, 1985)	1 2

Industry	OL – 5	Organizational Learning: The Contributing processes and literatures: The information in this practice contribute to a more complete understanding of organizational learning. It elaborates four constructs integrally linked to organizational learning (knowledge acquisition, information distribution, information interpretation, and organizational memory). Setting: Knowledge acquisition for scientists, educators or managers, about organizational- adaption, change and learning within an organization Practices used: • Constructs and Processes associated with OL • Different variations like … - Congenital Learning - Experimental Learning - Vicarious Learning: Acquiring Second-Hand Experience	Organizational learning, knowledge acquisition, information distribution, information interpretation, organizational memory, sub processes, types of learning Comment: Between and within organizations	(Huber, 1991)	1 2
Industry	OL – 6	Strategic Leadership and Organizational learning: Adopting the strategic leadership perspective, this practice develops a theoretical model of the impact of CEO and top manager leadership styles and practices on organizational learning. It takes a fine-grained look at the processes and levels of organizational learning to describe how strategic leaders influence each element of the learning system. Setting: Changing environment of companies, knowledge acquisition for scientists, educators or managers, about organizational- adaption, change and learning within an organization, strategic leadership Practices used: • Conceptual model and a set of propositions • Theoretical model of the impact of CEO and top manager leadership styles • Individual learning stock; Group learning stock, Organizational learning stock	Organizational learning, leadership, CEO, levels, top management, learning system Comment: Between and within organizations	(Vera & Crossan, 2004)	1 2
Industry	OL - 7	Tools for a learning organization: This summary of key actions in learning organizations based on projects presenting a roadmap how to implement a learning organization – working approach. Setting: Changing environment, competition environment Practices used: • Key-actions for OL • Case studies • stock	Organizational learning, Learning company, key actions, working approach, project, case study, tools Comment: Between and within organizations	(Pearn, 1994)	1 2

OLI4 = Organizational Learning with Industry 4.0 context					
Industry	OLI 4 - 1 (incl. Industry 4.0)	Management Approaches for Industry 4.0: Industry 4.0 is characterized by smart manufacturing, implementation of Cyber Physical Systems (CPS) for production, i.e.. . All these challenges require continuous innovation and learning, which is dependent on people and enterprise´s capabilities. Therefore, this practice aims at offering a viewpoint on best suitable management practices which can promote the climate of innovation and learning in the organization, and hence facilitate the business to match the pace of industry 4.0. Setting: Reconfigurable manufacturing Practices used: • Project-based team work • Leadership Practice: Transformational leadership (Motivation, etc.) • HR Practice: Training, Staffing, Compensation, Performance	Industry 4.0, Management practices, Organizational structure, Leadership style, HR practices Comment: Between and within organizations	(Shamim, Cang, Yu, & Li, 2016)	1 2
Industry	OLI 4 - 2 (incl. Industry 4.0)	Examining the Feasibilities of Industry 4.0 for the Hospitality Sector with the Lens of Management Practice: With the example of a hospitality sector this practice proposes a framework of management practices which can promote the environment of innovation and learning in an organization, and hence facilitate business to match the pace of Industry 4.0 by facilitating technology acceptance e.g., digital enhancements and implementation of cyber physical systems (CPS). Setting: Changing environment Practices used: • Framework of management practices • Non-Interactive Trainings • Problem-based learning: high employee turnover- knowledge loss	Industry 4.0; management practices; learning; innovative capability; information; knowledge management; hospitality Comment: Between and within organizations	(Shamim, Cang, Yu, & Li, 2017)	1 2
Academia + Industry	OLI 4 - 3 (incl. Industry 4.0)	Organizational Learning Supported by Reference Architecture Models - Industry 4.0 Laboratory Study: Less than a learning practice, this information presents a discussion about the experiences in organizational learning in the laboratory. Its about collecting and sharing up-to-date information and presenting an innovative use of reference models to support organizational learning (Reference Architecture Model Industry 4.0 = RAMI 4.0) Setting: Reconfigurable manufacturing Practices used: • Problem-based learning: Organizations not using enough innovation to improve their operations • RAMI4.0 Theoretical Model	Digital Manufacturing, RAMI 4.0, Enterprise Architecture, Smart Production, Organizational Learning Comment: Between and within organizations, OL Basics + Case study (Learning Factory)	(Nardello, Møller, & Gøtze, 2017)	1 2

		• Demonstration of the model in University´s Laboratory			
OLL = Organizational Learning with Lean Context					
Industry	OLL - 1 (incl. Lean Management)	Dynamics of organizational learning and continuous improvement in six sigma implementation: Does learning mechanism and continuous improvement practices support each other and how, and what type of learning can be identified in the improvement of business processes. An integrated framework of the main concepts "organizational learning", "Continuous Improvement" and "Six Sigma". Setting: Multicultural environments, Lean environments Practices used: • Single Loop • Double Loops • Case Study: Dynamics of continuous improvement and learning process, key factors • Top Management and Training to understand lean (six sigma) • Decision making: An integrated and on-time reporting system	Organizational learning, Six sigma, continuous improvement, process improvement, Finland Comment: Between and within organizations, Case study about customers and clients	(Savolainen & Haikonen, 2007)	1 2
Industry	OLL - 3 (incl. Lean Management)	Systems thinking lean production and action learning: This practice explores this underlying question, first by sketching the basic principles of systems thinking and 'lean' management especially as applied in the TPS, and noting the centrality of individual and organizational learning. Based on two case studies, guidelines and rules can be adopted for own implementation. Is there a link between total quality management and learning organizations?: This topic focuses on an attempt to determine whether or not there is a link between TQM and learning organizations. With five activities, companies need to be skilled at and an analyses which shows a clear link between TQM and OL, this serves as a guideline how to implement lean and OL. Setting: Toyota Production System Case Practices used: • Action Learning • Leadership: Improving rather than changing operations; from push to pull • Case study: Experimentation with new approaches • Learning and action loop-check-plan-do	Systems thinking; action learning, organizational change, organizational learning Comment: Between and within organizations, Focus on continues improvement	(Seddon & Caulkin, 2007)	1 2
Industry	OLL - 4 (incl.	The Impact of Lean Thinking on Organizational Learning: The aim of this content is to explore and assess the implementation of lean from the perspective	Lean, Organizational learning, Exploitation, Exploration, different	(Vince, 2002)	1 2

	Lean Management)	of organizational learning. A link between different levels of lean approaches and differently types of learning is illustrated in case studies. Setting: Competitive environment, Continuous improvement culture Practices used: • Differentiate long- and short- term lean approaches • Processes which accept lean, can be seen as instance of organizational learning • From lean production to lean thinking and lean solutions • Learning more from cases than from standard operating procedures without value	levels, differently types, case studies Comment: Between and within organizations		
Academia + Industry	OLL - 5 (incl. Lean Management)	Measuring Measuring organizational learning capability among the workforce Setting: Reconfigurable manufacturing Conceptual model of OLC: • Experimentation • Risk Taking (The tolerance of ambiguity, uncertainty, and errors • Interaction with the external environment (the degree of relationships with the external environment) • Dialogue (The sustained collective inquiry into the processes, assumptions, and certainties that make up everyday experience • Participative division making (the level of influence employees have in the process of decision making) • Teamwork, problem solving in groups, with particular emphasis on multi-functional teams • Questionnaire surveys and interviews with participants are most information which to just OL	Organizational learning Capability, Learning organizations, Measurement, conceptual model Comment: Between and within organizations	(Chiva, Alegre, & Lapiedra, 2007)	1 2
Academia + Industry	OLL – 6 (incl. Lean Management)	Barriers to organizational learning: An integration of theory and research: For theoretical and practical reasons this paper helps to understand barriers to OL. Based on the expanded 4I model a framework is explained to understand feedback: exploitation and feed forward: exploration and level of OL. Setting: Research to analyses OL concepts Practices used: • Single Loop Learning, Double Loop Learning • Theoretical and practical Impact to understand barriers of OL • Theoretical framework	Organizational learning, Group, Individual, Organization, barriers, 4I model, double-loop, single-loop Comment: Between and within organizations	(Schilling & Kluge, 2009)	1 2

Industry	OLL – 7 (incl. Lean Management)	Re-thinking TQM: toward a framework for facilitating learning and change in construction organizations: Organizations in the construction industry have eschewed Implementing TQM practices because short-term benefits are relatively minimal. As a result, re-engineering has emerged as an alternative to change. Albeit re-engineering seeks radical performance improvements, the path to its implementation is incremental. Therefore, organizational change should be viewed as a continuous process rather than a static or ``one-off'' event. Before construction organizations consider implementing re-engineering initiatives, they should re-address their existing approaches to quality, so that an adaptive learning TQM culture can be cultivated. In striving for this ambition and based on a review and synthesis of the literature, a framework for facilitating organizational learning and change in construction organizations is presented. Setting: Reconfigurable manufacturing, competitive environment Practices used: • Problem-based learning: Period of intense introspection as a result of numerous government initiated reports, adversarial business • TQM: Framework • Theoretical framework • Project-based learning • Facilitator role: Learn to unlearn (5S) instead of top-down analyses • Re-engineering: Teamwork, communication and commitment	TQM, Organizational learning, BPR, Organizational change, Continuous improvement Comment: Between and within organizations	(Love, Li, Irani, & Holt, n.d.)	1 2
OLC = Organizational Learning with cooperation focus					
Academia + Industry	OLC - 1 (incl. collaboration)	Creating Effective University-Industry Alliances - An Organizational Learning Perspective: This discussion explores university-industry (Ul) relationships from our vantage point as organizational researchers who have also had the experience of implementing and managing these relationships. It introduces a new way of thinking about University-Industry relationships. Setting: Network/Relationships Practices used: • Perspectives of each partner in collaboration • Conceptual framework: Effectiveness model • Guide for OL: Communicated to other organizational members, stored in organizational memory, available for shared interpretation by others • Strategy: Problem-based learning: Selection of a motivating problem	Organizational learning, collaboration, University-Industry relationship, innovative, effective learning perspective Comment: Academia + Enterprises	(Hendriks, 2000)	1 2 3

		• Team-based partnerships: Process: company provides funds-researcher does the work-reviews occur-final product is produced • Multiple relationships: Table of Strategies and Implications			
Industry + Industry / Industry + HEI	OLC – 2 (incl. (collaboration)	Acquiring technological competencies through inter-organizational collaboration: An Organizational learning perspective: This practice examines the relationship between organizations learning capability and inter-organizational collaboration in acquiring technological competencies. A general model is developed which suggests an "efficient fit" relationship between organizations ability to learn, characteristics of the technology, and mode of inter-organizational collaboration – concept of a learning gap. Creating Effective University-Industry Alliances - An Organizational Learning Perspective: This discussion explores university-industry (Ul) relationships from our vantage point as organizational researchers who have also had the experience of implementing and managing these relationships. It introduces a new way of thinking about University-Industry relationships. Setting: Network/Relationships Practices used: • Perspectives of each partner in collaboration • Conceptual framework: Effectiveness model • Guide for OL: Communicated to other organizational members, stored in organizational memory, available for shared interpretation by others • Strategy: Problem-based learning: Selection of a motivating problem • Team-based partnerships: Process: company provides funds-researcher does the work-reviews occur-final product is produced Multiple relationships: Table of Strategies and Implications	Organizational learning, collaboration, technical competencies, inter-organizational collaboration, model, relationship between organizations Comment: Academia + Enterprises + international borders	(Steensma, 1996)	1 2 3
Academia + Industry	OLC - 3 (incl. collaboration)	Organizational Learning in clusters – A Case study on material and immaterial dimensions of cooperation: This practice gives empirically based insights into forms and mechanisms of knowledge management and learning within clusters. It investigates learning systems and their particular forms at cluster level, differentiating especially between informal and participative learning. Each cluster shows distinct patterns of learning and uses different sources of knowledge.	Organizational learning Knowledge networks Clusters Geography of innovation Knowledge management Comment: Comment: Academia + Enterprises + international borders	(Steiner & Hartmann, 2006)	1 2 3

Industry	OLC - 4 (incl. collaboration)	Network learning: Exploring learning by inter-organizational networks: Four cases of network learning are identified and analysed to provide insights into network learning processes and outcomes. It is proposed that 'network learning episode' offers a suitable unit of analysis for the empirical research needed to develop our understanding of this potentially important concept. The concept of network learning – learning by a group of organizations as a group – is presented, and differentiated from other types of learning, notably inter-organizational learning (learning in inter-organizational contexts)	Inter-organizational learning, learning episode, network learning, concept, integrative model of learning Comment: Comment: Academia + Enterprises + international borders	(Knight, 2002)	1 2 3
Academia + Industry	OLC - 5 (incl. Industry 4.0)	A learning network framework for modern organizations: This practice develops an integrated learning network framework that embeds Knowledge Management (KM), Organizational Learning (OL) and Information and communication technology (ICT).	Knowledge management, Workplace learning, Communication technologies Comment: Comment: Academia + Enterprises + international borders	(Bennet & Tomblin, 2006)	1 2 3
Academia + Industry	OLC - 6	University–industry collaboration: using meta-rules to overcome barriers to knowledge transfer: The given method presents a step by step process how to use 'meta-rules', suggested tools and methods and structural characteristics for transferring knowledge from and to higher education. Setting: Collaboration/Relationships Practices used: • Theoretical and practical input: Knowledge transfer, resource limitations, conflicting priorities, involve internal and external stakeholders • Identifying meta rules • Knowledge transfer within a university context: Using student-projects, publications, executive education, consultancy and start up activity • Problem-based learning • Identified knowledge transfer channels • Practical examples of Department Level and Project Level • Four Main competences: Research Project, Knowledge Sharing Services, Boundary Spanning through HR, Patent and Entrepreneurship policy • Framework	Cross discipline approach, meta-rules, organizational decision making, knowledge transfer, tools, higher education Comment: Comment: Academia + Enterprises + international borders, Key-Elements, Environment and some tools for HEI/Industry Collaboration	(Alexander, Martin, Manolchev, & Miller, 2018a)	1 2 3