Lean European Action-learning Network utilizing Industry 4.0

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

D2.1 Organizational learning readiness assessment tool

Version: Final Report

Date: 20-05-2019

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 D2.1 Organizational learning readiness assessment tool
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Revision History:

Date	**Version**	Summary of Changes	Initials
15.04.2019	First draft ready		DKO
26.04.2019	Draft ready for internal evaluation	Updated after feedback	DKO
12.05.2019	Draft ready for external evaluation	Updated after feedback from internal evaluation	DKO
20.05.2019	Approved	Updated after feedback from external evaluation	DKO

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 – Organizational readiness Assessment Tool for LEAN 4.0

In order to apply the learning types, a readiness assessment tool will be developed to question the learning behavior of an organization. As the state of readiness of a company and the relation between enterprises and HEIs to be able to learn through network learning, it is necessary to develop an assessment tool to judge whether the company is ready for learning and what has to be done to improve the ability of learning. This task will consist of both developing an organizational readiness assessment tool for companies and for Network Action Learning between academia and industry.

2 WP 2 Research for learning practices

2.1 Theoretical background

It has been proven that different tools in the context of lean management help to build a "continuous improvement" culture in the company's business processes and helps to improve a company´s performance (Middel, Boer, & Fisscher, 2006). Methods just as 5S or Kanban are well known and established methods that help to reduce waste, help to analyze and optimize processes and can be applied along the value chain. Especially the famous PDCA-Circle (Plan-Do-Check-Act) is often associated with continuous improvement. However, continuous improvement is a widely used phrase and for many people it is synonymous with "innovation" and the continual quest to make things better in products and customer service. For others, it implies a preoccupation with sustained incremental change and quality improvement (Bessant and Caffyn, 1997).

In research projects, continuous improvement could be used in a more collaborative way between stakeholders in a supply chain. This was also called "collaborative improvement" and includes an collaboration across national borders (Middel et al., 2006). As a reference, a research project named "CO-IMPROVED" (Collaborative Improvement Tool for the Extended Manufacturing Enterprise) academics and enterprises analyzed collaborative improvement methods. It was not only mentioned in the context of lean management or continues improvement, but was also associated with "Organizational Learning" (OL) (Savolainen and Haikonen 2007). OL can be seen as a cycle of activities based on experience and success-factors like an attitude that supports continuous improvement and the ability to fundamentally renew and revitalize with different types of learning (Coughlan, P, Coghlan D., 2011). A LEAN 4.0 goal is to identify such types of learning. In addition, Organizational learning is also mentioning that inter-organizational learning is a type of organizational learning across national borders between both, universities and companies. It can help to improve better and faster (Lane and Lubatkin 1998). Based on shared experience of different organizations and countries such improvements can be implemented faster (Holmqvist 2003).

For this purpose, a research process is carried out. On the one hand, in order to implement new learning practices, it is necessary to consider the company's currently used practices. On the other hand, the task of a literature review is to identify the types of learning which could be associated with OL and should list examples and characteristics. Different types of learning can be found in the literature. Furthermore, it is necessary to find out which learning practices are suitable for achieving the objectives of LEAN 4.0. The procedure of the literature review and the research regarding types of learning and practices are explained in chapter 2.2 and 2.3. Here, LEAN 4.0 built a research model with research questions, so that literature could be collected with a systematic approach.

2.2 Research Model

To help operations managers to learn in networks and use the advantages of inter-organizational collaborations within the age of Industry 4.0, the development of a "LEAN 4.0 Blended

Network Action Methodology" was set as a goal and will be addressed with the following research questions:

What are suitable Learning 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 research, the research question was divided into two subordinate parts:

1) *What has to be done by organizations to integrate learning practices?*
2) *What types of learning can be practiced in the organizations?*

Based on the knowledge from literature and previous projects, LEAN 4.0 operates with two tools to find answers to these questions. The following Research model shows what results can be expected.

Research Question	What are suitable Learning Practices for international collaboration within and between universities, companies and supply chains for implementing Lean methods or Industry 4.0 technologies?	
Derived Questions	What has to be done by organizations to integrate learning practices?	What types of learning can be practiced in the organization?
Used Tools	A Readiness Assessment-Tool	A Taxonomy of learning practices
Expected Results	Self-assessment of current learning behavior in the organization, discussion and new input	Categorization of learning types and development of a best practice for the organization

Figure 1 shows that LEAN 4.0 operates with two tools to answer the derived questions.

(1) To answer a wide-ranging question like *What has to be done by organizations to integrate learning practices?* a readiness assessment-tool can be used. As a self-assessment this tool can help the organization to reflect on their own learning behaviour and to acquire valuable information. These tools make complex issues more tangible and are supporting decision-making (Triste et al. 2014). The Harvard University Centre for International Development´s defined the use of Assessment-Tools as "*the degree to which a community is prepared to participate in the networked world – a world in which everyone, everywhere, has the potential to reap the benefits of connectivity to the network*" (Aziz and Salleh 2011). This leads to the assumption that assessment tools can also find applications in different networks.

(2) The second derived question in the research model includes a specific question: *What types of learning can be practices in the organization?* To be able to answer such a precise question, the method of a taxonomy is used. Taxonomies can be created based on self-organizing maps, which concepts involves semantic descriptions of the inputs and outputs of operations provided by a practice (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.
In the following chapters the actual results of the literature review as a map of learning practices, a Readiness Assessment-Tool of Learning Practices and the Taxonomy of types of learning will be described.

2.3 Literature review

Based on the research question, keywords were identified and a search term was created for searching in specific databases. One finding of the first literature review was that too many results were found. This led to a too unspecific overview of learning practices. Therefore, a second literature review was carried out.

Table 1: Literature review - Searching terms

Keywords	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, virtual environment, e-learning, distance-learning, collaboration, skill, collaboration environment, teaching factory, learning factory, traditional learning, innovative learning, synchronous learning, asynchronous learning, learning management
First review 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")
Second review Searching-term #2	("Network Action Learning" OR "Action Learning" OR "Blended Learning" AND ("Practice" OR “Best” OR "Method" OR "Modell" OR "Framework") AND ("Industry" OR "4.0" OR "Lean“ OR “Smart”) AND (“collaboration” OR “inter” OR “Cooperation” OR “Network”)

The used keywords for the research were used to create searching-terms. These are relevant for using different databases in a systematic process and are listed in Table 1.
The results of the literature reviews are listed in Table 2. Here the comparison between the first and second literature searches is carried out and clearly shows the reduction in search hits.

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

Literature review according to Webster and Wattson								
Databases	**All Results**		**Results after Title-review**		**Results after abstract-review**		**Results after Fulltext-review**	
Review	**First Review**	**Second Review**	**First Review**	**Second Review**	**First Review**	**Second Review**	**First Review**	**Second Review**
Emerald	376	-	339	-	80	-	5	-
Science Direct	2744	603	2501	352	453	30	11	18
Springer Link	1337	451	1314	286	125	25	20	5
Wiley Online	503	51	482	26	46	9	0	4
EBSCOhost	270	-	263	-	11	-	0	-
Total	**5230**	**1105**	**4899**	**644**	**715**	**64**	**36**	**27**

According to Webstar and Watson, all results of a literature review can be reduced to only the relevant literature. The process can be seen on Table 2. For this purpose a step by step process is recommended (Webster and Watson 2002). Before the sorting process starts, the settings of the databases are standardized, such as a "without preview-only sources" setting.
In the first step the literature is filtered by title. All titles that deviate from the searched topic are thus sorted out. Second, the summary or abstract should be checked. This ensures that a more detailed review of the remaining literature can be carried out with a minimum of time required. Finally, the last sources are examined on a full-text basis, summarised in key points and key results are extracted.
Most of the results could be found in the databases *ScienceDirect*, *SpringerLink* and *WileyOnline*. This is the reason why a second literature search with a different search term was performed only on these three databases. The results are to be confirmed by this process. Nevertheless, information has been taking also from 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

The literature research reveals different types of learning from which practices could be used for the research project. The following table lists the identified learning types.

Table 3: Types of learning by literature

Types of Learning Practices found in literature	Reference
Organizational Learning	(Steiner & Hartmann, 2006)
Action Learning	(Revans 1982)
Blended Learning	(Kaur, 2013)
Network Action Learning	(Coughlan, P, Coghlan D., 2011)
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)

A closer look into the literature and internal reviews by the project consortium lead to a selection of **four** superordinate learning types (1. – 5.) which can be related to an effective inter-organisational learning approach. The LEAN 4.0 – Blended Network Action Learning Methodology can be adapted from the inter-organizational learning approach and combine criteria from different types of learning.
Alternative learning types (A. – F.) can be exclude.

1. A characteristic of **Organizational Learning** is that not only individual persons but the entire organization is constantly learning. It forms the basis for applying and combining other types of learning. Organizational Learning is good at creating new solutions and good at sharing knowledge with other members (Sugarman 2012).
2. **Action Learning** requires that actions be carried in an organization. It involves reflections of the ways things are carried out, changes in current actions, implementation and improvements (Olsson et al. 2010a). Furthermore, Action Learning members includes group work where members come together to form an action learning set. In this set, learning occurs through a continues process of reflecting and acting by the members on a defined problem (Graaf and Kolmos 2015).

3. **Blended Learning** includes a mix of offline- and online learning tools. It is provided by the effective combination of different modes of delivery and models of teaching which are exercised in an interactively meaningful learning environment (Kaur 2013).
4. **Network Action Learning** provides a valuable mechanism for building sustainability by building networks. It is also known that Network Action Learning - Networks can make the transition from strategic to learning and transformational networks. In this way, action learning may be conducted, both intra- and inter-organizationally. The network of action learning includes usually a group of people with defined tasks, which is called a set. 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 4 will define the selected types of learning in detail. In addition, the objective of an own LEAN 4.0 learning type is defined.

Table 4: 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 behaviour 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 pilotproject-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.	

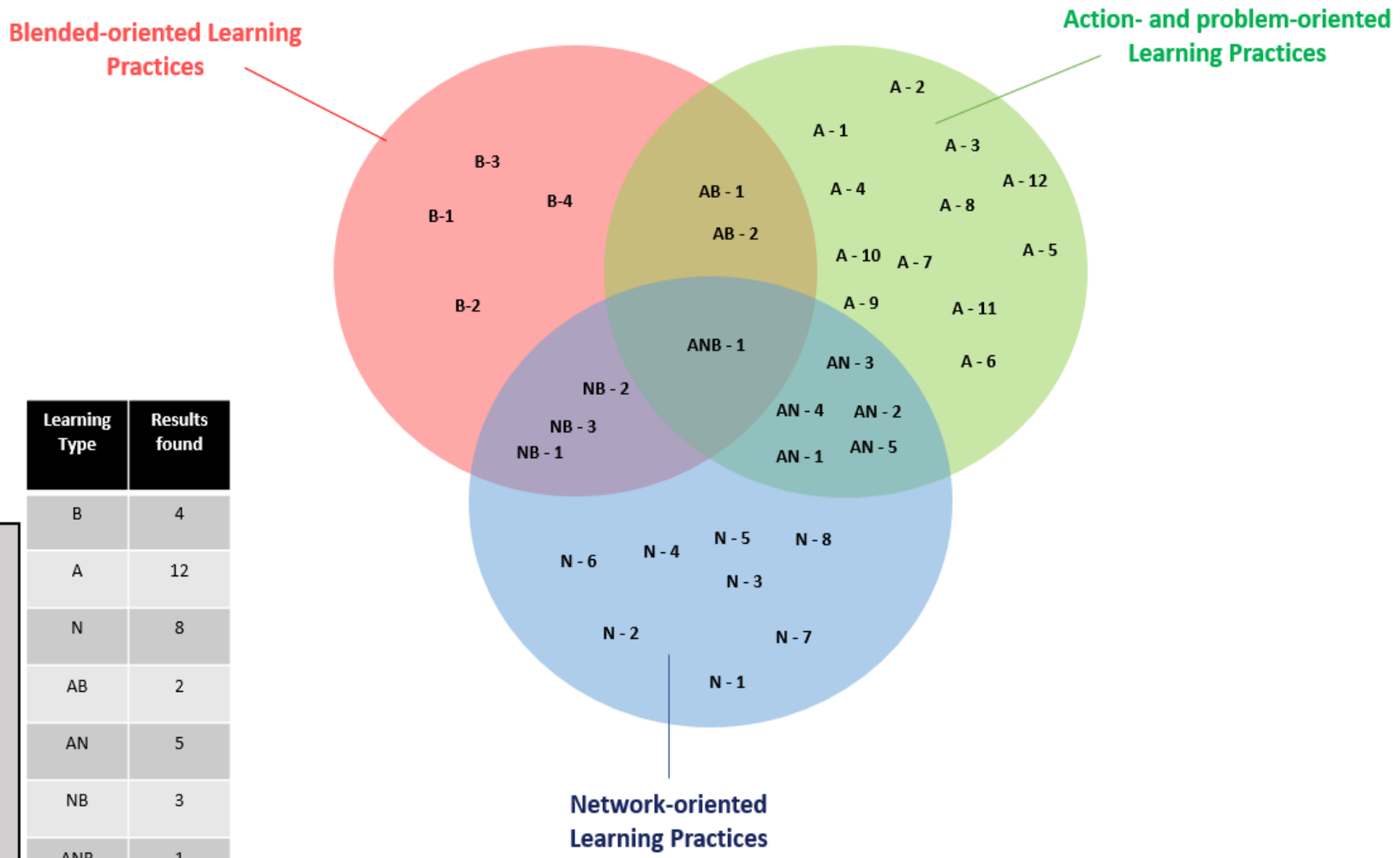
3.2 A Map of learning practices

As follows, a map of learning practices is used as a visualization to present the results of the literature review. 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. During the review of OL practices (4), 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 "OL-Practices", here as the characteristics and success-factors for all learning types are classified in the appendix 8.2 and not further considered in the map of learning practices.
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.

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.



Learning Type	Results found
B	4
A	12
N	8
AB	2
AN	5
NB	3
ANB	1

YY - ZZ

Numbering

Types of Learning Practices
B=Blended-oriented Learning
A=Action/Problem-oriented Learning
N=Network-oriented Learning

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. There may also be same characteristics in different practices what is represented through the intersection of the circles on the map. On the map, the learning practices are marked and numbered with the initial letter of the respective learning type. The learning practices usually include approaches of organisational learning. Organizational learning means that individuals do not learn as own units, but rather the entire organisation drives learning progress (Coughlan P., Coghlan 2011).

3.3 Deliverable 2.1 - Organizational learning Readiness Assessment-Tool for LEAN 4.0

3.3.1 Expected and actual outcome

The LEAN 4.0 project consortium decided on a readiness assessment tool to help operations managers and existing cooperation between organizations to incorporate the right learning behaviour into operational processes. The focus should be on NAL, as this is one of the basis of LEAN 4.0´s research project. The main literature 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, provide an excellent basis for developing the foundation of an effective assessment tool. So far, that is the expected outcome.

Table 5: Expected and actual results: Research components of the assessment-tool

Expected and actual results: Research components of the assessment tool		Sources
Expected Results	a) Organizational learning readiness assessment-tool focusing on NAL b) The tool is questioning the ability to learn (through networks) c) Guidelines for what has to be done to improve the ability to learn (for both: within companies and NAL between organizations)	a) Project Application b) Project Application c) Project Application
Learnings during the research process	a) NAL is not an established type of learning (not many references) b) To learn the right abilities for suitable learning behaviours, the research has to identify the story / basics of NAL and a research question can be adapt: How do we come up with characteristics of the right learning behaviour? c) To develop proper guidelines, references and sufficient success factors are needed	a) Literature review b) Past project-experiences, LeanManagement-Tool, Coughlan OL/NAL Book c) Past project-experiences, LeanManagement-Tool, Coughlan OL/NAL Book
Actual Results	a) Implementation of continuous improvement basics and enhanced by characteristics of collaboration improvement across national borders (innovative methods), organizational learning and NAL by Coughlan (2011) b) Connection of Lean Management Basics "Continues Improvement", Collaboration Improvement across national borders (innovative methods), Organizational learning, NAL characteristics and the use of Experience from past projects c) Using References from the map of learning practices to improve weaknesses in the learning behaviour of an organization and tested validity by an industrial partner by implementing an own learning practice	a) Literature review, Feedback from ROSEN b) Past project-experiences, Lean Management-Tool, Coughlan OL/NAL Book c) Literature review, Feedback from ROSEN

In Table 5 the expected results are divided into a), b) and c). In the course of the project, a lot of experiences were made. Problems and obstacles in the research process led to adjustments of the research results. Therefore, Table 5 shows both learnings and actual results of a), b) and c).

First, **a)** means that the result should include a readiness assessment tool, which was developed based on characteristics of OL and which also triggers the behaviour of an organisation with regard to NAL. However, what emerged during the literature review and in discussions with industry partners during the course of the research project is that there are just few references to NAL and it may is an unestablished or rather unknown learning method. As a consequence of this insight, experiences from past projects were considered and the project consortium started to research the basic principles of the subject. Since Coughlan mentioned in his book, that continuous improvement was concerned with both individual and organizational learning, LEAN 4.0 considered the structure of a lean management assessment tool of the HAN University of applied science (Hogeschool van Arnhem en Nijmegen, Netherlands) and connected them with the reviewed NAL characteristics. As an actual result, LEAN 4.0 created an Organizational Learning Assessment Tool what implements continuous improvement basics and is enhanced by the characteristics of OL, NAL and collaboration across national borders.

Second, **b)** the assessment tool should be able to questions the learning behaviour of an organisation. Organizational learning also defines that the learning of an individual (e.g. one

manager) has to be transformed into a holistic learning of an organization and the development of skills for using smart technologies can be easier and more sustainable. Here, too, the research on NAL encounters too few references to guarantee a holistic development of the tool. So LEAN 4.0 also benefits from the experience of previous projects by implementing basic lean management tools. As a result, the tool addresses a wide variety of organizations with diverse categories and the learning behavior is questioned holistically.

Third, **c)** to teach an organization how to not only question but also improve the already mentioned learning behavior from b), guidelines should be developed or researched. These guidelines support the learning of an organization, especially in relation to NAL.
In order to list such guidelines, it is necessary to review certain references with defined characteristics and success factors. The Map of learning practices is the ideal tool for this purpose, as it lists a large number of different learning practices and can show already developed frameworks, systematic processes or case studies from practice.
These references can be used to research the weaknesses or strengths of the own organization and to adapt solution approaches. The scores and the visualization in the assessment tool reflect the weaknesses and strengths. The validity of the tool was tested by a LEAN 4.0 partner and applied to one of his own results from the tool. The test is described in detail in chapter 4.

3.3.2 Phases

The Assessment-Tool includes a step-by-step process which is visualized in Figure 4.
In the **first step** there are given behaviours regarding organizational learning which have to be scored by the following people in an organization through a questionnaire that will be reported in section 3.3.5:

1. Between one and three employees from the shopfloor-level or an office-professional **position from one specific department**, who is taking care of the workflow at the shopfloor. The idea is to consider an opinion what comes from someone who is the closest to problem areas and mainly implements manual work.
2. Between one and three responsible persons from the higher management, which are in a decision making position.
3. Between one and three persons from the LEAN 4.0 consortium or academic partners which are responsible for answering questions of the organization about the structure or meaning of the tool during the evaluation. It is possible also to get objective opinions about the learning behaviours.

This group of three to nine different people has to reflect the behaviours of the organisation from their own perspective and increase the relearn potential for one department. The assessment tool can be used in different departments several times in one organisation. The results can then be compiled and discussed. By Fiol a learning alignment implies that the company must have the potential to learn, unlearn or relearn based on its past behaviours (Fiol, C. M.; Lyles 1985). In addition, analysing the state of learning in the own organization belongs to the ten key actions of organizational learning from (Pearn 1994). The question here is to what extent they resemble the process structure of the company.

The **second step** involves reflecting the result using a visualization. The scores are displayed in a diagram with the help of an Excel sheet. This evaluation is carried out by a partner of the LEAN 4.0 project, so that the user himself is not tempted to adjust the results afterwards. The visualization allows an overview of all set scores and thus the identification of all negative or positive units. These ups and downs are discussed with involved or affected persons. In the best case, specific approaches for improvement can be addressed.
The **third step** isn´t part of filling out the Assessment-tool anymore, aims to open the door to open discussions with LEAN 4.0 partners and invites them to reflect on the results of the assessment tool. The aim is to identify strengths and weaknesses. In a best case scenario, identified weaknesses can be addressed during the next steps. Furthermore, an overview of opportunities to better leverage strengths through lean experts in LEAN 4.0 can be listed.

Step four 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 address the weaknesses, which could identified for an organization by using the assessment tool. All found learning practices are listed in the appendix in table 8. Here, too, further discussions are to be held with LEAN 4.0 partners or experts from the respective fields to analyze the content.

Steps five and six 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 ideally communicates them in a BNAL approach. 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. Figure 3 shows the structure of the assessment tool.

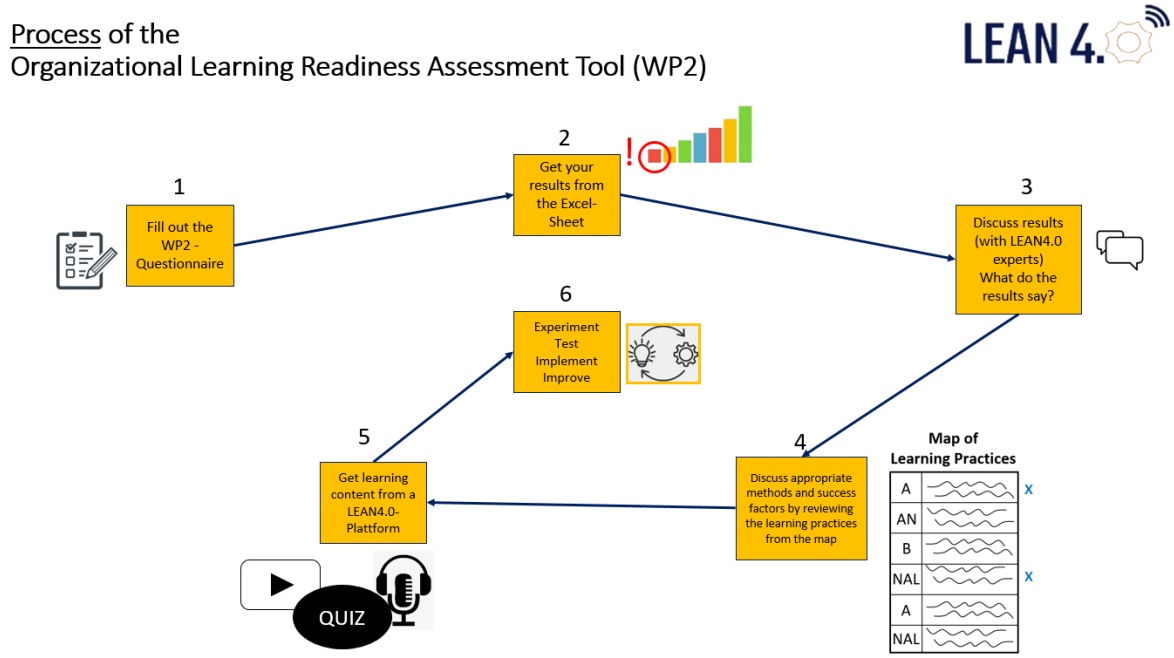
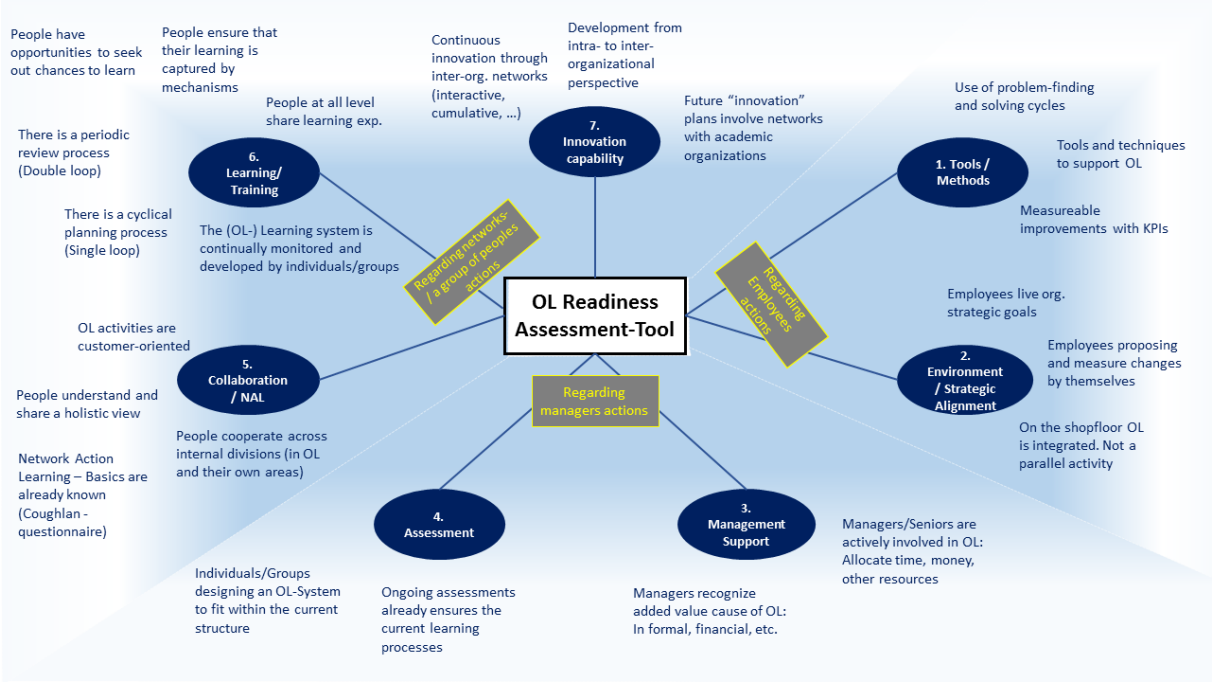


Figure 3: Step-by-Step Process: Assessment-Tool

3.3.3 Structure of the Assessment-Tool

Before an assessment tool can be used, the user should understand the structure of the 'questionnaire' in table 6. It is less a questionnaire but more a catalogue of statements and actions, which can be divided into at least seven different categories. These categories contain key-elements regarding learning practices which got identified by past project experiences of project partners and literature. The key-elements should question behaviours and attitudes regarding the learning environment by the organisation. The structure of the assessment-tool can be seen in Figure 3. For example, the Network Action Learning approach (in category 5: Collaboration / NAL) complements the assessment tool with the information about building a network. It helps to address efficiently problems in Academia and Industry within using modern technologies in collaborative ways. Since the **Network Action Learning** approach is very specific and extensive, **a separate questionnaire** is attached in the **appendix** 8.1. The tools and methods (in category 1) challenge common lean methods of the company, while category 2 and 3 question the strategic orientation and learning behaviour / support of the management level. After the assessment tool is to evaluate which assessments are already being made in learning processes, the training tools in category 6 are also to be questioned. Finally, the skills for innovation in learning behaviour will be examined. For example, how is the move from the well-known continuous improvement to continuous innovation already given in the organisation? In the following Figure 4 it can also be seen that the categories are divided in employees actions, managers actions and the actions of a group of peoples (networks).

Figure 4: Structure of the Assessment-Tool



3.3.4 Target Groups

LEAN 4.0 identified both Academia and Enterprises as a target group for using the Assessment-Tool. It is primary designed for the Industry or other organisations with high circulation of goods or production lines. Academic organisations can also apply the tool in different types of networks or research projects.
Companies have to consider that participants of supply chains, project-partner or learning groups should do the same assessment to discuss similarities and differences. As soon as more similarities are found in the discussion, the corresponding scored behaviours can be further developed and promoted. If differences are identified in the discussion, the processes should be reconsidered to reveal collaborative potentials and / or learning behaviours to enable organizational learning.

3.3.5 Self-assessment of learning behaviour in the organization

Objective of this Step – Are you ready to learn? Find out which criteria of OL your organization considers and how.
Please indicate the extent of implementation of each of the following behavior of efficient learning / lean practices in your organization (according to your opinion) Please choose a score between 1 (Disagree) to 5 (Agree). That could lead to discussions about learning aspects and to find potential to increase your organizational learning skills.
Wording: Suppliers are people or organizations, which provide you with resources and/or information. Customers purchase your products. Suppliers and customers could be the similar people or organizations. If that is the case, please answer each question for these organizations in their different roles (supplier or customer).
A LEAN 4.0 industry partner filled out the following template of the assessment tool.

Table 6: Self-Assessment of learning behaviour in the organization

Categories	No.	To what extent does the behavior below describe the situation in your organization? Insert: 1 (Disagree) to 5 (Agree)	Score
1 Tools and Methods[1]	1.1	People make use of some formal problem-finding and solving cycle (e.g. PDCA of A3). *(Optional entries)* *If there are some – Which ones?* _____	*3*

[1](Sobek and Jimmerson 2006), (Steiner and Hartmann 2006), (Coughlan, P, Coghlan D., 2011)

	1.2	People use appropriate tools and techniques to support organizational learning (fishbone diagram /cause-effect diagram, MCTs, VSMs, etc.). *If there are some – Which ones?* _____	*2*
	1.3	People use measurement to shape the improvement process. *e. g. KPIs*	*4*
2 Environment / Strategic Alignment[2]	2.1	Individuals and groups use the organization's strategic goals and objectives to focus and prioritize improvements everyone understands (e.g. is able to explain) what the company's or department's strategy, goals and objectives are. *If not: Employees don´t know why the processes used to be the way they are at the moment and what is the outcome or is it efficient*	*4*
	2.2	Individuals and groups (e.g. departments) assess their proposed changes (before embarking on initial investigation and before implementing a solution) against departmental or company objectives to ensure they are consistent with them. They have the chance to measure first results as well. *e. g. Experiments to test the changes are possible?*	*2*
	2.3	On the shopfloor, organizational learning activities are an integral part of the individual- or groups work, not a parallel activity. *List some of those activities:*_____	*3*

[2] (Locke 2013), [2](Sobek and Jimmerson 2006), (Hartley and Allison 2002), (Holmqvist 2003)

3 (Senior/- Higher) Management Support[3]	3.1	Managers/Seniors support the organizational learning process through allocation of time, money, space and other resources. They are actively involved. *List, what they are doing exactly*:_____	*3*
	3.2	Managers recognize in formal (but not necessarily financial) ways the contribution of employees to organizational learning.	*2*
4 Assessment[4]	4.1	Ongoing assessment ensures that the organization's structure, infrastructure, and the organizational learning system consistently support and reinforce each other. *What kind of assessments are used?* _____	*2*
	4.2	The individual/group is responsible for designing an organizational learning system to fit within the current structure and infrastructure. A longer-term observation or reviews to assess the results are included. *What are the results of the assessments from 4.1?* _____	*3*
5 Collaboration[5]	5.1	People cooperate across internal divisions (e.g. cross-functional groups) in organizational learning as well as working in their own areas. Representatives from other departments are involved in cross-functional activities.	*4*
	5.2	People understand and share a holistic view (process understanding and ownership). *Are tools used to make this easier/possible?* _____	*3*

[3] (Sobek and Jimmerson 2006), (Locke 2013)
[4] (Steensma 1996), (Coughlan, P, Coghlan D., 2011)
[5] (Middel et al. 2006b), (Goyena 2019), (Hartley and Allison 2002)

	5.3	People are oriented towards internal and external customers in their organizational learning activity. *e. g. (Organizational) Learning / Network projects, collaboration activities with universities, etc.*	*3*
	5.4	"Network Action Learning" – Basics are already known and (partially) integrated. *(a separate questionnaire on NAL is attached)*	*3*
6 Learning/Training[6]	6.1	The organizational learning system is continually monitored and developed; A defined individual- or a group monitors the organizational learning system and also measures the incidence (i.e. frequency and location) of organizational learning-activity and the results.	*5*
	6.2	There is a cyclical planning process whereby the organizational learning system is regularly reviewed and, if necessary, amended (single-loop learning). *e. g. Improving by considering results based on common actions*	*4*
	6.3	There is a periodic review of the organizational learning system in relation to the organization as a whole, which may lead to a major regeneration (double-loop learning). *e. g. Improving by questioning the underlying assumptions behind the common actions*	*4*
	6.4	Individuals seek out opportunities for learning/ personal development (e.g. actively experiment, set their own learning objectives).	*4*

[6] (Shrivastava 1983), (Coughlan, P, Coghlan D., 2011)

	6.5	Individuals and groups at all levels share (make available) their learning from *all* work experiences. The organization consolidates it. *e. g. there is a platform (or similar) to share experiences*	*3*
	6.6	People and teams ensure that their learning is captured by making use of the mechanisms provided for doing so.	*3*
7 Innovation capability[7]	7.1	The organization focuses on continuous innovation as a chance to obtain sustainable competitive advantages with the help of inter-organizational networks and external collaboration.	*4*
	7.2	The organizations attention have to be shifted from intra-organizational group perspective to inter-organizational network perspective.	*2*
	7.3	In future "innovation" plans / projects with intra- or inter-organizational collaborations - A learning network involving academic, researchers and participating organizations can be considered.	*5*

[7] (Coughlan, P, Coghlan D., 2011), (Olsson et al. 2010a), (Holmqvist 2003), (Alexander et al. 2018a)

3.3.6 Result (Example Visualisation): Organizational Learning Assessment-Tool

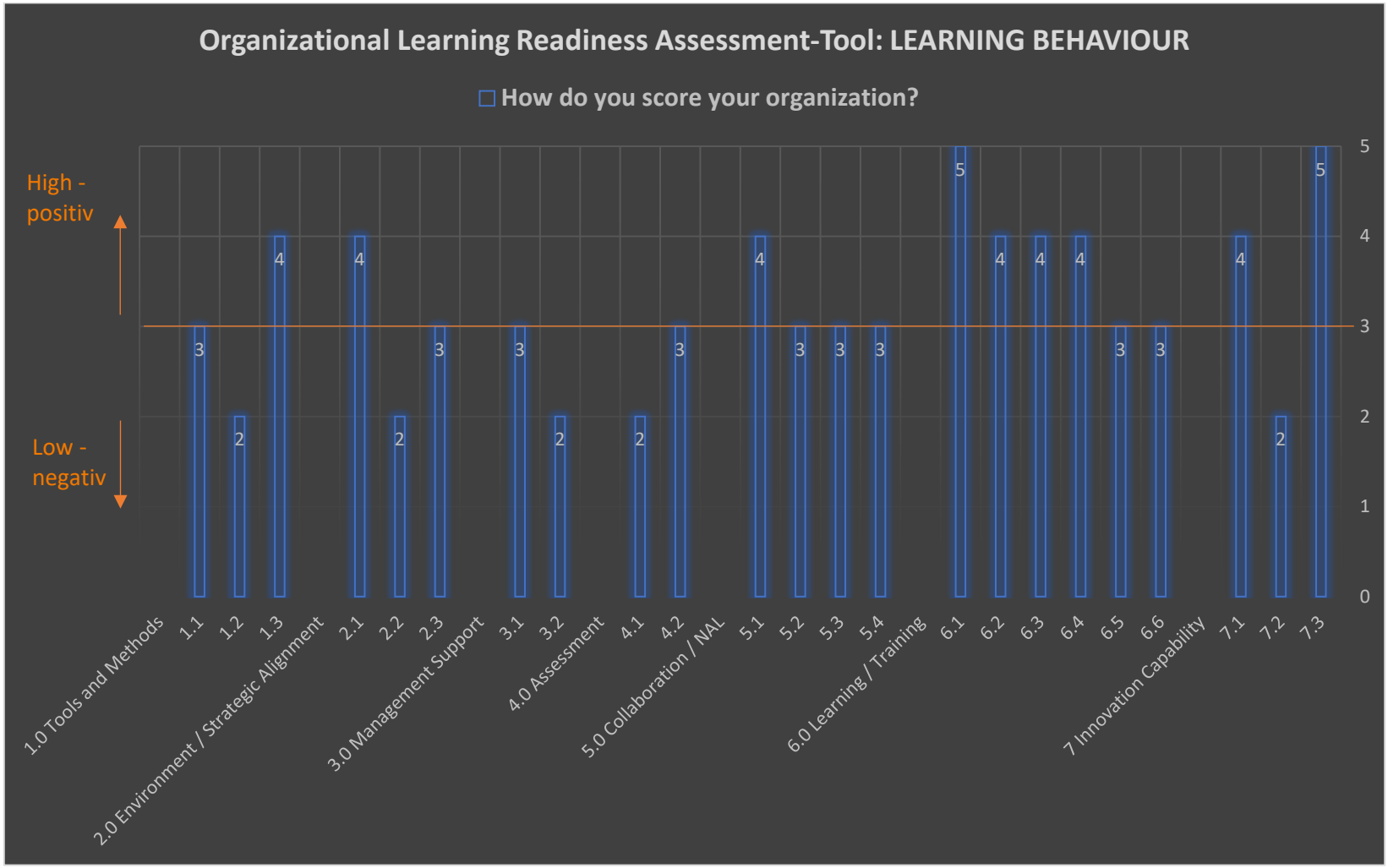


Figure 5: Result of the Assessment-Tool (Example)

In this example, the visualization of the result of the assessment tool is based on the entries from an Industry-Partner of LEAN 4.0. It can be clearly seen that there are at least two very good scores (6.1 and 7.3). However, it can be seen that there are also a couple of low scorings. For example, statement no. 1.2 is a score of 2, which reflects a low score. As this is the category "Tools and Methods", it can be deduced that the organization is facing challenges in the area of applying standard lean and learning methods.
The following actions can be suggested:
After the old tools and methods have been reflected, a discussion follows with the persons involved in the department to find barriers and solutions. This can be facilitated through an expert-interview with a LEAN 4.0 partner. The establishment of a new method in the organization can be kicked off by a pilot project also. In order to be able to solve this problem on their own, the LEAN 4.0 project grants chosen users of the assessment tool access to a learning platform which contains further information and studies on current pilot projects and plans in LEAN 4.0.
For the best rated categories, a best-case report can be created to adapt the methodology to other categories. It is also worth to mention that the organization does not need to optimize in this area as much as in other categories in comparison. In this example, the category "Learning/Training" is rated really well. But the evaluated statements also encourage reflection on how these areas can be further developed. While statement no. 6.1 were evaluated with 5 points on the highest score, 6.5 and 6.6 in the same category "only" scored 3 points. This raises the question how this can be optimized with the help of LEAN 4.0 learning content or learning practices. The following chapter ‘Learning Practice from Participant in the project’ shows a learning practice from the industry partner of LEAN 4.0 to justify the strengths which are shown in the assessment tool.

4 Learning Practice from Participant in the project

The assessment tool of the industry partner of LEAN 4.0 clearly shows some strengths in the area of "learning/training". The following Learning Practice describes how the organisation has developed these strengths.

LEAN 4.0 – Partner: ROSEN GROUP, Germany

(1) Team Foundation Server: At Rosen, Microsoft's Team Foundation Server (TFS) is used by the design department as a learning practice. In general, the TFS system offers many different functions such as project management, document management, reports or central task management and error tracking. From these possibilities, Rosen uses the central task management and error tracking for the improvement of different components taking into account problems during production. Here, problems or suggestions for optimization that were noticed during the mechanical production of the component or during the montage are stored in a so-called ticket system.

In this ticket system, for example, a task is created in mechanical production in which the part and SAP numbers indicate which component is involved. Thus, it is still given at a later time that each department knows which component or assembly it is and which modification should be tackled. In addition, this task provides each employee involved with the opportunity to track the status of the project.

This is followed by a detailed description of the possible improvements, which are shown in detail with drawings or models.

In addition, possible components with similar structures are pointed out in order to be able to implement the possible optimization in as many components or assemblies as possible. This should ensure that new product designs are always based on the latest technology.

The new task then appears during design and is now released for editing. The responsible designer evaluates the proposal and checks its feasibility. In doing so, he considers not only the individual component, but also the overall assemblies in order to be able to rule out that the change will not lead to conflict with other components in later work steps. In addition, he also checks whether the modification can be easily transferred to other designs.

Finally, depending on the complexity of the change, an economic analysis is carried out. This ensures that the redesign of the component or assembly does not become more cost-intensive in other departments. In addition, it is taken into account that as many similar components as possible can be simplified or even components can be reduced, whereby, for example, one or two components are created that can be used for several superstructures instead of having a modified variant for each superstructure. This reduces the number of variants and component costs due to, among other things, the increased number of identical components.

Finally, the changes are brought into the system and the ticket is closed in the Team Foundation Server by the design department. Results including time-saved processes up to 50%, high flexibility and quality improvement of the products.

(2) Training and Education (TED): The Training & Education department serves the managers at Rosen as a business partner and supports them in the planning, organisation and implementation of training courses. In addition, it records the training progress of the employees, evaluates the results and communicates them to the HR department and the responsible managers.

All training courses offered are managed as modules in the Global Training Program (GTP). In addition, the modules in the GTP are divided into different areas. The training modules are sorted according to the qualifications required for the position and the qualifications required are based on the job descriptions in RADIS, workflows and processes. If, for example, the Tool Operator L1 module is considered, all relevant training modules are listed below in order to fulfil the tasks of a Tool Operator. This also shows employees the development path they follow to build knowledge and skills for the job. The Global Training Program is basically based on a blended learning approach and combines virtual classrooms, simulators, blogs and freely accessible information sources on the intranet.

The TED department uses the Training & Competence Management System (TCM) as a learning platform for its employees, who can use it to take exams and even evaluate the training they have attended. For the management and the individual employees, the program offers the possibility to view the training history and existing qualifications. This enables an employee to view his or her data and a manager to view the data of his or her team. For maintenance and administration, TED has access to all data of their respective location.

The software includes different views in which the employee is informed about open tests and missing feedback. Furthermore, employees are shown which modules and qualifications need to be refreshed soon or have already expired. The number of days remaining is listed and thus provides a simple overview. The employee is reminded to record the times for the training internally and to display times that have not yet been posted. In addition to the possibility to display open training courses in TCM, TED normally also sends e-mails to the employees to informing them of the training. The safety instruction can serve as an example for this. Every employee is obliged to carry out these once a year. New employees also carry out this training during on boarding. This is coordinated by TED. The safety instruction is structured as follows:

There are individual topic chapters with information texts and explanations. Between the chapters there are short queries and playful elements, e.g. cards that have to be sorted or something similar. Finally, the most important points are asked again with the help of a multiple-choice test in an examination. To pass, a certain percentage of the questions must be answered correctly. The results are managed and evaluated by TED. In cooperation with the respective managers, TED also ensures that all employees take part in the safety briefing. Results including more communication processes between employees, possibilities to give feedback on learning processes and a high variation of learning tools.

5 Learning Practice from Partners outside the project

In the result presentation of the assessment-tool it is clearly visualized that the area "Collaboration / NAL" was scored rather in the lower level.
For this purpose, a learning practice from organizations outside the LEAN 4.0 partner consortium is used as a reference to derive possible solutions.

One of the learning practices, which can be raised, is the “Usability First via collaborations” practice, which is known in the “Glasshouse” – project from the “Hochschule Osnabrück – University of applied sciences”. Glasshouse tries to analyses and implement the use of Augmented Reality with Smart Glasses along a supply chain in enterprises. From previous projects, they have run into problems during the production of applications for the Smart Glasses for customers from the industry. That leads to time delay and wasted resources. Later they have learned to share these problems with other Universities to perform problem-statement and problem-solving solutions. With following customers, Glasshouse got support from different Universities to perform the concept of prototypes in a very early stage. That helps to create an application together with the customer himself during the project, which led to customer-oriented usability and avoided problems. Glasshouse was thus able to establish itself as the successor to the “Glassroom” research project. Due to the collaboration with other academic partners, it was possible to deliver conceptual content at an early stage and generate particularly high customer acceptance. Finally, Glasshouse created a learning practice which can be understand as a network learning practice which is based on openness and leads to customer satisfaction , collaboration between academics and follow-up projects.

6 Summary of WP2 and Added value for LEAN 4.0

Based on a literature search, state-of-the-art network learning practices could be identified and knowledge about the types of learning could be categorized. The knowledge is also used to create a map of learning practices, what serves as a pre-step to take a closer loot at common learning practices from practice and to identify them as references.
With D2.1 Partners inside or outside the project are getting a first idea of how learning and types of learning can look like. The assessment tool should help the user to better assess whether and to what extent learning is already present in the company. Furthermore, the application of the assessment tool questions the success factors behind organizational learning and motivates the participants to reflect on their own learning behavior. Based on defined categories in the assessment tool, individual groups consisting of employees of a department, the higher management level and shop floor employees can be addressed with the tool. Thus, the organizational learning of a company should be questioned and not the learning behavior of single individuals. As a result, the assessment tool develops a visualization of the assessment of own learning behavior and optimally leads to the development of strengths or the improvement of weaknesses.

To wrap this work up, the given input serves also for creating a LEAN 4.0 learning concept, the Blended Network Action Learning methodology, to use tools and practices in the rightful way to implement smart technologies in organizational learning settings and network action learning for partner inside and outside the project.

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8 Appendix

8.1 Network Action Learning – 'Questionnaire – self assessment'

This NAL-self-assessment is part of the assessment tool. As the field of Network Action Learning is very specific and extensive, a separate questionnaire was created for this purpose in order to particularly question the knowledge of an organisation with regard to the NAL approach.

Network Action Learning Approach	10.1	The organization meets innovativeness (e.g. Industry 4.0) with work-integrated learning and knowledge (e.g. learning by doing, learning factory) to develop new (critical) competences of employees.
	10.2	Different stakeholders inside and outside the organization are effectively implemented for meeting the requirements of innovation.
	10.3	To facilitate this (10.2), a company uses employees who are able to build and use appropriate networks.
	10.4	Innovations – especially radical ones – often require solving complex and mostly ill-structured problems, which cannot be addressed appropriately by using previous solutions. Consequently, creativity and creative problem-solving competencies are involved in a learning concept for the employees.
	10.5	The organization uses knowledge transfer across internal and external boundaries contributes fundamentally to the innovativeness.
	10.6	The receivers of this knowledge are the innovators which are technology- and market-oriented. They posse a good overview over different (technical) areas and are able to recognize new market trends.
	10.7	The organization focus on utilizing smart technologies in line with the digitalization of the production process actively with the help of academia and a smart manufacturing concept. Together, applied research skills will be created for addressing the complex challenges faced by industry.
	10.8	In collaborative research, the organization could help researchers to understand the intricacies and complexities of practical problems better and show them how they act upon events unfolding in the research.
	10.9	The academic researchers, in turn, could help the organization to explicate their reflective learning and to understand the effects of their actions.
	10.10	This (11.3) know-how transfer required a high amount of practical hands-on experience to foster and expand the knowledge for the organization.
	10.11	Employees have high problem solving skills as well as exceptional creativity in order to independently find innovative and creative solutions to the numerous issues.
	10.12	Consequently (13.1), new ways of life-long teaching and learning are necessary in order to keep up with the (innovative) developments and are implemented in employees training system.

	10.13	Therefore, competency profiles are changing rapidly, whereon work-integrated learning processes (e.g. learning factories) have to react. The curriculum of a learning factory is verbalized by intended competencies.
	10.14	Online learning, teleconferencing, internet, Computer Assisted Learning (CAL), Web-Based Distance Learning (WBDL) and other technologies are integrated. This blended learning environment has become the major role in training and education scene.
	10.15	The four main characteristics of Industry 4.0 are considered in designing and developing: 1. vertical networking of production systems; 2. horizontal integration of global value chain networks; 3. end-to-end engineering of overall value chain; 4. using high-impact disruptive technologies.
	10.16	The increasing complexity of work are also concerned the shop floor level. Simple tasks will be more and more automated and the remaining tasks will mostly consist of problem solving (as the complexity of machines and plants within the smart factory will increase rapidly).
	10.17	The Organization sees the worker is a central key success factor.
	10.18	The increasing complexity of manufacturing machines results in a clear need for support of machine operators within Industry 4.0. To manage the work processes adequately, the machine operator needs special knowledge about the work processes which is supported by a continuous/network learning concept.
	10.19	Focusing on the facts above (16.4), there is a clear demand and an already implemented modern learning system, which can solve these problems by the use of digital media workplace-integrated learning tools and will provide learning content for the worker.

8.2 Organizational Learning findings

This table summarizes all the characteristics of OL that were identified in the literature research.

Table 7: 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	Examples in Learning Factory approaches	(Nardello, M., 2017)

Development of organizational memory		
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)

8.3 Detailed Learning Practices

The following table summarizes all learning practices that have been visualized in the Map of Learning practices. The approaches of Organizational learning practices are also listed.

Table 8: Learning Practices regarding literature

Target-Group	Numbering	Title/Description	Keywords and Comment	Reference	Assessment-Tool: Address categories
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)	6 7
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	Blended learning, strengths, weaknesses, distance education, sustainable project outcomes, multinational, multi partner Comment: Case Study about BL – Project, no practice described	(Ari and Taplamacioglu 2012)	6 7

		• 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			
Academia + Industry	B - 4	PBL – Problem Based Learning for Companies and Clusters: Learning methods been developed with 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, groups and self-learning, Control – defined timetable, Behaviorism and social cognitive • Step-by-step process how to teach PBL	ICT, Clusters, joint action plan, pbl, SME, e-learning, international, research	(Hamburg and Vladut 2016)	6 7
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)	1 6
Academia	A – 2	Design Training Systematically and Follow the Science of Training: A	Designing training, ksa	(Salas and Stagl 2012)	1

		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	(=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		6
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 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	Supply chain knowledge, modelling knowledge types, SCM problems, case study, knowledge acquisition Comment: Types of Supply Chains / Knowledge sharing – no learning practice	(Almuiet and Salim 2013)	1
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 –	competency development; education; learning factory; morphology; vocational training, industry and academia, collaborative working group, scenarios Comment: Example for a best practice	(Abele et al. 2015)	1 6

		Nonacademic Partner – Profit oriented partner			
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 practice	(Müller et al. 2017)	1 6
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 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	Small-group interaction, collaborative projects, research studies, co-construct knowledge, complex problems, developing knowledge, discourse-based/object-oriented Comment: Analysis and a guide for small-group learning,	(Damşa 2014)	6
Industry + Industry /	A – 7	Center of Excellence for Lean Enterprise 4.0: Using action research and action learning for entrepreneurial network capability development and to develop	industry 4.0, lean enterprise, learning environment, changed	(Dombrowski et al. 2019)	1 2

Industry + Academia		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	competency, theoretical presentation Comment: Example for a best practice		6 7
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)	1 2 6 7
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)	1 2 6 7

		• 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)	1 2 7
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	Industry 4.0, learning concepts, learning factory, maturity model, scenario-based, research-project adaption Comment: Evaluation about E-learning, no practice	(Wienbruch et al. 2018)	1 3 4

		• 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	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 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	Industry 4.0, learning factory, problem-oriented, scenarios, develop skills and competencies, complex problems Comment: Best Practice for a learning factory approach in Industry 4.0	(Erol et al. 2016)	1 6 7
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	Collaboration, working together, research, relationship between factors, collaborative improvement, partner characteristics	(Middel et al. 2006a)	1 5

		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	Comment: Good basics and knowledge		
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 • 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	knowledge management; learning; networks, black box of knowledge sharing, effectively create and manage network-level, suppliers, motivate members to participate, reduce costs Comment: Client+Supplier, OL + Network learning, small-group learning, Example of a best practice	(Dyer and Nobeoka 2000)	1 2 5
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	Environmental management; Knowledge exchange; Knowledge management; Knowledge transfer;	(Reed et al. 2014)	1 2 3 5

		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	Knowledge translation; Research; Stakeholder engagement; Stakeholder participation Comment: Good elements of knowledge exchange, no practice		
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 et al. 2016)	5
Academia + Industry	N - 5	Innovative Tools Used by Business Networks and Clusters in Communication: Innovative tools used by business networks and clusters in communication with 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	best practices; business communication; clusters; innovation; networks; social media Comment: Too strong focus on social media	(Negruşa et al. 2014)	5 7

		• 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.			
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)	5 6 7
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 Electrodomésteciś, 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 et al. 2009)	5 6 7

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 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	critical competencies, implicit knowledge, industry 4.0, knowledge transfer, networked competence development, work-integrated learning, creative problem-solving Comment: Good Basics for international borders and supplier + clients	(Kinkel et al. 2017)	2 5 6
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	(Wannapiroo n 2014) (Laisema and Wannapiroon 2014)	1 2 5 6
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,	Research-Based Learning Blended Learning Research Competency Critical Thinking Skills Cloud Learning Management System Comment: NAL – Practice from	(Panlumlers & Wannapiroon , 2015)	5 6 7

		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.	popular project: CO-IMPROVE		
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 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	Cooperative Learning; Cooperative Skill; Learning Activity; Online Environment; Problem-Based Learning Comment: Area of students, many examples of blended learning	(Wannapiroon 2014)	5 7
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 –	Working together, collaboration, continuous improvement, research, relationships between factors,	(Kaltoft et al. 2006)	1 5

		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	interplay of factors, competences Comment: NAL – Practice from popular project: CO-IMPROVE		
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 et al. 2010b)	1 5 6 7
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 activities in which firms in a network can engage together.	Action learning, network, collaborative strategic improvement, actual cases, operations management, knowledge-generation Comment: Famous book about NAL-Author, basis for taxonomy	(Coughlan, P., 2012)	1 2 3 4 5 6 7
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,	(Darun et al. 2019)	1 5 7

			innovation level, complex challenges Comment: Example of a best practice		
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 et al. 2016)	1 5
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 and Wannasawade 2016)	2
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 7
Industry	ANB - 1	Engineering Education in Changeable and Reconfigurable Manufacturing - Using Problem-Based 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.	Changeable manufacturing, 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	(Andersen et al. 2019)	1 2 3 4 5 6 7

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 7
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 et al. 2002)	1 2 4 5

		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 et al. 2008)	1
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".	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 3

		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)			
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 5
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	Organizational learning, leadership, CEO, levels, top management, learning system Comment: Between and within organizations	(Vera and Crossan 2004)	2 3 5

		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			
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)	2
Industry	OLI4 - 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 et al. 2016)	2 3 7
Industry	OLI4 - 2 (incl.	Examining the Feasibilities of Industry 4.0 for the Hospitality Sector with the Lens of	Industry 4.0; management practices; learning;	(Shamim et al. 2017)	2

	Industry 4.0)	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	innovative capability; information; knowledge management; hospitality Comment: Between and within organizations		7
Academia + Industry	OLI4 - 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 • Demonstration of the model in University´s Laboratory	Digital Manufacturing, RAMI 4.0, Enterprise Architecture, Smart Production, Organizational Learning Comment: Between and within organizations, OL Basics + Case study (Learning Factory)	(Nardello et al. 2017)	1 7
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”.	Organizational learning, Six sigma, continuous improvement, process improvement, Finland Comment: Between and within organizations, Case	(Savolainen and Haikonen 2007)	1 3 6

		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	study about customers and clients		
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 and Caulkin 2007)	1 2 3 6
Industry	OLL - 4 (incl. Lean Management)	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 of organizational learning. A link between different levels of lean approaches and differently types of learning is illustrated in case studies.	Lean, Organizational learning, Exploitation, Exploration, different levels, differently types, case studies	(Vince 2002)	1 2 6

		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	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 et al. 2007)	1
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.	Organizational learning, Group, Individual, Organization, barriers, 4I model, double-loop, single-loop	(Schilling and Kluge 2009)	1

		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	Comment: Between and within organizations		
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 et al.)	1

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 • 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, University-Industry relationship, innovative, effective learning perspective Comment: Academia + Enterprises	(Hendriks 2000)	5 7
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	Organizational learning, collaboration, technical competencies, inter-organizational collaboration, model, relationship between organizations Comment: Academia + Enterprises + international borders	(Steensma 1996)	5 6 7

		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			
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 and Hartmann 2006)	5
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,	Inter-organizational learning, learning episode, network learning, concept, integrative model of learning Comment: Comment: Academia + Enterprises + international borders	(Knight 2002)	2 5 6

		notably inter-organizational learning (learning in inter-organizational contexts)			
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 and Tomblin 2006)	5
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 et al. 2018b)	1 5 6