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Learning factories for the operationalization of sustainability assessment tools for manufacturing: bridging the gap between academia and industry

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Abstract

Sustainability assessment is recognized as a powerful decision support tool that promotes actions toward sustainable development, cultivates social learning and leads to a shift in sustainability knowledge and views. The Learning Factory as a new concept for both academic and industrial learning can help to operationalize assessment tools and close the gap between academia and industry. This paper conceptualizes the Learning Factories on Sustainability Assessment which create a good environment for the operationalization of sustainability assessment tools for manufacturing organizations through education, research, and innovation.

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Keywords: Organizational learning; sustainability assessments; learning factory concept.

1. Introduction

The pressure of globalization, continuously changing customers' expectations, interconnected and complex value chains, and sustainability challenges force manufacturing organizations to adapt continuously to a turbulent environment. Such adaptations require an understanding of the organisation behaviour. These adaptations change what organizations do and why they do it.

"Sustainable development" and "learning organization" have been propounded as two strategies that can help organizations in conditions of global challenges and continuous changes. Sustainability assessment is a decision support tool that is able to foster sustainable development and enhance learning in an organization about sustainability. However, the successful operationalization of sustainability assessments for manufacturing organizations is limited by the challenges organizations face during the choice and use of tools [1, 2]. Most of these challenges are due to the lack of collaboration between academia and industry.

Both academia and industry have a crucial role to solve problems that a global community faces. Thus, knowledge exchange between academia and industry is required. Moncaster et al. [3] argued that knowledge transfer between academia and industry within the area of sustainability is both critical and crucial now. Collaboration between academia and industry within the context of sustainable development has been argued by different authors, e.g. [4, 5]. Many attempts have been made to create an effective collaboration between academia and industry, by means of activities as international projects, students' projects within manufacturing, etc.

According to Mavrikios et al. [6], most of the applications of the Learning Factory concept focuses on the academic training rather than on industrial learning. The objective of this paper is to investigate the use of Learning Factory concept for both academic training and industrial learning in the context of sustainable development.

In this paper, "Learning Factory on Sustainability Assessment" is proposed as a platform for knowledge exchange and as an environment for the operationalization of sustainability assessment tools for manufacturing organizations.

Due to their mutually supportive nature of learning organization (LO) and sustainable development (SD), [7, 8], this paper uses them as the development framework for the learning factory on sustainability assessment. LO is an

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organizational renewal methodology to address systematic problems that ignites and enhances learning throughout the organization. Its dynamics suit the kind of strategy that SD requires because instead of focusing on linear problem solving, it aims to identify underlining causes, gain a deep understanding of the condition of the organization, and attain goals by developing new practices, behaviors, and strategies, using shared values and vision.

2. Sustainability Assessment for Sustainable Development of Manufacturing

2.1. Manufacturing and Sustainable Development

Increased awareness of the quality of life, environmental degradation, and economic development has led to the need to place "sustainable development" as an agenda for nations, local communities, organizations, etc., see e.g. [9, 10]. There is no unified definition of sustainable development [11-13] and the discussion about the meaning of the term is still going on [14]. In one of the latest research works it is argued that the semantic openness of the "sustainability" concept cannot be managed or eliminated, and it does not lead to meaninglessness [15]. Despite the never-ending discussion on the true meaning of sustainability, manufacturing organizations have started to apply a variety of practices associated with it. Eco-efficient activities, corporate social responsibility, green procurement, and environmental reporting have been adopted by many organizations for decades [16]. Since manufacturing plays an important role in employment, pollution, economic development, consumption of natural resources, and wealth generation, sustainability has become an integral part of the planning and operations in many organizations. Sustainability has been recognized as a strategy to cope with complex problems, conflicts between goals or stakeholders' interests, a diversity of requirements and regulations, and turbulent environment in which the organizations has to operate. Moreover, sustainable development is viewed as a strategy to tackle global sustainability-related issues e.g. environmental degradation, unemployment, and wealth creation [17-19]. To foster sustainable development and address global sustainability challenges, manufacturing organizations need to make decisions taking into account a series of complex social, economic, and environmental issues simultaneously. This makes sustainability assessment an essential aid for decision-making in sustainable development [20-22].

2.2. Sustainability assessment – an aid for sustainable development

Since the concept of sustainable development is central to sustainability assessment, pluralism of sustainable development has led to a diversity of definitions of sustainability assessment [23-27] and approaches to assessment, see e.g. [23, 27-32]. The variety of viewpoints on what sustainability assessment is and how to perform resulted in a vast number of sustainability assessment tools.

Sustainability assessments can be categorized according to the underpinning sustainability discourse, representation of sustainability within the assessment process, or decision-making context [33]. Three aspects of decision-making context are the level of decision-making, the decision question being asked, and the party responsible for assessment [33]. Manufacturing organization may use sustainability assessment to evaluate the policy, practice, product, etc., to identify which alternative is more sustainable or if the product is sustainable. In addition, assessment can be conducted by an external party and used for external reporting or internal assessment can be performed to inform planning.

Since manufacturing is a part of the large system, Moldavska and Welo [32] argue that sustainability assessment is responsible for providing information that can truly lead to the identification of actions that will contribute both to sustainable development of an organization and to global sustainable development. Although different opinions exist on the purpose of sustainability assessment, Waas et al. [20] outlined four purposes of sustainability assessment:

- Information generation for decision-making;
- Operationalization and forum for participation, debate and deliberation;
- Social learning;
- Structuring complexity.

Sustainability assessment can enable debates among various stakeholders and lead to a shift in their knowledge and views. It also generates information that allows making better decisions regarding sustainable development and helps to structure the complexity of sustainable development.

2.3. Shortcomings of sustainability assessment tools

Moldavska and Welo [32] have divided shortcomings of sustainability assessment tools into two groups, those related to the methodology behind a tool and those related to the implementation of a tool. The authors stressed the need for the adoption of systems thinking in order to overcome shortcomings related to the methodology behind a tool.

Shortcomings associated with the implementation of a tool are those that manufacturing organizations face when choosing and applying tools. One of the denominators for this type of shortcomings is the lack of collaboration between academia and industry, i.e. those who develops a tool and those who uses it. Some sustainability assessments may be considered too theoretical and general [34, 35], or too technical and complicated for manufacturing organizations [36, 37]. Moreover, sustainability assessment is usually resource intensive and Taisch et al. [2] state that the gap between scholars and practices leads to the significant time required for implementation of sustainability assessments. In addition, the authors argue that because of the number of specific assessments focused on the specific criteria, sectors, or sustainability aspects, an organization may require time to identify an assessment or a combination of assessments that can serve the organization's needs.

All in all, it can be argued that there is a need for knowledge exchange and collaboration between academia and manufacturing organizations on the topic of sustainability assessment—to identify how to measure sustainability and sustainable business. The following issues should be resolved; how to develop an assessment tool that can foster sustainable development instead of being a complication for an organization, how to simplify the identification of existing tools by manufacturing organizations, and how to satisfy both researchers' and manufacturing' interests.

3. Learning Factories and Learning Organization

The learning factory is a concept originated in 1994 as a way to deal with the socio-technical challenges industries face, and it refers to spaces of different scale and duration where participants learn about current practices and develop new solutions and new knowledge for industry and academia [38]. More extensively the concept is currently used to develop competencies in education, industry and research [7]. The term 'learning factory' is used interchangeable with the term 'teaching factory' among researchers and practitioners.

The concept was devised in the United States, but it was quickly replicated in Europe. Initially proposed as a way to provide an environment of continuous learning for blue-collar workers and engineers, it was the ideal field for academia to acquire state-of-the-art knowledge about current practices at the same time that they could prepare students better for the work their future work life.

Ever since created, learning factories have been used for different purposes. Mostly focused on product and process aspects, e.g. [39, 40]. A variety of learning factories, based on the combination of the education, research, and innovation, have been developed, (e.g. [41]). In this paper, the authors propose its use for adjusting sustainability assessment to the manufacturing environment, using a learning organization approach.

The rationale for the use of this methodology in learning factories for sustainability assessment is that it provides the dynamics to generate the organizational renewal that sustainable development demands, and, at the same time, provides the systemic analysis crucial for the tuning of the tools.

The use of organizational learning to create solutions for sustainable development is not novel. Initially proposed by core authors of learning organization such as [8], and more recently by [7, 42]. This approach tries to use the aim of deep systemic understanding of organizations and the learning potential to develop practices that should put organizations on the path of sustainable development.

The concept of learning factory might be innovative for sustainability assessment domain, but it is not new for learning organizations. In 1990, Senge talked about the importance of what he called "Learning Laboratories" [43]. In his view, the concept was important to enhance the collective intelligence and creativity. Differently than what is proposed here, the learning laboratories discussed in his article were for management teams, and the aim was to provide effective practice field where, both, "meaningful business issues with meaningful interpersonal dynamics" were to be discussed by participants.

The difference of these learning laboratories, in comparison with reality, is that the factors that hinder learning were suppressed, e.g. the overlook of consequences in the long-term and systematic scheme. The focus was on developing new learning skills by reflecting deeply on the assumptions of the participants.

Senge warned that if this simulation environment were to lack connection with relevant problems for the organization, focus on skill developing, or systemic comprehension, it would lack the transformational value LO aims to have. This stresses the importance of the use of learning factories for sustainability assessment tools, because it both integrates them in a realistic environment where they deal with real systems and their concerns and demands.

4. Learning Factories on Sustainability Assessment

The learning Factory on Sustainability Assessment aims at integration of three cornerstones, i.e., education, research, and innovation, into a single initiative to promote sustainable development and learning in an organization. The extended Learning Factory concept, proposed by Mavrikios et al. [6], is used as a base for the Learning Factory on Sustainability Assessment, see Fig. 1.

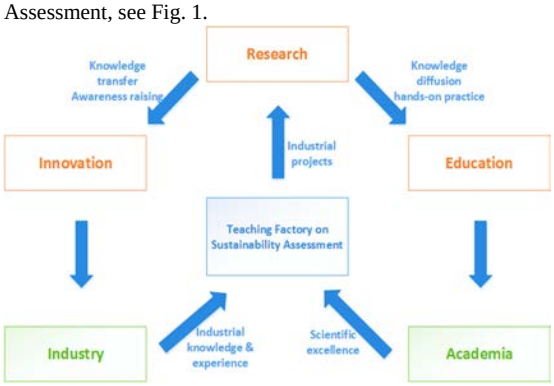

Fig. 1.Learning Factory on Sustainability Assessment based on [6].

The possible input from industry to "Learning Factory on Sustainability Assessment" is the experience in the use of assessment tools, tacit and explicit knowledge, and insight about state-of-the-art practices, in addition to a realistic environment for the participants of the learning factory.

Academia brings the knowledge on the current state of the art in sustainability assessment and existing approaches to assessment with its pros and cons, knowledge it techniques and tools for assessment process such as system dynamics, multi criteria analysis. In addition, academia has developed the range of methodological requirements to sustainability assessment

that should enable truly sustainable development rather than "greenwashing".

The benefits of "Learning Factory on Sustainability Assessment" can be seen in the three domains, i.e., education (academia), research (academia and industry), and innovation (industry).

Education:
Employment of new teaching schemes to communicate new knowledge, e.g. what organizations assess during sustainability assessment, why organizations assess what they assess, challenges that organizations face trying to choose and conduct sustainability assessment.
Employment of teaching about current complex problems that manufacturing has to deal with in order to prepare students for the environment in which decisions should be made. Introduce the range of decisions that different organizations have to make at strategic, tactical, and operational levels. This may enable an understanding of what information sustainability assessment should provide.
Employment of teaching about real-life industrial practices in sustainability assessment.
Understanding by teachers of what skills students should have in sustainability assessment.
Educational curriculum keeps pace with manufacturing understanding of and current practices in sustainable development.
Research:
Researchers can study manufacturing needs, problems, and experience in order to develop a better assessment tools that can help organizations to foster sustainable development.
Researchers can study manufacturing needs in sustainability assessment, currently used assessment approaches and experience in assessment.
Incorporation of industrial knowledge into the development of assessment tools that can be easily adapted by an organization.
Researchers can study what manufacturing understand as sustainable development and thus, what is assessed by sustainability assessments.
Manufacturing is introduced to scientific excellence in sustainable development and sustainability assessment, e.g. the need for integrated assessment, sustainability criteria/issues.
Manufacturing is introduced to the variety of existing sustainability assessments and how they support sustainable development.
Creation of awareness among industry about sustainable development and the role of sustainability assessment in fostering sustainable development of an organization and global sustainable development.
Increasing of manufacturing organization's motivation to use sustainability assessment as a means to enhance sustainable development.
Manufacturing learns what is important to measure in order to foster sustainable development.
Manufacturing learns how to use existing approaches to sustainability assessment.
Improvement of mental models of decision makers due to participation in the development of sustainability assessment tools.
Researchers and students learn how manufacturing conduct sustainability assessment and challenges related to it.
Innovation:
Manufacturing receives new knowledge from the research projects, i.e., what is sustainable development and how it can be supported by sustainability assessment, what sustainability assessment is, requirements which sustainability assessment should satisfy.
Manufacturing receives new technology from the research projects, i.e., sustainability assessment tools that are based on the combination of real-life experience and scientific excellence, and which are customized for an organization's environment and needs.

From an organizational learning point of view, the value of a learning factory consists in the creation of the space for teaching, learning, testing, and tuning. A learning factory can work as a laboratory rather than as a classic classroom, opening the door for dynamics and knowledge that might not emerge in classic learning environments. As Naude [7] explains, organizational learning consists of three processes around knowledge: creating, retaining, and transferring; and learning factories have the possibility to play a major role in the three of them.

The six points proposed by Jamali [44] about the potential role of organizational learning in sustainable development strategies can be used to analyze the possibilities which learning factories on sustainability assessment have to offer bridging the gap between industry and academia:

1. Challenge Mental Models: One of the ways in which learning factories aid to close this gap is by revealing the hidden assumptions behind the mental models that are employed to develop the SA tools, and the actual practices in the firms. Mental models are pervasive and often implicit ways of thinking that influence the way in which people perceive reality and solve problems. The problem with mental models is their often-implicit nature, which makes hard to make them evident for people within the organization. By bringing participants from academia, these mental models are more likely to be exposed and challenged. The same occurs for the rest of the participants from academia or research, whose mental models will be challenged by those existing within the organization.

The guidelines of how to reveal and address the mental models and their implications for the participants have been described by Senge [43]. In The leader's New Work he details how to carry out dynamics concerning the identification and analysis of mental models.

2. Foster fundamental change: As described by Senge [43], and echoed in the literature on knowledge management and

learning organization [45, 46], the purpose of learning organization is to create a sustainable organizational change using the least amount of effort. This is the result of identifying a practice or behavior that if changed, would direct the organization towards the shared vision.

3. Engage extensive collaborating activity: One of the most relevant aspects of learning organizations; the use of a learning factory for sustainability assessment is the communication system, it can enable for academia and industry the valuable flow of information and knowledge that will help minimize the gap between communities.

As argued above, a greater insight in the system configuration would lead to more effective sustainability assessment tools.

4. Revisit core assumptions about business and its purpose: Intrinsically connected with point 1 and 2, is the discovery of shortcomings in the organizational design or that there was a wrong assumption between the espoused theory and the practice of the business and its operation. This realization could also be experimented by the researchers or academicians who participate, and often approach practices from a more theoretical angle.

5. Implement system-level thinking: This element from learning organizations, as propounded by Senge [43], can influence learning factories regarding sustainability assessment as a systemic approach, as it has been proposed by Moldavska and Welo [32]. The motivation for the use of this modality in the analysis is to create a deep understanding of the functioning system devising solutions that lead to an organizational change (as expressed by Senge [43]). System-level thinking is a powerful means to create a set of tools that can lead to high comprehension of the current state of the organization and its potential state after the insertion of the solution.

6. Foster a culture of learning and experimentation: Once the techniques to reveal and analyze mental models and system design are mastered, it becomes easy to build a dialogue between the stakeholders where honest inquiry can conduct to more revolutionary discoveries and enhanced understanding of the products, processes, and overall practices.

5. Learning Factories on Sustainability Assessment

The description of the details of the proposed learning factory is beyond the scope of this paper, which focuses on proposing the conceptual model. But based on other existing learning factories we suggest for this environment to occur in a physical setting within the industry where collaborators from academia meet people from the industry who are responsible for sustainability assessment. That way academicians have the opportunity to interact with their knowledge and practices in their natural environment, opening the door for greater understanding and facilitating their interaction with the assessment practices.

However, this proposed design does not argue against the inclusion of virtual elements of interaction and knowledge sharing, but advocates for as much physical interaction as possible.

Conclusion

Bridging the gap between academia and manufacturing organizations on the topic of sustainability assessment can enhance the practicing of sustainable development through learning organization strategies. Developing better insight and understanding of the manufacturing industries, and challenging the mental models researchers, practitioners, and academicians use to approach the matter.

We demonstrated that Learning Factory is an ideal concept for both industrial training and academic learning. Through Learning Factories on sustainability assessment academia can learn about industrial needs and expertise in assessment, while industry can learn about state of the art in sustainability assessment and available tools, benefiting multiple stakeholders at the same time.

The environment that this kind of learning factory would enable would allow to fine-tune sustainability assessment tools, by including challenged-mental models, and real scenarios of use that would provide more insight on what are the changes required in these tools.

More importantly, these learning factories would create a communication channel in which the required collaborative effort academia-industry can address systemic understanding that can help target issues of organizational change and sustainable development.

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