

Fostering Transformative Learning Processes in Industrial Engineering Education

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Abstract

The educational requirements of industry and society are constantly changing and, therefore, need to be realigned to the current situation where the usage of e-learning tools has constantly increased in all levels of education within the European Union and from an international perspective as well. Therefore, this paper explores new ways of teaching and learning in the context of industrial engineering by exemplary reshaping a lecture for industrial logistics engineering education. These adaptations contribute to the transformation of teaching and learning processes and offer new opportunities of learning to the students in a world characterized by ongoing trends like digitalization, autonomization, 'glocalization', pandemics, and environmental disasters. Therefore, the authors discuss new learning platforms by incorporating the latest teaching and learning methods for students to create an opportunity for bridging the gap between traditional teaching methods and the digital generation.

Keywords

Industrial Logistics Engineering Education, Transformative Learning, Industry 4.0, Teaching and Learning

1. Introduction

In a world of ongoing change, professional education, teaching, and learning must continuously be reshaped by considering a multitude of internal as well as external influencing factors. Thereby, the continuous adaptation of educational initiatives will support a shift toward a transformational society (Schäffter 2001). Moreover, within the framework of a transformational society, the transitions themselves are becoming more differentiated, individual, and risky. Individualization and de-standardization of educational initiatives are the keywords of today's society. On the one hand, this uncertainty or indeterminacy offers the individuals the chance to plan their ideas on their own and develop their learning paths. On the other hand, however, they face the challenge or the risk of excessive demands. Support services in the field of pedagogical professionalism could be helpful to ensure an awareness of the sustainable usage of various tools and methods, especially

amongst younger students. Learning and education are becoming increasingly important in this context. The challenge in transitions requires a closer look at learning and educational processes. In the sense that a phenomenological or social-constructive view of learning is generated through the experience of the process of coming to terms with oneself and of the world. In line with current trends, the new learning pathway will provide new platforms of experience, incorporating the latest teaching and learning methods by creating an opportunity to bridge the gap between traditional teaching methods and the digital generation (Schäffter 2001; Felden 2014).

The individual management of transitions and the design of a lifelong adaptation are determined by individual learning processes and institutional frameworks and are, thus, integrated into the process of lifelong learning. In this context, lifelong learning describes the expectation of the subjects to deal with learning and educational processes throughout the entire life course due to social changes in the knowledge society, based on keywords, e.g., industrialization 4.0, the half-life of knowledge, etc., and, therefore, the associated need for action. By focusing on the EU definition, lifelong learning can be understood as "any purposeful learning activity aimed at the continuous improvement of knowledge, skills, and competences" (European Commission 2001). Accordingly, lifelong learning is both an opportunity and a challenge for all people; the basic competence here is self-management and organization. However, the risk here is the shifting of responsibility for education to individuals. Lifelong learning sees itself as an overall process of learning in terms of 1) time, 2) content, and 3) space (Hof 2009):

1) Lifelong learning focused on time: Entire life course, no longer limited to the separate stages (e.g., childhood, youth). The focus is on learning and education over the entire life span. 2) Lifelong learning focused on content: Lifelong learning refers to all learning processes within and outside educational institutions. Thus, learning does not only take place in educational institutions, but also in other places of learning and in different forms. 3) Lifelong learning focused on space: Lifelong learning no longer involves the mere acquisition of cultural assets or professional skills, but encompasses all kinds of subjects/objects as well as the development of skills and the change in self-perception and perception of the world (Hof 2009).

This turning toward learning in the course of life requires the following conclusions and implications: 1) Learning processes must be examined in terms of time and process. Learning is a lifelong process, not only the short-term acquisition of new knowledge, but also the longer-term engagement with the world. Learning is embedded in life and, thus, also in the biography. 2) Turning toward the learning person. The focus is on individual learning in the course of life. 3) Greater focus on the life course. For pedagogical practice, orientation toward the design of educational offers for the entire life course, as well as the fit between lifelong learning and learning offers. The focus is on people as 'individual educational subjects' with specific life situations and goals (participants-orientation, life-world orientation, etc.) (Delory-Momberger 2007; Dausien 2008; Hof 2013).

Hereby, transitions must also be considered, and the following questions must be addressed in more detail: 1) What problems arise during the transition from one educational institution to another? 2) How can these transitions be accompanied (institutionally)? This last point is of importance in this connection, since - institutional or biographical - transitions could trigger

possible learning processes. Connectivity, thus, becomes a task for pedagogical-professional staff (Hof 2018).

The lifelong learning approach leads to a dissolution of boundaries in learning and, thus, to massive changes at the institutional level. Accordingly, the pedagogical focus must not only focus on the design of suitable learning environments, but also on the creation of suitable institutional framework conditions. Here, following the example of America, among others, the modularization of educational offerings can be one way of creating flexibility and achieving the goal. In any case, networking and cooperation are essential at all levels. Educational institutions and levels must be more closely coordinated, and forms of learning must be expanded to include informal and non-formal learning processes. Thus, previous learning experiences can be coordinated with subsequent individual and organizational ones. This should influence not only the micro-level, but also the meso-level and macro-level of lifelong learning (Hof 2013).

2. Theoretical Framework of Transformative Learning

The model of transformative learning was developed in the 1970s by the American adult educator and sociologist Jack Mezirow (Mezirow 1978). The approach of 'transformative learning' has been given little consideration, only by Marotzki in the 1990s, from the perspective of education as transformation in the sense of a theoretical explanatory model. Marotzki's focus here is placed on the assumption that results of learning processes at any age produce transformative education (Mezirow 1978; Mezirow 1991; Koller 2012).

The goal of the transformative learning approach is the development of the ability to act - both individually and collectively - from both a social and political perspective. This implies a change or further development of changes in all situations in life. Therefore, this learning theory can be seen as a supplement to existing concepts of adult education. In particular, Mezirow refers to the respective learning outcomes and investigates the question of how learning can lead to a transformation of previous attitudes, judgments, opinions, views, etc. in adults to develop into a critical, autonomous individual capable of acting and judging. Hence, the statement 'dare to use your own mind' to become an active shaper of society (Mezirow 1991).

The starting point of the theory was transformation processes, which led to changed life circumstances through critical life events, so-called 'disorienting dilemmas' (Mezirow 2000), or due to voluntary decisions and subsequently to changed views, opinions and beliefs. Learners validate and construct experiences that are restructured and formulated in the course of these formal, non-formal, or informal learning processes and, thus, according to Mezirow (2000), leading to the transformation of identity. Learning in this context is understood as the coupling of experience and interpretation. The role of the teachers is, therefore, to methodically and didactically accompany/support these transformative learning processes. Here, the dimensions of meaning, experience, critical reflection and rational discourse are important to be able to initiate transformative learning processes. These dimensions are illuminated against the background of the individual frame of reference. This frame of reference contains subjective and collective experiences, attitudes, and opinions of a person, which are accumulated, interpreted, and internalized from the socialization processes in the course of a lifetime and, thus, lead to the formation of the personality - the 'self'. The approach of transformative learning is based precisely on this change in the frame of reference - either intentionally or by chance. For such a change,

critical reflection, i.e. the critical questioning of points of view, thinking habits, is fundamental. Mezirow (1991) assumes that learning always takes place through interaction and that, in the context of transformative learning processes, reflexive discourse is an essential dimension for achieving mutual understanding in the sense of Jürgen Habermas' concept (the concept of domination-free discourse) and, thus, for changing subjective attitudes. Mezirow (2000) emphasizes that not all learning automatically leads to transformation or that people always allow transformation processes (Mezirow 1991; Mezirow 2000).

Schugurensky (2002) describes the dimensions of transformative learning processes based on three stages: 1) The transformation of individual consciousness; 2) the transformation of individual behavior; and 3) the social transformation (Schugurensky 2002). Moreover, it is important to note that reaching level 1 does not automatically lead to level 2 or 3. This means that someone can change their attitude, but the behavior or society remains unchanged (Zeuner 2014).

Transformative learning processes aim to develop the ability to judge and to think independently; the processes are as open-ended as the learning settings themselves. Thus, it can be said that the concept of the theory of transformative learning does not exist. However, the definitions of transformation, transformative learning, and transformative education are considered uniform as 1) the result of a transformative learning process; 2) the process of changing learners' behavior; and 3) planned educational programs or pedagogical practices that aim at transformative learning processes (Fisher-Yoshida et al. 2009).

Within the framework, three different methodological-didactical approaches are discussed as to successfully accompany transformative learning processes. Among other things, the participants-orientation will be addressed, as well as participatory approaches, which aim to work together - teachers and learners - toward a common goal. These approaches, however, depend on willingness, trust, the respective (learning) experience, and the resistance to learning (Zeuner 2014).

3. Review of Recent Literature

Based on the combination of cognitive learning theory and experiential learning theory, Daramola (2018) investigated possibilities for the enhancement of transformative learning in large classes. Thereby, the focus was placed on the usage of a flipped classroom where students view short videos or listen to audiotapes of lectures at home before the class session and the normal class session is based on exercises, discussions, and case studies (Daramola 2018). Karkoub and Abdulla (2018) investigated new teaching and learning tools for mechanical engineering students by focusing on the usage of mechatronic kits, which led to a high level of engagement by the students as well as an appreciation for hands-on activities (Karkoub and Abdulla 2018).

Seniuk Cicek et al. (2017) used an ethnographic action research study to develop transformative learning procedures in an engineering classroom by focusing on the iterative planning, implementation, observation, and critical reflection of a mechanical engineering professor with 26 years of academic experience (Seniuk Cicek et al. 2017). Cate and Heer (2018) explored potential influences that contribute to transformative learning in an electrical and computer engineering capstone design project. As an exemplary result, students who have completed internships/or participated in clubs are more likely to work well in teams, to value communication skills, to

identify as engineers, to be confident in their engineering skills, and to complete the course quickly (Cate and Heer 2018). Orthaber et al. (2020) discussed concepts for e-assessment in STEM on the example of engineering mechanics in contrast to traditional paper-pencil exams by using the learning management system Moodle at the Montanuniversitaet Leoben (Orthaber et al. 2020).

4. Exemplary Redesign of the Course “Production Planning, Production Control, and Production Logistics”

In this chapter, the authors redesign the didactical framework of the course ‘Production Planning, Production Control, and Production Logistics’ (PPPCPL) as an exemplary program within the industrial logistics engineering education at the Montanuniversitaet Leoben in Austria to include the implications from the previous discussion and the transformation of teaching contents and methodologies to the current social situation as well as to the permanently changing industrial environment.

3.1. Traditional Teaching and Learning Approach

The content of the PPPCPL course (6 ECTS credits within the Bachelor program) can be summarized as follows:

- Understanding the role of production as a value-added process in the inner- and inter-company value chain.
- Knowledge regarding the basic concepts and elements of production systems.
- Knowledge of logistic principles, strategies, and concepts of planning and control of production logistics in production systems.
- Evaluation and design of production processes according to logistical principles.
- Knowing the most important measures, performance factors, and cost factors of production logistics in production systems.
- Application of methods for the analysis and design of production logistics in production systems.
- Modeling of production systems.

As an overall learning objective, the students should know the basics and methods of production planning and control as well as the logistical requirements of production systems. Therefore, lectures, individual work, and group work are applied as traditional teaching and learning methods. As a learning outcome of the traditional lectures, students understand the role of PPPCPL in industrial enterprises based on theoretical input and individual as well as collective case studies.

3.2. New Transformative Learning-Orientated Teaching and Learning Approach

By focusing on a new transformative learning-orientated teaching and learning approach, the authors suggest enriching the PPPCPL course by using the following teaching and learning methods:

- DES (discrete event simulation) for the design of production systems.

- DES (discrete event simulation) for the evaluation of production planning and control strategies in production systems (e.g., MRP, KANBAN, CONWIP).
- Blended learning approach by using a hybrid combination of in-class and online lectures.
- Group work by using virtual flipcharts and breakout sessions in the online lectures.
- Constant feedback through audio, video, and surveys in the online lectures.
- Application of e-Learning tools (e.g., the Moodle platform), for the planning, organization, realization, and evaluation of exercises.
- Laboratory-based simulation of material flow in logistics systems.
- Laboratory-based simulation of information flow in logistics systems.
- Laboratory-based evaluation of new Industry 4.0-related technologies (e.g., Industrial Internet of Things, Augmented Reality, pick-by-light, pick-by-voice, and pick-by-vision technologies).

By using a set of modern teaching and learning approaches, the traditional pathways of learning will be enriched by experiencing the role of PPPCPL in industrial enterprises based on e-learning tools that simulate an environment close to the industrial reality. Thereby, students experience the impact of various PPPCPL measures on logistics performance indicators, which further increases the understanding of complex logistics systems.

4. Conclusion

Based on the evaluation of the theoretical framework for transformative learning processes and under the consideration of recent studies, this paper explores new ways of teaching and learning in the context of industrial engineering by exemplary reshaping a lecture for industrial logistics engineering education. When explaining learning processes in the context of transformative processes, a set of different learning theories must be considered a significant influence on the design and implementation of courses. Thereby, behaviorism, cognitivism, and constructivism result as a symbiosis in a practicable mix of methods for the design of courses, even in these uncertain times (Meir 2019). Schütz and Luckmann (2003) further outline that people gain knowledge based on subjective experiences. This is sufficient, as long as there are certain routines between industrial requirements and available knowledge. However, when a problem occurs which cannot be mastered using existing knowledge, the previously gained experience must be reinterpreted (Erraut 2000; Sütz and Luckman 2003; Wittpoth 2014; Illeris 2007). For this reason, both teaching and learning theories must be transformative and, therefore, constantly change and be made flexibly applicable to changing situations in the economy and society. Therefore, further research in the context of industrial engineering education should focus on the investigation of cause-effect relations between the usage of new technologies and the achievement of various learning outcomes.

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