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Program Planning in the Context of Industrial Logistics Engineering Education

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Abstract

The training and further qualification of employees in terms of collaboration, digitalization, automation, sustainability, circular economy, and emerging technologies are seen as one of the most important requirements for the successful implementation of Industry 4.0 strategies. In this context, the systematic planning of educational initiatives can be used to guarantee a continuous professionalization and, therefore, a targeted individual as well as collective competence development. This paper reviews state of the art approaches for successful program planning in the context of industrial logistics engineering education. Moreover, the authors introduce a concept for the development of educational services for ILEE and preliminary validate a toolkit, respectively a scale, for the measurement of program planning success factors by conducting an exploratory factor analysis based on survey data.

Keywords: Industrial Logistics Engineering Education, Industry 4.0, Program Planning, Smart Logistics, Logistics 4.0

1. Introduction

Industrial enterprises are constantly challenged with the task of developing their products, processes, and organizations to gain sustainable competitive advantage [1]. In this context, Industry 4.0 provides a multitude of approaches, especially in the areas of smart production, smart logistics, and organization and management models [2,3]. However, only a few studies have systematically investigated the barriers and requirements of Industry 4.0 initiatives from a logistics and educational point of view [4].

Based on an international survey and expert interviews, Dallasega et al. evaluated the requirements for the implementation of smart logistics in industrial enterprises. Thereby, the research topic "culture, people and implementation" suggests a detailed investigation of a set of measures for a sustainable development of qualified and trained employees to implement and handle Industry 4.0 concepts in daily business [5,6].

Further studies outline that the quality of education and training initiatives can be ensured by planning, implementing, and using standards and methods which are focused on specific learning outcomes [7].

Systematic program planning is seen as a major prerequisite for the guarantee of continuous professionalization and, therefore, a targeted development of individual, collective, and organizational knowledge and competences.

Therefore, in this research study, the authors will investigate the success factors of professional program planning in the context of industrial logistics engineering education (ILEE).

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2. Theoretical Framework and Literature Review

In this section, the authors will briefly outline the theoretical framework and the recent literature on professional program planning in the context of ILEE.

Didactics as a theory of teaching and learning investigates goals, contents, processes, and actions in teaching and training initiatives. Therefore, the planning of programs and educational services is considered as one of the core topics of professional adult education [8]. Moreover, the following questions arise: 1) which programs, 2) which period, 3) which target group and 4) which institutional settings should be considered to contribute to the professionalization of ILEE? All these questions further imply that the scope of this program planning is accordingly seen as one of the most important tasks of professional ILEE. Thereby, the terms supply planning and program planning are often used synonymously, although supply planning is seen more as a sub-process of program planning initiatives, as it tends to refer to specific events, i.e., to the micro- and meso-didactic planning, and, thus, it aims more toward the interaction with the participants. However, program planning also includes interactions on the macro-didactic level, i.e., the entire coordination, administration, and organization of programs and educational services [9].

For a better understanding of program planning, a precise definition of the essential terms is needed. In contrast to other educational sectors, program planning in ILEE must be more flexible and, therefore, closer to the wishes or expectations of the target group and more specialized in terms of content and methodology. Moreover, program planning not only includes needs, but also basic educational and economic principles, goals, frameworks, and interdisciplinary scientific findings. Indeed, many actors are involved in the complex planning process, meaning that the specific demands or interests must be continuously reviewed, adjusted, and balanced. In that regard, a program is defined as the entire range of educational services offered to the public based on the operationalized strategy of a specific educational institution [10]. According to Tietgens, the development of educational services requires information search activities, i.e., possible wishes or expectations of the target group. The success of an educational service depends on the concordance of expectations between planners and participants [9].

Educational services are defined as the variety of programs that an institution wants to develop and offer to the market. The success of the educational services highly depends on a multitude of internal and external influencing factors. The quality of the educational services, as immaterial goods, is very difficult to measure because it always includes the successful interaction with the participants as an indispensable constant regarding the learning success. Therefore, the development, optimization, and modification of educational services are further critical components of program planning.

However, didactic initiatives in the ILEE can be divided into different levels of action. Table 1 displays the five levels of didactic actions which are further defined as macro-level (A, B, C), meso-level (C, D), and micro-level (E) [11-13].

Table 1. Levels of didactic actions [11-13].

Levels of didactic actions	Didactical levels of action transferred to adult education
Institutional, economic, personnel and conceptual framework (A-level)	Implicit didactical decisions regarding educational, social and economic policy (external framework)
Holistic teaching and school concepts (B-level)	Self-image and strategic orientation of the institutions and associations of adult education (institutional didactics)
Learning areas and teaching concepts (C-level)	Program planning and program coordination for parts of the institution (didactics for the field of activity)
Lessons (D-level)	Planning of areas of learning (didactics of events)
Teaching and learning situations (E-level)	Preparation, implementation, and evaluation of specific training measures (process didactics)

Professional program planning can reduce complexity and provide professional and methodical security and service orientation. The planning takes place on four different levels: 1) cognitive orientation level, 2) cognitive strategy level, 3) material-based practice level, and 4) social process level. Level 1 and 2 are cognitive decision-making processes [14], e.g., the setting of long-, medium- and short-term targets including the measurement as well as the selection and preparation of learning content, teaching and learning methods, timeframe, supporting media, etc. However, all the previously outlined variables of program planning are interrelated with each other. Level 3 includes the compilation of teaching and learning materials and the establishment of written plans. Hereby, pedagogical content knowledge [15] is achieved by linking the subject-related and pedagogical knowledge together. Level 4 means, for example, the involvement of seminar participants in the planning process or the collaborative planning with colleagues, enterprises, or authorities. Moreover, social (e.g., competence development, emancipation, etc.), sustainable and organizational goal settings should be considered in the planning process [16].

In addition, the planning of learning content should focus on the application of proven methods and the usage of new media. The dissemination of learning content should be prepared to attract the interest and attention of the participants. Moreover, experience plays an important role in program planning. In this context, Bastian describes four types of lecturers: 1) subject-oriented (without further consideration participants´ interests), 2) expert advisors (open to participants´ interests), 3) process-oriented (seeing the seminar as an opportunity to learn) and 4) personality-oriented (focusing on the seminar as a potential contribution to personality development) [17]. Hof distinguishes between specialist training and personality development initiatives in the course of the subjective knowledge transfer of didactic actions, depending on whether the lecturers are subject-orientated or method-orientated experts. Subject-orientated lecturers want to transfer fact-based knowledge for future actions while method-orientated lecturers focus on the knowledge transfer based on the specific requirements and interests of the participants or target group [18]. This indicates that the planning of learning content is dependent on the individual knowledge of the lecturers, organizations, on the type of events, organizational culture, work climate, communication strategy, planning autonomies, etc. In contrast to schools, micro-didactic planning is mostly not

remunerated. Program planning must further consider opportunities for an implicit and conjunctive development of experiences based on knowledge transfer [19]. In terms of measures for quality development, organizations should define specific requirements to evaluate the didactic actions of their lecturers. In this context, some organizations with a process-oriented perspective assume that didactic actions can be anticipated and planned, but, in the end, they must be designed openly in terms of knowledge transfer [20]. Moreover, Stanik defines six fields for decisions (content, use of methods and media, learning targets, social forms of interactions, inclusion/exclusion of participants, and timeframe) which are influenced by organizational-orientated, participant-orientated, lecturer-orientated and subject-orientated determinants [16].

For the investigation of program planning in the context of ILEE, the authors performed a systematic literature review (SLR) in Scopus by using the following search sting: "TITLE-ABS-KEY (education) OR TITLE-ABS-KEY (training) OR TITLE-ABS-KEY (teaching) AND TITLE-ABS-KEY (logistics) OR TITLE-ABS-KEY (engineering) AND TITLE-ABS-KEY (industry 4.0) AND TITLE-ABS-KEY (program AND planning) AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "ENGI")) AND (LIMIT-TO (LANGUAGE , "English"))".

The SLR focused on studies that investigated program planning from an educational, training, or teaching perspective in the areas of logistics or engineering and the context of Industry 4.0. The research string further included only articles and conference papers in the English language. To ensure a psychosomatic sound outcome of our SLR, an independent research team, which consisted of three Postdocs, conducted a structured screening process [21]. According to Hokka et al., the first step included the title and abstract screening, where we used a scoring method to evaluate the appropriateness of the identified studies to our predefined research objectives [23]. Papers with or without significant differences in the scoring were excluded or included for further full-text analysis while papers with differences were reevaluated by an additional expert. In total, the systematic literature review resulted in only a handful of relevant studies for this research. In total, we identified eight studies, whereby three were identified by using a forward and backward research strategy (latest update on 02 January, 2020).

Most of the studies focused on the application of practical-orientated teaching and learning methods as the main success factor of program planning for ILEE. In the context of Industry 4.0-related training and education, Ghafar et al. outlined the need for industry-driven and practical-based academic programs by reviewing data-driven scenario planning, big data analysis, and collaborative decision-making as the most important skills for future Industry 4.0 applications [22].

Moreover, the operationalization of measurement items for the program planning success is important. In this context, Tseng et al. 2019 investigated the implementation of an industry-driven program in the mold industry. Furthermore, the authors evaluated the effectiveness of their training by using a pre- and post-program survey. Thereby, the engineering practice within the program was rated as one of the highest success factors [24]

The application of new teaching and learning methods in ILEE is seen as an essential part to ensure higher learning outcomes. For example, Maheso et al., introduced a state-of-the-art concept for learning factories in the area of rail manufacturing industry by focusing on the systematic development of educational initiatives [25]. Aris et al. provided a framework for multidisciplinary courses in the curriculum structure of universities for the enhancement of intellectual collaboration among and beyond faculty members [26], and Wilke and Magenheim analyzed the requirements for workplace-integrated mobile learning designs and the development of a context-sensitive mobile application in engineering education. Moreover, they further focused on the educational use of smartphones and tablet computers, devices currently less utilized in the learning environments of training companies and vocational schools [27].

3. Concept for the Development of Educational Services in the Context of ILEE

In this section, the authors propose a concept regarding the development of educational services in the context of ILEE. The concept is based on the framework of Smart Logistics which can be divided into the following three levels: 1) Intelligent and Smart Supply Chains, 2) Intelligent Logistics through ICT, and 3) Intelligent Logistics Systems and Transport Vehicles [3]. Educational services for ILEE should be focused on a set of innovative teaching and learning methods to provide tools for a lean and agile cooperation in interlinked networks and the digital interconnectivity of organizations. Participants must be able to understand and use state of the art information and communication technologies (ICT) which allow the digital interconnectivity through data networks, sensors and actors and intelligent technologies for the identification and the continuous tracking of materials, components, and products throughout the supply chain. Moreover, ILEE must raise the awareness for man-machine interaction within logistics systems. Autonomous transport vehicles in combination with automated warehouses as well as automated storage and handling infrastructure change requirements in ILEE regarding the systematic development of the industrial workforce for efficient and collaborative internal and external material flow processes [3]. The model of proposal development for the program planning in the context of ILEE is outlined in Figure 1.

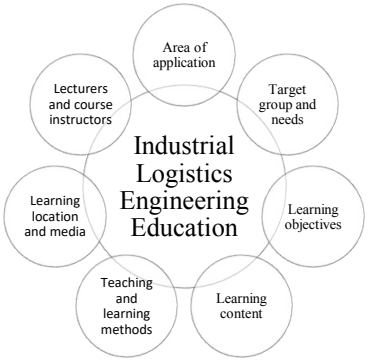

Fig. 1. Concept for the planning of educational services for ILEE [28].

By referring to the concept for the planning of educational services for ILEE, the following seven sections should be considered in the conceptualization of educational initiatives in the context of ILEE [11,12,13,29]:

1) Area of applications. This section focuses on the applicability and usability of learning content in terms of practical application. The subsequent practical usage of educational services in the context of ILEE can be facilitated by pre-structuring and determining specific requirements of the industrial environment and the subjective factors, e.g., the wishes or expectations of the target group as well.

2) Target group and needs. A target group includes prospective participants who can be defined by certain group characteristics (students, professionals, etc.). However, these target groups do not exist per se, but are constructed by using a set of specific categories. In addition to socio-cultural, demographic and economic factors, educational attainment, motivation and learning requirements are also very important. Furthermore, this section should consider situationally orientated learning styles and learning behavior of future participants.

3) Learning objectives. Learning objectives are defined as an interface between external requirements and internal content design. Learning objectives provide information about what participants should have achieved after a course. Thus, the educational services must be aligned to one or more learning objective, so that the learning success can be systematically controlled. Learning objectives can be a structure in terms of time, content, and methods within the framework of micro-didactic planning.

4) Learning content. The learning content, and, therefore, the learning targets in terms of future knowledge and skills of the participants are orientated to the predefined learning objectives. The selection of relevant learning content is based on didactical decisions which can be considered as a compensatory and iterative process. Hereby, Siebert further refers to the term “didactic reduction” [30]. The content should be specifically selected for the participant and situation and, therefore, also adapted toward the wishes, interests, and expectations of the participants. This is necessary because individual, as well as collective characteristics, are essential for learning success. The definition of the content has a substantial influence on further decisions and questions in the planning process (e.g., learning location, media, teaching and learning methods).

5) Teaching and learning methods. This section defines the type of lecture (e.g., seminar, interactive lesson, etc.) the timeframe of the educational service and the number of hours per lecture. For example, middle-class participants prefer shorter, weekly dates, while the upper-class participants prefer to block events. The choice of methods strongly depends on content and participant-orientations. For ILEE, we further suggest a mixture of traditional and modern teaching and learning methods (e.g., case studies in Industry 4.0 laboratories, demonstration of augmented reality technology for logistics, etc.).

6) Learning location and media (where and with what?). Learning locations are visited for a limited period to learn - consciously or unconsciously. The learning locations, their design, and the entire learning organization make a significant contribution to learning success. Premises should be functional and coordinated with the methods and are part of the macro-didactic planning. There are, again, differences in the design of these places: Traditional milieus prefer the school-like design, young milieus that like to experiment prefer open places with the personal freedom of design (even lecturers have preferences). The principles of adult education apply to the use of media.

7) Lecturers and course instructors. Lectures should also contribute to the overall development of educational services in the context of ILEE. Lectures are considered as a very important component regarding the learning success and overall subjective satisfaction of the seminar participants. The selection of lecturers is based on pedagogical, social, didactic, professional, and interpersonal dimensions. Previous knowledge or experience with the respective target group could also be important [31].

The advertising of educational services in the context of ILEE is also very important. Therefore, the usage of marketing tools should be included in the program planning process. Proactive service policy includes the realization of information events, which can be organized by presenting programs and services target specific groups which can then be selected by using prespecified characteristics regarding their age, region, institution, etc. In this context, a missing practical orientation, no evidence for the efficiency of an educational service and a limited differentiation from the other programs are listed as potential barriers. Therefore, Schlutz suggests testing innovative measures within the framework of development seminars with prospective participants, lecturers, and planners [28]. Another approach for pretesting would be the model of product clinics, which originates from the automotive industry, where customers test the products before market launch, break them down into more detailed aspects, and subsequently optimize them. In this way, the wishes, interests, and expectations of the future target group can be considered in the development phase [13]. Moreover, both scientific knowledge and professional-pedagogical skills are essential for the planning of educational services for ILEE, whereby various areas of knowledge must be related and aligned with each other.

5. Empirical Study

In this section, the authors will introduce and preliminarily validate a scale of the measurement of program planning success factors in the context of logistics engineering education. Therefore, the authors conduct an exploratory factor analysis (EFA) based on a data set that captures the feedback from program participants regarding the program design, the program process, and the program results [32].

5.1 Research Methodology and Measurement Development

In this study, the development of measurement indicators is based on the guidelines as suggested by Esser [33]. In this research study, the variable program planning success factors (X1) is defined and, therefore, measured by nine items. Therefore, X1 reflected the quality of information content, the practical relevance, the provision of problem-solving approaches, the target orientation of the seminar, the quality of the seminar environment, the clarity of information content, the usage of teaching methods, the possibilities for interaction and the quality of feedback [32,34]. The measurement items of the variable were operationalized by using a Likert scale from 1=strongly disagree to 4=strongly agree.

The survey data were collected by using a standardized questionnaire in the timeframe from 2015 to 2018. In this context, standardized questionnaires offer high external validity and transferability of research results and, therefore, guarantee a structured research process with relatively low costs [35].

5.2 Research Results

The final data set included a total of 3,307 responses. Missing values were coded with '0' leading to a total of minimum 2,923 and maximum 2,981 valid responses for further statistical analysis.

For the preliminary validation of the proposed measurement scale for program planning success factors in the context of ILEE, we used IBM SPSS Statistics 24 to perform an exploratory factor analysis (EFA) by using Principal Axis Factoring as an extraction method and Promax with Kaiser Normalization as rotation method. Following our theoretical conception, the computation results lead to a single factor with nine items in four iterations.

The EFA further resulted in 0.951 for the Kaiser-Mayer-Olkin (KMO) measure of sampling adequacy, which is above the request value of 0.500 and, therefore, indicates the appropriateness of the scale and an approximate Chi-Square of 24,557.408, df 36 and sig. 0.000 for the Barlett´s Test of Sphericity, showing that there are no issues with inter-matrix correlations. Also, all communalities are above 0.300 and all factor loadings are among the minimum threshold of 0.40 [36,37]. Moreover, the descriptive statistics, communalities and factor loadings are summarized in Table 2.

Finally, we assessed the reliability of the scale by calculating the Cronbach's alpha (CBA) value. The resulting CBA of 0.957 exceeds the recommended threshold of 0.700 [36]; therefore, the reliability of our proposed measurement scale can be ensured.

Table 2. Measurement items and statistical results.

	Measurement Items	N	Mean	Std. Dev.	Communalities	Loadings
X1.1	quality of information content	2981	3.687	0.620	0.734	0.857
X1.2	practical relevance of seminar content	2932	3.577	0.729	0.659	0.812
X1.3	provision of problem-solving approaches	2954	3.591	0.717	0.745	0.863
X1.4	target-orientation of the seminar	2972	3.703	0.635	0.719	0.848
X1.5	quality of the seminar environment	2978	3.714	0.621	0.646	0.804
X1.6	clarity of information content	2971	3.673	0.651	0.743	0.862
X1.7	usage of teaching methods	2960	3.593	0.726	0.755	0.869
X1.8	the possibilities for interaction	2952	3.654	0.688	0.727	0.853
X1.9	quality of feedback culture	2923	3.709	0.652	0.730	0.855

6. Conclusion

This paper adds a contribution to the scientific literature by transferring educational theories of learning and teaching to the specific area of industrial logistics engineering education (ILEE).

The findings from the systematic literature review justify the need for structured program planning initiatives to contribute to the professionalization of ILEE. Program planning not only includes the wishes or expectations of the target group, but also basic educational and economic principles, goals, frameworks and interdisciplinary scientific findings which must be continuously reviewed, adjusted, and balanced. The introduced concept for the development of educational services in the context of ILEE can be used to contribute to the acquisition of knowledge and development of new competencies by focusing on a precise planning regarding the area of application, the target group and needs, the learning objectives, the teaching and learning methods, the learning location and media as well as on the lecturers and course instructors. For ILEE, we further suggest a mixture of traditional and modern teaching and learning methods (e.g., case studies in Industry 4.0 laboratories, demonstration of augmented reality technology for logistics, etc.) which should be pretested, subsequently reviewed and optimized by including prospective participants, lecturers and institutional leaders in the planning process.

Up to now, little attention has been paid to an operationalization of critical success factors in the program planning process of educational services. The paper introduced, developed, and preliminarily validated a novel scale for the measurement of program planning success factors that can be used for the review and subsequent development of current program planning processes in ILEE to ensure higher learning outcomes. In conclusion, it can be shown that scientific knowledge, as well as pedagogical skills, are essential for planning educational services for ILEE.

The research results are based on the computation of an exploratory factor analysis (EFA) and, therefore limited in terms of validity and reliability. The model should be further evaluated by using confirmatory factor analyses (CFA) for

various first- and second-order models. Moreover, causal relationships between the independent variable program planning success factors and dependent variables, e.g., learning outcomes, participants´ satisfaction, etc., should be investigated by applying multivariate analysis, such as structural equation modeling procedures, in further research studies.

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