Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 23 (2018) 213–218

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

8th Conference on Learning Factories 2018 - Advanced Engineering Education & Training for Manufacturing Innovation

A Method for Improving Production Management Training by Integrating an Industry 4.0 Innovation Center in China

Shun Yang[a,*], Karin Hamann[b], Benjamin Haefner[a], Chuan Wu[b], Gisela Lanza[a]

[a]*wbk Institute of Production Science, Karlsruhe Insitute of Technology (KIT), 76131 Karlsruhe, Germany*
[b]*Fraunhofer Institute for Industrial Engineering IAO, 70569 Stuttgart, Germany*

Abstract

Production Management is an important issue for organizations that spend considerable amounts of investment annually on personnel training. Especially in the era of Industry 4.0 and Intelligent Manufacturing, considering the exponential growth of new knowledge and information, personnel need to update and supplement the necessary knowledge. Nevertheless, there is a lack of adequate methodology for executing trainings in the field of production management. This paper aims to develop a method for executing production management training which combines online learning and offline training as well as practical parts by using an Industry 4.0 Innovation Center equipped with model devices. A procedure is to first starting with an E-Learning module containing basic knowledge, accessible on the Learning Platform Moodle. Secondly, an on-line survey is created to collect expectations and requirements. Then the training schedule is carried out for execution of professional training. The training part in the innovation center will contribute to build up the basis for adaptions of the training knowledge to practical need of a company. Lastly the test and evaluation is conducted via virtual team room (Vitero). A case study based on training service provider is used to validate the feasibility of the approach. The derived results are presented and conclusions are discussed.

Peer-review under responsibility of the scientific committee of the 8th Conference on Learning Factories 2018 - Advanced Engineering Education & Training for Manufacturing Innovation.

Keywords: Production Management; Training concept; Industry 4.0; Innovation Center; E-Learning

* Corresponding author. Tel.: +49-721-608-44013; fax: +49-721-608-45005.
E-mail address: shun.yang@kit.edu

2351-9789
Peer-review under responsibility of the scientific committee of the 8th Conference on Learning Factories 2018 - Advanced Engineering Education & Training for Manufacturing Innovation.
10.1016/j.promfg.2018.04.019

1. Introduction

Production management aims to increase enterprise productivity by optimizing the relation between inputs and outputs of a production system [1]. For improving productivity and optimizing the production management system, people need to understand and use concepts or methods such as Lean Manufacturing (LM), Theory of Constraints (TOC), Total Quality Management (TQM), Six Sigma (SS), Total Productive Maintenance (TPM), Kaizen [2]. On top changing new concepts and framework conditions such as Global Production Industry 4.0 and Intelligent Manufacturing require to consider even more concepts and methods [3]. In order to apply the latest technologies of networked production, highly qualified employees as well as open access to technology are essential. As a result, intensive training and continuing education of employees is crucial [4].

However, recent studies have shown that future employees need to adopt teaching curricula in order to cope with increasing industrial requirements [5, 6]. This challenge leads to the requirement for a training provider to design customer-oriented trainings that support the trainees to transfer the knowledge into practice of production management. In this context, the present approach, focuses on how to build a systematic training, including online learning and offline teaching as well as interactive case studies. The main objective is to achieve greater proximity to customer's qualification needs by developing adequate and well-structured trainings. In chapter 2, the state of the art regarding this topic is presented. The present method is elaborated in chapter 3. Afterwards the case study is introduced to validate the presented approach in chapter 4. Finally, chapter 5 concludes with a summary.

2. State of the art

Regarding classical training, a multi-method approach is developed which allows both, real time quality improvement and long term planning [7]. The simulation game is described in the training which points out the need for shop floor management in combination with the new field of Accounting for Lean [8]. However it does not mention how to combine E-Learning with the professional training in production management.

With regard to practice-oriented training, the teaching factory concept is presented which comprises the industrial project, the relevant educational approach and the ICT configuration for the facilitation of interaction between Industry and academia [6, 9]. Instead of lectures and theoretical content the learning factory focuses on problem based learning and interactive tasks [4]. Vin designed a Lean Factory, which is a training environment that realistically resembles an industrial environment [10]. Salas suggested four concepts into training: information, demonstration, practice, and feedback so that training is a systematic process [11]. A multi-criteria resource planning method and tool is presented for optimizing the production, delivery, and installation of Industrial Product Service Systems [12]. A digital and real, energy-efficient, multi-process, networked, manufacturing system is developed for different industries [13]. However, it lacks E-Learning modules as self-preparation. By considering E-learning, the Moodle@UA contains some of the main tools of the standard Moodle platform, like Assignments, Chats, Forums, News and Quiz/Survey [14]. A study about using E-Learning platform in university teaching process is presented [15]. Nevertheless, it lacks of systematical training model for follow-up.

With respect to training curriculum models, the competency models is established which consists of twelve competencies in the three main clusters professional/methodological, social and personal competencies [16]. The new didactical concept is created to impart knowledge regarding the effects on workplaces and labour conditions for employees using a learning factory setting [17]. Billett presented three curriculum models, namely wholly practice-based experiences, practice-based experiences with educational interventions (action learning, action research, project work) and wholly education institution-based experiences [18]. Ganefri put out a production-based learning model, which can improve the students' entrepreneurial interest [19]. In addition, Ganefri and Hidayat created a syntax of production based learning model for vocational education and training via expert validity test with focus group discussion (FGD) [20]. Badea presented the learning process in a collaborative buyer-supplier relationship and the development of shared knowledge, skills and attitudes in supply chain relations, which include four domains and seventeen competencies [21]. However, there is a lack of E-Learning modules as a further option.

As a conclusion drawn from looking into existing approaches for training offers most of them provide different training methodologies as E-Learning, training cycle and practical oriented training center like learning factory.

However, as it appears there is a lack of taking into account standards concerning a systematic realization, including the whole training cycle (preparation, execution, and follow up as well as online & offline training).

3. Methodology

The presented approach helps to overcome this gap mainly with the PILOT model. This model was developed within project DrAagon (DrAgon stands for "Export of German vocational education to China"). The developed PILOT model serves as a basis for customized training offers for companies and consists of five parts (see Figure 1). One major reasons for PILOT model is that classical training focuses on face to face training and case studies, which often causes either trainees passive acceptance or limited interaction and discussion. However, trainees could not improve their learning experience in all-round way such as self-preparing before the training and professional follow-up and qualification process after the training.

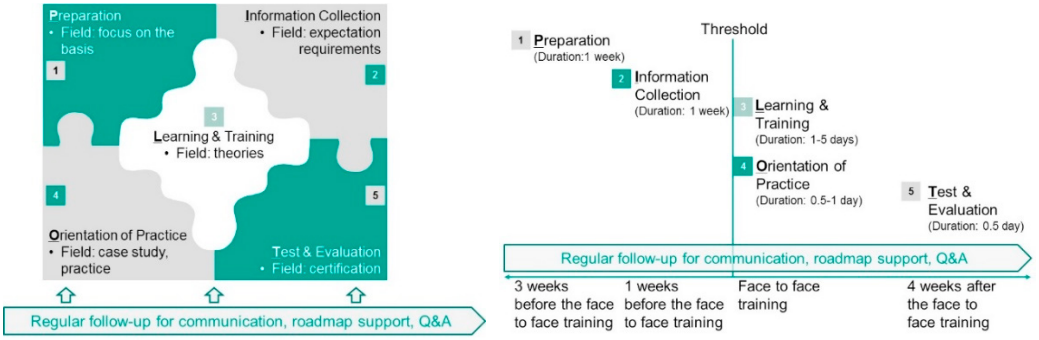

Fig.1. PILOT model of training approach with indicative time schedules.

Firstly, the basic knowledge will be introduced. Secondly the information collection aims to gain more insight regarding to customer's expectations and challenges. The following Learning phase is to present the professional knowledge on a higher level and build on the basic knowledge. Subsequently the orientation of practice focuses on conduction a case study in practice ideally in the own operational environment. Last but not least, the Test and Evaluation period is necessary for continuous improvement of training and for evaluating the qualification of trainees. A communication channel serves as a basis for constant exchange. By contrast of classical learning factories trainings, this framework provides more patterns such as E-learning and on-line expectation collection which facilitate the interaction between trainees and trainers. It adapts to the learning factories for educational purposes. The following subsections explain the specific aims and challenges of the PILOT model.

3.1. Preparation

To achieve the same trainees' background knowledge base, preparations are necessary. In this segment, the basic information will be introduced such as the training background and the history of the topic. Time and Cost saving E-learning method is very suitable for trainees attending from different locations. In this paper, the Learning Management System Moodle is chosen, since it provides all essential communication tool features [22]. In preparation, design course system is based on customer and market demand, putting instructional elements like cartoon, video, quiz, Sharable Content Object Reference Model (SCORM) and comment to encourage trainees and to cause reactions. The main framework of the E-Learning content on the Moodle includes motivation, core content, expansion and feedbacks.

3.2. Information collection

Expectations and requirements of the learners will be collected. In this systematic model, the information collection phase requires a good connection between preparation phase and the learning phase, because the customer could review their needs and specific questions based on the feedback of self-learning at the E-Learning. They could

additionally share the general information with their daily work background, which is not included in the E-Learning. According to the training experience, the information is clustered in the following three catalogs like which kind of level you are on the topic, what your challenges are during the work and what your expectations and demands are. The information collection will be conducted through on-line tools such as web-based platform “Wenjuan Wang” or Moodle platform is available here to identify the needs of customers.

3.3. Learning

Based on the needs of customers, the trainer develops the professional training material at first. The handbook, standards, related videos and practical photos, as well as drawings are collected. Secondly, the implementation methodology is developed according to five factors, respectively time, input content, approach, outputs, and documents. Time is the agenda for the whole training. Normally a basic unit takes about half an hour. The Input content means which kind of the information need to be delivered to the trainees. There are various ways concerning the methodology, such as video, presentation, scenario introduction, brainstorming, etc. The outputs will explain the expected deliveries of learning sections. Optionally the documents will be collected as experience acquisition. Based on this, the learning process is well planned to transfer the theoretical knowledge to trainees.

3.4. Orientation of practice

By introducing the theoretical knowledge in the Learning phase, the orientation of practice needs to be considered. This will design the case study which could reflect the real situation in the factory. The learning factory is one example for a good solution in Germany, in contrast it is announced as Innovation Center in China which might need more explanation about this concept. This kind of facility is built as a platform to do the case study for production management topics.

In this article, the case study is designed based on the Industry 4.0 Innovation Center, which is an assembly line with four stations. It could provide the real production case through the assembly of the valve slides. Some application of Industry 4.0 enabling technologies (see Figure 2) are available such as Cordless Wi-Fi nutrunner, Digital shop floor management or Pick by light technology. It provides the further insight of production management for the trainees. The output of this phase is to connect the theoretical knowledge into the practice, meanwhile realize the self-reflection and peer discussion. The trainees are able to understand the knowledge deeply and are motivated to transfer the knowledge into their own working environment.

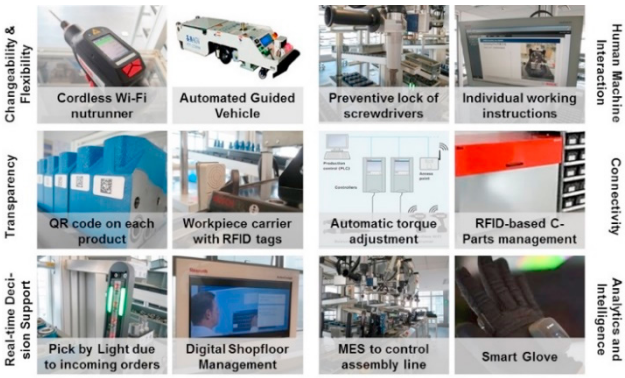

Fig. 2. Application of Industry 4.0 enabling technologies for case study.

3.5. Test and Evaluation

The test and evaluation consists of two parts. Firstly, it is the test for trainees to check whether they are qualified after the training. More precisely, it requires the trainees to do the tiny project at their company to apply the learned knowledge at training and to solve one typical problem in one month. The trainee is also required to join the oral exam

which is to check the theoretical level. If both tests are sufficiently passed, the trainee will receive the corresponding certificate authorized by the training organization. Secondly, it is to evaluate the training itself by the trainees.

4. Case Study

A case study at a training service provider company, entitled Global Advanced Manufacturing Institute (GAMI), is executed as validation. In the validation, the training topic 'Lean Line Design' (LLD) is conducted.

The whole case study process will be carried out according to the upper mentioned methodology. The outputs of LLD training via PILOT model are that the trainees gain the systematical ways to streamline a process in order to remove waste and are able to redesign production and logistics so as to increase productivity. Additionally, the trainees gain the holistic interaction from the E-learning by themselves, expectation collections until test and evaluation after the trainings which improve their learning experience in all-round way. Based on this successful learning experience, the trainees are motivated to continuously learn and communicate with trainer. Therefore, comparing with single course with limited learning time, the PILOT model facilitate a positive and open environment for continuous learning.

The training assessment is based on the GAMI standard criteria. It includes the overall satisfaction, helpfulness of training for job, the performance trainer (see Table 1)

Table 1. Evaluation of training

	1		2		3		4		5		Average
The overall satisfaction for this training	0.00%	0	0.00%	0	0.00%	0	10.00%	1	90.00%	19	4.95
Will this training be helpful for your job	0.00%	0	0.00%	0	5.00%	1	35.00%	7	60.00%	12	4.55
Are expression of trainer well organized?	0.00%	0	0.00%	0	0.00%	0	10.00%	2	90.00%	18	4.9
Is the training attractive?	0.00%	0	0.00%	0	0.00%	0	15.00%	3	85.00%	17	4.85
Is there enough interaction during the training?	0.00%	0	0.00%	0	0.00%	0	10.00%	2	90.00%	18	4.9
Are you satisfied with the cases in the training	0.00%	0	0.00%	0	5.00%	1	20.00%	4	75.00%	15	4.7
Does trainer provide you with satisfactory guidance	0.00%	0	0.00%	0	5.00%	1	25.00%	5	70.00%	14	4.65
Is training content clear and easy to understand?	0.00%	0	0.00%	0	0.00%	0	10.00%	3	90.00%	17	4.85

In total, 20 trainees joined the training and got the evaluation for the training itself. In the average column, 5 means excellent, 1 means bad. The average value in each segment is larger than 4.5 (previous training average performance). As one of evidence, it was proved that the PILOT model method lead to an improvement for the training performance in the defined scope.

5. Summary

The presented paper deals with identifying and proving an adequate methodology for executing trainings in the field of production management, especially for small and medium enterprises. The PILOT model is built to combine online learning and offline training as well as theoretical training and practical learning. The Industry 4.0 Innovation Center serves as an important facility to support pragmatic application. It connects the theoretical knowledge into the practice and meanwhile realize the self-reflection and peer discussion. A case study is conducted to qualitatively and quantitatively validate the feasibility and the benefits when applying the PILOT methodology. As one of novelties, it provides the standard patterns how to develop a holistic training which can improve the learning experience of trainees. Moreover, it delivers the highly added value such as making more systematical training development, increasing self-learning and self-reflection of trainees, keeping good communication between trainees and trainers, saving the preparation time of trainings for the trainers. In shortly, it brings benefit with respect to trainee's needs and satisfaction as wells trainer's request.

For the next steps, the developed methodology could add the customized categories for different target group, respectively production managers, production line leaders and production operators. For each target group, the contents need to be adapted according to target group's job description. In this way, it can better fulfill the industrial

needs. Additionally, further research needs to be done on integration excursion in this training model and the application in other training segments.

Acknowledgements

The methodology regarding the PILOT model mentioned above has been developed within the research project "Export of German vocational education to China (DrAgon)", funded by the Federal Ministry of Education and Research (BMBF), Grant number 01BEX01A13.

References

[1] D. Scott Sink, Productivity Management: Planning, Evaluation, Control, and Improvement. John Wiley & Sons, (1985) ISBN 0471891762.
[2] A. Kosieradzka, Maturity model for production management, Procedia Engineering 182 (2017) 342-349.
[3] J. Qin, Y. Liu, R. Grosvenor, A categorical framework of manufacturing for industry 4.0 and beyond, Procedia CIRP 52 (2016) 173-178.
[4] L. Merkel, J. Atug, L. Merhar, C. Schultz, S. Braunreuther, G. Reinhart, Teaching smart production: an insight into the Learning Factory for Cyber-Physical Production Systems (LVP), Procedia Manufacturing 9 (2017) 269-274.
[5] J. Ramazani, G. Jergeas, Project managers and the journey from good to great: the benefits of investment in project management training and education, International Journal of Project Management 33 (2015) 41-52.
[6] L. Rentzos, M. Doukas, D. Mavrikios, D. Mourtzis, G. Chryssolouris, Integrating Manufacturing Education with Industrial Practice using Teaching Factory Paradigm: A Construction Equipment Application, Lean Production training for the manufacturing industry - experiences from Karlstad Lean Factory, Procedia CIRP, 17 (2014) 189–194.
[7] H. Hayes, V. Scott, M. Abraczinskas, J. Scaccia, S. Stout, A. Wandersman, A formative multi-method approach to evaluating training, Evaluation and program planning, 58 (2016) 199–207
[8] S. Blöchl, M. Michalicki, M. Schneider, Simulation game for Lean leadership – shop floor management combined with accounting for Lean, Procedia Manufacturing, 9 (2017) 97–105.
[9] G. Chryssolouris, D. Mavrikios, L. Rentzos, The Teaching Factory: A Manufacturing Education Paradigm, Procedia CIRP, 57 (2016) 44–48.
[10] L. Vin, L. Jacobsson, J. Odhe, A. Wickberg, Lean Production training for the manufacturing industry - experiences from Karlstad Lean Factory, Procedia Manufacturing, 11 (2017) 1019–1026.
[11] E. Salas, S. Tannenbaum, K. Kraiger, K. Smith-Jentsch, The science of training and development in organizations: what matters in practice, Journal of the American Psychological Society, 13 (2012) 74-101.
[12] K. Alexopoulos, S. Koukas, N. Boli, D. Mourtzis, Resource Planning for the Installation of Industrial Product Service Systems, IFIP International Conference on Advances in Production Management Systems, (2017) 205-213.
[13] P. Calefati, J. Pandremenos, A. Fysikopoulos, G. Chryssolouris, Energy Efficient Process planning System – the ENEPLAN Project, International Conference on Advances in Production Management Systems, 397 (2012) 119-126.
[14] C. Costa, H. Alvelos, L. Teixeira, The use of Moodle e-learning platform: a study in a Portuguese University, Prodedia Technology 5 (2012) 334-343.
[15] G. Oproiu, A study about using E-learning platform (Moodle) in University teaching process, Procedia Social and Behavioral Sciences 180 (2015) 426-432.
[16] L.C. Müller-Frommeyer, S.C. Aymans, C. Bargmann, S. Kauffeld, C. Herrmann, Introducing competency models as a tool for holistic competency development in learning factories: Challenges, example and future application, Procedia Manufacturing, 9 (2017) 307–314.
[17] M. Reuter, H. Oberc, M. Wannöffel, D. Kreimeier, J. Klippert, P. Pawlicki, B. Kuhlenkötter, Learning factories‘ trainings as an enabler of proactive workers' participation regarding Industrie 4.0, Procedia Manufacturing 9 (2017) 354 – 360.
[18] S. Billett, A. Henderson, S. Choy, D. Dymock, F. Beven, A. Kelly, I. James, J. Lewis, R. Smith, Change, work and learning: aligning continuing education and training, NCVER, (2012) 15-18.
[19] G. Ganefri, The development of production-based learning approach to entrepreneurial spirit for engineering students, Asian Social Science, 9 (2013) 162-167.
[20] G. Ganefri, H. Hidayat, Production based learning - an instructional design model in the context of Vocational Education and Training (VET), Procedia - Social and Behavioral Sciences, 204 (2015) 206–211.
[21] A. Badea, G. Prostean, A. Hutanu, S. Popa, Competency training in collaborative Supply Chain using KSA Model, Procedia - Social and Behavioral Sciences, 191 (2015) 500–505.
[22] N. Cavus, T. Zabadi, A comparison of open source learning management systems, Prodedia Social and Behavioral Sciences 143 (2014) 521-526.