

Möller, Klaus; Gairing, Fritz; Mezger, Daniel; Jehnichen, Thomas

Research Report

Design of training processes in manual order picking

Beiträge der Hochschule Pforzheim, No. 175

Provided in Cooperation with:

Hochschule Pforzheim

Suggested Citation: Möller, Klaus; Gairing, Fritz; Mezger, Daniel; Jehnichen, Thomas (2020) : Design of training processes in manual order picking, Beiträge der Hochschule Pforzheim, No. 175, Hochschule Pforzheim, Pforzheim, <https://nbn-resolving.de/urn:nbn:de:bsz:951-opus-138>

This Version is available at:

<https://hdl.handle.net/10419/222611>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.



<https://creativecommons.org/licenses/by-nc-nd/4.0/deed.de>

BEITRÄGE DER HOCHSCHULE PFORZHEIM

Prof. Dr. Klaus Möller, Prof. Dr. Fritz Gairing, Daniel Mezger, Thomas Jehnichen

Design of Training Processes in Manual Order Picking

Nr. 175

Herausgeber: Prof. Dr. Thomas Hensel, Prof. Dr. Norbert Jost,
Prof. Dr. Thomas Cleff, Prof. Dr. Roland Scherr,
Prof. Dr. Christa Wehner, Prof. Dr. Hanno Beck
(geschäftsführend; hanno.beck@hs-pforzheim.de)

Sekretariat: N.N.

Hochschule Pforzheim

Tiefenbronner Str. 65

75175 Pforzheim

E-Mail: beitraege.hochschule@hs-pforzheim.de

Ausgabe: Juli 2020
ISSN 0946-3755

**Prof. Dr. Klaus Möller, Prof. Dr. Fritz Gairing,
Daniel Mezger, Thomas Jehnichen**

Design of Training Processes in Manual Order Picking

Index

FIGURE INDEX	1
1 BACKGROUND	1
2 METHODOLOGY	2
2.1 RESEARCH-METHODOLOGICAL BACKGROUND	2
2.2 RESEARCH DESIGN: MIXED METHODS DESIGN	4
2.3 QUANTITATIVE STUDY THROUGH SYSTEMATIC INVESTIGATIONS IN THE LERNLAGER LABORATORY	5
2.4 QUALITATIVE STUDY THROUGH REFLECTION WORKSHOPS WITH PRACTICING EXPERTS	7
3 OUTCOMES	7
3.1 OUTCOMES OF THE SYSTEMATIC INVESTIGATIONS IN THE LERNLAGER LABORATORY	7
3.2 RESULTS OF REFLECTION WORKSHOPS WITH PRACTICING EXPERTS	11
3.2.1 <i>Evaluation of the Workshops – Order Pickers</i>	11
3.2.2 <i>Evaluation of the Workshops – Managers</i>	13
4 INTERPRETATION AND DISCUSSION.....	14
4.1 INTERPRETATION OF THE RESULTS FROM THE SYSTEMATIC STUDIES IN THE LERNLAGER LABORATORY	14
4.2 INTERPRETATION OF THE RESULTS FROM THE REFLECTION WORKSHOPS WITH PRACTICING EXPERTS	17
4.3 INTEGRATION AND DISCUSSION	18
5 CONCLUSIONS	19
ACKNOWLEDGEMENTS	22
BIBLIOGRAPHY	22

Figure Index

FIGURE 1: ERROR-TIME DIAGRAMS FOR THE FOUR PICKING TECHNOLOGIES.	9
FIGURE 2: INITIAL TRAINING CONCEPT FOR EMPLOYEES IN MANUAL ORDER PICKING IN THE CONTEXT OF THE CORPORATE, HR AND IT STRATEGIES.....	20

Abstract

Logistics processes are strongly affected by automation but due to the prevailing conditions the demand for human labor will still remain in intralogistics, in particular in manual order picking. While the results of previous research work on learning processes in manual order picking are mainly available in the form of learning curves, the present research project focuses on the qualitative dimension of these learning processes. Based on current teaching-learning research, suitable learning formats were developed and consolidated as learning packages for practical use. We have considered a variety of learning methods, from enhanced instruction methods common in many companies to the use of modern learning media such as tablets or Virtual Reality. These can be used in companies today and in the future.

An extensive study with test persons in a laboratory environment called LernLager (Learning Warehouse) focused on and optimized those learning packages, looking particularly at four different picking technologies: Pick-by-Light, Pick-by-Scan, Pick-by-Voice and Pick-by-Vision. In order to reflect on the results of the test persons' experiments and to prepare transferring the results into practice, hands-on experts subsequently discussed the practicability and transferability of the learning packages in workshops.

The results of the research project show that if methodologically and didactically elaborated learning formats are adapted to practical situations and target groups, they can significantly promote the learning process. At the same time, new employees are motivated to play an active role in the learning process and to acquire new knowledge and skills in the long run.

1 Background

Despite continuously increasing possibilities of automation technology in production and distribution logistics, it is currently not possible to foresee if and when humans as service providers in intralogistics will become obsolete, especially in the picking processes. In addition to the high demand for qualified personnel in general, companies need to react flexibly to seasonally varying demands and other challenges. This requires highly effective learning processes for manual order picking using various picking technologies.

In economics, the development of competence acquisition and the resulting increased efficiency in production or in the provision of services are often described by means of learning curves. The learning effects that are subject to these increases in efficiency or learning curves manifest themselves in time and cost savings as well as in better quality of the work results.¹ A variety of learning curve models can be used to quantify learning effects.

While learning curves are based on a quantitative approach, learning theories based on psychology of learning focus on the qualitative dimension of learning processes. Learning in this context can be understood as “[...] a relatively permanent change in behavior due to a person’s interaction with their environment”.² Consequently, behavioral change is a key indicator of learning. Learning includes the acquisition of new information as well as the modification and reinforcement of both existing knowledge and already imprinted behavioral patterns, skills, values and preferences.³ To this end, it is recommended that learning be “[...] transferred to the place where the task is performed [...] and that it be viewed in the context of the interplay of the three factors man, technology and organization”.⁴

Current literature on organizational psychology discusses the importance of interdependence of individual learning and organizational context for successfully applying the new skills in everyday practice.⁵ In connection with in-company training and strategic personnel development, learning in the workplace is thus becoming increasingly important in the educational debate.⁶ “Learning processes take place in the form of experiences and insights gained [...] in work processes, mostly by examining work requirements and executing work tasks [...]”.⁷ Today, such learning formats based on the field of work are discussed and recommended mostly in the field of self-directed or action-oriented learning.⁸

This means that in the context of in-company learning, an integrated approach is necessary, combining the perspectives of measurable quantitative effects with the qualitative dimension of learning and the organizational component. An exclusively behavioristic view of the picking performance development with univariate learning curve models ultimately serves to describe learning effects only. It does not

¹ Cf. Duane (1964), Hieber (1991), Delaney *et al.* (1998).

² Kauffeld (2010), p. 38.

³ Cf. March (1991), Fioretti (2011), Schacter *et al.* (2011).

⁴ Petzoldt and Bullinger-Hoffmann (2017), p. 185.

⁵ Cf. Rosenstiel (2003), Scharmer (2014), Gairing (2017).

⁶ Cf. Dehnbostel (2018).

⁷ Senderek *et al.* (2015), p. 285.

⁸ Cf. Kauffeld (2016).

answer the question of the didactic and methodological design aspects of learning processes and the sensible organizational measures to promote and consolidate learning. With respect to digital transformation, both the design of learning processes in the form of suitable learning formats and the organizationally conceived process flow for training new employees are currently gaining particular importance.

With this in mind the LernLager research project was launched focusing on the following three research questions:

1. Which learning format is particularly suitable for training processes in manual picking?
2. Which learning format is particularly suitable for a specific picking technology?
3. Which operational influencing factors and general conditions significantly impact the selection and design of a learning format?

2 Methodology

In order to understand the research-methodological background, we describe two separate research lines that look at the phenomenon of in-company learning from different perspectives.

On the one hand, the quantitative description of learning progress and, on the other hand, the psychological approach to learning that focuses on the human being. The LernLager research project brings both approaches together and develops a “Mixed Methods Design” for the research approach, in which a quantitative study is carried out in a laboratory environment and a qualitative study is carried out together with business companies.

2.1 Research-methodological Background

“In industrial production, the phenomenon of learning known from psychology [is] predominantly considered in connection with what is called a learning curve”.⁹ Learning curves are usually presented as direct expenditure in the form of man-hours or production costs per unit, depending on the cumulative production quantity. Accordingly, learning is seen as a planning variable to be considered in the context of production economics. Psychological approaches to learning, on the other hand, focus on the content-related, methodological and thus qualitative approach to learning, which today is of particular importance in educational research and in-company educational work as part of personnel development.

How do two such different perspectives of learning in a company come about? Which historical developments have led to the two different scientific concepts “learning curve theory” and “psychological learning theories,” which dominate the respective scientific discourses?

One explanation for the development of learning curve theories can be seen in the tight dovetailing of learning-curve theory and scientific management. In the course of industrialization and the Taylorist

⁹ Mochty (1996), p. 1074.

work concepts, the division of labor was at the forefront. The resulting time savings and learning effects are discussed both by Taylor¹⁰ and in Wright's theory of learning curves.¹¹ Both approaches aim to increase efficiency and productivity in the production industry. Moreover, Taylor's industrialization concept promoted the separation of work and learning. The intention is "[...] to rationalize learning in order to achieve the best possible performance when executing fragmented actions".¹² Consequently, learning was moved away from the workplace and learning content was generalized.

Another influence can be traced back to the paradigms in learning research accepted at the time. Behavioral approaches to learning dominated the psychological discourse on learning at the heyday of learning-curve theory until about 1960. Later literature on the learning curve also includes cognitivistic explanatory models for human learning behavior. For example, cognitivistic information processing is applied to the justification of technical or organizational learning.¹³

Various studies, such as by Adler and Clark¹⁴, Dar-El¹⁵, Azizi et al.¹⁶ or Lapré¹⁷, address the significance of various influencing factors on learning curves, such as the motivation of the learner. However, no further psychological approaches to learning are considered or even discussed. A comparison of the literature dealing with industrial learning-curve theory or learning processes in the production industry shows that these often pursue a similar goal. The authors attempt to put knowledge about learning curves into mathematical formulas in order to make predictions about learning processes and productivity.

In the course of the 20th century and along with the debate on learning curves, however, a different approach to learning in the workplace developed, which was mainly due to questioning some of Taylor's assumptions. The change came from the consequences of the Hawthorne research¹⁸ and led to the "Human Relations movement" in the scientific view of management, which did not first and foremost focus on work processes and structures, but on people. The core thesis of this approach is that higher job satisfaction among employees increases motivation and thus productivity. Motivation and social relationships play an important role in this concept.¹⁹ In Europe in the 1970s, the topic of "humanizing work" set in motion the implementation of scientific findings from psychology and occupational science. This led not only to topics such as human-oriented leadership, but also made people aware that work concepts should promote learning.²⁰

Following the development histories of learning curve theories and approaches based on psychology of learning, one can rightly conclude that two different approaches to learning within business management

¹⁰ Cf. Taylor (1911).

¹¹ Cf. Wright (1936).

¹² Sonntag and Stegmaier (2007), p. 22.

¹³ Cf. Henfling (1978), Breit (1985), Hieber (1991).

¹⁴ Cf. Adler and Clark (1991).

¹⁵ Cf. Dar-El (2000).

¹⁶ Cf. Azizi *et al.* (2010).

¹⁷ Cf. Lapré *et al.* (2000).

¹⁸ Cf. Roethlisberger and Dickson (1939).

¹⁹ Cf. Bea and Göbel (2010).

²⁰ Cf. Sonntag and Stegmaier (2007).

have developed in parallel, if not in almost isolated ways: On the one hand, the quantitative access via the learning-curve theory, which still dominates production-economical research and doctrines today. On the other hand, a qualitative view on learning, which places peoples' individual behavior and actions in the foreground and focuses on questions concerning the design of professional learning processes. It thus represents the key for company personnel and training efforts.

2.2 Research Design: Mixed Methods Design

The LernLager research project continues the tradition of the business-management view of learning in the sense of learning-curve theory. However, the investigation focuses on the qualitative view of the learning process in manual picking in the form of the methodological and didactic design of a learning arrangement and in the sense of psychological learning theories. Therefore, the project investigates learning processes in order to gain insights into the approaches for optimizing learning processes in manual order picking.

In order to investigate the research question for relevant success criteria focusing on successful learning concepts in manual order picking, the LernLager research project deliberately relied on an empirical Mixed Methods Design.

Quantitative and qualitative methods are based on different research models: Quantitative research generally intends to examine research questions determined in advance, and statistical evidence is sought in this context. Qualitative research, on the other hand, serves to explore the actors' subjective perspectives, which requires an open and more explorative approach.

Through a combination of quantitative and qualitative research, possible limitations of one methodological tradition can be offset by methods of the other tradition. For example, quantitative data can be supplemented by a qualitative survey in order to reflect and interpret the quantitative data from the point of view of the actors concerned. The present study follows this approach of a Mixed Methods Design in the form of what is called the "in-depth model".²¹

Accordingly, at the beginning of the research process, there is a quantitative study with a larger sample, i.e. the test person experiments in the LernLager laboratory. The data from this study is then evaluated quantitatively. This is followed by a qualitative study, i.e. the reflection workshops with practically experienced picking experts, which helps to better interpret the quantitative material at hand. The qualitative study serves to enhance the results of the quantitative study, and to differentiate them on the basis of hands-on assessments. The following sections describe these two methodological approaches in detail.

²¹ Cf. Moschner and Anschütz (2010).

2.3 Quantitative Study through Systematic Investigations in the LernLager Laboratory

In the quantitative study, different learning formats were tested under laboratory conditions. In a learning phase, each respondent first learns the picking process and a picking technology using a specific learning format and then carries out a picking process with a standard order data record. In addition to the training time, the learning results were measured using the parameters picking performance (time) and picking quality (errors).

In order to investigate the learning benefit, meaningful learning formats were consolidated in three learning packages during the training phase. They differ in their methodological and didactic design and represent different learning arrangements of in-company training. Each learning package has basic methodological building blocks, but is adapted to the combined use with the respective order picking technology.

Learning package CAPT

The CAPT learning package extends the traditional instruction method “cognitive apprenticeship” (CA) and combines it with a peer-tutoring method (PT). The learning method Cognitive Apprenticeship is based on the traditional instruction method (master-apprentice principle) and the application-oriented mediation and learning processes between “experts” and “novices”.²² Beyond the pure transfer of knowledge, cognitive apprenticeship in the course of learning aims at the development of an expert-like action competence allowing learners to independently develop solution strategies.²³

In the CAPT learning package, consisting of four learning phases, a training process is initially used to introduce two learners to the work of manual order picking and the functioning of the respective picking technology. In the first learning phase, the trainer processes and explains a picking order as well as the picking technology. In the second learning phase, one of the two learners processes and explains a picking order. This second phase is accompanied by the trainer and the second learner. In the subsequent peer tutoring, the two learners act as a learning team, largely without trainers, and in the third and fourth learning phases, they alternately process picking orders using the respective picking technology. This cooperative instructional learning activity between the peers leads to intensive and active dealing with the learning task. Mutual explaining and mediating as well as joint solving of problems also promote the social competence of learners.²⁴

Learning package E-Learning

The second learning package was designed in the form of an E-Learning application to test a standardized learning process for manual picking, which was accompanied by digital learning media. The developed E-Learning application was provided on a tablet and consisted of two modules, each with final success controls. In the first module, the learner was given theoretical access to the work area and to

²² Cf. Kauffeld (2016).

²³ Cf. Sonntag and Stegmaier (2007).

²⁴ Cf. Robinson *et al.* (2005), Büttner *et al.* (URL).

important basic concepts of manual order picking through a partially animated lesson with sound. In the second module, the learner acted directly in the warehouse with the learning medium tablet and learned the specific work steps of manual picking and the application of the respective picking technology in a hands-on way.

Learning package Virtual Reality

The use of Virtual and Augmented Realities can enable innovative application scenarios for educational processes.²⁵ With this in mind, the use of virtual learning processes for intralogistics was developed and tested in the form of a learning package. The didactic concept was based on two learning modules as well as on the technical development and availability of a virtual warehouse. In the beginning, movement and action with Virtual Reality technology were trained in the first learning module. The trainee was able to gain first experiences and train movement sequences. For this purpose, the participant acted in a virtual practice room. A “real” trainer was available for support and accompanied the entire learning process on a separate screen. In the second learning module, the learner acted in a virtually designed picking warehouse that contained all the essential objects required for picking. Written instructions conveyed the picking process and the functioning of the picking technology, and the learner then carried out individual picking orders.

LernLager Laboratory

The laboratory for testing and investigating the learning packages comprised three picking aisles with approximately 1,000 storage locations on a picking area of about 120 m². The provisioning of articles took place locally and statically in the form of person-to-goods picking. The order picker moved to the prepared goods in a linear motion. A picking trolley was used as picking aid.

After the training phase, i.e. during the picking phase, each test person processed 18 picking orders with a total of 63 order positions using one of the following previously learned picking technologies:

- Pick-by-Light (single-order picking)
- Pick-by-Scan (multi-order picking)
- Pick-by-Voice (multi-order picking)
- Pick-by-Vision, using a finger scanner (multi-order picking)

Unlike the CAPT and E-Learning learning packages, the Virtual Reality learning package is tested on two selected picking technologies. The focus was on the question to what extent virtual-learning applications are practicable for the operational learning process in times of learning digitization.

²⁵ Cf. Zobel *et al.* (2018).

2.4 Qualitative Study through Reflection Workshops with Practicing Experts

In the second research step, the learning packages used in the LernLager laboratory were presented to representatives from two companies in the consumer goods and logistics services sectors and then reflected in the form of group discussions. In this step, it was relevant to offer access to the actual target group, i.e. the order pickers. This access was enhanced by interviews with managers in order to guarantee a holistic view. The goal of these four reflection workshops was to collect data in order to find better and more differentiated interpretations of the available quantitative material, based on the perspective of order pickers and practicing experts. In addition, these practical assessments were expected to point out other expected and unexpected effects and the potential for transferring the results of the quantitative study.

In the reflection workshop, the group discussions were evaluated on the basis of qualitative content analysis,²⁶ which was accompanied by a semi-standardized interview guideline.

The interviews were evaluated with respect to the following categories:

- Assessment of the learning packages
- Utilization potential in the company
- Fitting accuracy with the target group of order pickers
- Virtual Reality as an innovative learning method

3 Outcomes

We are presenting the outcomes of the “Mixed Methods Design” implementation. On the one hand, the laboratory tests for each picking technology can be described separately, based on evaluating the three parameters training time, picking time and position error rate for each learning package used. On the other hand, we systematically present the practical reflection workshop assessments with the two industry partners, for order pickers as well as managers, across the four relevant categories described above.

3.1 Outcomes of the Systematic Investigations in the LernLager Laboratory

In order to assess the systematic investigations, we have determined parameters for evaluating the quantitative dimensions of learning processes in manual order picking. For each of the four picking technologies, Figure 1 shows a diagram with the parameters training time, picking time and position error rate.

²⁶ Cf. Mayring (2015), Lamnek and Krell (2016).

Training time

The parameter “training time” describes the time span from the beginning to the end of the actual learning process. The parameter was collected manually by the test director. The welcoming of the test subject by the test director and the general introduction to the test procedure were not included in the training time. For the CAPT learning package, the training time for the entire learning process was recorded. Due to the simultaneous training of two test persons, the CAPT training time has been divided by two for evaluation.

Picking time

The picking time per order is the time required to complete picking an individual order. It is made up of the base time per order as well as the handling, dead and travel times per order position.

$$\text{Picking time per order [s]} = \text{Base time} + \sum_{r=1}^n (\text{Travel time}_r + \text{Handling time}_r + \text{Dead time}_r)$$

In order to determine the effects of the learning processes over a longer picking period, the LernLager project defines picking time as the sum of the picking times of all 18 customer orders.

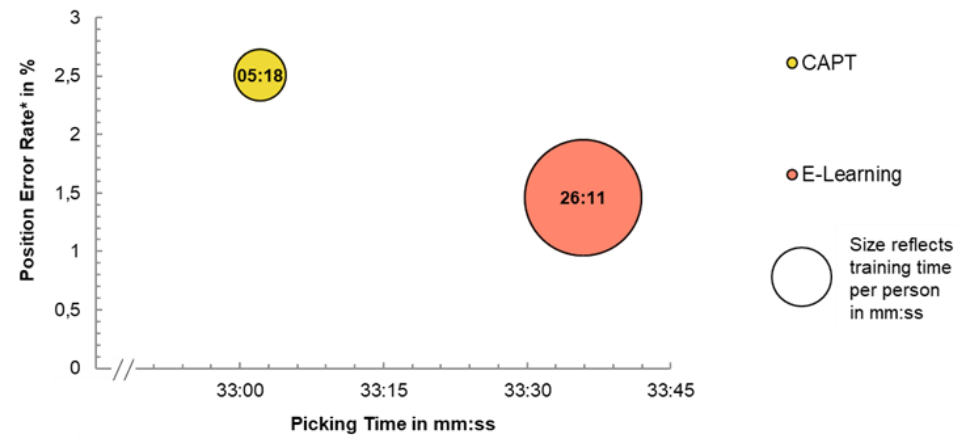
Position error rate

The position error rate is defined as the ratio of the number of incorrectly processed order positions in a test series to the total number of processed order positions in a test series. It is calculated as follows:

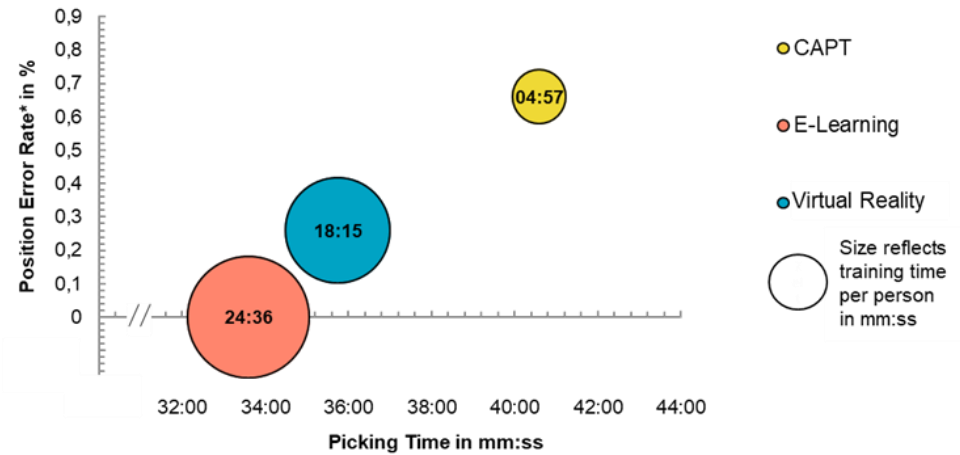
$$\text{Position error rate in \%} = \frac{\sum \text{incorrect order positions in a test series} \times 100}{\sum \text{order positions in a test series}}$$

The position errors of each test person are manually recorded by the test director after completion of the test sequence. The position errors include quantity, omission, type and storage errors. In the error evaluation, any storage errors detected in multi-order picking are counted as two position errors because they yield two incorrect customer orders. In the LernLager, a total of 124 test persons first learned how to pick and then applied their new skills in the picking phase. For each parameter of a learning package, the mean value was calculated for all test persons and then presented separately for each picking technology (see Figure 1). The results were determined for all learning packages in the test series of at least 12 test persons.

Error-Time Diagram: Learning Packages for Pick-by-Scan

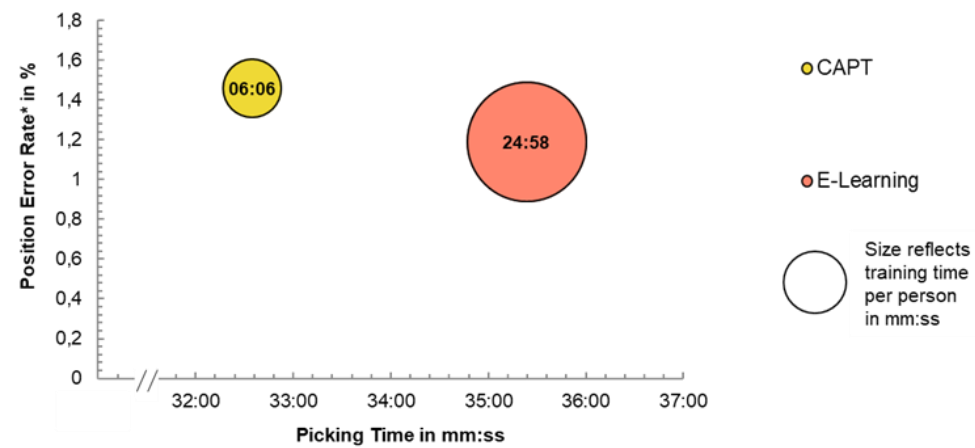


Error-Time Diagram: Learning Packages for Pick-by-Voice

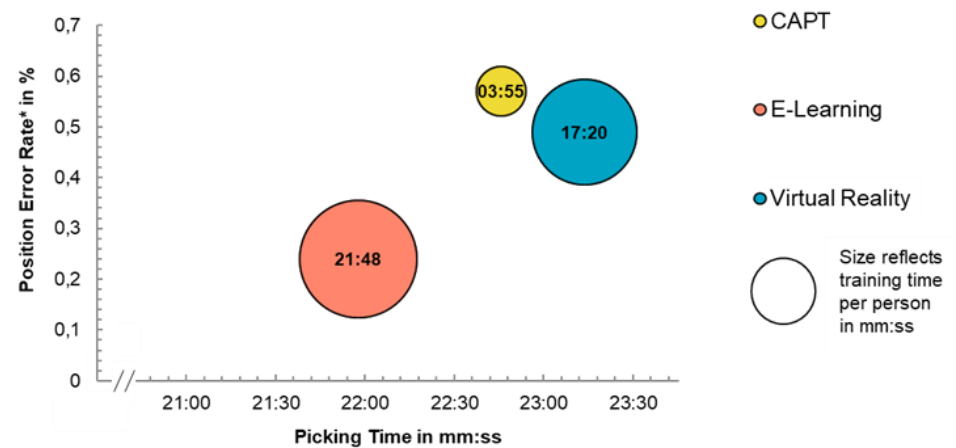


* All position error rates are below a value of 1%.

Error-Time Diagram: Learning Packages for Pick-by-Vision



Error-Time Diagram: Learning Packages for Pick-by-Light



* All position error rates are below a value of 1%.

Figure 1: Error-time diagrams for the four picking technologies.

Pick-by-Light

With 3:55 minutes, the Pick-by-Light picking technology with single-order picking shows the shortest training time per person in the CAPT learning package. The E-Learning learning package (21:48 minutes) has a significantly longer training time per person compared to CAPT.

The picking times for both learning packages are in a similar range. The E-Learning learning package has a slightly shorter picking time of 21:58 compared to 22:46 minutes for CAPT.

The position error rates of the two learning packages are below the 1% threshold. The E-Learning learning package has the lowest position error rate (0.24%). The error rate of the CAPT learning package is more than twice as high (0.57%).

Pick-by-Scan

For the Pick-by-Scan picking technology with single-order picking, the CAPT learning package has the shortest training time per person (5:18 minutes). For the E-Learning learning package, we find a significantly longer training time of 26:11 minutes.

The picking times of the learning packages are very similar. For example, the CAPT learning package has a slightly shorter picking time than the E-Learning learning package (33:02 vs. 33:36 minutes).

The position error rate of both learning packages is below 3%. In the E-Learning learning package, a position error rate of 1.46% occurred, compared to a position error rate of 2.51% with CAPT.

Pick-by-Voice

For the Pick-by-Voice picking technology with multi-order picking, the CAPT learning package has the shortest training time per person of 4:57 minutes. The E-Learning training method requires a significantly longer training time of 24:36 minutes for Pick-by-Voice.

The E-Learning learning package has the best picking time with 33:35 minutes compared to CAPT with 40:35 minutes. The position error rates of the two learning packages are below the 1% limit. In the E-Learning learning package, no position errors occurred during the picking phase. The CAPT learning package also shows a low position error rate of 0.66%.

Pick-by-Vision

For the Pick-by-Vision picking technology with multi-order picking, the CAPT learning package has the shortest training time per person (6:06 minutes). E-Learning requires a significantly longer training time of 24:58 minutes.

With 32:35 minutes, the CAPT learning package ranks best in picking time. The E-Learning learning package, on the other hand, has a picking time of 35:24 minutes. The position error rates of all learning

packages come in below 2%. The E-Learning learning package shows a position error rate of 1.19%, compared to 1.46% for the CAPT learning package.

Virtual Reality as a special case

The Virtual Reality learning package was used as a special case for the picking technologies Pick-by-Light and Pick-by-Voice. With the Virtual Reality learning package, the picking technology Pick-by-Light with single-order picking achieves a training time of 17:20 minutes and is thus located between the training times of the CAPT learning package (3:55 minutes) and E-Learning learning package (21:48 minutes).

The picking time for the Virtual Reality learning package (23:14 minutes) is in a similar range as for the other learning packages (CAPT: 22:46 minutes / E-Learning: 21:58 minutes).

At 0.49%, the position error rate of Virtual Reality is located between the other two learning packages (CAPT: 0.57% / E-Learning: 0.24%).

With the Virtual Reality learning package, the picking technology Pick-by-Voice with multi-order picking shows a training time of 18:15 minutes and is thus located between the two training times of the CAPT learning package (4:57 minutes) and E-Learning learning package (24:36 minutes).

The picking time for the Virtual Reality learning package (35:44 minutes) is in a similar range as for the other learning packages (CAPT: 40:35 minutes / E-Learning: 33:35 minutes).

At 0.26%, the position error rate of Virtual Reality comes in between the other two learning packages (CAPT: 0.66% / E-Learning: 0%).

3.2 Results of Reflection Workshops with Practicing Experts

3.2.1 Evaluation of the Workshops – Order Pickers

In this section, we present the results of the workshops with the order pickers.

Assessment of the learning packages

All learning packages were generally assessed by the order pickers as feasible and as suitable for practice. In their assessments, the order pickers also emphasized that the learning packages should be embedded in a human-centered learning setting. After a first training phase, very specific questions may sometimes arise, which can be answered more flexibly by a contact person.

The order pickers pointed out the great importance of language in the learning process. In their opinion, complex facts are better understood in a person's mother tongue and can subsequently be elaborated in the German language in practice. Also, written instructions may lead to a similar improvement in the learning process. Reading instructions may help new employees with native languages other than German more than verbal or auditory communication only. Learners may be able to more effectively pick

up and understand facts at their own pace and in a self-directed manner. As a result, the E-Learning application in particular is seen as a useful tool for teaching employees with a mother tongue other than German.

In addition, the pickers found it very important to get to know the field of work before their first work day or the start of training. The pickers explained this by the fact that potential employees can better decide at an early stage whether they really want to work in the picking department. This might prevent employees from deciding against this field of work after a training phase and leaving the company again. Other positive effects, as seen by the pickers, are competence development and reduction of training time in practice after receiving a solid preparation.

Therefore, some respondents advocated training through Virtual Reality or E-Learning, combined with a subsequent training phase in the company, e.g. through CAPT. If new employees with previous knowledge and skills are trained in practice, previously learned theoretical matters may be memorized better, which is another advantage.

Utilization potential in the company

In addition to the general application options described above, the respondents cite a number of other application scenarios for the learning packages presented. For example, the CAPT and E-Learning learning packages could be used for training in the field of transporting conveyors, in particular for forklift trucks and high-speed machines.

Fitting accuracy with the target group of order pickers

The order pickers see it as part of their duty toward employers to be open to new learning methods. It should be noted that older employees might be less motivated to learn in general and more reluctant to learn new picking processes or technologies. Basically, the idea prevails, however, that the training methods used are suitable for the colleagues because employees should be open to new training formats. A particularity of employees in manual order picking is the large variety of native languages other than German, leading to difficulties when communicating information in German. As described before, the workshop participants therefore particularly emphasized the E-Learning learning package in a positive way.

Virtual Reality as an innovative learning method

The order pickers looked at Virtual Reality as a training method in a very positive way. Many order pickers considered learning with Virtual Reality as a method that could represent the future of learning. This insight also correlates with employee loyalty and their required openness to new learning technologies, as previously described. Currently, respondents consider the lack of technology and a possibly low media competence of the employees as an issue. They emphasize the application's game character, which could have a motivating effect especially on employees who like gaming. Some consider Virtual Reality as an opportunity for company branding in order to attract new employees.

3.2.2 Evaluation of the Workshops – Managers

This section presents the results of the manager workshops.

Assessment of the learning packages

The presented learning packages were generally well received by the respondents. They consider CAPT as a simple learning package, which can be implemented easily and directly. Some companies already train in a similar way. Similar to the order pickers, the managers interviewed expressed that in some work areas, such as manual order picking with forklift trucks, a 1:1 training method is preferable to the simultaneous training of two employees. Safety aspects also play a role in the decision against CAPT in some areas. The respondents also confirmed the importance of direct personal contact in the training phase. Respondents from both companies therefore suggested a combination of learning support (by a trainer or similar) with a technical learning medium, such as E-Learning or Virtual Reality. This kind of learning support is able to react flexibly to questions from a new employee and also to better support the employee's familiarization phase after the training phase. In addition, the interviewees pointed out that training represents an integration phase in the company as well. Again, they did not want to do without another employee as a trainer. The interviewees named the didactic training of such trainers (train-the-trainer) as an important prerequisite.

Utilization potential in the company

Overall, the E-Learning application was considered to have a high utilization potential in the company. The respondents of the consumer-goods manufacturer saw this as an opportunity to enhance parts of the training process using electronic learning media. The respondents of the logistics service provider saw the application as an enhancement of the company-internal learning-management system. As a reason for this, they mentioned the flexible use of such an application in idle times and the possibility of monitoring success.

As specific application scenarios for E-Learning in manual order picking, they highlighted the initial briefing, mediation of change processes and implementation of aptitude assessments. Furthermore, all respondents could imagine using the listed learning packages in other intralogistics work areas as well. Again, the combination of human-centered and electronic learning is considered a prerequisite. Implementation examples mentioned include safety trainings through E-Learning and the introduction to operating a forklift truck through Virtual Reality.

In the group interviews, respondents repeatedly highlighted the cost-benefit issue of the E-Learning and Virtual Reality learning packages presented. The interviewees were aware that these learning packages might require a great deal of effort for the companies. In the field of manual order picking, there is still a lack of well-founded scientific knowledge as to whether this effort will eventually translate into added value with respect to learning success.

Virtual Reality as an innovative learning method

Respondents evaluated the use of Virtual Reality as an innovative learning method in a variety of ways. They mostly saw its benefits in the practical illustration of work processes and “practicing without consequences.” Furthermore, such a method could be used after an initial training phase. It is conceivable to train the quality awareness of the employees through practical scenarios in the virtual environment. As previously mentioned, the respondents considered the high development effort of Virtual Reality technology as a disadvantage. They saw young and game-oriented order pickers as the main target group. The managers were reluctant to use Virtual Reality as the main training method for current employees. Particularly, the logistics service provider considered Virtual Reality as a future learning method and underlined its branding effect for employee recruitment. Consequently, they are currently testing pilot applications for this technology.

4 Interpretation and Discussion

On the one hand, this chapter looks at the results of the previous chapter and interprets them with regard to each individual method, separating the laboratory experiments with test persons from the reflection workshops with the business partners. On the other hand, however, an important added value results from the chosen method design. In a separate section, we bring together the lines of interpretation and discuss them as a whole.

4.1 Interpretation of the Results from the Systematic Studies in the LernLager Laboratory

In order to evaluate the research results, we consider and interpret all ten research series with regard to the main research areas. The first research question is:

- Which learning format is particularly suitable for training processes in manual order picking?

Considering the parameters training time, picking time and position error rate, no specific learning package can be identified as the most suitable for the learning process in manual picking. Taking the respective picking technologies into consideration, we look at the study series from the perspective of the second research question, which is:

- Which learning format is particularly suitable for a specific picking technology?

The results show that we cannot identify a specific learning package as the best in training time, picking time and position error rate for any of the picking technologies (see Figure 1). But by comparing the learning packages E-Learning and CAPT, we can further interpret the parameters for each picking technology. Additionally, we need to qualitatively evaluate them according to the organizational, didactic and resource-related characteristics of the learning packages.

Comparison of learning formats with regard to training time

For the training of test persons, E-Learning takes about four to five times longer than CAPT.

Based on a purely quantitative point of view, the CAPT learning package seems a more suitable learning package at first. CAPT can be expected to require more personnel and time than E-Learning in the training phase, depending on the number of trainers and their efforts. E-Learning, on the other hand, involves a largely self-directed learning process, which can be supplemented in a meaningful way by a trainer as needed.

Comparison of learning formats with regard to picking time

When considering picking times, no learning package clearly dominates for Pick-by-Scan and Pick-by-Light because they only differ by less than 5%. For Pick-by-Voice, E-Learning requires a 17% shorter picking time compared to CAPT. For Pick-by-Vision, however, the picking time for E-Learning is 9% higher than for CAPT. From a purely quantitative point of view based on picking time, initial training with E-Learning as a picking technology can be recommended for Pick-by-Voice and with CAPT as a picking technology for Pick-by-Vision. Once again, qualitative characteristics should be considered as well. The alternating learning process in the CAPT learning package allows the learners to start building up their relationships as colleagues during the training phase. They can later make use of such relationships when difficulties come up during the picking process, which, in turn, may considerably reduce problem-solving times. In the case of training based on E-Learning, however, this can be achieved through employee integration as well.

Comparison of learning formats with regard to position error rate

When considering the picking position error rate, and from a quantitative point of view, initial training with E-Learning is less prone to errors than with CAPT. Starting with a significantly lower error rate for Pick-by-Vision, it decreases even further and is reduced by almost half for Pick-by-Light and Pick-by-Scan. The picking technology Pick-by-Voice even shows a picking position error rate of 0% when E-Learning is used, compared to 0.66% for CAPT. From a qualitative point of view, it should be added that both learning packages are able to teach the learners how to avoid typical error sources in manual picking. As the training content to be used for E-Learning lessons is rather rigid, however, a suitable and limited pre-selection of error sources to be trained must be made. In the CAPT learning package, it is possible to react dynamically when sources of errors come up, to respond to specific questions by the test persons and to recognize and correct the occurrence of processing errors directly and accordingly.

Comparison of the parameters for the Virtual Reality learning package

For the Pick-by-Light picking technology, the Virtual Reality learning package comes out between CAPT and E-Learning in terms of training time and position error rate. However, the picking time is highest with Virtual Reality.

For the Pick-by-Voice picking technology, Virtual Reality comes out between CAPT and ELearning in all evaluated parameters. For example, the Virtual Reality learning package provides longer training times than the CAPT learning package, but shows a lower position error rate in turn. Compared to E-Learning, the training time is shorter but the position error rate is higher. Therefore, we cannot make a clear statement for the Virtual Reality learning package overall. As a digital learning format, however, it offers fundamental benefits over classic learning methods.

In addition to the findings as described above concerning the two research questions, further characteristics have to be considered when selecting the learning packages.

Considerations with respect to the individual learner

Successful training should be designed with a focus on each learner. As far as learning methodology is concerned, CAPT employs a very trainer-related learning approach. In turn, ELearning focuses more on self-directed learning. CAPT requires much lower media skills. ELearning, on the other hand, requires basic understanding of touch-controlled devices. Media-skill requirements and learning methodology have to be aligned with the target group for manual order picking depending on the staff composition.

Consideration of the company resources

Fundamental decisions for learning formats have to be made with the available resources in mind. Essentially, the costs of creation, implementation, deployment and quality management have to be considered. Designing and training a CAPT learning package will require fewer resources than the professional design and technical equipment of an E-Learning application. On the other hand, the implementation of CAPT requires more staff resources, while the ELearning learning package is based on self-directed learning and only temporarily requires additional support by a human trainer. In the case of the CAPT learning package, poor evaluation results or changes in the picking process may lead to costs for long-term quality management measures, which can be decreased through retraining the trainers. In comparison, updating an E-Learning application will typically lead to higher costs. When a company decides on a learning package, it is necessary to analyze the required internal and external resources and their individual importance.

Consideration of the company learning culture

The decision to use digital or non-digital learning formats (E-Learning or CAPT) should be made reflecting the company-specific demands on learning process design and personnel development. The company should also take into account how sustainable and future-proof a particular training format is. We can safely assume a higher degree of standardization in ELearning applications. This guarantees a constant and long-term knowledge transfer and the acquisition of competences by the employees after an initial training phase. For the CAPT learning package, consistent quality depends on the trainer's skills. Appropriate guidelines may enhance the quality of knowledge transfer in this case as well.

Digital learning applications offer additional possibilities for training in manual order picking. With an eye on multilingual personnel, companies may consider using simple language or the respective mother

tongue if possible. In the future, the learning environment may be enhanced with digital learning applications such as E-Learning, allowing applicants to acquaint themselves with the work environment or E-Learning applications to function as a reference.

4.2 Interpretation of the Results from the Reflection Workshops with Practicing Experts

In the group discussions during the reflection workshops, industry experts confirmed the potential of the learning packages considered. In addition, they provided clear indications for answering the third research question, which focuses on the operational influencing factors and general parameters for selecting and designing a learning format.

The survey with the practice experts results in the key statements listed below:

- All learning packages conceived within this project are suitable for implementation in practice.
- The concrete company situation including all relevant influencing factors and general parameters (in particular corporate strategy, IT and ERP concepts, order picking technology and personnel development) drives the selection and applicability of any learning package at hand.
- Optimization of training processes in manual order picking must not be limited to the selection and use of learning packages. The key conditions mentioned before must be analyzed and considered in order to ensure a holistic and goal-oriented learning and integration process in the company.
- Due to the multinational, multicultural and multilingual background of new employee candidates in manual order picking, focusing on the learner's native language represents a significant success factor for the learning process. If possible, the practical implementation of any learning package should be configured accordingly.
- Employees in manual order picking are open to new forms of training and welcome technically demanding digital learning media, among others, as possible learning formats.
- Decisions for the development and implementation of new training formats should try to close the gap between financial and time resources on the one hand and feasible learning outcomes via the targeted training strategies on the other. It is therefore essential to perform solid cost-benefit planning as well as, relevant argumentation and accurate communication with the operational decision makers.

From industry experts' perspective, there is neither a final recommendation for any specific learning package nor a ranking. Instead, they consider all three basic qualification formats (or even possible hybrid forms) as helpful because of the following facts:

- They are soundly conceived in terms of didactics and represent the state of the art in learning psychology.
- They ensure a systematic and structured approach.
- They appropriately evaluate the personnel policy topic "initial training process" and claim the required attention and support from management.

4.3 Integration and Discussion

The research-methodological design in the LernLager project is based on two empirical formats: the empirical surveys in the LernLager laboratory and the workshops with warehouse managers and order pickers.

The results of the quantitative study in the LernLager laboratory show no significant correlation between a specific picking technology on the one hand and a specific learning format on the other. Rather, each learning package has specific advantages and disadvantages depending on the order picking technology. However, this does not allow us to clearly evaluate the learning formats used with respect to qualification or differentiation. In contrast, however, it became clear both in the quantitative laboratory study and in the qualitative workshop surveys that a conscious, well-crafted and didactically sound learning-formats design will significantly contribute to new employees' successful initial training.

From the statements of the workshop participants, we can conclude that systematically designed learning concepts – whether in classic interaction format or in digital form – are of great benefit. Systematic learning concepts are therefore both effective and efficient: They effectively fulfill the goal of “gaining qualified and functionally deployable employees” and they use the tools for achieving the desired results in an economically efficient way. This is neither surprising nor new. The effectiveness of integrated learning processes in practical work environments has been proved sufficiently.²⁷ However, the hands-on experts confirm that this insight has not yet been implemented consistently in practice. Rather, there seems to be a general lack of standardized and systematic approaches to training in picking that employ both a didactically elaborated concept and appropriately qualified trainers. In most cases, initial training is carried out with rather simple and pragmatic forms of instruction by more experienced employees. Success thus depends very much on the situational setting and the individual skill teaching competence of the actors involved.

Nevertheless, the industry experts are convinced that training can produce consistent and solid learning results independently of the persons involved if the training process follows a systematic structure, involves recurring process loops and employs a variety of implementation technologies. The two digital learning packages “E-Learning” and “learning with Virtual Reality” are particularly important in this respect. The test persons used these digital formats with interest and good results in the LernLager laboratory, and the experts evaluated them as important learning formats for the future. The possibility of self-guided learning as well as the design and determination of the learning pace through autonomous recapitulation and repetition are particularly helpful. Due to mostly multi-national staff structures in manual order picking, it may be of great advantage to translate the digital learning formats into different languages provided cost and effort are reasonable. This offers applicants the opportunity to learn the essential activities of manual order picking in their mother tongue.

²⁷ Cf. Sonntag and Stegmaier (2007), Moltzberger *et al.* (2008), Dehnbostel (2018).

An essential finding from the workshops is that for the time being, companies should use a professional and reasonably sophisticated learning concept for their employee trainings, which should also be tailored to their needs, i.e. easily scalable. In addition to the implementation of an elaborate training concept, it is of particular importance that the training of industrial employees receives more attention. Consequently, the qualification and personnel development of this group of employees has to be included in the HR policy portfolio. In general, employees in manual order picking are rather low-skilled workers. However, the development and qualification of such workers is still given a low priority in many cases.²⁸ It is therefore important to focus on qualification programs for the low-skilled, particularly in a situation of general shortage of skilled workers.

In addition, systematic and standardized training concepts have the great advantage that they can be reproduced at any time, i.e. they can be carried out at different times at different locations by different actors in a largely uniform way.

The two digital learning formats used in the research project, E-Learning and Virtual Reality, offer a special opportunity. In an elaborated future version, these formats may even be implemented without trainers and instructors. This would give the trainee the opportunity to learn independently of the place of work and to partly or completely use the learning program outside of the company. On the one hand, such learning packages could be used to realistically provide job information to interested parties, and the company could use them to preselect applicants.

On the other hand, the applicants' subjective assessment may help them decide whether the task fits well with their own expectations and offer them a first and serious motivation test. At the same time, this would be a sensible kind of preselection because it could reduce the dropout rate of applicants at a later stage in the recruitment process, which may help to avoid significant investments in personnel recruitment. In addition, the use of digital learning formats may help to partially decouple the learning process from the corporate environment. This offers the possibility to introduce essential learning topics – such as specialist knowledge, background information, general work environment conditions, etc. – either before their actual implementation in practice or at the same time as the in-company hands-on training.

In addition, digital learning formats offer the best prerequisites for digital learning in today's digitization context.²⁹ Offered via digital learning platforms, they promote self-directed and self-responsible learning as well as competent dealing with digital work structures. Both are core competencies for the digital transformation process and are thus placed in the very center of the current digital education offensive.

5 Conclusions

Even though digitalization will significantly change the work processes in production and distribution logistics, humans will still be needed in intralogistics in the future. In particular, manual order picking will still be characterized by manual activities in the future, mostly due to its low investment costs and high

²⁸ Cf. Klein and Schöpfer-Grabe (URL).

²⁹ Cf. KPMG (URL), Dehnbostel (URL).

flexibility. However, all industrial work processes, including logistics, must adapt to possibly turbulent changes due to globalization, digitization and demographic change, and find effective answers to those challenges. With this respect, employee qualification and motivation represent key success factors because they are the main prerequisites for productivity, flexibility and innovative ability. This is why the design of effective and sustainable learning processes in manual order picking is very important.

A systematic and elaborate training and learning concept can significantly help to ensure that employees will quickly master their area of expertise, integrate socially into a team or department and identify with the company.³⁰ Consequently, a concept for training new employees should always be seen as part of a corporate strategy, an HR strategy and, more specifically, a consistent onboarding concept. Companies should also consider all relevant structural conditions, including the IT and ERP strategies and the picking technology used in the company. In line with these key influencing factors, a stable onboarding process for new manual-picking employees should be set up in the company, whose core should be an elaborate training format. An appropriate initial training concept should be didactically elaborated and fit well into the company situation. Such training concepts can help to train new employees in both a professional and psychosocial dimension (see Figure 2).

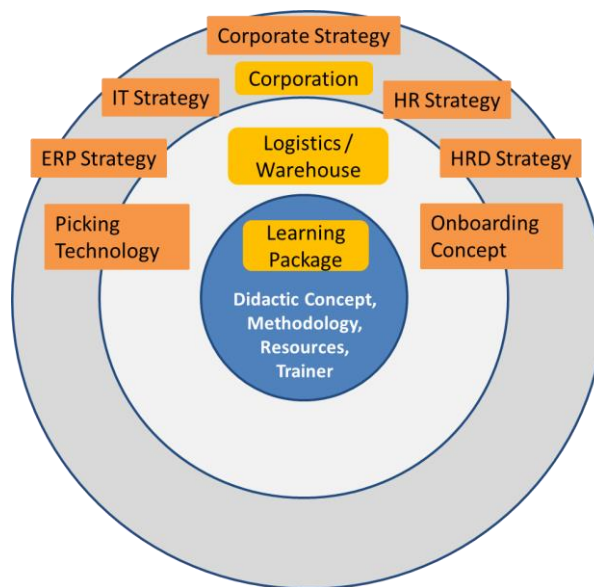


Figure 2: Initial training concept for employees in manual order picking in the context of the corporate, HR and IT strategies.

In the future, digital transformation will force consistent implementation of digital educational formats and, consequently, use of digital learning management systems in companies.³¹ On the one hand, this means a consistent HR-development concept based on systematic competence management and in line with the corporate strategy. On the other hand, digital learning formats will become significantly more important in the future.³²

³⁰ Cf. Moser *et al.* (2018).

³¹ Cf. Gensicke *et al.* (2016).

³² Cf. Mauth (2018).

If training concepts are systematically designed, feature cutting-edge content, method and technology, are planned and implemented with energy and management support, they will allow new employees to effectively familiarize themselves with their new job and contribute to a high degree of employee identification with and commitment to their new employer. The “psychological contract” between employee and employer,³³ which includes their mutual expectations and demands, can thus be shaped positively. If this step is successful, there will be an “affective commitment”, in other words, being part of the company is important for the employee, and it is marked by positive feelings such as satisfaction or pride.³⁴

The LernLager research project has presented new approaches for familiarizing new employees with picking. The learning packages provide a very practical reference for companies because they were tested through empirical surveys in the LernLager laboratory as well as in reflection workshops with experts from the industry. The project opens up design perspectives for efficiently setting up and implementing solid personnel development processes using a company’s own resources, especially for small and medium-sized enterprises (SMEs). With qualified employees, SMEs will be able to react to dynamic environmental challenges in the future as well. For this purpose, it is necessary to develop employee competencies in line with operational requirements and to provide professional learning concepts for them. Competent, motivated and loyal employees are an essential prerequisite for economic success and competitive capacity – especially in times of fast-paced changes.

For the future, it is important for further research projects to investigate the specifics of suitable learning formats in initial and continuing professional in-house training measures for the low-skilled. The group of low-skilled workers, at the focus of the present LernLager research project, faces multiple dilemmas. Firstly, qualification of workers in the respective occupations does not yet receive enough attention and priority.³⁵ Secondly, functions performed by low-skilled workers are disproportionately affected by rationalization measures.³⁶ Another research focus in the context of “digital learning at work” could also be whether low-skilled workers may have a higher orientation towards digital learning media, particularly to “game based” learning media.³⁷ The combination of gaming and digital media is a familiar field of action for the digital-natives generation. This fact may offer great opportunities for learning formats.³⁸ In view of the massive upheavals caused by digitization, we can safely assume fundamental changes in work processes and fields, which will face employees with completely new challenges. For this reason, the key competencies for elaborate action will play a significant role both in transformation processes and in digital work formats.³⁹ We should examine which key competencies employees in the industrial sectors will need in order to remain competent in times of digital transformation and agile organizational structures. It remains to be seen whether these extra-functional competencies are only necessary for

³³ Cf. Conway and Briner (2005).

³⁴ Cf. Wegge and van Dick (2005).

³⁵ Cf. Zobel *et al.* (2018).

³⁶ Cf. Matthes and Weber (URL).

³⁷ Cf. Staudacher (2019).

³⁸ Cf. Gensicke *et al.* (2016), Feichtenbeiner *et al.* (URL).

³⁹ Cf. Heyse *et al.* (2018).

specialists and managers in the context of “New Work” or whether lower-skilled workers in industrial production should be “empowered” to adapt to changing professional environments as well.

Acknowledgements

This article is based on results from the research project LernLager (No. 19375 N) which was granted by the Industrielle Gemeinschaftsforschung (IGF).

Bibliography

Adler, P. and Clark, K. (1991), Behind the Learning Curve: A Sketch of the Learning Process. *Management Science* 37 (3): P. 267-281.

Azizi, N., Zolfaghari, S. and Liang M. (2010), Modeling job rotation in manufacturing systems: The study of employee's boredom and skill variations. *International Journal of Production Economics* 123(1): P. 69-85.

Bea, F. X. and Göbel E. (2010), *Organisation*. 4. Auflage. UTB, Stuttgart.

Breit, C. (1985), *Lern- und Erfahrungseffekte in der Produktionstheorie*. GBI, München.

Büttner, G., Warwas, J. and Amini, K. (URL), Kooperatives Lernen und Peer Tutoring im inklusiven Unterricht. In: *Zeitschrift für Inklusion* (2012/1-2). Inklusion Online. URL: <https://www.inklusiononline.net/index.php/inklusion-online/article/view/61>, accessed: 07.03.2019.

Conway, N., Briner, R. B. (2005), *Understanding Psychological Contracts at Work: A Critical Evaluation of Theory and Research*. Oxford University Press, Oxford.

Dar-El, E. M. (2000), *Human learning: from learning curves to learning organizations*. Springer US, Norwell / Massachusetts.

Dehnbostel, P. (2018), Lernen im Prozess der Arbeit als Kompetenzentwicklung. In: Rauner, F. and Grollmann, P. (Hrsg.), *Handbuch Berufsbildungsforschung*. 3. Auflage. wbv Media, Bielefeld, P. 392-399.

Dehnbostel, P. (URL), Betriebliche Lernorte, Lernräume und Selbstlernarchitekturen in der digitalisierten Arbeitswelt. In: *Magazin erwachsenenbildung.at*. Das Fachmedium für Forschung, Praxis und Diskurs. Ausgabe 35/36, 2019. S. 04_1 – 9. *Erwachsenenbildung*. URL: https://erwachsenenbildung.at/magazin/19-35u36/04_dehnbostel.pdf, accessed: 13.03.2019.

Delaney, P., Reder, L., Staszewski, J. and Ritter, F. (1998), The Strategy-Specific Nature of Improvement: The Power Law Applies by Strategy Within Task. *Psychological Science* 9(1): P. 1-7.

Duane, J. T. (1964), Learning Curve Approach to Reliability Monitoring. IEEE Trans. Aerosp. 2 (2): P. 563-566.

Feichtenbeiner, R., Mohoric, A. and Ruhland, C. (URL), Lernen mit digitalen Medien im Betrieb. Pädagogisches Fortbildungskonzept zur Lernprozessbegleitung für Ausbilder/innen. Fbb. URL: https://www.fbb.de/fileadmin/Projekte/Mewa/MeWA_Fonzept_Fortbldg_LPB.pdf, accessed: 13.03.2019.

Fioretti, G. (2011), From Men and Machines to the Organizational Learning Curve. In: Mohamad, Y. Jaber (Hrsg.), Learning curves. Theory, models and applications. Boca Raton: CRC Press: P. 57-70.

Gairing, F. (2017) Organisationsentwicklung. Geschichte – Konzepte – Praxis. Kohlhammer, Stuttgart.

Gensicke, M., Bechmann, S., Härtel, M., Schubert, T., García-Wülfing, I. and Güntürk-Kuhl, B. (2016), Digitale Medien in Betrieben – heute und morgen. Eine repräsentative Bestandsanalyse. 2., korrigierte Auflage. Bundesinstitut für Berufsbildung, Bonn.

Henfling, M. (1978), Lernkurventheorie – Ein Instrument zur Quantifizierung von produktivitätssteigernden Lerneffekten. 1. Auflage. Lehman, Würzburg.

Heyse, V., Erpenbeck, J., Ortmann, S. and Coester, S. (2018), Mittelstand 4.0 – eine digitale Herausforderung. Führung und Kompetenzentwicklung im Spannungsfeld des digitalen Wandels. Waxmann, Münster / New York.

Hieber, W. (1991), Lern- und Erfahrungskurveneffekte und ihre Bestimmung in der flexibel automatisierten Produktion. F. Vahlen. München

Kauffeld, S. (2010), Nachhaltige Weiterbildung. Betriebliche Seminare und Trainings entwickeln, Erfolge messen, Transfer sichern. 1. Auflage. Springer, Berlin / Heidelberg.

Kauffeld, S. (2016), Nachhaltige Personalentwicklung und Weiterbildung. Springer, Berlin / Heidelberg.

Klein, H. E. and Schöpfer-Grabe, S. (URL), Arbeitsplatzorientierte Grundbildung für Geringqualifizierte: Ergebnisse einer IW-Unternehmensbefragung. IW-Trends, 42(3), 133. Iwkoeln. URL: https://www.iwkoeln.de/fileadmin/publikationen/2015/242676/IW-Trends_2015-03_07_Klein_Schoepfer-Grabe.pdf, accessed: 13.03.2019.

KPMG (URL), Digitales Lernen in Unternehmen. Wie wird es „richtig“ umgesetzt? KPMG: URL: <https://assets.kpmg/content/dam/kpmg/pdf/2015/09/digitales-lernen-in-unternehmenKPMG-2015.pdf>, accessed: 13.03.2019.

Lapr , M., Mukherjee, A. S. and Van Wassenhove, L. N. (2000), Behind the learning curve: Linking learning activities to waste reduction. Management Science Volume 46, Nr. 5: P. 597-611.

Lamnek, S. and Krell, C. (2016), Qualitative Sozialforschung. Mit Online-Materialien. 6., überarbeitete Auflage. Beltz, Weinheim / Basel.

March, J. (1991), Exploration and Exploitation in Organizational Learning. *Organization Science* 2 (1): P. 71-87.

Matthes, B., Weber, E. (URL), Veränderungen der Arbeitswelt - Zu den Auswirkungen der Digitalisierung und des demografischen Wandels für Geringqualifizierte. IAB-Stellungnahme 1/ 2017. IAB. URL: <http://doku.iab.de/stellungnahme/2017/sn0117.pdf>, accessed: 13.03.2019.

Mauth, R. (2018), Zukunftsbild „Digitales Lernen“: Das lernende Unternehmen 2025. In: Plugmann P (Hrsg.) *Innovationsumgebungen gestalten*. Springer, Wiesbaden, P. 191-205.

Mayring, P. (2015), *Qualitative Inhaltsanalyse. Grundlagen und Techniken*. Deutscher Studien Verlag, Weinheim.

Mochty, L. (1996), Lernen in der industriellen Produktion. In: Kern, W., Schröder, H. and Weber, J. (Hrsg.), *Handwörterbuch der Produktionswirtschaft*, 2. Auflage. Schäffer-Poeschel, Stuttgart, P. 1074-1085.

Moltzberger, G., Schröder, T., Dehnbostel, P. and Harder, D. (2008), *Weiterbildung in den betrieblichen Arbeitsprozess integrieren*. Waxmann, Münster.

Moschner, B. and Anschütz A. (2010), Kombination und Integration von qualitativen und quantitativen Forschungsmethoden in einem interdisziplinären Forschungsprojekt. In: Diethelm, I., Dörge, C., Hildebrandt, C. and Schulte, C. (Hrsg.), *Didaktik der Informatik. Möglichkeiten empirischer Forschungsmethoden und Perspektiven der Fachdidaktik*. Gesellschaft für Informatik e.V., Bonn, P. 11-20.

Moser, K., Soucek, R., Galais, N. and Roth, C. (2018), *Onboarding – Neue Mitarbeiter integrieren*. Hogrefe, Göttingen.

Petzoldt, A. and Bullinger-Hoffmann, A.C. (2017), Lernen und Kompetenzerwerb am wissensintensiven Arbeitsplatz – Organisationale und technologische Entwicklungen. In: Breit, H., Bullinger-Hoffmann, A.C. and Cantner, U. (Hrsg.), *Produktivität von industriellen Dienstleistungen in der betrieblichen Praxis. Methodik, Dogmatik und Diskurs*. Springer Fachmedien, Wiesbaden, P. 181-193.

Roethlisberger, F. J., Dickson, W. J. (1939), *Management and the worker*. Harvard University Press, Cambridge.

Robinson, D. R., Schofield, J. W. and Steers-Wentzell, K. L. (2005), Peer and cross-age tutoring in math: Outcomes and their design implications. *Educational Psychology Review*, 17(4): P. 327-362.

Rosenstiel, L. von (2003), *Grundlagen der Organisationspsychologie. Basiswissen und Anwendungshinweise*. 5., überarb. Auflage. Schäffer-Poeschel, Stuttgart.

Schacter, D., Gilbert, D. and Wegner, D. (2011), Psychology. 2nd ed. Worth Publishers, New York.

Scharmer, C.-O. (2014), Theorie U. Von der Zukunft herführen. Presencing als soziale Technik. 2. Auflage. Carl-Auer-Verlag, Heidelberg.

Senderek, R., Mühlbradt, T. and Buschmeyer, A. (2015), Demografiesensibles Kompetenzmanagement für die Industrie 4.0. In: Jeschke, S., Richert, A., Hees, F. and Jooß, C. (Hrsg.), Exploring Demographics. Springer, Wiesbaden, P. 281-295.

Sonntag, K. and Stegmaier, R. (2007), Arbeitsorientiertes Lernen: Zur Psychologie der Integration von Lernen und Arbeit, 1. Auflage. Kohlhammer, Stuttgart.

Staudacher, N. (2019), Digitale Spiele und ihr Potenzial als Bildungs- und Lernräume - In: Magazin Erwachsenenbildung.at 13 (2019) 35-36, P. 7.

Taylor, F. (1911), Scientific management. Comprising shop management, the principles of scientific management [and] testimony before the special House committee. Conn. Greenwood Press, Westport.

Wegge, J. and van Dick, R. (2005), Arbeitszufriedenheit, Emotionen bei der Arbeit und organisationale Identifikation. In: Fischer, L. (Hrsg.), Arbeitszufriedenheit. Konzepte und empirische Befunde. Hogrefe, Göttingen, P. 11-36.

Wright, T. P. (1936), Factors Affecting the Cost of Airplanes. Journal of the Aeronautical Sciences 3 (4): P. 122-128.

Zobel, B., Werning, S., Berkemeier, L. and Thomas, O. (2018), Augmented- und Virtual-RealityTechnologien zur Digitalisierung der Aus- und Weiterbildung – Überblick, Klassifikation und Vergleich. In: Thomas, O., Metzger, D. and Niegemann, H. (Hrsg.), Digitalisierung in der Aus- und Weiterbildung. Virtual und Augmented Reality für Industrie 4.0. Springer, Berlin, P. 20-34.

52. **Werner Pepels** Aug. 1990
Integrierte Kommunikation
53. **Martin Dettinger-Klemm** Aug. 1990
Grenzen der Wissenschaftsfreiheit. Überlegungen zum Thema: Freiheit und Verantwortung des Wissenschaftlers
54. **Werner Pepels** Sept. 1990
Mediaplanung – Über den Einsatz von Werbegeldern in Medien
55. **Dieter Pflaum** Sept. 1990
Werbeausbildung und Werbemöglichkeiten in der DDR
56. **Rudi Kurz (Hrsg.)** Nov. 1990
Ökologische Unternehmensführung – Herausforderung und Chance
57. **Werner Pepels** Jan. 1991
Verkaufsförderung – Versuch einer Systematisierung
58. **Rupert Huth, Ulrich Wagner (Hrsg.)** Aug. 1991
Volks- und betriebswirtschaftliche Abhandlungen. Prof. Dr. Dr. h.c. Tibor Karpati (Universität Osijek in Kroatien) zum siebzigsten Geburtstag. Mit einem Vorwort von R. Huth und Beiträgen von H.-J. Hof, H. Löffler, D. Pflaum, B. Runzheimer und U. Wagner
59. **Hartmut Eisenmann** Okt. 1991
Dokumentation über die Tätigkeit einer Industrie- und Handelskammer – Dargestellt am Beispiel der IHK Nordschwarzwald
60. **Ursula Hoffmann-Lange** Dez. 1991
Eliten und Demokratie: Unvereinbarkeit oder notwendiges Spannungsverhältnis?
61. **Werner Pepels** Dez. 1991
Elemente der Verkaufsgesprächsführung
62. **Wolfgang Berger** Dez. 1991
Qualifikationen und Kompetenzen eines Europa-managers
63. **Günter Staub** Jan. 1992
Der Begriff „Made in Germany“ – Seine Beurteilungskriterien
64. **Martin W. Knöll, Hieronymus M. Lorenz** Mai 1992
Gegenstandsbereich und Instrumente der Organisationsdiagnose im Rahmen von Organisationsentwicklungs (OE)-Maßnahmen
65. **Werner Lachmann** Juni 1992
Ethikversagen – Marktversagen
66. **Paul Banfield** Juni 1993
Observations On The Use Of Science As A Source Of Legitimation In Personnel Management
67. **Bernd Noll** Aug. 1993
Gemeinwohl und Eigennutz. Wirtschaftliches Handeln in Verantwortung für die Zukunft – Anmerkungen zur gleichnamigen Denkschrift der Evangelischen Kirche in Deutschland aus dem Jahre 1991
68. **Siegfried Kreutzer, Regina Moczdlo** Aug. 1993
Die Entdeckung der Wirklichkeit – Integrierte Projektstudien in der Hochschulausbildung
69. **Sybil Gräfin Schönfeldt** Aug. 1993
Von Menschen und Manieren. Über den Wandel des sozialen Verhaltens in unserer Zeit. Vortrag gehalten im Rahmen des Studium Generale der Hochschule Pforzheim, Wintersemester 1992/93
70. **Hartmut Löffler** Dez. 1993
Geld- und währungspolitische Grundsatzüberlegungen für ein Land auf dem Weg zur Marktwirtschaft – Das Beispiel Kroatien
71. **Hans-Georg Köglmayr, Kurt H. Porkert** Nov. 1994
Festlegen und ausführen von Geschäftsprozessen mit Hilfe von SAP-Software
72. **Alexa Mohl** Febr. 1995
NLP-Methode zwischen Zauberei und Wissenschaft. Vortrag gehalten im Rahmen des Studium Generale der Hochschule Pforzheim, Wintersemester 1994/95
73. **Bernd Noll** Mai 1995
Marktwirtschaft und Gerechtigkeit: Anmerkungen zu einer langen Debatte
74. **Rudi Kurz, Rolf-Werner Weber** Nov. 1995
Ökobilanz der Hochschule Pforzheim. 2. geänderte Auflage, Jan. 1996
75. **Hans Lenk** Mai 1996
Fairneß in Sport und Wirtschaft. Vortrag gehalten im Rahmen des Studium Generale der Hochschule Pforzheim, Wintersemester 1995/96
76. **Barbara Burkhardt-Reich, Hans-Joachim Hof, Bernd Noll** Juni 1996
Herausforderungen an die Sozialstaatlichkeit der Bundesrepublik
77. **Helmut Wienert** März 1997
Perspektiven der Weltstahlindustrie und einige Konsequenzen für den Anlagenbau
78. **Norbert Jost** Mai 1997
Innovative Ingenieur-Werkstoffe
79. **Rudi Kurz, Christoph Hubig, Ortwin Renn, Hans Diefenbacher** Sept. 1997
Ansprüche in der Gegenwart zu Lasten der Lebenschancen zukünftiger Generationen
80. **Björn Engholm** Okt. 1997
Ökonomie und Ästhetik. Vortrag gehalten im Rahmen des Studium Generale der Hochschule Pforzheim, Wintersemester 1996/97. 2. geänderte Auflage. Jan. 1998
81. **Lutz Goertz** Sept. 1998
Multimedia quo vadis? – Wirkungen, Chancen, Gefahren. Vortrag gehalten im Rahmen des Studium Generale der Fachhochschule Pforzheim, Wintersemester 1996/97
82. **Eckhard Keßler** Nov. 1998
Der Humanismus und die Entstehung der modernen Wissenschaft. Vortrag gehalten im Rahmen des Studium Generale der Hochschule Pforzheim, Wintersemester 1996/97
83. **Heinrich Hornef** Febr. 1998
Aufbau Ost – Eine Herausforderung für Politik und Wirtschaft. Vortrag gehalten im Rahmen des Studium Generale der Fachhochschule Pforzheim, Wintersemester 1997/98

84. **Helmut Wienert** Juli 1998
50 Jahre Soziale Marktwirtschaft – Auslaufmodell oder Zukunftskonzept? Vortrag gehalten im Rahmen des Studium Generale der Hochschule Pforzheim, Sommersemester 1998
85. **Bernd Noll** Sept. 1998
Die Gesetzliche Rentenversicherung in der Krise
86. **Hartmut Löffler** Jan. 1999
Geldpolitische Konzeptionen - Alternativen für die Europäische Zentralbank und für die Kroatische Nationalbank
87. **Erich Hoppmann** Juni 1999
Globalisierung. Vortrag gehalten im Rahmen des Studium Generale der Hochschule Pforzheim, Sommersemester 1999
88. **Helmut Wienert (Hrsg.)** Dez. 1999
Wettbewerbspolitische und strukturelle Konsequenzen der Globalisierung. Mit Beiträgen von Hartmut Löffler und Bernd Noll
89. **Ansgar Häfner u.a. (Hrsg.)** Jan. 2000
Konsequenzen der Globalisierung für das internationale Marketing. Mit Beiträgen von Dieter Pflaum und Klaus-Peter Reuthal
90. **Ulrich Wagner** Febr. 2000
Reform des Tarifvertragsrechts und Änderung der Verhaltensweisen der Tarifpartner als Voraussetzungen für eine wirksame Bekämpfung der Arbeitslosigkeit
91. **Helmut Wienert** April 2000
Probleme des sektoralen und regionalen Wandels am Beispiel des Ruhrgebiets
92. **Barbara Burkhardt-Reich** Nov. 2000
Der Blick über den Tellerrand – Zur Konzeption und Durchführung eines „Studium Generale“ an Fachhochschulen
93. **Helmut Wienert** Dez. 2000
Konjunktur in Deutschland - Zur Einschätzung der Lage durch den Sachverständigenrat im Jahresgutachten 2000/2001
94. **Jürgen Wertheimer** Febr. 2001
Geklonte Dummheit: Der infantile Menschenpark. Vortrag gehalten im Rahmen des Studium Generale der Hochschule Pforzheim, Wintersemester 2000/01
95. **Konrad Zerr** März 2001
Erscheinungsformen des Online-Research – Klassifikation und kritische Betrachtung
96. **Daniela Kirchner** April 2001
Theorie und praktische Umsetzung eines Risikomanagementsystems nach KontraG am Beispiel einer mittelständischen Versicherung
97. **Bernd Noll** Mai 2001
Die EU-Kommission als Hüterin des Wettbewerbs und Kontrolleur von sektoralen und regionalen Beihilfen

Peter Frankenfeld
EU Regionalpolitik und Konsequenzen der Osterweiterung
98. **Hans Joachim Grupp** Juni 2001
Prozessuale Probleme bei Beschlussmängelstreitigkeiten in Personengesellschaften
99. **Norbert Jost (Hrsg.)** Juli 2001
Technik Forum 2000: Prozessinnovationen bei der Herstellung kaltgewalzter Drähte. Mit Beiträgen von Peter Kern, Wilhelm Bauer, Rolf Ilg; Heiko Dreyer; Johannes Wößner und Rainer Menge
100. **Urban Bacher, Mikolaj Specht** Dez. 2001
Optionen – Grundlagen, Funktionsweisen und deren professioneller Einsatz im Bankgeschäft
101. **Constanze Oberle** Okt. 2001
Chancen, Risiken und Grenzen des M-Commerce
102. **Ulrich Wagner** Jan. 2002
Beschäftigungshemmende Reformstaus und wie man sie auflösen könnte
Jürgen Volkert
Flexibilisierung durch Kombi-Einkommen? Die Perspektive der Neuen Politischen Ökonomie
103. **Mario Schmidt, René Keil** März 2002
Stoffstromnetze und ihre Nutzung für mehr Kostentransparenz sowie die Analyse der Umweltwirkung betrieblicher Stoffströme
104. **Kurt Porkert** Mai 2002
Web-Services – mehr als eine neue Illusion?
105. **Helmut Wienert** Juni 2002
Der internationale Warenhandel im Spiegel von Handelsmatrizen
106. **Robert Wessolly, Helmut Wienert** Aug. 2002
Die argentinische Währungskrise
107. **Roland Wahl (Hrsg.)** Sept. 2002
Technik-Forum 2001: Weiterentwicklungen an Umformwerkzeugen und Walzdrähten. Mit Beiträgen von Roland Wahl, Thomas Dolny u.a., Heiko Pinkawa, Rainer Menge und Helmut Wienert
108. **Thomas Gulden** April 2003
Risikoberichterstattung in den Geschäftsberichten der deutschen Automobilindustrie
109. **Günter Altner** Mai 2003
Lasset uns Menschen machen – Der biotechnische Fortschritt zwischen Manipulation und Therapie. Vortrag gehalten im Rahmen des Studium Generale der Hochschule Pforzheim, Sommersemester 2003
110. **Norbert Jost (Hrsg.)** Juni 2003
Technik-Forum 2002: Innovative Verfahren zur Materialoptimierung. Mit Beiträgen von Norbert Jost, Sascha Kunz, Rainer Menge/Ursula Christian und Berthold Leibinger
111. **Christoph Wüterich** Februar 2004
Professionalisierung und Doping im Sport. Vortrag gehalten im Rahmen des Studium Generale der Hochschule Pforzheim, Sommersemester 2003
112. **Sabine Schmidt** Mai 2004
Korruption in Unternehmen – Typologie und Prävention
113. **Helmut Wienert** August 2004
Lohn, Zins, Preise und Beschäftigung – Eine empirische Analyse gesamtwirtschaftlicher Zusammenhänge in Deutschland
114. **Roland Wahl (Hrsg.)** Sept. 2004
Technik-Forum 2003: Materialentwicklung für die Kaltumformtechnik. Mit Beiträgen von Andreas Baum, Ursula Christian, Steffen Nowotny, Norbert Jost, Rainer Menge und Hans-Eberhard Koch
115. **Dirk Wenzel** Nov. 2004
The European Legislation on the New Media: An Appropriate Framework for the Information Economy?

116. **Frank Morelli, Alexander Mekyska, Stefan Mühlberger** Dez. 2004
Produkt- und prozessorientiertes Controlling als Instrument eines erfolgreichen Informationstechnologie-Managements
117. **Stephan Thesmann, Martin Frick, Dominik Konrad** Dez. 2004
E-Learning an der Hochschule Pforzheim
118. **Norbert Jost (Hrsg.)** Juni 2005
Technik-Forum 2004: Innovative Werkstoffaspekte und Laserbehandlungstechnologien für Werkzeuge der Umformtechnik
119. **Rainer Gildeggen** Juni 2005
Internationale Produkthaftung
120. **Helmut Wienert** Oktober 2005
Qualifikationsspezifische Einkommensunterschiede in Deutschland unter besonderer Berücksichtigung von Universitäts- und Fachhochschulabsolventen
121. **Andreas Beisswenger, Bernd Noll** Nov. 2005
Ethik in der Unternehmensberatung – ein verminntes Gelände?
122. **Helmut Wienert** Juli 2006
Wie lohnend ist Lernen? Ertragsraten und Kapitalendwerte von unterschiedlichen Bildungswegen
123. **Roland Wahl (Hrsg.)** Sept. 2006
Technik-Forum 2005: Umformwerkzeuge - Anforderungen und neue Anwendungen. Mit Beiträgen von Edmund Böhm, Eckhard Meiners, Andreas Baum, Ursula Christian und Jörg Menno Harms
124. **Mario Schmidt** Dez. 2006
Der Einsatz von Sankey-Diagrammen im Stoffstrommanagement
125. **Norbert Jost (Hrsg.)** Okt. 2007
Technik-Forum 2006: Innovative neue Techniken für Werkzeuge der Kaltverformung. Mit Beiträgen von Franz Wendl, Horst Bürkle, Rainer Menge, Michael Schiller, Andreas Baum, Ursula Christian, Manfred Moik und Erwin Staudt.
126. **Roland Wahl (Hrsg.)** Okt. 2008
Technik-Forum 2007: Fortschrittsberichte und Umfeldbetrachtungen zur Entwicklung verschleißreduzierter Umformwerkzeuge. Mit Beiträgen von Klaus Löffler, Andreas Zilly, Andreas Baum und Paul Kirchhoff.
127. **Julia Tokai, Christa Wehner** Okt. 2008
Konzept und Resultate einer Online-Befragung von Marketing-Professoren an deutschen Fachhochschulen zum Bologna-Prozess
128. **Thomas Cleff, Lisa Luppold, Gabriele Naderer, Jürgen Volkert** Dez. 2008
Tätermotivation in der Wirtschaftskriminalität
129. **Frank Thuselt** Juni 2009
Das Arbeiten mit Numerik-Programmen. MATLAB, Scilab und Octave in der Anwendung.
130. **Helmut Wienert** August 2009
Wachstumsmotor Industrie? Zur Bedeutung des verarbeitenden Gewerbes für die Entwicklung des Bruttoinlandsprodukts
131. **Sebastian Schulz** Sept. 2009
Nutzung thermodynamischer Datensätze zur Simulation von Werkstoffgefügen (aus der Reihe „Focus Werkstoffe“, Hrsg. Norbert Jost).
132. **Hanno Beck; Kirsten Wüst** Sept. 2009
Gescheiterte Diäten, Wucherzinsen und Wartepremien: Die neue ökonomische Theorie der Zeit.
133. **Helmut Wienert** Sept. 2009
Was riet der Rat? Eine kommentierte Zusammenstellung von Aussagen des Sachverständigenrats zur Regulierung der Finanzmärkte und zugleich eine Chronik der Entstehung der Krise
134. **Norbert Jost (Hrsg.): Technik-Forum 2008**
Werkstoffe und Technologien zur Kaltverformung
135. **Frank Morelli** Januar 2010
Geschäftsprozessmodellierung ist tot – lang lebe die Geschäftsprozessmodellierung!
136. **T. Cleff, L. Fischer, C. Sepúlveda, N. Walter** Januar 2010
How global are global brands? An empirical brand equity analysis
137. **Kim Neuer** Juni 2010
Achieving Lisbon – The EU's R&D Challenge The role of the public sector and implications of US best practice on regional policymaking in Europe
138. **Bernd Noll** Sept. 2010
Zehn Thesen zur Corporate Governance
139. **Pforzheim University** März 2011
Communication on progress. PRME Report 2008
140. **Rainer Maurer** März 2011
Unternehmensverantwortung für soziale und ökologische Nachhaltigkeit – darf man auch anderer Meinung sein? Einige kritische Anmerkungen zum PRME-Report der Hochschule
140. **Rainer Maurer** März 2011
Unternehmensverantwortung für soziale und ökologische Nachhaltigkeit – darf man auch anderer Meinung sein? Einige kritische Anmerkungen zum PRME-Report der Hochschule
141. **Barbara Reeb, Malte Krome** Okt. 2011
Arm trotz Arbeit? Zum Für und Wider von Mindestlöhnen
142. **Daniel Wyn Müller** Mai 2012
Titanschäume als Knochenimplantat (aus der Reihe „Focus Werkstoffe“, Hrsg. Norbert Jost).
143. **Alexander Martin Matz, Norbert Jost** Mai 2012
Fouling an offenporigen zellulären Werkstoffen auf Al-Basis unter beheizten wässrigen Bedingungen (aus der Reihe „Focus Werkstoffe“, Hrsg. Norbert Jost).
144. **Norbert Jost, Roman Klink (Hrsg.)** Sept. 2012
Tagungsband zum 1. Pforzheimer Werkstofftag
145. **Norbert Jost, Roman Klink (Hrsg.)** Sept. 2012
Tagungsband zum 2. Pforzheimer Werkstofftag. Aus der Reihe „Leichtbau“, Hrsg.: N. Jost, R. Klink.
146. **Helmut Wienert** Febr. 2014
Zur Entwicklung der Hochschulen für Angewandte Wissenschaften (Fachhochschulen) in Deutschland
147. **Jürgen Antony** April 2014
Technical Change and the Elasticity of Factor Substitution
148. **Stephanie Görlach** April 2014
Ressourceneffizienz in Deutschland
149. **Norbert Jost (Hrsg.)** Sept. 2014

- Focus Werkstoffe. Tagungsband zum 3. Pforzheimer Werkstofftag
150. **Bernd Noll** Aug. 2014
Unternehmenskulturen – entscheidender Ansatzpunkt für wirtschaftsethisches Handeln?
 151. **Human Resources Competence Center** April 2015
50 Jahre Personalmanagement an Der Hochschule- Jubiläumsband
 152. **Rainer Maurer** Mai 2015
Auf dem Weg zur weltanschaulichen Bekenntnisschule: Das wirtschaftspolitische Leitbild der Hochschule Pforzheim
 153. **Norbert Jost (Hrsg.)** Okt. 2015
Tagungsband Pforzheimer Werkstofftag
 154. **Jessica Elena Balzer** Nov. 2015
Spielen mit guten Gewissen: Ein Vorschlag zur Zertifizierung der deutschen Spielwarenindustrie und ein Schritt näher zum Schachmatt des Greenwashing
 155. **Jaqueline Paasche** Jan. 2016
Kopieren, transformieren, kombinieren – Ideenklau und Plagiarismus in der Werbung
 156. **Vanessa Zeiler** Jan. 2016
Mobile User Experience – Der Einfluss von kognitivem Entertainment auf die Nutzung mobiler Anwendungen
 157. **Mario Kotzab, Maximilian Pflug** Jan. 2016
Das bedingungslose Grundeinkommen
 158. **Marco C. Melle** Jan 2016
Harmonisierung der heterogenen Unternehmenssteuern in Europa? Plädoyer für einen Mittelweg
 159. **Klaus Möller, Julian Gabel, Frank Bertagnolli** Aug. 2016
fischer Befestigungssysteme: Change Management in der Distributionslogistik – eine Fallstudie
 160. **Klaus Möller, Julian Gabel, Frank Bertagnolli** Aug. 2016
fischer Befestigungssysteme: Change Management in der Distributionslogistik – eine Fallstudie
 161. **Wolfgang Heinz** Nov. 2016
Die Ethik des Strafens
 162. **Norbert Jost, Simon Kött (Hrsg.)** Okt. 2016
Pforzheimer Werkstofftag 2016
 163. **Bettina C.K. Binder**
Kennzahlenmanagement und –controlling Prozessorientiertes Performance Management in internationalen Unternehmen
 164. **Stefan Walz, Jonas Tritschler, Reinhard Rupp**
Erweitertes Management Reporting mit SAP S/4HANA auf Basis des Universal Journals
 165. **Simone Harriehausen**
Wenn ich zwanzig Ziegen will und Du mir keine geben magst – Ein Überblick über die Möglichkeiten und Methoden der Streitbeilegung
 166. **Norbert Jost, Simon Kött (Hrsg.)** Okt. 2017
Pforzheimer Werkstofftag 2017
 167. **Helmut Wienert** Dez. 2017
Pforzheim: Alles Schmuckstadt – oder was?
 168. **Norbert Jost; Simon Kött** September 2018
Pforzheimer Werkstofftag 2018
 169. **Bernd Noll** November 2018
21. Juni 1948 – Startschuss mit Folgen
 170. **Katja Flosdorff** April 2019
Identifikation und Evaluation von Bewertungskriterien zur optimalen Auswahl von Ideen während des Innovationsprozesses
 171. **Theresa Süß** Juni 2019
Inwiefern kann Behavioral Economics das Ernährungsverhalten erklären und beeinflussen?
 172. **Viktor Waldschmidt** Juni 2019
Clickbait, der ganz große Wurf? Eine Studie über die Verwendung von Clickbaits durch Online-Nachrichtenportale und deren Konsequenzen
 173. **Rainer Maurer** Oktober 2019
Normative Werturteile und Wirtschaftswissenschaften
 174. **Kristina Weber** Mai 2020
Künstliche Intelligenz im wertorientierten Marketing – Konzeptualisierung des „Value in Context“ und eine Bewertung KI-gestützter Marketingaktivitäten