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Subject-oriented learning - A new perspective for vocational training in learning factories

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Abstract

The transformation to a digitized company changes not only the work but also social context for the employees and requires inter alia new knowledge and skills from them. Additionally, individual action problems arise. This contribution proposes the subject-oriented learning theory, in which the employees´ action problems are the starting point of training activities in learning factories. In this contribution, the subject-oriented learning theory is exemplified and respective advantages for vocational training in learning factories are pointed out both theoretically and practically. Thereby, especially the individual action problems of learners and the infrastructure are emphasized as starting point for learning processes and competence development.

Keywords: Subject-oriented learning; action problems; vocational training; learning factories

1. Introduction

Work profiles will change massively due to technical innovations and digitized workplaces. Examples are the use of mobile technologies in production that enables faster communication channels between individuals as well as the increased use of databases in problem situations [1]. Therefore, the competence to deal with new technologies is required. At the same time, technical systems are becoming more complex as a result of increasing automation, which raises their susceptibility to errors due to situations that cannot be anticipated in advance [2]. Among other things, employees have the task of acting as control authorities to react reflexively to errors in technical working environments [3]. Experience-based activities and the ability to apply this knowledge also in the sense of action competence accordingly gain in importance. Therefore, it is not sufficient to only consider the technical dimension of digital

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transformation. Technology-addressing training must be accompanied by theoretically sound and conceptually designed vocational training to supplement individual learning processes and train competencies [4]. In conventional vocational training, competence development is realized through control and steering of individual learning processes. Thereby, it is assumed that competences can be developed through teaching. This assumption is based on the behavioristic tradition that reduces human learning to a "stimulus-response pattern" and presumes controllability of the learning process. This mechanistic mode of operation is considered to be outdated [5] because complex processes taking place within the individual - such as the subjective evaluation of individual action problems and social influences - are excluded under the metaphor of the "black box" [6]. Social mechanisms and their influences on individual learning reasons remain unnoticed by this stimulus-response scheme [5]. This opens up a functionalist perspective on learning, which understands people as controllable "trivial machines" by means of action stimuli. The main addressed question in the *behavioristic understanding of learning* is how people learn. The questions of what people motivates to learn and how this can be triggered remain unanswered. As a result, the widely prevalent behavioristically motivated vocational training must be critically questioned.

Disregarding the influences of social mechanisms on human learning means equating human and animal learning behaviors [7, 8]. Humans are social beings and cannot exist outside social contexts. The investigation of human behavior must accordingly be carried out with recourse to social contexts [9]. Addressing the problematic exclusion of social contexts, an alternative learning approach must recognize people as social beings whose (learning) actions (1) are influenced by society [5]. Peoples (learning) actions are also intrinsically motivated. Therefore, (2) individual learning reasons have to be considered for explaining learning processes and included in teaching approaches [5]. Intrinsic motivation is not enforceable by external stimuli. Accordingly, (3) a causal connection between learning and external stimuli cannot be assumed because (4) learning cannot be understood as a process that is controllable from outside [5].

In this contribution, a paradigm shift towards subject-oriented training is proposed, in which individual learning dispositions are the beginning of training activities. The goal of this paper is to introduce a complementary approach for vocational training, which is based on subject-oriented learning (SOL) theory and focuses employees´ action problems and individual reasons to learn as a starting point for competence development. For this purpose, a theory transfer is applied. First, different approaches to learning are worked out on the basis of a literature analysis. Following this, the basic ideas of traditional theories and SOL are emphasized and compared to each other (Sec. 2). Afterwards, the understanding of SOL will be further explored. On this base, the potentials of individual reasons to learn and individual action problems for vocational training are pointed out (Sec. 3). These individual action problems can be picked up in learning factories, in which employees can learn and train without interrupting production processes (Sec. 4). Finally, a summary is given and conclusions are drawn (Sec. 5).

2. Overview of learning theories

Human work performance remains a relevant success factor of digital transformation [4]**.** However, the topic of target group-oriented vocational training does not receive sufficient attention both in theory and in practice due to the technology focus [10]**.** Adults require special formats and forms that cannot be realized by traditional approaches [3]: Vocational training is mostly done through frontal teaching, which is based on the behaviouristic stimulus-response model or related concepts that assume a causality between teaching and learning [5]**.** Their popularity is based on supposed controllability: if learning processes can be controlled and planned, they can inter alia be used for economic exploitation. This understanding proved to be too short-sighted, since unexpected human behavior [7] cannot be explained and individual reasons to learn are not taken into account.

The criticism of the "black box" was taken up by the *cognitive-psychological approach*. Individuals are understood as open systems whose internal structures are not simply recognizable from the outside [8]. Learning processes are understood as information processing processes between subjectively constructed structures and structural conditions of the environment [7]. Central factors are the individual and the environment. Essential aspects are the adaptation to environmental influences by the individual (assimilation) as well as the change of the environment by the individual

(accommodation) [11]. The focus is on balancing individual and external forces through both processes [12]. Cognitive-psychological approaches, however, do not include social contexts in the analysis of learning processes. By excluding social dimensions, a causality subordination of human learning remains prevalent [8]. This limits the scope of cognitive learning theories. In addition, the social implications of the changes induced by digitization are too great to leave them unnoticed in vocational training.

Constructivist learning theory also regards learning as the processing of external information. Within this approach, both, radical and moderate constructivism have developed. Radical constructivism understands objective reality as an entity constructed individually by each person. However, the existence of collective truths is hidden [8]. In moderate constructivism, subjects are not understood as open but as closed and thus self-referential systems [7]. The individual learner's structures, intentions, and processes cannot be penetrated from the outside. Although teachers and learners cannot reconstruct each other, both systems are loosely coupled with each other. Statements about social connections and their emergence can, however, only be made as individual integrations [13]. A critical reflection of socially given mechanisms of action on individual learning reasons is thus not possible, since these do not actually exist in this theoretical perspective. The exclusion of social context in vocational training is to be regarded as extremely critical against the socio-economic consequences to be expected from digitization.

The *subject-oriented understanding* of learning defines learning as an intrinsically motivated process that cannot be controlled from outside and is based on individual reasons for learning [5]. Learning processes are aimed at expanding the self-understanding and the influence on the environment [14] by realizing opportunities given by society. In this way, this understanding of learning clearly distinguishes itself from the other which understand learning processes as an adaptation to external stimuli [8]. The basis for this is the assumption that the relationship between subject and environment is characterized by a duality, that is, social contexts constitute the world in which individuals live. Equally, however, individuals also shape this society through actions, whereby both aspects are mutually dependent [5, 15]. Consequently, learning processes cannot be initiated by external influences such as teaching and their results cannot be predetermined [5]. Teaching is understood as external activity. Learning processes can be supported by teachers, but they cannot be triggered or purposefully directed by them [16]. The table (1) shows the results of the comparison of the theories using the criteria introduced in section 1.

Table 1. Evaluation of learning theories.

Criteria	Behaviouristic learning theory	Cognitive psychology learning theory	Constructivist learning theory	Subject-oriented learning theory
Inclusion of social influences	○	◉	◉	●
Inclusion of individual reasons for learning	○	○	○	●
No causality between learning and stimuli	○	○	◉	●
Learning is not controllable from outside	○	○	●	●

● *criteria fulfilled,* ◉ *criteria partly fulfilled,* ○ *criteria not met,* □ *criteria not assessable*

Learning processes and consequential learning successes cannot be "produced". Based on the SOL theory, which is particularly promising for adults [3], the individual reasons to learn and action problems, as well as the conditions under which these learning processes are initiated and intrinsic factors (e.g., meaningful use of time and individual interests), are increasingly coming to the fore. To point out the full potentials of SOL for training, it is necessary to give a deeper understanding of basic concepts, especially to action problems and individual reasons to learn.

3. Basic positions of subject-oriented learning

In SOL, a distinction is made between defensive and expansive learning [5, 16]. Defensive learning marks an adaptation to external expectations and remains located at the level of primary action. The learners try to meet requirements with all means at their disposal - for example by memorizing presented facts or by cheating - to avert external threats. Although externally defined further training objectives can be achieved, a deeper penetration of

knowledge content is not sufficiently possible. This so-called restrictive ability to act [5] cannot meet the challenges of digitally transformed working environments as, for example, the control of machines requires a comprehensive process understanding. The extension of the individual ability to act, on the other hand, is defined as expansive learning [17]. Possibilities for action are materialized in objects, which in principle can be turned from people into learning objects with the aim of expanding individual power of disposal [5]. Learning is initiated, when subjects encounter action problems on a level of primary action that they cannot solve with existing skills. Parts of an action problem are transformed into a learning problem located on a level of learning action in order to resolve them with the help of learning loops. Therein, objects are abstracted in order to expose materialized options for action by means of object digestion. The gained knowledge leads to an extended individual ability to act (Fig. 1).
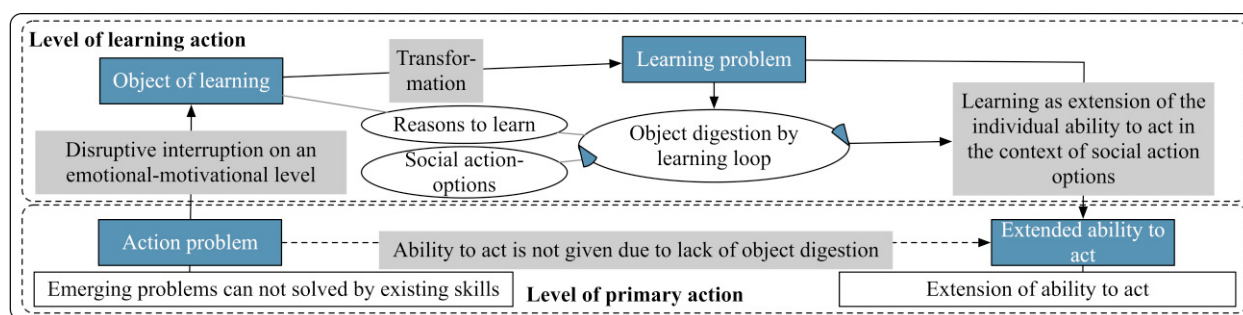

Fig. 1. Learning process on the basis of SOL learning theory.

3.1. Action problems as a basis for learning problems

An action problem marks the irritating interruption of everyday action processes in which emerging problems can no longer be solved by existing skills [5] and are thus regarded as initiators of learning processes [17]. Action problems, however, are only classified by subjects as the starting point of learning efforts, if they are perceived as such. Only the subjectively classified action problems are transformed into learning problems [14], which trigger learning processes and ultimately lead to learning success. In the respective reference action on the level of primary action, experiences must be made that show the individual's lack of access to a topic. The resulting action problem must irritate everyday action to such an extent that it can only be resumed by solving the problem through learning. This leads to a disruptive interruption on an emotional-motivational level, on which learning objects are created [5]. Reasons for this imperceptibility can be social limits or a lack of knowledge as well as abilities that have not (yet) been acquired but are elementary for keeping the ability to act [18,14]. The anticipation of a problem's potential relevance is elementary for its transformation into learning problems [18]: The transformation is only initiated by an individual if the resolution of the problem through learning is regarded by the individual as an effective way to expand social participation [17]. The discrepancy between will and ability should also not be resolvable by learning at the level of primary action, as this would make abstraction unnecessary [5].

3.2. Learning problems as a starting point for learning processes

The abstraction of an action problem into a learning problem and its reflection occurs as a learning loop that aims to expand the individual ability to act in the context of opportunities given by society. In the loop, the learner is given the opportunity to reflect on current or anticipated problematic action situations. The resulting knowledge increases the learner's own ability to act [5]. The possibility of acquiring or securing the individual ability to act, which is inherent in every learning process, is therefore also to be understood as an expansion of social participation (-possibilities). In this context, learning also means recognizing and overcoming social given boundaries. For example, if employees recognize limits in vocational training like subjectively perceived or existing risks of rationalization, these limits must consequently be discussed and addressed in a solution-oriented manner as obstacles to individual power of disposal. If this is not done or if the concerns of the employees are not taken seriously, resistance to learning

and its justifications remain in the behaviouristic understanding of a disorder. However, the assumption in behaviourism that these learning resistances can be overcome with the help of external stimuli always leads to defensive learning.

3.3. Extended ability to act by object digestion

Learning addresses an objective approach. For this purpose, both objectively existing and objectified possibilities for action as well as subjective approaches must be considered. The understanding of an object can be "deep" or "flat". The deeper a subject penetrates the objectified possibilities of action, the better can these be placed in larger social, organizational, or procedural contexts. The SOL theory defines this as an extended ability to act [5]. The penetration can take place by the exchange with teachers. Teachers and learners should not stand in conventional teacher-student structures, since immanent hierarchies can lead to defensive learning [5]. Learners should be understood as experts like teachers with the right to exchange knowledge and ideas. The task of the teacher is to understand the individual reasons to learn and to take these into account when communicating one's own knowledge about the object [17]. The different perspectives give a learner the opportunity to expose materialized options for action, which leads to an extended individual ability to act. If, however, the learning object and the actual object coincide, only a restrictive ability to act is realized. In summary, the acquisition of an extended ability to act can, inter alia, lead to an increase in reflexive ability to act in the context of fluid work situations, as is necessary for work in digitally modified work environments. As explained above, however, in addition to expansive reasons for learning, an orientation towards the individual action problems of the employees´ is necessary, because only these can be transformed into learning problems.

4. Advantages of subject-oriented vocational training in learning factories

Practical relevance is a relevant success factor for vocational training [3]. In learning factories, it can be created by simulating products, processes, and resources in an experience-oriented and participative learning environment, whereby knowledge about processes and procedures as well as concrete manual skills are developed [4]. However, adults only learn when learning efforts are intrinsically motivated and in line with their own interests [3, 5]. If the educational opportunities in learning factories are designed without reference to the individual needs of the learners, it can lead to a negative attitude which favours defensive learning. By pursuing a SOL approach, learning factories can be (re-)configured at all times to the individual interests and needs of learners. That allows for prepossessing the prerequisites of adult learning. Utilizing given technically capabilities, addressing action problems in learning factories can take place by simulated scenarios. These scenarios should be oriented at real-world situations. Learning factories need to cover a large number of them to deal with different topics from different perspectives because a machinist has different action problems (e.g., changes in the work process) than an engineer (e.g., combinability with analogue machines). SOL can be realized by diverse approaches. Two options are exemplarily introduced in the following, that are concerned with employees´ action problems: 1.) selecting and modifying a potentially relevant scenario according to an existing individual action problem and 2.) taking advantage of the infrastructure of learning factories to confront participants with new action problems (e.g. a machine failure in the production process).

4.1. Addressing an existing action problem with scenarios

For addressing learners' action problems, they must be recognized as such and a broad catalogue of possible scenarios needs to be available. For example, the action problem *working in a digitized logistic* could be identified in an interview. A matching scenario helps to show participants the advantages of a digitally enriched environment. The scenario *working in a digitally enriched warehouse* could be a suitable scenario. By adding special features (e. g., integrating tablets to present potentials for remote controlled packet flow), a focus depending on individual interests can be set. The learners have to use the tablet to check and navigate (simulated) packages equipped with radio-frequency identification in the (simulated) warehouse. If the perceived potentials of the tablet using (e.g., access and control options to digital warehouse infrastructure through tablets) are great enough, the experience can lead to the motivation to deal more intensively with the possibilities of digitized logistic environments. As a result, the participants

also recognize that in order to be able to use these identified potentials, certain new knowledge and skills are necessary, which they do not possess (yet). In this case, these could be the skills to properly use digital media as knowledge carriers. If this knowledge leads to a disruptive interruption on an emotional-motivational level, certain learning objects are outsourced by employees´ in order to resolve the action problem and gain their ability to act. Individual learning problems can arise - for example, the urge to understand and use the potentials of digital working environments for more comfortable work - and can be addressed and resolved by deep penetration of the (learning) object. Exchange with teachers provides learners the opportunity to explore this object in learning loops. E.g., penetrating the learning object *principles of networked environments with a focus on digital media* can extend the ability to act by increasing the understanding of processes.

4.2. Learning environment as trigger for new action problems

New action problems can also be triggered using the infrastructure of learning factories. A possible option is to deliberately cause malfunctions in scenarios. To ensure practical relevance, it is necessary to create or choose a scenario that is constructed similarly to the work processes of the employees. If a maintenance-related action problem should be triggered, a scenario *digitally supported machine maintenance* could be created or modified. To enable a high immersion in the simulation, both the type of machines and the type of potential malfunctions must be configured according to the employees´ workplace. Learning factories also allow to modify and implement parts of existing work processes into scenarios. By replacing an analogue machine with a digital machine, it is possible, for example, to display upcoming workplace changes or scale the degree of digitization. Other action problems can be triggered as a result. When learners check the machines for anomalies in the current maintenance related scenario, they can get confronted with exceeded measured values on a simulated machine. The challenge of analysing and dealing with the detected disruption can trigger individual action problems (e.g., dealing with malfunctions in digital productions). Resulting learning problems such as the use of digital media for troubleshooting can be resolved in the learning factory by process-oriented object penetration: own solutions like accessing a repair database and applying identified information can be developed and tested in the learning scenarios without pressure and risks like production downtimes. A consequent exchange with teachers gives learners the option to reflect on their solutions at the level of learning actions. The combination of a highly immersive scenario and the following reflection enables employees to extend their ability to act in own work processes like the *purposeful use of digital media in maintenance*.

5. Conclusion, implications and outlook

Employees play an elementary role in digital transformation. However, working environments and processes are becoming increasingly fluid. This results in the necessity of reflexive ability to act based on one's own knowledge, skills, and competences. At present, however, the conceptual and practical work of vocational training is based on an understanding of learning that is most comparable to that of behaviourism. The therein lying stimulus-response pattern cannot do justice to the complexity of human learning and understanding processes. In conceptual and practical terms, conducting vocational training based on a SOL approach can help to meet the challenges of digitization in a future-oriented way: By picking up employees' individual action problems, the addressed person independently realizes a deep penetration of learning objects at the level of learning action. Additionally, it is very important to take into account employees´ reasons to learn because they only will learn if they can increase their individual ability to act in the context of opportunities given by society. For vocational training, this means to move away from a top-down motivated approach. Rather, employees and their reasons to learn must be positioned as equal partners through a participatory approach in vocational education and training.

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