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The need for diverse and safe Learning Factory Environments

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Abstract

In much adult education, some participants cannot immediately see the benefit of what and why they must learn. The reason for this can be that they are 'sent' to education without experiencing a need for learning, or they cannot see the educational content reflected in their daily routines. In both cases, the better the learning facilitator/designer can provide a convincing learning environment, the more motivated the participants. If adult learners experience perceptions contrary to their own, they try to reconcile these perceptions so that there is coherence in their universe of meaning. However, in this way, the learning process starts. The diverse and safe learning factory environment concept aims to make a more relevant learning environment and let the learner bridge these perceived gaps easier. A relevant learning process needs to contain a balanced degree of challenge in the form of 'disturbances'. If the challenge is too small, the participants' motivation is limited because the content is not interesting or relevant. The participants are bored. If the challenge is too great, the participants' motivation decreases because it creates uncertainty. The participants become insecure and feel unsafe. Therefore, it is central that the learning factory environment is scoped and targeted with respect to the participants' diverse perceptions and can relate to them through diverse interactions. Furthermore, the type and scope of challenges also affect the design of the learning environment. This paper investigate concepts to create well-scoped learning factory activities, and diverse environments towards adult learners enrolled in learning factories for further education. These concepts are described with regards to both operational models and didactics, targeting diverse learners and circumstances.

1. Introduction

Despite agreement on the potential for using Industry 4.0 (I4.0) technologies to make technological advancements in the production [1] and improve the competitiveness of the company [2], the implementation in the industry of innovative and valuable i4.0 solutions is highly complicated and requires a dedicated focus on developing new skills and competences [3, 4, 5]. However, existing learning methods may be too time-consuming for extramural learners under upskilling, while they, at the same time, may restrict the inclusion of participants' experiences and thereby the potential for achieving innovative solutions [6]. Consequently, new and faster learning methods which support the development of i4.0 manufacturing systems and other learning areas are required [7]. Several examples exist from academia and industry where learning factories are used to train and thus support development [7, 8, 9]. However, we argue that the concept of learning factories has broader usefulness for conceptualising the development and design of generic learning environments and learning processes. Since research on this topic is scarce and fragmented, a common frame of reference is needed to create a conceptual understanding of the field. Reference models seek to create shared understandings of, e.g., a research field [10].

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Therefore, this research aims to present the initial work of a reference model, which can provide a common understanding of the development and design of diverse learning environments in Learning Factories. This is achieved by seeking to answer the research question: How can diverse learning environments and approaches support processes of learning in Learning Factories? This article investigates the need for diverse learning environments in dynamic settings with a fast expiration of knowledge and skills, such as the I4.0-setting. First, the generic adult learning context is introduced. Afterwards, different approaches to adult learning are unfolded and related to the conceptualisation of diverse learning environments in Learning Factories operating in the adult continuing education system. Finally, conclusions on the research are presented.

2. Adult learners want to learn, but encounter learning with ambivalence

When adults participate in learning situations, they basically want to obtain skills and competencies they can see concerning their everyday lives [11]. They want to become wiser and develop their skills, and they are basically motivated to learn[12]. However, they also want to feel comfortable in the learning situation, and they want to be involved in deciding how the learning process proceeds and how they should relate to what is learned [13]. If the learning environment contributes to this, then the motivation of the adult learner is maintained.

When you learn something, it means you change your way of thinking [14]. Learning can help you become better at doing what you are used to do, and reach higher taxonomical levels: You become more experienced, and are able to link these experiences with new and old knowledge [14, 15, 16,]. Learning can also help you to do something different from what you are used to. You can break the routines[17]. But having to do something else can be emotionally stressful. It can be associated with fear and insecurity to change ones established action patterns and habits[17]. This dilemma means that adult learners often encounter learning situations with ambivalence [18].

The adult learners ambivalence can be observed when the learning situation is relevant and relate to something significant [11]. It is therefore important that the ambivalence is coped constructively. A constructive coping may be that the learners become aware that it is precisely about learning something new, breaking routines that is difficult[17]. The constructive coping with ambivalence thereby allows the participants to work with and reflect on the learning process so that they are allowed to integrate the new insight into their self-understanding [19]. If the participants understand the ambivalence, it is constructive, and not simply accept of it. When the learning process enables the adult participant to cope with the ambivalence; the more relevant the learning process becomes, the more motivating the learning process becomes and the more learned.

If *not* acknowledged and coped with, ambivalence may lead to resistance[11, 17]. Resistance to learn can take different forms in learning processes - some more visible than others. Resistance from the learner can be observed when that they become introverted or silent. Furthermore, it can be a strong emotional reaction, such as crying or aggression towards the instructor and the learning process. The participants' resistance can be converted into parallel learning, where learning exists in the learning situation but does not influence the learner's everyday actions. Finally, the resistance can also consist of a total mental or physical rejection of the learning process.

Enke et al describes how the learning factory can become too narrowly focused on a minor, technical detail [20]. This type of learning design flaws can cause ambivalence towards the learning factory, as the applicability of the learning within own practice can be overshadowed by complexity or technicality. Furthermore, the didactics of the learning factory needs to counter this ambivalence for the adult learners, as it can be a obstruct their learning.

2.1. Learning must challenge and create curiosity

Adults are often motivated to learn if they encounter something surprising and disrupt their perceptions of connecting things [11]. If adults experience perceptions contrary to their own, they try to create consistency between these perceptions so that there is coherence in their universe of meaning [14, 19]. In this way, the learning process is started. Therefore, a relevant learning process must contain an optimal degree of challenge in the form of 'disturbances' [21, 22]. This is also an integrated part of the learning factory literature [7]. If the challenge is too small, the motivation and activity of the learners are limited because the content is not interesting [11]. The learners are bored. If the challenge is too great, the learners' motivation decreases because it creates uncertainty, and the learners become insecure [14]. The degree of disturbance depends on the inividual learners' ability to cope with disturbances. Some learners are good at dealing with disturbances; others may experience the disturbance as conflicts and a threat to their self-understanding. It is therefore important to observe the differences among the learners and cope with them differently. However, the degree of disturbance also depends on the learning environment. The more unsafe and challenging the learners perceive the learning environment, the greater the degree of disturbance, that needs to be coped within the learning process.

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This is one of the major strengths of the learning factory, as it, with a proper operational model which contextualises the learning, can create curiosity and motivation [20]. Furthermore, this curiosity can also activate the diffuse mode thinking [14], and activate prior knowledge [16]. This enables the learner to link the new topic with the prior learning.

2.2. The learning process must be applicable to the adult learner's life situation

Motivation for adult learning depends on the extent to which the learner perceives the learning process and outcome as relevant [11]. It must be applicable to what the adult learner is preoccupied with. Most adult learners have a functional relationship to learning. They want to learn something they can use: be it the development of personal competence, for solving specific work tasks, qualification in an educational context, development of social and cultural insights, or use in the learners' private activities. In short, most adult learners want to develop skills that are relevant to their life situations.

One way to ensure relevance is by involving the adult learner as much as possible in designing and determining the learning process's goals, content, and form. In much adult education, there will be learners who cannot immediately see the benefit of learning. This may be because they are 'sent' to education without experiencing an individual need for learning or cannot see the benefit to their daily routines. In both cases, the adult learners can ask the instructor: 'Why should I actually learn what you are trying to teach?' The better the adult learner is provided a convincing answer to the question - whether the question is asked openly or just thought - the more motivated the participants will be in the learning process.

To achieve this involvement in the learning factory, the educator can create open-ended assignments [23, 24] and draw parallels to industry [25]. The open-ended assignments and authentic tasks are known to cause reflection among the learners, enabling them to transfer their learning to a higher extent [26]. This is further enhanced if the problem or visualisation resembles a real industrial problem or setup [25]. However, to do this for upskilling students might require other efforts than for full-time students without industrial background [6].

3. Positive emotions and a perceived safe learning environment

Motivation is closely linked to the adult learner's emotions [13]. Desire, joy, commitment, and positive expectations promote motivation, just as unwillingness, boredom, lack of commitment, reluctance, anxiety and insecurity decrease motivation. It is central to acknowledge that the emotional side of learning is just as important as the formal content side in the learning situation [14]. Learning processes are thus as much about the adult learner's commitment and motivation as it is about enlightenment and professionalism.

As mentioned in the previous section, an important feeling is the adult learner's perception of safety. Adult learners need a safe learning environment where they can discover, define and develop without fear of feeling stupid. In a safe learning environment, the psychic energy is used to learn, not to defend or protect oneself. It develops positive emotions when you become wiser and master a new situation. On the other side, learning can be associated with failing and a learners experience of not coping or succeeding [14, 17]. It is important for motivation that adult learner's positive emotions are continuously developed as part of the learning process. Therefore, the learning process must give the adult learners a series of small 'victories'. Suppose the participants experience that they can master the learning and experience a positive learning environment. In that case, it will promote the learning process – and equally important, it promotes the desire for more learning. The better the content of the learning process is linked to the adult learners' experiences, the more motivating it is, the better the learned is remembered, and the greater the probability that it will be used afterwards (transfer).

Based on the above, there may be a relevant reason to consider how to incorporate the adult learner's experiences in designing the learning environment and learning process. For the learning factory, reflection activities and activation of prior knowledge must be part of the operational and didactic model [22]. The adult learner will be encouraged to link their findings to prior knowledge, even as part of the course assessment. This can, e.g., be as a part of reflection portfolio.

3.1. Adult learner's experiences are important

One of the essential prerequisites that adult learners encounter in learning situations is their experience [16]. Adult Learners act significantly based on their experiences, and they want to see what they learn concerning what they already can and do. Therefore, it is relevant for the learning outcome how adult learners' experiences are included in the learning process [22]. Are the adult learners experiences expanded and put into perspective, or are they disseminated in relation to the academic content of the learning process?

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Regardless of the content of the learning process, and regardless of which 'subjects' are learned, it is important to relate to the adult learners' experiences. The central point is that the adult learners can see the connection between the learning process and the adult learner's everyday life activities. But why does the involvement of experience matter? The involvement of experience is important for motivation, the cognitive side of learning and for the application (transfer) of what has been learned:

Motivation increases adult learners' motivation if the learning process includes their experiences. It is motivating and gives a greater desire to learn if the learners experience knowing something and what you know is useful in the learning process. If the learning process is related to something familiar, the adult learners better see the purpose of the learning process and the meaning.

Cognition: It is important for the cognitive side of learning that what is learned is linked to what the participants do and their experiences. In this way, the experiences become illustrative examples that promote understanding. They become a kind of 'hook' on which the content of the learning process is hung.

Application: It is important for the application (transfer) of what is learned so adult learners can connect the learning to everyday activities. The better the learning relates to the adult learners everyday experiences, the greater the likelihood that the adult learners will apply what they learn. The better the content of the learning process can be linked to the adult's experiences, the better it will be remembered and the more it will be used (transfer).

3.2. Design of learning with the inclusion of experiences

Learners can involve/learn themselves in a subject to acquire the logic of the subject and pass an exam or can involve/learn themselves to use the subject in daily activities [15]. Learning will use the subject as its primary purpose from an experiential pedagogical perspective. For example, participants must see how calculations can be used in their daily activities [15, 23].Technical learning must be related to the learners 'technical experiences, and management teaching must shed light on the adult learners social practice. The experiential pedagogical process can take two forms:

- In form one the subject is the basis of the learning process.
- In form two the adult learner's experiences are the basis.

The two forms are linked to different subjects and professional environments. The first can be used particularly in subjects with a tool character and a relatively fixed logical structure, for example, calculations [27]. The second form can be used in subjects that relate to actions and the social environment and have a less fixed logical structure, such as sales, innovation, or management [23, 27]. The two forms of the experiential pedagogical process are further described below.

In the first form of experiential pedagogy, the subject is the focal point of learning, and the adult learners experiences must therefore be linked to the subject. In this context, the experiential pedagogical perspective is about the content of the subject being linked as far as possible to the adult learners' knowledge, skills, and experiences [23, 27]. This can be done through examples from everyday activities, where the subject is included.

It can be solving problems from the adult learner's situation, through structured exercises, cooperative learning, or practical tasks. It can also be through simulation and role-playing or in project-organised learning. In short, it can be in any form of learning processes where knowledge and experience meet. A relevant principle in this context is that the more examples of application/transfer of the subject, the better the adult learners can find. The logical structure of the subject sets the framework for learning, and it is concerning this structure that the adult learner's experiences serve as instructive examples.

In the second form of experiential pedagogy, the adult learners experiences are the focal point of the learning process [16, 19]. It is therefore relevant to have these experiences presented in the learning situation, so that together they can shed light on important points in a learning theme that could be a collaborative relationship, management or sustainability. The theme can be chosen from the adult learners perspective, for example a common perceived problem, or from a professional view, for example a topic that can illuminate a central part of the subject. The form can be used in those learning processes where the adult learners have many, linked and relevant experiences in relation to the content of the learning.The starting point is that the individual adult learner makes his or her own experiences with the learning theme clear. Then the different adult learners present their experiences. Learners can visualise their experiences by talking about what they do and why they do it. It can be useful to reflect on one's own experiences when one have the opportunity to present them. It makes it clearer to oneself what one is actually doing and why, one is doing it.

Experiences are subjective. Therefore, they are linked to something the adult learners have done and experienced and are perceived by the presenter [14, 16]. If adult learners are to learn from the experiences of others, there must be a coupling of the individual's experiences with others. A systematic and conscious analysis must be carried out of where the different experiences are similar, where they are different, and the reason for the

differences. In this learning process, the adult learners reflect on the consequences for their own experiences and other adult learners experiences. In this way, the adult learners get their own experience relativised and become aware that there are different ways of acting, perceiving and experiencing.

A concrete example of this kind of experiential pedagogical approach could be innovation's theme [28]. In connection with this theme, the adult learners could consider and present their own experiences with innovation and the contextual conditions that promote or challenge innovation. Against this background, a common experience-based understanding of how innovation is experienced and created could be developed. This understanding could then be embedded in the adult learner's collective innovation theory.

4. Positive emotions and a perceived safe learning environment

If the experiential pedagogical process consists solely of the presentation and exchange of experiences, it can easily end in an exchange of common ignorance' - a confirmation of erroneous perceptions. To avoid this situation, the theory of the subject must be brought into play. Therefore, it is crucial for the quality of the learning process that there is an interconnection of theoretical knowledge and experiences [14, 16]. The subject, the theoretical insight that the subject includes, must gather, systematise, put into perspective, and be confronted with adult learners' experiences. The subject must contribute to illuminating the adult learners 'experiences, and the participants' experiences must illustrate the subject's content. The participants' experiences will exemplify theoretical knowledge [16]. In other cases, the theoretical knowledge will explain and perspective the adult learners experiences. The key to the experiential pedagogical learning process is that adult learners can relate the subject to their own everyday activities, which can be difficult for the adult learner. It can be challenging to find the theoretical knowledge that explains and perspectives the experiences. It can be challenging to confront and relativise adult learners' experiences with theoretical knowledge. In this context, the facilitator/instructor has a crucial role in ensuring the interconnection of the subject's knowledge and the adult learner's experiences.

Based on John Dewey's thesis that learning happens through action ('learning by doing'), the experiential pedagogical principle can be formulated as follows: The better the adult learners are able to reflect on the connection between action, experience and knowledge, the more they will learn, and the better it will develop the adult learners ability to learn, and the better they will be able to apply what they learn. That is the more integrated the professional knowledge is included in this learning process, the better the participants will acquire the subject and apply/transfer it in their daily routines and activities. [29]

5. Conclusion and proposed model for acceptance and activation of prior knowledge in learning factories

We propose a model (figure 1) for how prior knowledge is implemented in learning factories for upskilling based on the adult learner. The model can be used to operationalise the didactical dimension of the mature learning factory, as it highlights how curiosity, applicability, and acceptance of prior knowledge aids the learning process.
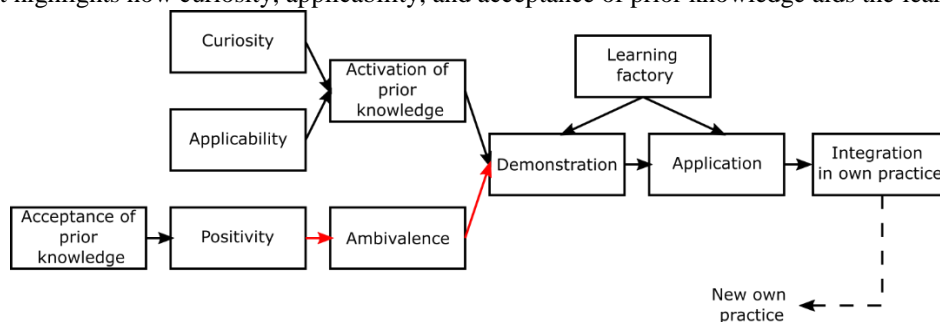

Figure 1. Model for the impact of prior knowledge in the learning factory for upskilling purposes. It is important that the prior knowledge is accepted by the educator and co-students and activated within the didactical and operational model, which needs to demonstrate applicability and cause curiosity.

According to Merrill, based on the described literature, curiosity and applicability are precursors for the activation of prior knowledge, which is the starting point of learning. At the same time, accepting prior knowledge as an integrated and valued part of the learning factory leads to positivity among adult learners. This positivity lowers the ambivalence that certain learners [11], exhibit when undergoing upskilling. This ambivalence can retard the trust in the demonstrations embedded in the learning factory, and hence the rise of positivity through acceptance of prior knowledge leads to higher gains from the demonstrations. Its build-in operational model aids the demonstration and application of knowledge. Hence, curiosity, applicability of the topic, and acceptance of prior knowledge are key elements in a safe learning environment for learners with diverse backgrounds.

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