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Introducing first year non-experienced mechanical engineering students to an action-oriented approach of a 'machining license'

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Abstract

The absence of real-world experiences is a lasting challenge in the field of higher engineering education. Therefore, learning-scenarios, which are highly reliant upon the students' powers of imagination alone, would not be promising at all. Particularly with regard to the increasing complexity of information-, material- and workflow networks in a digitized industry, future manufacturing engineers need to be trained towards an ability to act and within situated contexts similar to shop floor conditions. Hence, scenarios enabling a sustainable anchorage of theoretical knowledge through the link between thinking and action are a necessity. In response to increased dropout rates and as a result of repealing the compulsory pre-study internship for bachelor candidates in mechanical engineering, first year students receive the opportunity to gain their experiences and get a so-called 'machining license'. In the spirit of a holistic 'hands-on engineering'-approach, the students will run through the entire process – from idea to product – and experience various manufacturing processes in a mechanical workshop – the 'Technikum': a 500 square meter production facility at the Hochschule Ruhr West. The developed scenario has been derived from a cooperation with the TU Dortmund Universities' professorship for Engineering Didactics, where the course design was used for teaching woodcraft to adults.

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Keywords: engineering didactics; acion-oriented; real-word expierences; learning factories; mechanical engineering

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1. Introduction

Bologna again – while discussing drop-out rates for German Higher Education Institutions (HEIs) a reliable approach could be the exploration of motifs that decides the Learners to quit their studies, another is analyzing the determinants – here, Bolognas' aftermath and the desideratum of today's competencies claim comes in [1], [2]. With some certainty, the structural absence of experiences that foster tangible (engineering) abilities will be a lasting challenge in the field of higher education for the time being at least. Not only since Bologna, but also during this course of competence-orientation, the degree of abstraction needed to focus towards the broader goal of academic literacy during the studies, appeared at least indistinct to learners [3], [4], [5].

While in recent years several research projects and meta studies identified the 'nature of engineering competencies' (see e.g.: [6], [7], [8], [9], [10], [11]), those innovative learning opportunities, which offer settings adjustable to the working environments of Industry 4.0 while promoting development of activity-oriented learning processes, are still quite rare. In this context 'learning factories' offer an excellent opportunity to provide method learning with practical attitude in situated learning scenarios. Current learning factories are mostly rooted in the field of industrial engineering and production optimization, which would result in a very complex setting for first year students and does not provide the necessary reduction of complexity for them to reflect their study choices [4], [12], [13].

In response to increased dropout rates and as a result of repealing the compulsory pre-study internship for bachelor candidates in mechanical engineering, first year students at the 'Hochschule Ruhr West' will receive the opportunity to gain their experiences and get a so-called 'machining license' for metal processing. This action-oriented approach derived from a cooperation with the professorship for Engineering Didactics at TU Dortmund University, where the 'machining license - woodcrafts' is a continuing education offer for school teachers in technical subjects. The Institute of Mechanical Engineering at the 'Hochschule Ruhr West' (University of Applied Sciences), the professorship for Engineering Didactics of the TU Dortmund University and the Junior professorship of Technical Training and Learning at the University of Siegen each contribute to academic and vocational education, research and application in the field of manufacturing and engineering.

The paper at hand provides a concept progressing from the identification of fundamental competences necessary within mechanical engineering curricula of the future, comparing two didactical frameworks to foster engineering experiences in terms of the 'Conceive-Design-Implement-Operate'(CDIO) notion – which offers a framework, that is oriented towards continuous improvement of engineering education curricular by dint of a self-assessment instrument.

2. Methodology

2.1. To the understanding of 'competence'@ German HEIs - including a brief assessment of Learning Factories

Considering the current landscape of teaching and training in Germany, concepts of competence generally describe competence as a disposition to independent action (see e.g.: [14], [15], [16], [17], [18], [19]). From a more technology-specific point of view, competencies are those human dispositions, which are fundamental for a successful management of variable requirement situations in a domain [20]. Figure 1 shows an example of such a domain specific competence profile – based on the competence model of Erpenbeck and Rosenstiel [18] – that emerged from a Meta-analysis regarding the afore mentioned studies concerning (future) engineering competences. The direction of the arrows indicates that personal competences depend acquisition, development and linkage of the three further partial competences in action situations dispositive from a meta level. In a specific situation of action, personal competences appear only indirectly, but they in fact are essential for being capable to act creative, independent and responsible – these includes processing of experienced situations creatively towards new emotions and motivations. Ultimately, the (evaluable) execution within a specific context becomes visible by means of the performance [21]. A subsequent content analysis carried out in the course of 2016 regarding mechanical engineering curricula of Federal Universities showed very little in comparison with the requirements projected [22]. First approaches of competency-oriented learning environments for engineers were shown in the context of the so-called 'hands-on engineering' in the Anglo-American engineering education [23].