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Development of evaluation tools for learning factories in manufacturing education

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Abstract

Evaluation tools for learning factories in manufacturing education are scarce and there is lack of research in this field. Simulations used as a learning approach have long traditions in many different educational fields as well as manufacturing education. Learning factories is one of these approaches. Nursing education has also focused on development of evaluation tools for learning with use of simulations. The following article discusses possibility of transferring this knowledge to manufacturing education and developing adaptable evaluation tools for our context. A case study has been conducted where the aim was to learn how evaluation questionnaires used in nursing education could be applicable for learning factories. A group of master students attended a one-day workshop in Leanlab – learning factory. Three separate evaluation tools from nursing hospitals were used for self-evaluation. The students were also asked to meta-analyse the tools themselves. In the next phase a merged and revised beta-tool was tested on students as well as participants from industry. Another project, where development of a learning factory from scratch was the case, gave insight in connecting learning outcomes and learning activities in a learning factory, which then provided possibility to explore how to look at learning activities, learning outcomes and assessment in learning factories according to the theory of constructive alignment. The beta tool will be subject of further research for validation and revision but is shortly presented in this paper. Moreover, challenges in designing an evaluation tool for debriefing will be discussed.

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1. Introduction

Simulation as a learning approach where the aim is to transfer theoretical knowledge into a practical context and thus contribute to bridging the theory-practice gap[1, 2], can be useful approach when real life training is costly and of some risk for companies. High fidelity, real life like, simulation settings[3] such as learning factories can be found

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globally, and knowledge on using these facilities as learning platforms are widely spread[4-7]. Quality criteria for measuring learning effect is hard to find [8, 9], and as Xu et al.[10] discusses, “knowledge”, as a result of learning processes, is difficult to objectify and it is relevant explore methods that can describe concrete knowledge activities and evaluate knowledge effects. Thus evaluation of learning outcome and knowledge on how and whether learning factories are efficient tools for learning manufacturing processes need more exploration. Is there a value transfer to i.e. to companies on both long term and short term through taking part in learning processes in these facilities? Educational practice must be knowledge-based[1], this inclines the manufacturing education institutions to continue working on creating knowledge on what actually works regarding wanted effect of learning activities.

This article presents part of a process of developing an evaluation tool for students and other participants in a learning factory simulation. The aim was to develop a generic beta - tool for manufacturing education, which both measures/indicates usefulness of the simulation training as feedback to the trainers/teachers, but more importantly, help students create awareness of their own learning process and possible learning outcome after training in a simulator. This was divided in three main goals: (I) Test questionnaires from a nursing education simulation context in a Norwegian manufacturing learning factory context. (II) Translate and merge questionnaires from a nursing education simulation context and thus make an evaluation tool fit for learning factory simulations in manufacturing education and industry training settings. (III) Make a tool that can aid manufacturing students’ in creating awareness of, and describe their experiences in a learning factory simulation. In our high-fidelity simulators set up for different processes of a production chain, the aim is often to create new organizational knowledge, but the individuals’ cognitive learning processes are key elements and *“instructors and learners need tools that provide organized objective feedback”*[11]

Manufacturing education can learn from experience the field of nursing has acquired when it comes to simulation as a learning approach, and especially when it comes to evaluation of learning outcome[2]. This work aims to learn from health sciences, and we hereby describe a process of using instruments developed in nursing education context for testing and further development within the field of simulation in manufacturing education to see whether a useful tool for evaluation of learning outcome can be developed. Manufacturing originates from natural sciences, and evaluation of and reflection on cognitive processes is less common and more new ground for this field. But it is noteworthy that research on simulation in the field of nursing and health simulations in general also say there has been *“little investment ... in developing suitable measures for the assessment of learning outcomes, particularly those relevant for a practice discipline”*, stated by Tanner (2011) in[12].



Fig.1. Simulation session at leanlab.no



Fig.2. Students working at the roller skis learning factory

Simulation as a learning approach in manufacturing education has developed over years. We see a lack in evaluation of actual learning outcome of simulation training, so called aligned assessment where learning outcome, instructional activities and assessment is part of a didactic whole aimed to find out whether the students are learning what we initially intended[13]. The focus is still leaning more towards practice-oriented learning processes [4, 14-20], but tools for reflection and assessment of learning outcome are missing, although there is an ever increasing focus[5, 21]. Feedback from teachers, peer review and self-evaluation are quality criteria well founded in research regarding effect on learning outcome, but quantitative feedback does not necessarily give the same as qualitative feedback; students should have the opportunity to evaluate and reflect on their individual performance [22].

1.1. Background projects

Department of Manufacturing and Civil Engineering at NTNU in Gjøvik was involved in two projects related to development and implementation of learning factories. The first project is LeanLab learning factory (Figure 1), where

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