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Realization of a learning environment to promote sustainable value creation in areas with insufficient infrastructure

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Abstract

To increase the rationally demanded sustainability with its ecologic, environmental and social dimensions, innovative technology shall be exploited. For example waste can be used by means of closed loop material cycles for the production of new products. The understanding of such material cycles can help to deal responsibly with resources. Considering the limited awareness of more than seven billion humans on globe about the sustainability challenge, the teaching and learning productivity has to be boosted to hitherto not achieved levels. Complex interdependencies have to be scaled down to daily life experiences, so that people of different skill levels or even laypersons can draw a practical benefit and become capable of self-sustainable value creation.

How locally available plastic waste can be used for the production of new products in areas with insufficient technical and social infrastructure is explained in detail on the example of the mobile learning environment CubeFactory. This mini-factory was designed to support knowledge transfer for sustainable manufacturing competencies, independently from the need of any infrastructure. In this context, the term „infrastructure" contains all technical as well as social necessities needed for production. These may be the access to a durable energy and material supplies, as well as the access to machine tools or knowledge. Sustainability utilizes all elements to its advantage to serve as a beneficial tool for the society, the local economy and the environment. The CubeFactory represents an example of how to produce on local level what is immediately needed. It integrates a 3D printer as a manufacturing tool, a recycler for the filament production, a solar-powered energy supply and the knowledge for the application of this resource-saving technology.

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1. Introduction

Sustainability is considered to be an important key to improve social equity while avoiding the environmental risks and ecological scarcities. Sustainability can be understood as a concept to describe the use of a regenerative system, while meeting „the needs of the present without compromising the ability of future generations to meet their own needs" [1]. Nevertheless, most countries have recognized the importance for such a balanced system, but a global and binding strategy to enforce this is still missing. At least since the *United Nations Conference on Sustainable Development –Rio +20* the question has arisen to what extent the international community has a legitimate interest in the enforcement of measurable goals and is willing to represent a strong position on social and environmental issues. Many scientists rather advance the view that those debates detract from the urgent problems by focusing our attention on misleading subjects. Perchance the key problem is more an entirely anthropocentric once, and perhaps it is not to set new limits of pollution than rather to strengthen our set of values and the way the global community is related to the natural world [2]. Regarding to this agenda the founder

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of the *Centre for Interactive Research on Sustainability (CIRS)* Prof. J. Robinson notes in his paper „Some thoughts on the idea of sustainable development“ that he suggests on the long-term it is more promising to promote “new forms of social learning” for having “better-trained-citizens”. He recommends to “focus its attention more strongly on developing the knowledge, tools and training required to address the challenge of sustainability” and argues for an integrative approach that is action orientated and goes beyond technical fixes to engage local communities in a new way [3].

The mobile mini-factory CubeFactory pursuing this approach of engaging local communities, but with a particular focus on the qualification of unskilled people for the application of sustainable value creation in areas with poorly supported infrastructure. Just as value creation targets to enrich the shareholder, Sustainable Value Creation tracks an almost identical goal, but a more multifaceted and compatible one, involving economic, social and environmental concerns. The value-added performance is affected in a dominant, balanced and prospective way to create competitive advantages for a measurable profit and a community benefit without harming environmental needs.

2. Approach

The CubeFactory is an infrastructure independent production and learning factory that carries everything needed for sustainable production in itself – the tools, the suppliers and the knowledge. It is formed by the modules manufacturing (Fused Deposition Modeling (FDM) 3D printer), material supply (plastic recycler for the production of 3D printer filament), energy supply (solar cells) and knowledge transfer (tablet interface). These modules are integrated in a compact $1m^3$ large extendable cube that can be used worldwide with only a small amount of prior knowledge (Fig. 1).

Fig. 1. Realization of the learning environment CubeFactory © Ulrich Dahl

2.1. The Approach of Learnstruments

In the development special focus of the CubeFactory was laid on the application by unskilled users. For this purpose the concept of Learnstruments was implemented, a research field of the CRC 1026 Sustainable Manufacturing, in which the CubeFactory is located. The Learnstrument is a user-centered design approach to combine learning and working to increase the employee’s productivity and awareness, in this case the awareness for sustainable value creation. “Learnstruments are objects which automatically demonstrate their functionality to the learner. They consist of aspects of cognitive stimulation and emotional association with new and existing ICT and design approaches for productive mediation” [4]. This concept prevents an intuitive learning cycle that covers all aspects of perception and processing continua to increase the learning productivity and to reduce human activity-oriented errors. The user is methodically supported in knowledge creation by the elements of motivation (experience), awareness (reflection), systematic knowledge (abstraction), skills (practice), innovation and transformation (experimentation). This appealing method enables the user to expand his knowledge and skills independently and is aimed at both, beginner and advanced. The CubeFactory itself can also be regarded as a Learnstrument.

This learner-centered design approach was directive in the design of hardware and software. The aim was to design both elements in a way, which is appealing and easy to use, especially for untrained users to tap into their functions and benefits immediately. Owing to the novelty of this approach it was impossible to resort to a finished software solution that is suitable to the requirements. Therefore custom software was developed and programmed to form the link between physical and virtual learning respectively value creation environment. For the selection of other components the use of Open-Source applications was preferred. This discloses the potentials of open standards, dropped licensing costs and provides a broad supporting community.

2.2. Mediation Content

2.2.1. Closed Loop Material Cycles

The main aspect of the teaching of sustainable value creation is the descriptive inclusion of a closed loop material cycle. Sustainable economies require innovative products as well as processes with a life-cycle-orientated way of thinking and acting. This does not end with the customer, but continues with the disposal of goods and the further handling of materials.

In the case of the CubeFactory the customer must be enabled to integrate key aspects of sustainability into products and production, with a “Cradle to Cradle” way of thinking. It starts from the very beginning, like the planning and designing of products and processes, up to the manufacturing, the use and the end-of-life treatment. This does not only take into account the manufactured products, but also the equipment and materials. For this purpose, the approach of a closed loop

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