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Learning in Product Development: Proposed Industry Experiment Using Reflective Prototyping

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Abstract

This article discusses the aspect of learning activities in product development by leveraging a strategy for capturing and transferring tacit knowledge through the extensive use of reflective prototyping. With the overall aim of finding new ways for organizations to learn faster, the theory from knowledge transfer is converted into a framework for using reflective and affirmative prototypes. Rooted in this framework, an automotive industry in-situ experimental setup for studying learning, continuous evaluation and knowledge generation in product development is proposed and discussed.

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Keywords: internal, reflective prototypes; prototyping; learning activities; design fixation; product development; experiment

1. Introduction

In this article, we investigate learning in product development, and the influence of concept representations at varying levels of affordance. Specifically, this includes exploring the role of reflective prototyping and design fixation. This article attempts to make two contributions to current literature.

Firstly, we review the relevant literature relating to creation and transfer of knowledge in product development. Furthermore, we review the role of several types of prototyping, design fixation and the concept of affordance in the context of product development.

Secondly, we propose an experimental setup on the role of concept representations in (early phase) product development. This experiment is intended for a R&D department of a global automotive tier 1/2 supplier.

The automotive industry is subject to steadily increasing demand for faster development cycles and higher quality products. Making mistakes leads to costly and time consuming rework. The product life cycles are generally in the order of five to ten years. Thus, changes have major implications on manufacturing process and planning.

In the early phases of automotive product development projects, the problems and concrete solutions are yet undefined. The main focus is on mapping possible directions for the R&D team. In this phase, quick learning cycles and continuous evaluation and selection of concepts are key. Poorly based decisions will lead to rework. In this regard, learning from past projects and managing the company's tacit and explicit knowledge is of high importance. The proposed experiment attempts to uncover some tangible aspects of how to approach these issues.

2. Theory: Learning Activities in Early Stage Product Development

In (1, 2), Simon lays a foundation for a "science of design". This is drawn up due to the recognition of the gap between professional knowledge and real world practice, applying methods from optimization within statistical theory; thus, laying the groundwork for a scientific approach to treating knowledge in design work.

This is criticized by Schön (3) for assuming technical rationality. He argues the focus should be on the extraction of requirements from real-world conditions, rather than the

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treatment of already well-formed ones. In (4), he further argues for reflective iteration as a learning tool, and elaborates on the difficulty of treating and directly creating explicit knowledge, without taking the tacit dimension into consideration.

2.1. SECI-model and Knowledge in Product Development

In (5), the theory of "Organizational Knowledge Creation" is proposed as the capability of a company as a whole to create new knowledge, as a result of studying the success of certain Japanese companies. This is further elaborated in (6) by establishing the SECI-model of dynamic knowledge transfer and creation. The SECI-model spirals through the stages of Socialization (tacit-to-tacit), Externalization (tacit-to-explicit), Combination (explicit-to-explicit) and Internalization (explicit-to-tacit). Through these stages, tacit and explicit knowledge are transferred alternately. To quote the original authors; "When tacit knowledge is made explicit, knowledge is crystallized". Thus, in a learning perspective, the most interesting stages of the SECI-model are those transferring explicit to tacit knowledge, or vice versa (i.e. Externalization and Internalization), when considering individuals. Additionally, transferring tacit to tacit knowledge (i.e. Socialization) is interesting when considering groups.

Another contribution of (5, 6) is the establishment of knowledge assets, which are Experiential (e.g. individual skills, interpersonal relationships), Conceptual (e.g. product concepts, images), Routine (organizational routines, culture) and Systemic (e.g. documents, databases, patents). The study performed in (7) concludes Conceptual knowledge assets to be the most efficient tool in facilitating Internalization and Externalization. They are defined as "knowledge articulated through images, symbols and language" (6), and although not specified in the definition, this can be understood to include sketches and physical models.

2.2. The Concept of Affordance

The concept of 'affordance', first introduced by Gibson (8, 9), describes the relation between an object and the actions that an animal could perform as a result of this object's properties. This was slightly modified by Norman (10), who stated that "the term affordance refers to the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used". The latter definition has gained major traction within certain product design communities. Despite some confusion around the use (and misuse) of the term in certain product design communities (11), the term is most often used as for describing physical objects and their meanings.

When using the term prototype affordance to describe both physical attributes and meanings of a product in engineering design, it is useful to make the distinction between prototype affordance and semantics (12). We differentiate between object meaning in prototype affordance and semantics, as affordances cover all perceivable information provided by the object itself. On the other hand, the semantics cover perceived (and user-processed) product meanings provided by the object and context. Hence, prototype affordance – in our setting – is all the physical properties and all information embodied in the given object, before any interpretation (i.e. in SECI-model; internalization) is done by the participant.

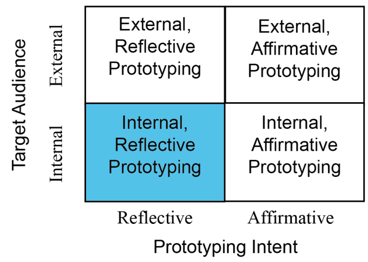

Figure 1 - A model of four prototyping categories (14).

2.3. The Role of Prototypes in Learning Activities

In (13), prototypes are defined as "an approximation of the product along one or more dimensions of interest", and prototyping is defined as "the process of developing such an approximation of the product".

For the purpose of distinguishing between prototyping activities by their function, the authors propose categories in (14), dividing prototypes by the prototyping intent (reflective or affirmative) and the target audience (internal or external). The referenced work is focusing on physical prototypes, while this paper is focusing on the prototyping activity. However, we argue that the categories are transferable (Figure 1).

External, affirmative prototyping is typically used for approximating a nearly finished model, and may be termed alpha or beta prototypes (15). These prototypes are highly detailed, and may be made for external validation (e.g. certification test for customers etc.), showcasing, or in-depth customer interaction.

Internal, affirmative prototyping is intended for function, reliability and feasibility testing. Examples include subsystems, fatigue testing of separate parts, or project milestones as a means of measuring the progress. Despite the high fidelity this prototyping is rarely done for public display.

External, reflective prototyping is building models for feedback from external sources. The responses and reactions are recorded, and the user interaction is carefully observed for further improving the concepts.

Internal, reflective prototyping is a learning activity. It is applied by product development teams for learning and conceptualizing ideas. This category of prototyping is exploring, understanding and experimenting with functionalities essential for the final product's success. The low-fidelity nature of the prototypes means there is less investment in the idea for the originator, and there is a relatively low threshold for criticism, change, or discarding.