Working Paper

A Taxonomy of Testing Activities in Product Development

Author[s]:
Boës, Stefan; Batliner, Martin; Stücheli, Marius; Meboldt, Mirko

Publication Date:
2017-12

Permanent Link:
https://doi.org/10.3929/ethz-b-000214845

Rights / License:
Creative Commons Attribution 4.0 International

This page was generated automatically upon download from the ETH Zurich Research Collection. For more information please consult the Terms of use.
A Taxonomy of Testing Activities in Product Development

Stefan Boës¹, Martin Batliner¹, Marius Stücheli², Mirko Meboldt¹

¹Product Development Group Zurich, Department of Mechanical and Process Engineering, ETH Zürich, Switzerland
²The Research Hub by Electrolux Professional, Ljungby, Sweden

(published in December 2017)

Abstract: We propose a taxonomy for categorizing testing activities on distinct levels with respect to the type of knowledge they are intended to provide. Our taxonomy adds to the well-established testing categories validation and verification the categories of experiment and trial-and-error. This theoretical model should help practitioners and educators to understand and explain different types of tests and to pass on knowledge.

I. INTRODUCTION

Testing is an important activity of the product development process in disciplines involving engineering design, but testing methodology does not yet find a prominent place in literature and education. The resources spent on testing and building up the testing environment are in general a significant part of the total development effort. Even though this fact is well known to practitioners and educators, we state that approaches and methods for physical testing are underrepresented in research and in the engineering design curriculum. In the standard work about methods in product development Pahl and Beitz et al. [1] and Ehrlnspts and Meerkamp [2] as well as in the VDI 2221 guideline [3], there is no general methodology about testing presented, despite the process oriented TOTE scheme. The VDI 2206 guideline [4] mentions testing only in the context of verification and validation.

On the one hand, traditional product development methods in engineering design place testing at later stages of product development. On the other hand, in current industrial practice, a lot of testing activities are being conducted before the dedicated verification & validation phase. What is more, with the advent of rapid prototyping technologies, such as 3D printing, and the digitalization of development tools, manufacturing is getting faster and more accessible and the cost associated with testing at early stages decreases. These developments made it possible that already in early stages of the product development testing plays an increasing role. However, the terminology in product development has not caught up with these trends.

We see a need in testing methodology on a theoretical level to help practitioners as well as educators to pass on general knowledge that is highly relevant in product development. Thus, we define testing and propose a taxonomy for categorizing testing on distinct levels with respect to the type of knowledge they are intended to provide.

II. DEFINITION OF TESTING

In the context of product development, we define testing as exposing a physical system to a condition or situation in order to observe the system’s response. Thereby

- this physical system represents the product as a whole or one of its subsystems,
- the condition or situation corresponds to a use case as a whole or its effect on a subsystem, for example a mechanical load or an electrical signal, and
- the system response might be the performance of a desired function, as well as an undesired failure mode.

With this definition we consciously distinguish testing as a physical act from the solution of analytical models and numerical approximations (simulations).

III. TAXONOMY OF TESTING ACTIVITIES

Our taxonomy adds to the well-established testing categories validation and verification the categories of experiment and trial-and-error. Experiment is used with a similar meaning as in fundamental science, but instead oriented on products and the development process. The trial-and-error category refers to little unstructured testing approaches at early stages of the product development process. In the order from trial-and-error to experiment, verification and validation, typically the design space is narrowed down, whereas in reverse order the use case is more and more reduced and simplified. Figure 1 summarizes the differentiation between the four categories and briefly sketches out what purpose the respective test should fulfill.

Validation checks whether a realization of a product fulfills the intended purpose, which is the fulfillment of certain user’s needs. Originally, the expression was used for examining to which extent a test result actually registers what is meant to be
determined by that test [3]. For product development, this implies also the identification of unknown effects and the interaction of the product in its use case in its final usage environment. For such a test at least the behavior of the product from a user perspective must be defined (e.g. for an experience prototype). More commonly, validation tests are performed with integrated, fully functional prototypes where all design parameters are set.

Verification checks whether a realization of a product or one of its subsystems and components fulfills the defined requirements and specifications [3]. These fulfillment criteria are set at the beginning and over the course of the development process. Verification tests are typically characterized by unambiguous binary pass/fail results. At this point, the design parameters are not varied anymore but a fixed design is checked before a further integration of subsystems or a further development towards series production and release.

Experiments in product development are characterized by a structured approach to explore the effect of varying certain design parameters on the behavior of a product or one of its subsystems. These tests follow a similar concept as experiments in fundamental science, where also parameters are varied and a resulting behavior is observed. Such a structured approach to exploring the defined design space lets the developers build up the necessary system knowledge to find the ideal design regarding the respective design goals. Existing hypotheses about the system’s sensitivity to changing design parameters can be confirmed or falsified, which also allows us to create models of the system behavior.

Trial-and-error is about gaining a basic understanding of the development challenge, its environment and constraints. It contains the first steps in a development process of getting a feeling for the working of single function and the interrelations of multiple functions of a system. By building simple prototypes, playing with them and “trying things out”, the designers develop a better understanding of the problem and its critical aspects and build up an intuition for the product and for its functions. This problem understanding and intuition for the functions again help to inspire the further design process. Additionally, it serves as a nonverbal form of communication of ideas within the development team and to involved users. Both the product concept and the use cases may still be very open at the time such tests are performed.

IV. CONCLUSION

This taxonomy of testing activities should help practitioners and educators to understand and explain different types of tests and the differences in the knowledge they are intended to provide. In particular, the inclusion of the trial-and-error and the experimentation shall help product developers to embrace testing in its full broadness and along the complete development process from the fuzzy front-end to the series production. It also integrates an understanding from design thinking [5] into testing in modern product development: early and continuous testing with high uncertainty and low product maturity is of high importance for a fast and front-loaded product development.

The model has been taught in mechanical engineering education at ETH Zurich over several years now and has to be further discussed and shaped based on scientific insights and practical experience.

REFERENCES