Empirical and Normative Research on Fundamental Ideas of Embedded System Development

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Motivation

Embedded systems are seen as one of the main innovation drivers in the international computer science industry (Eggermont, 2002). Educating future experts is particulary difficult, because of the interdisciplinary nature of the development process, relying on competences from informatics, electrical engineering, physics, maths, and oftentimes in depth knowledge of the specific application area. Embedded systems correlate to terms like the internet of things, ubiquitous as well as pervasive computing, making the real impact on our every day life hard to grasp. Determining the fundamentals of embedded systems development may ease this task by providing students with a core set of competences that are useful in their professional careers, but in addition, can serve as a guideline to decide whether the student should investigate into a new technique later or not.

Schwill has described an approach to extract fundamental ideas for general computer science with a focus on school education (Schwill, 1997). The author describes a different approach which connects empirical and normative proceedings to determine fundamental ideas for embedded system developers. The DFG-funded research project *competence development with embedded micro- and nano systems* (KOMINA) provides empirical data for university teaching, derived from an experts survey and a laboratory course observation. These results have been published as an empirical refined competence struc-

ture model (ECSM) (Schäfer et al., 2012). This competence structure model is meaningful for many educators concerned with embedded system development, because it gives insights to the importance of the most common competence descriptions in this field of application.

The project members used these competence descriptions to exemplify the reconstruction of a typical hardware-focused laboratory at the University of the Siegen. The observation of this laboratory course is the second source of empirical data, which provides insights into common mistakes and detours of students when developing embedded systems.

The competence descriptions in the ECSM are sometimes application specific (FPGA development, usage of the C-Language) and other times very generic (interplay between hard- and software). This is problematic, because the competence descriptions offer plenty of room for interpretation, which restricts their use as a guideline for course creation. The inspection of the ECSM results with an approach like the fundamental ideas helps to create unified descriptions, useful for the specific audience and application area. In order to do that, modifications of the original criteria are unavoidable because Schwill's research methods have been created under different conditions (school education, computer science in general). Starting with Schwill's four criteria, the author has been researching proposed additions and own thoughts on how to separate fundamental from common ideas. The poster will give an overview of five criterions with their descriptions. Those are the advanced training criterion, the horizontal criterion, the criterion of time, the criterion of sense and the criterion of variance. The advanced training criterion is similar to the vertical criterion by Schwill. It, however, omits references to the spiral curriculum and instead focuses on basics needed for the students' career, justifying topics, which serve as groundwork for many other topics. The horizontal criterion has been adopted with minor, but very important changes. Due to the interdisciplinary nature of embedded systems development, fundamental ideas may be found at the borders of computer science and even other disciplines, too (e.g. electrical engineering or physics). While the criterion of time is without change, the criterion of objective conflicts with the authors understanding of the criterion of sense and is therefore dismissed.

The criterion of sense makes sure that an idea has a significant relevance in practice or in science, which is in contrast to Schwill's definition not the everyday life, but the life as a professional developer or researcher. In a first proof of concept where all criterions have been applied to a catalogue of techniques and methodologies currently discussed in science, the author noticed, that some fundamentals occur multiple times with only minor differences. The

criterion of variance makes sure, that every potential fundamental idea connects existing ideas in a new and significant way or that it is a completely new idea by it self.

The current work encompasses the revision of Schwill's criteria with regard to higher education. A subject specific collection of ideas has been derived in a normative and empirical way. All criteria have been applied to this collection.

References

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Biography

Steffen Büchner received his diploma in informatics (2011) from the University of Siegen, Germany. Since August 2011 he has been employed as a research assistant at the University of Siegen. He focuses on research in the field of competence oriented teaching for embedded system design and development.