

## Competence Assessment and Competence Reflection in Software Engineering Education

**Lisa Henschel**

Department of Electrical Engineering and Computer Science, University of Applied Sciences and Arts Coburg, Germany

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### **Abstract**

*In the course of digitalization, software is becoming increasingly important and is characterized by growing complexity. Without software, the use of digital technologies would be impossible. The increasing complexity brings major challenges for teaching and learning of software engineering with it. The dynamic of change in software engineering leads to permanent learning requirements, which have to be fulfilled holistically. The fact that the development of software requires a high degree of interdisciplinary thinking and a systematic cooperation of different roles, results in the demand for the development of interdisciplinary competences and makes the continuous holistic competence development indispensable, since technical skills are absolutely necessary, but not sufficient.*

*A central issue in the course of the holistic competence development is to be able to recognize existing competences in order to use them for the personal biography and competence development. In this context, the process of reflection plays a decisive role as it can make implicit areas of competences aware.*

*This contribution outlines a qualitative research approach which focuses on the question of how the reflection process of students in software engineering can be stimulated and supported by the use of a learning process-oriented competence assessment system.*

**Keywords:** *Competence Assessment; Reflection; Competence Development.*

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## **1. Introduction**

In the course of digitalization, software is becoming increasingly important and is characterized by growing complexity. Without software, the use of digital technologies would be impossible. Software engineering is a knowledge-intensive discipline characterized by rapid development cycles and a permanent change in knowledge content.

Until a few years ago the academic education in software engineering was characterized by the pure imparting of specialist knowledge. Although the job profiles in the practice of software engineering require specialist knowledge, it alone is not sufficient for the fulfillment of the entire range of tasks (Sedelmaier, 2015). Comprehensive skills and the ability to reflect on the individual competence profile are also necessary to meet the requirements of the occupational field and it is emphasized, that the development of a professional and personal identity presupposes the integration of new information's into the personal context of knowledge (Hilzensauer, 2008; Schreiber & Söll, 2014). For a number of years, teaching in software engineering is increasingly changing. There is a change of perspective that addresses the promotion of holistic competences in the sense of an appropriate combination of expertise and interdisciplinary competences (Sedelmaier, 2015). Next to the accentuation of the comprehensive competence development a central issue in this context represents the ability to recognize and name existing competences in order to be able to use these for the personal biography and the further competence development. This ability is a prerequisite for the planned and conscious design of the individual life and the creation of the individual learning (Seidel, 2010). In order to be able to evaluate the individual competence profile and to consciously apply what has been learned situationally in other contexts, conscious deliberations with the self are required (Atkins & Murphy, 1993; Gillen, 2006). This requires a reflection performance that cannot be assumed from the outset, but has to be promoted through differentiated didactical and methodical instruments.

Currently, there is no regular use of instruments that help students in software engineering to reflect on their own competences. Against the background of the stated significance of the holistic promotion of competences in software engineering and the importance of reflecting on the individual learning processes and competence domains, it is necessary to empirically investigate the research aspects addressed.

This contribution focuses on the question of how the reflection process of students in software engineering can be stimulated and supported by the use of a learning process-oriented competence assessment system. In order to approach this question, it is first necessary to set out the theoretical frame of reference before the research design is substantiated and initial results are presented.

## **2. Theoretical Framework**

### ***2.1. The orientation to the concept of competence***

Against the background of social, technological and economic changes at all levels of human life and the change from an industrial society to a knowledge society, the concept of competence has been widely discussed within the national and international educational debate (Gillen, 2006). The restructuring of companies, which took place increasingly in the 1980s was associated with new forms of learning and organization and led to the demand for the entire spectrum of the professional, social and personal skills of the subjects. This resulted in an intensive discussion of competences, that play a key role in fulfilling the increased living and working conditions associated with these changes (Gillen, 2006). The demand for the full range of competence of subjects leads to the fact that the formal transmission of knowledge alone is not sufficient to meet the differentiated demands of our current society. Informal and non-formal acquired skills that cannot be proven in certificates therefore increase (Arnold & Rohs, 2014). This development is accompanied by a reassessment of learning, which focuses on all ways of knowledge acquisition and on all forms of learning and learning outcomes (Seidel, 2010). In the course of this development, methods for recording, assessing and documenting competences are given great importance (Kollewe, 2012). It should be mentioned that no consistent concept of competence exists. Different approaches of the concept of competence exist due to the respective theoretical tradition and the reference of the practice field (Preißer & Völzke, 2007). This contribution understands competences as resources that enable a subject to act adequate in different contexts and defines competences as a compound of trainable subjective action potentials with respective external conditions of action (Bender, 2009).

### ***2.2. Self-directed competence development and the reflection of individual potentials***

In today's knowledge society, knowledge content is rapidly becoming obsolete. This results in continuous learning requirements for individuals in all areas of life. Coping with the increased demands strongly depends on the self-directed development and reflection of individual potentials (Kollewe, 2012). It is emphasized that people no longer only learn in preparation, but are continuously confronted with new learning requirements, which demand constant competence development and competence reflection (Arnold & Rohs, 2014). In the course of the EU-wide discussion about self-directed lifelong learning the importance of reflection is increasing. Reflection is given great importance in order to be able to consciously apply and transfer what has been learned situationally in other contexts and to facilitate the integration of theoretical contents of study into the practice of the working environment (Hilzensauer, 2008). This understanding is conceptually justified, in particular through the work of John Dewey and Donald Schön, which have exposed the specific relationship between own experience, targeted reflection and communicative interaction for learning

(Dewey, 1910/1997; Schön, 1983). Dewey defines reflexive thinking as “[...] active, persistent, and careful consideration of any belief or belief in the light of the grounds that support it, and the future conclusion to which it is [...]” (Dewey, 1910/1997, p. 6). Dewey assumes that thoughts build consecutively upon each other and new insights are gained on the basis of existing knowledge and related to previous experiences. Reflection takes place with two emphases. On the one hand as a deductive activity that focuses the recourse on already made experiences and existing knowledge. On the other hand as inductive activity, which leads to new insights and conclusions (Dewey, 1910/1997). Donald Schön’s reflection concept builds on Dewey’s theory. Schön distinguishes two differentiated modes of reflection, namely, “Knowing-in-action” and “Reflection-in-action”. “Knowing-in-action” is knowledge that manifests itself in action. Schön describes this form of reflection as reflecting on the incident and as action-inherent. Reflection-in-action is also action-inherent and refers to the ability to react spontaneously and intuitively to surprising turns in a situation based on previous experiences (Schön, 1983). For the investigation of the reflection process in relation to the individual competence profile in software engineering, the stated considerations of the understanding of reflection from a constructivist perspective is suitable, because from this perspective learning is an active construction process in which new domains of knowledge develop, based on previous experiences and in connection to existing knowledge domains (Arnold, 2012).

Against the background of the stated significance of reflexive processes in relation to one’s own knowledge and individual competence domains, it becomes clear that the reflection of the individual competence profile therefore plays an important role, as it initiates the promotion of personality development and self-knowledge and contributes a reflected and self-organized acquaintances with individual decision making and action-taking.

### ***2.3. Competence development and competence assessment***

The emergence of new competences is directly related to the recognition of already existing competences. In addition to the qualifications acquired and certified in formal education processes, the focus has to be on comprehensive skills and competences acquired in informal and non-formal learning processes, as the holistic competence profile must be reflected in order to reposition and depict as a subject in the changing society (Seidel, 2010). One way of promoting the reflection process in connection to the individual competence profile represents the process of competence assessment. Competence assessment is a dynamic process in which skills are collected through differentiated reflections. In addition to formally acquired competences, the focus is also on those that were acquired in in- and non-formal areas. In the last decade, a multitude of instruments for competence assessment with a wide variety of possible applications and objectives has emerged (Kaufhold, 2006). These instruments can be differentiated against the background of their various characteristics and properties. The underlying concept of competence, the method of data collection and the target orientation

of the assessment can be used as a basis for differentiation. The observation of the concept of competence used by the differentiated procedures allows to draw conclusions about their quantitative or qualitative orientation. While quantitative methods of competence assessment focus on the external perspective and aim at the pure measurability of the competences and their characteristics, qualitative methods try to describe the inner perspective of the competence dispositions (Erpenbeck et al., 2017; Kollewe, 2012). Quantitative methods assume that competences can be accounted in objective terms by measuring them against externally established standards, which do not take the complexities of human coexistence into account. Qualitative methods, however, focus on the individuality of the subject. Since competences are always subject-bound, these methods do not assume that they can objectively measure competences, but rather aim at the description and assessment of competences resulting from methods such as narrative interviews and biographical methods (Erpenbeck et al., 2017).

### **3. Research Design**

The importance of the competence-orientation in our modern society was carried out in the previous chapter and the consideration of the related work turned out how important the reflection process is in connection to a comprehensive competence development and the assessment of existing competences. In order to answer the question of how to stimulate and support the reflection process of students in software engineering by the use of a learning process oriented competence assessment system, the description of the research design is given in the following chapter. The aim of the study is to examine the contextual conditions of the reflection process with regard to the target group of students in software engineering as well as the peculiarities of these target groups in relation to the reflection process. To achieve this goal a survey conducted with students in software engineering in the first, third and seventh semesters was carried out. The survey form interview was selected as a form of qualitative interview, since the basic idea of this form according to Strübing is to create an almost everyday conversation situation during the interview so that the interviewed individuals are encouraged to present their perspectives and assessments (Strübing, 2013). In order to achieve the objectives of the study and to evaluate the interpretation patterns of the students in relation to the reflection process of their individual competence profile, this method of data collection has become particularly suitable. During the interview a non-standard guide with open questions was used. The guideline served as a guide during the survey, which should ensure that all important aspects of the research interest were focused. The chosen survey method required moderation of the interview, which did not aim at the merely querying of the pre-formulated questions, but maintained the flow of conversation and mapped the relevant structure of the interview. The following focuses were placed in the interview in order to evaluate the interpretation patterns of the students in relation to the

competence reflection process. They were asked for their subjective description of their study and their learning actions, the assessment of the necessary / individual competence profile in software engineering and for individual expectations of their further study / professional life. Due to the qualitative orientation of the stated research question, the research design was based on the classical, theory-generating survey method, the grounded theory (Strübing, 2013). This methodology was chosen since it is particularly suitable for the evaluation of interview data and allows a systematic interpretation.

#### **4. Results and Outlook**

The consideration of the collected data with regard to the awareness of the individual competence profile has revealed, that it is not yet fully developed, especially among young people. It turned out that students in the first semester, who have not yet had examinations in their field of study, do not dare to adequately assess their competences, since they have not yet received any "formal feedback" for their performance during their studies. This focus on the formal evaluation results of the examinations, which only test the expertise and its application, shows the lack of awareness for the differentiated forms of learning and ways of competence acquisition, which also lie outside the formal education sector. The development of this awareness strongly depends on the formation of the self- and concept-knowledge, since the self-image must be developed and knowledge about structures of the professional world in software engineering must be acquired, at the beginning of the study. In this regard it is important to notice, that competences are considered to be the result of differentiated learning and socialization processes and are acquired in the process, but cannot be taught. Similarly the development of competences is a process characterized by a biographical history in which complex causal relationships exist that demand the reflexive consideration of the individual living and working context of the learning subjects (Ratschinski, 2014). Furthermore, the analysis of the data has shown that the awareness of the importance of interdisciplinary skills is well-developed among students. Thus, students are already aware of the importance of interdisciplinary competences and state that those are important as software is developed in teams of individuals who need to interact with each other and various stakeholders. While software engineering education in the past mainly focused on training of technical and methodical competences (e.g. programming, development of software modules, etc.) in recent years it concentrates more on the promotion of interdisciplinary competences (Sedelmaier, 2015). An important aspect of this support is the education of students' awareness. In exercises where they meet customers or develop their own software systems as a team and have to adapt to their team members and customers, the awareness of the importance of a holistic competence profile is specifically trained.

In order to integrate a "reflected practice" into everyday academic life in software engineering training, subject-specific course development is necessary. This requires a deliberate solution

of certain role ideas and the encouragement of the self-learning and thinking of the students. Through deliberate stimulation and complementary cognitive access, the significance of the individual actions becomes more conscious and understandable through systematic analysis, theorization and classification into larger contexts. For this the students need to be made aware or even irritated, so that they recognize all kinds of learning. Based on the first results of the data analysis, the ProfilPASS as an already existing competence assessment tool is currently examined with regard to its suitability for the target group of students in software engineering. The ProfilPASS is a development-oriented competence assessment instrument that places the individual and its development at the center of the competence reflection. Since personal competences, abilities and knowledge are shown in coping with everyday situations and situational actions, the focus of the ProfilPASS procedure is on the reflection of the individual action and the derivation of subjective competences. The aim of using the ProfilPASS in software engineering education is to examine it with regard to its contribution to the promotion of the awareness of the individual competence profile. In the course of this investigation, supporting factors of the ProfilPASS are examined, which are considered to be profitable for students in software engineering in the process of competence assessment. The analysis results are then used as the foundation for the conception of a didactic design, which should support the students in recognizing and naming both their technical and their interdisciplinary competences. The students can use the results of this competence assessment as a basis for reflection with regard to their future life and work perspectives. On this basis, it is possible to draw important conclusions for the formation of the individual educational, occupational, and life biography.

## Acknowledgment

This work is part of the EVELIN project and funded by the German Ministry of Education and Research (Bundesministerium für Bildung und Forschung) under grants 01PL12022A and 01PL17022A.

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