FAKULTÄT FÜR !NFORMATIK
Faculty of Informatics

Evaluation of digital badges for knowledge exchange platforms

DIPLOMARBEIT

zur Erlangung des akademischen Grades

Diplom-Ingenieur

im Rahmen des Studiums

Wirtschaftsinformatik

eingereicht von

Gregor Kastner
Matrikelnummer 0828732

an der
Fakultät für Informatik der Technischen Universität Wien

Betreuung: ao.Univ.-Prof. Dipl.-Ing. Dr. Juergen Dorn

Wien, 01.06.2017

(Unterschrift Verfasser) (Unterschrift Betreuung)

FAKULTÄT
FÜR !NFORMATIK
Faculty of Informatics

Evaluation of digital badges for knowledge exchange platforms

MASTER'S THESIS

submitted in partial fulfillment of the requirements for the degree of

Diplom-Ingenieur

in

Business Informatics

by

Gregor Kastner
Registration Number 0828732

to the Faculty of Informatics
at the Vienna University of Technology

Advisor: ao.Univ.-Prof. Dipl.-Ing. Dr. Juergen Dorn

Vienna, 01.06.2017

(Signature of Author) (Signature of Advisor)

Erklärung zur Verfassung der Arbeit

Gregor Kastner
Klopstockgasse 50/24, 1170 Wien

Hiermit erkläre ich, dass ich diese Arbeit selbständig verfasst habe, dass ich die verwendeten Quellen und Hilfsmittel vollständig angegeben habe und dass ich die Stellen der Arbeit - einschließlich Tabellen, Karten und Abbildungen -, die anderen Werken oder dem Internet im Wortlaut oder dem Sinn nach entnommen sind, auf jeden Fall unter Angabe der Quelle als Entlehnung kenntlich gemacht habe.

(Ort, Datum) (Unterschrift Verfasser)

Acknowledgements

I want to thank my advisor Jürgen Dorn for his assistance and patience during my work on this thesis.

Furthermore I would like to thank all my friends and colleagues during my time at Vienna University of Technology for their assistance, collegiality and mental support by motivating me during lectures and learning phases. I would also like to take this opportunity to express my particular thanks to David Madner for his friendship and his cooperation in joint projects and group-work during our study.

Finally, I would like to express herewith my gratitude to my family and parents for their support and encouragement to achieve my graduation.

Abstract

Digital badges may be virtually awarded by several organizations (for example educational institutions) upon an individual's achievements. Internet technologies, such as user profiles on social media or web services, may be used to collect and present these digital badges.

This thesis discusses the application of digital badges in knowledge management. More precisely, it is about the proof of personal expert-knowledge and competencies, acquired through informal learning. Whereas formal learning approaches are using a curriculum to define the learning path and certificates to proof learning achievements, a proof of additional competencies, such as experience in a particular topic or soft skills, is often missing.

This thesis introduces a concept how digital badges will solve the problem of a missing proof of hidden knowledge. We discuss the approach based on an online knowledge-sharing platform. TechScreen is such a platform that allows users to submit problems (challenges) and to discuss about them, respectively to submit solution approaches. Our approach uses digital badges to image one's gain of knowledge during knowledge sharing on TechScreen.

Based on this personal competence profile, TechScreen issues digital badges. As part of the research question of this thesis, we further defined a long-term study to evaluate whether digital badges are an adequate proof of hidden knowledge. Secondly, we conducted a questionnaire to evaluate the acceptance of digital badges and its resulting willingness to proactively share knowledge.

Kurzfassung

Digitale Abzeichen (sogenannte „digital badges“) werden von verschiedenen Organisationen (etwa Ausbildungsstätten) an Personen für bestimmte Leistungen, virtuell vergeben. Die Aufbewahrung und Darstellung dieser virtuellen, digitalen Abzeichen, erfolgt über Internet-Technologien (etwa Benutzerprofile in sozialen Medien oder über Web-Schnittstellen).

Diese Diplomarbeit behandelt die Anwendung von digital badges im Wissensmanagement, im Besonderen mit der Darstellung von persönlichem Fachwissen und Kompetenzen die über informelle Lernmethoden erlangt wurden. Während beim formellen Lernen (etwa in der akademischen Ausbildung) Lehrpläne und Zeugnisse als Kompetenzindikator herangezogen werden, fehlt meist der Nachweis von Zusatzkompetenzen, wie etwa fachspezifische Erfahrung oder softskills.

Diese Arbeit stellt ein Konzept vor, wie digital badges als Wissensnachweis dienen und wie dieses Konzept genutzt wird um das Problem des fehlenden Nachweises von persönlichen Kompetenzen zu lösen. Wir zeigen den Ansatz anhand einer online Plattform zum Wissensaustausch. TechScreen ist eine solche Plattform auf der Benutzer sich zu Problemstellungen (Challenges) austauschen können und Kommentare bzw. Lösungsansätze einbringen können. Wir zeigen, wie anhand des Wissensaustausch auf TechScreen das persönliche Kompetenzprofil eines Benutzers in Form von digital badges abgebildet wird.

Basierend auf dem persönlichen Kompetenzprofil werden in dem hier vorgestellten Konzept digitale Abzeichen von TechScreen ausgestellt. Im Rahmen der Forschungsfrage dieser Arbeit wurde zum einen eine Langzeitstudie definiert um die Tauglichkeit von digital badges als Kompetenzindikator für zusätzliche Kompetenzen zu evaluieren. Weiters wurde auch die Akzeptanz von digital badges und die damit verbundene Bereitschaft, Wissen zu teilen, im Rahmen einer Umfrage evaluiert.

Contents

CHAPTER 1

Introduction

1.1 Motivation

We constantly keep learning every day, collecting skills, gain experiences and specialize us on particular topics. Human beings acquire this knowledge often at educational institutions (schools, colleges, universities, etc.) or during professional practice, when approaching new challenges for example. Anyhow, knowledge acquisition and competence development furthermore happens also on a more subliminal level, when enjoying hobbies for instance. A lot of experience and skills one has gained in his personal life is simply not documented since there is no formal certificate or proof of competence available for this type of knowledge. But even in formal education, for example at University, this phenomena can be noticed. Courses and exercises often have a certain goal, but due to the scope and the learning path to successfully complete the the lecture, additional valuable competencies may be acquired. The grade of a lecture certifies that one has met the goal of a lecture but may not proof any other, additionally acquired competencies. Lets consider Advanced Software Engineering, a lecture offered by Vienna University of Technology, to precise this idea. All students of this course need to define a software development project they want to implement. There are quite few restrictions neither regarding the application type (e.g. Desktop application, Web application, Mobile application) nor regarding the used technologies such as programming language, used frameworks, type of database, etc. As per the scope of this lecture, all students shall learn about the different management phases of a software development project such as specification, team leadership, time and resource planning, product implementation as well as testing and quality assurance. Hence the aim of this lecture is to practice management skills in software development projects it is not required to focus on any particular technology and a positive certificate proofs the acquisition of these skills during the lecture. However, there is often a concomitant. Students tend to use this lecture to pursue personal interests and explore new technologies during the project realization resulting in additional competency-building which is not necessarily subject of the scope of the lecture. The concept of digital badges might be a way to ensure the documentation of this additional competency gain as well.

All this growth of knowledge in addition to conventional education with a curriculum is called informal learning and may appear in different situations of curriculum based learning. We can perceive this continuing learning beyond formal education in information technology where we face a rapid progress in the development of new technologies. New trends and paradigms arise permanently and fast, thus further training is always essential in computer science.

The European Commission and other governmental institutions of the member states of the European Union recognize the importance of identification, assessment and recognition of informal learning. [6]. This is not just an important issue for governments and their educational policy. The emergence of new Internet technologies offer new strategies for knowledge management in enterprises [4] : "Competence management as part of knowledge management is a recent trend in enterprises to organize the development and recruitment of the work staff better." [12]. Only this two examples show that informal learning methods and competence management is omnipresent and the possibilities of knowledge management grew with the emergence of recent computer technologies.

There is a lot of scientific research on various topics around informal learning. Part of that research is to find appropriate approaches to detect hidden knowledge as well as the assessment of informal learning and the determination of reliability and validity. This context has a strong relation with knowledge management systems. Communities of practice (CoP) are essential for knowledge sharing and competence mining [24]. Social software systems are an approach to establish a digital community of experts using Internet technologies to share knowledge. [12]. Such knowledge exchange platforms support knowledge management in three respects. First to enable knowledge sharing and organization. Second to derive a user's competence profile, and third to mine competencies and to refer experts to a given problem statement. Behind knowledge exchange platforms, there is often a large user community. Such platforms often reveal different competences of particular users. Thus it can be a good indicator for an individual's competence, skills and experience. Part of this master's thesis is the evaluation of the capabilities of digital badges to make hidden knowledge more transparent.

> "Badges are digital tokens that appear as icons or logos on a web page or other online venue. Awarded by institutions, organizations, groups, or individuals, badges signify accomplishments such as completion of a project, mastery of a skill, or marks of experience." [8]

An example of such a digital badge is shown in figure 1.1. It is a badge, issued by Mozilla Webmaker[1]. Webmaker is a project that helps one to create web content to exchange and publish knowledge. The example, shown in particular, reveals the earner's competence in CSS design for Mozilla Webmarker projects. Digital badges are not only used for learning achievements. Moreover, they are used to indicate particular soft skills or sportive achievements. One example of an issuer of digital badges for sportive achievements is the organization committee of the New York Marathon [2]. They are offering the participants of the tournament to self-issue a digital

[1] http://webmaker.org

[2] http://www.tcsnycmarathon.org/welcome-to-marathon-season/claim-your-badge

badge. The verification if one is entitled to earn this badge is done trough the marathon starter's e-mail address.

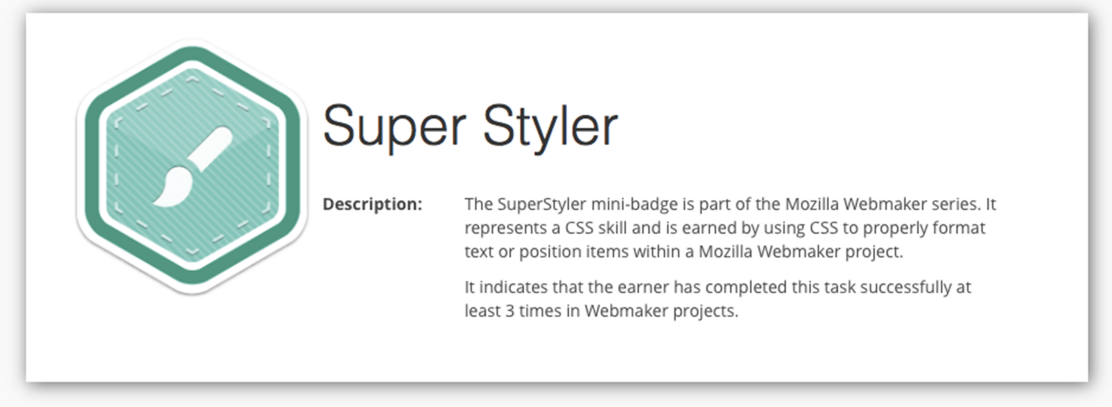


Figure 1.1: Example of a digital web maker badge

1.2 Problem statement

In this master thesis I focus particularly on knowledge exchange platforms and on-line communities. With the emergence of the Internet, it became very popular to acquire and share knowledge trough the Internet. Wikis, bulletin boards and question and answer platforms (Q&A platforms) are the most common on-line application types for knowledge sharing trough web technologies. With the launch of Stackoverflow, a Q&A platform for software engineering related topics as well as other scientific problem statements, in November 2008 [42], Q&A platforms became very popular for knowledge sharing. It is quite obvious that there is a strong connection between informal learning and knowledge sharing platforms. Users of an online-community may have a very strong expert knowledge which is simply not documented. Moreover, such kind of users are not awarded because of their efforts to share this knowledge.

There are several problems social on-line communities are facing in general but also a certain number of particular problems for knowledge sharing platforms. A key factor to all on-line communities is the user participation. It must exceed the critical mass to become attractive for it's users, to pro-actively interact with the community. When considering Q&A platforms, studies conducted on the example of Stackoverflow have revealed that only 0,5% of the users having resolved a third of all challenges with their answer. Thus it can be derived that users of on-line communities must see a personal advantage to contribute without any financial efforts - often this incentive is not given. Digital badges may be used to give users an additional value to compensate their efforts and motivate them to pro-actively join the community. Such additional values may be a sign of reputation or, when used in combination with formal learning approaches, an additional basis for assessment.

Research issues

Over the last years, digital badges became more and more part of different online-communities. Literature and empirical analyzes are only available of recent date. Long-term studies are quite rare, however a few case-studies of implementation projects of digital badges in online-communities are available and revealed the following conclusion:

(a) Digital badges are motivating users for self-directed learning

- Users are animated trough digital badges to explore new topics and establish their personal learning map. The concept of digital badges and its transparent awarding criteria, shows up different learning paths for users to follow.
- With digital badges, it is possible to split more complex learning targets and topics into smaller parts with different intermediate goals which will be awarded with a particular badge. This results in a continuous motivation to the user to go further in the topic.

(b) Digital badges increase user contribution and motivation to participate within the online-community.

- A competition among users of an online community arises and people are endeavored to achieve a particular rank in the community, which is expressed trough different badges.
- Social communities usually require the community to pro-actively contribute to the community without any financial incentive. Digital badges are an alternative to receive a valuable asset for ones personal activities within the community.

(c) Digital badges make hidden knowledge more visible and are a feasible proof of competencies.

- With digital badges, awarded trough different organizations, it is possible to express a user's competencies which may not be documented otherwise.
- Competencies in terms of technical skills that are gained beyond formal education (e.g. long-term experience during one's profession) will become transparent within the community and documented trough digital badges.
- Soft skills and personal attitudes may become visible as well. Digital badges may be awarded upon personal efforts to the community as well as other soft skills such as perception, solution-oriented thinking, helpfulness, interest in new topics, diligence, just to name but a few.

(d) Digital badges are a sign of reputation

- A distinction between different badges allows to award different involvement within the community. Users are usually performing different tasks within an online-community. Being an expert for a particular topic for example, or moderate an online-community,

by doing social tagging or rate different postings. Dedicated badges to express a user's commitment in terms of collaboration in the community as well as separate badges for passive users, who are mainly consuming information are possible. This lets a large number of the community with different intentions to earn badges and gain motivation which results in a lively online community.

- Digital badges are publicly stored in an user's personal badge repository. Different interfaces to social media lets a user share his or her badges, which are representing a valuable asset, also outside the online-community. Users may use this certified reputation in their curriculum vitae and for job applications for example.

(e) Digital badges are a novel approach for grading

- Generally, the increasing role of Internet-technologies and social media aided self-directed learning, has arrived at traditional educational institutions. Different case-studies, which we present in the next chapter, have proven this movement. Sharing knowledge, peer-to-peer among students by using Internet platforms as well as e-learning are tools, which are extending traditional assessments for grading.
- The motivation of students arises as they are having a larger flexibility of their learning-path with these new learning-tools.
- Tutors are having a larger basis of valuation. Personal interests and an additional research of a particular topic, performed by a student more in-depth than required by the lecture, will further influence the final grade of a passed course.

Based on the above mentioned expectations of digital badges with regards to their capability of being a proof of competencies, this thesis evaluates whether the use of digital badges are an adequate instrument to certify implicit knowledge as well as competencies, acquired trough informal learning. We are applying this concept to an online platform for knowledge sharing. This leads to the research question: **Are digital badges, used in knowledge sharing platforms, an adequate indicator for implicit knowledge?**

A further issue, that has an immediate impact on the research question, is user participation. We consider a sufficiently large user community as a prerequisite for the evaluation in order to be able to collect an adequate amount of meaningful data. Moreover users have to be motivated to share their knowledge, experience new learning paths and see personal advantages when receiving digital badges for their efforts as a necessary part to draw conclusions about the user behavior. We assume a positive answer on the above mentioned research question by validating the following hypotheses:

(i) A considerable number of students will accept digital badges and will be motivated for learning more than in a traditional environment. This is because digital badges will attest personal expert knowledge to user's who are sharing knowledge on such kind of platform. On the other hand user's will react on open questions of a discussion, combine existing knowledge and acquire new knowledge in order to approach these open question.

(ii) There will be a significant increase of online-users per day on the knowledge sharing platform as well as postings per day as the above mentioned arguments will provide additional advantage to students to share their knowledge trough the online platform.

(iii) A student's online badge repository provides a transparent self-reflection on one's personal competencies. Different types of badges will provide a personal competence-profile as it enables one to categorize competencies as well as determine the level of expertise on a particular topic. Additionally the transparently published collection of available badges with its requirements of competencies in order to receive a particular badge, will help users to establish a personal learning path and dive deeper into topics they are interested in. For that learning effort they will further be granted with a digital badge.

1.3 Methodological approach

The underlying scientific foundation for this master thesis, particularly related to the methodology, is the design science paradigm. Design science is defined as follows:

> "The resultant IT artifacts extend the boundaries of human problem solving and organizational capabilities by providing intellectual as well as computational tools. Theories regarding their application and impact will follow their development and use." [20]

The acquisition of knowledge that aids the productive application of information technology to the universality requires to combine the design science paradigm with behavioral science. Behavioral sciences refers to the explanation of human behavior (e.g. deriving theories, laws, or principles) [20] .
The roadmap for scientific work of the design science paradigm is as follows:

1. **Knowledge absorption**
   Existing state-of-the-art implementations of digital badges and the required processes will be observed. Recent publications concerning case-studies of projects on implementing digital badges in online-communities as well as Q&A platforms in academic environments will be evaluated as well. This resources will provide the underlying domain specific knowledge.

2. **Evaluation of requirements**
   The requirements will be defined to enable a Q&A platform to feature digital badges. This contains all relevant use-cases and features a user expects and to be required that digital badges can meet the expectations, defined in 1.2

3. **Conception/Design**
   The design artifact will be a concept of implementing the required features of the Q&A platform based on available frameworks. The focus is on an university context. We will consider a knowledge sharing platform for students on an intra-organizational level. The

purpose of this platform is to be a contact point for students at Vienna University of Technology who are working on projects or papers during a lecture or seminar as well as students who are working on their bachelor, master or Phd thesis. It further contains a definition of different badges and its awarding-criteria with a particular focus on how the knowledge-related badges are linked to competencies and how these competencies are measured. We further evaluate available open badge frameworks in terms of their capabilities to allow users to collect digital badges and share them across multiple online platforms. Finally the design will be validated against the requirements and verified against the expectations, defined in 1.2.

4. **Prototype**
   The proposed prototype will be the applied design to the TechScreen Q&A platform. TechScreen linking together students and other scientific-staff to share expert knowledge. It takes the concept of a Q&A platform, such as Stackoverflow, further and provides a platform for knowledge exchange, with built-in functionalities for self-assessment for one's personal education. It has an integrated competence mining, in detail, the application calculates an user's knowledge and competencies with machine learning technologies. The prototype will use the result of TechScreen's competence calculation and contain a definition of the digital badge management, the awarding process, a user's badge repository and how these badges can be shared beyond the system borders of TechScreen. The prototype will not be a fully productive-ready implementation, however it will show the collaboration between the different components of TechScreen, such as voting of user-posts, social tagging and competence cockpit.

5. **Evaluation**
   Existing insights of TechScreen are available beginning form TechScreen's launch a few years ago as well as the recurring "Knowledge management" lecture. These insights reveal the current problems by analyzing the user behavior on TechScreen as well as questionnaires. The prototype will be evaluated against the research issue, particularly against the hypothesis: With lessons-learned form existing studies, the impact of digital badges on the user-contribution to the community and motivation for self-directed learning can be evaluated. Additionally a long term evaluation is required to see whether there are significant changes in user behavior as well as if users ascertain a positive impact on their personal lifelong-learning path when using digital badges. We will describe an evaluation method in this chapter.

1.4 Aim of the work

As mentioned before, there is a strong motivation to detect hidden and undocumented knowledge, derived by informal learning. The overall ambitions of that field of research is to ensure a transparent measurement of this knowledge with uniform standards. Individuals can profit from this since it proofs an additional skill. Several methods could be feasible and the key questions are always how to detect hidden skills and how to document them. This thesis figures out whether if a knowledge sharing platform is an appropriate way to measure such kind of skills and

if digital badges are a convenient way to document and proof the knowledge. It will discussed based on the TechScreen platform.

1.5 Structure of the work

Applied to this master's thesis, the work is subdivided into 6 chapters. The next chapter is a discussion of state of the art of various related topics. Three key topics are forming the three cornerstones of the underlaying state-of-the-art of this master thesis. First there is an overview of learning-concepts. Second all existing and related web technologies, especially social media platforms and online communities are described. There will be further a particular focus on how expert communities have been moved to the Internet and how knowledge is shared nowadays across the world wide web. Third, the state-of-the art of digital badges will be discussed. Furthermore it will be drilled down to digital badges in online communities with regards to Q&A platforms. I also present some case studies of existing approaches and empirical studies to use digital badges in social software as well as in education. These empirical studies cover conducted measurements on the user-behavior of social community's members.

Chapter 3 is about the requirement analysis. I will collect all requirements for an implementation of a digital badge infrastructure to TechScreen. These requirements are functional and non-functional requirements, given from the system behavior of TechScreen's processes as well as to meet the above mentioned targets. Furthermore there will be a description of use-cases around the digital badging process. Basis for the evaluation of requirements are insights, resulting from empirical research and lessons-learned during the implementation of digital badges at various social platforms.

Chapter 4 describes the design. We will describe all processes related to digital badges in details in order to fulfill the requirements and use-cases to meet the above mentioned objectives. We will furthermore describe all badges that could be earned and its corresponding awarding-criteria. TechScreen offers a lot of interaction possibilities, starting from submitting new challenges, posting and discussing about a particular topic and posing correct solutions, up to moderate the community in terms of tagging posts or vote about the quality of particular posts. Also passive activities like gaining knowledge by consuming contents and pursuing an discussion among experts may lead to a badge. This different types and reasons for earning a badge will be discussed and have influence to the design.

The evaluation of the prototype will be described in chapter 5: A validation and a verification of the prototype will be performed [45]. The increase of transparency of digital badges will be evaluated as well as the reliability of digital badges with regards to security and trustworthy. Since TechScreen is used for teaching assistance in certain lectures (e.g. Knowledge Management), a meaningful evaluation on the question, if there is an influence on the users activities within the knowledge management exchange platform is noticeable, can be performed.

Chapter 6 contains an outlook on this topic and future work. In this thesis there is only a focus on

digital badges for a knowledge sharing platform at Vienna University of technology. There are many links to further topic. First, TechSchreen is focused on the needs and competencies around the faculty of informatics. Thus the systems has a competencies catalog, limited to computer science, mathematics, business management and economics. TechScreen with its digital badge infrastructure can be enlarged to be used in other faculties. Second, TechScreen can be opened to a public user community, outside the boundaries of Vienna University of Technology to see the influence on the quality of contribution. Third, the digital badge could be extended to an integrated soultion for all learning resources at the university. This could be the e-Learning system or lecturers and tutors who are issuing badges beside TechScreen. As future research there should be an evaluation of concepts how to integrate acquired badges to the grading process and what are feasible approach to substitute parts of challenges of a lecture with self-directed learning.

CHAPTER 2

State of the art

In this chapter I describe the result of my state-of-the art evaluation. The corresponding topics of this master's thesis are extensive, beginning from concepts of knowledge management and education science to Internet technologies with a special focus on Web 2.0 concepts and in particular on social software.

First it starts with a literature research on learning types. Since this master thesis has a particular focus on digital badges in context on educational institution, it is important to understand the different learning types. There is a difference between the curriculum based formal way of learning which is the basic of education on academic institutions and the use of new Internet technologies such as social software and the use of digital badges. When using digital badges as an additional skill indicator and basis for graduation it is essential to understand the difference of this two approaches form the point of view of the different learning types.

Second we go further with explaining social communities. Social communities became more and more popular with the emergence of Web 2.0 technologies. It changed they way people communicate and sharing information and knowledge across the boundaries of geographic regions, enterprises and cultures. Different social communities raised recently for different problem domains with different types of web based applications (e.g. Bulletin board, Wikis, Question and Answer Platforms).

Third we explain digital badges and its concept behind. This chapter contains a technical explanation of how such a badge is digitally represented as well as all processes and use-cases related to digital badges. Moreover some state of the art implementation of digital badges will be shown as well as a discussion of available literature about concepts of using digital badges in education including empirical analysis of the impact of digital badges on social communities.

Learning types, social communities and digital badges are the three cornerstones of the underlying theory of this master thesis. Finally there is a reference to available state of the art platforms

and technologies to perform my experiments during this master thesis. We will consider all procedures, related to education, applied at Vienna Technical University. Moreover there is a project running called TechScreen, representing a social community in terms of a Question and Answer platform. Finally I use a Mozilla Open Badge Infrastructure based implementation for handling all processes with regards to digital badges. All this instances of the underlying theory will be used for my solution approach and will be introduced in the last subsection of this chapter.

2.1 Learning types

Literature research reveals a lot of scientific research activity on different learning types. Together with the term learning types, the term lifelong learning goes hand in hand. Moreover, different learning strategies my lead to achieve the learning objectives. A learning strategy describes how to acquire knowledge (e.g. trough courses, trial-and-error approaches, literature research, etc.). Lifelong learning is not a new term and there are many different definitions about that, starting form a philosophic point of view, to a very narrow definition of that term [25]. A common sense of most of the researchers on learning types is that lifelong learning is not associated with a particular age group. Donald W. Mocker and George E. Spear evaluated the different definitions of lifelong learning in their paper: "Lifelong learning, non-formal, informal and self-directed". After comparing different approaches on the term lifelong learning they came to the conclusion that "The authors are suggesting that an operational definition of the concept of lifelong learning should be based on the locus of control for making decisions regarding the goals and means of learning. Many, perhaps most, adult educators and psychologists agree that one of the distinctive characteristics of adulthood is the willingness of individuals to assume responsibility for decisions that affect their lives" [25]. Additionally they derived the lifelong learning model (see figure 2.1)
Considering the lifelong learning model, here is a brief overview about the different learning types. Formal learning describes a human's learning process in a structured and systematic way. It is mostly intentional and knowledge will be delivered trough an instructor. It is the traditional way of learning we all know from school, college and university as well as training courses in adult education or inter-organizational trainings. With formal learning, the learner has no control over the objectives (learning targets) as well as the means (methodology of learning). Both, objectives and means are predefined by the organization. In contrast to formal learning, there are informal learning concepts arising. One important driver for the raise of importance, attached to informal learning concepts, is the rapid growth of Internet based technologies that contributes to the development of new informal learning scenarios. Web 2.0, especially social software systems based on Internet technologies are useful tools to link experts together and establish so called communities of practice over the Internet. The two terms will be highlighted later, first we give a definition of informal learning. The informal learning concept was introduced by John Dewey [29]. There are many different definitions of informal learning but the key message of all of them is nearly equal: Informal learning often happens subliminal and is experience oriented. It is further a non-structured learning process that does not follow any curriculum. Moreover informal learning happens more often on demand than formal learning. That means an individual

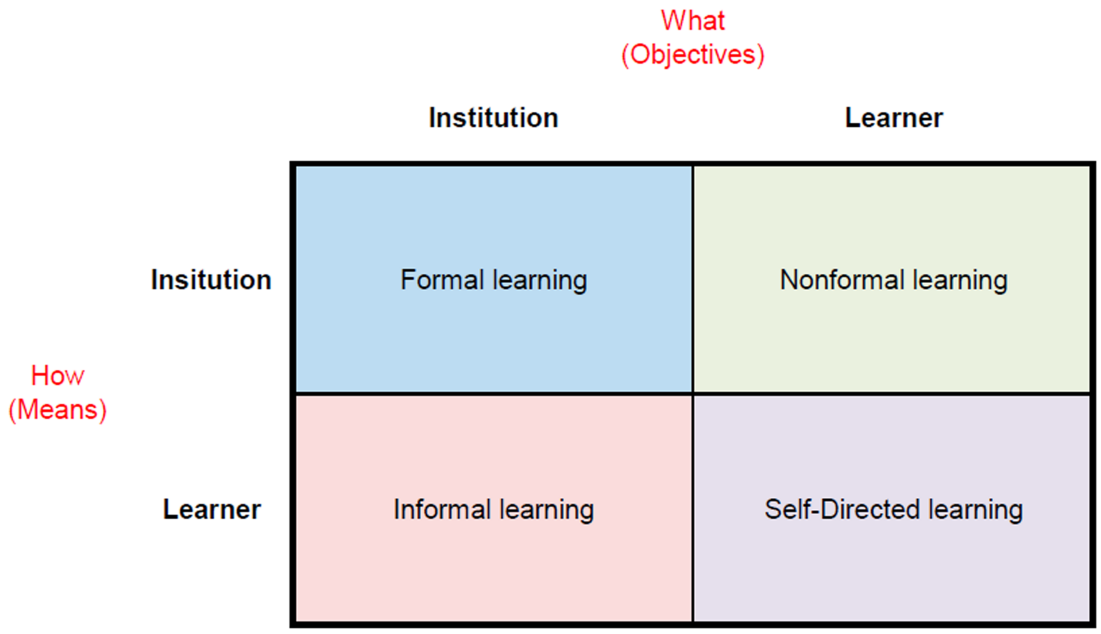


Figure 2.1: Lifelong learning model

will gain knowledge in a particular topic once he or she is facing a certain problem.

> "In contrast to traditional knowledge transfer, corporate learning should emphasize the sharing of knowledge by capturing experiences, reusing them, creating new knowledge and recognizing and solving workplace problems in a process-oriented, collaborative manner. Such learning can best be supported via the cultivation of communities of practice." [29]

> "Other definitions on informal learning may be, for example, the spontaneous and non-structured learning that occurs in our daily life that go by in different contexts; any activity involving the pursuit of understanding, knowledge or skill which occurs outside the curricula of educational institutions, or the courses or workshops offered by educational or social agencies" [19]

One important issue in informal learning is the validation of the learning success of informal learning. Eventually one aim of this master's thesis should be an approach of validating informal learning by using digital badges for knowledge exchange platforms. There is a lot of research activity in the topic of validation of informal knowledge. The CEDEFOP (European Center for the Development of Vocational Training) published the European Guidelines for validating non-formal and informal learning [3]. This publication is the result of conferencing and figuring out how to validate informal learning. It points out the different phases of the validation and certification process during formal as well as informal learning methods and the inferences

between them (see figure 2.2). The project behind this publication ran two years in total and experts of more than 20 European countries have been part of it. The publication can be seen as a compendium of experiences and best practices, but it does not provide any legal basis. However this paper is a valuable basis for the evaluation of the scientific problem solving approach of this master's thesis. We come back to this guidelines more in detail later in the evaluation phase of this thesis.

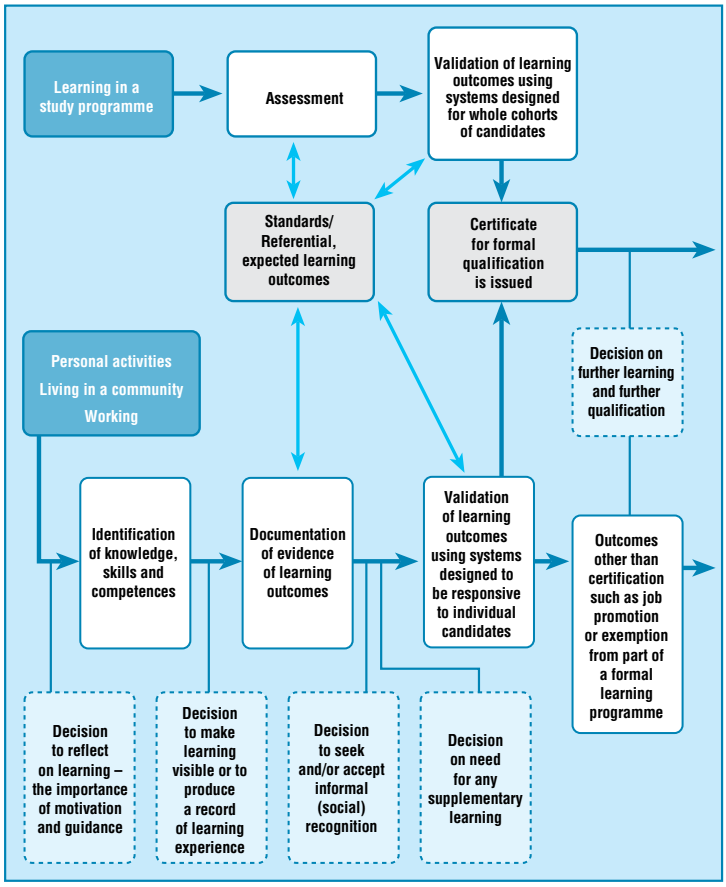


Figure 2.2: Routes from learning to certification [3]

Coming back to the lifelong learning model, here comes a brief discussion of non-formal learning and self-directed learning. A non-formal learning approach has certain similarities with

informal learning, however it is more structured with regards to the means (e.g. “how to learn”) that informal learning. A typical example of informal learning are seminars or workshops. All kinds of community based learning with dynamic learning targets are non-formal learning situations. Self-directed learning is a learning situation where no institution commit any influence on what are the learning objectives as well as how to learn. Typically a human being is learning a lot during the first years of his life (e.g. language, social behavior, etc.). However, for educational learning only formal and informal learning is relevant.
A second interesting project, referring to this topic, is the TRAILER project. It is supported by the European Commission as well and is not about the validation process of informal knowledge but outlines the importance of making informal knowledge transparent. Its objectives are to facilitate the consciousness of informal learning being part of an individual's development. [28] Moreover it points out the requisite to establish communication channels to publish and share informal knowledge among all involved stakeholders. This stakeholders might be the learner, who provides a certain competence, teachers and tutors who are validating informal knowledge and others who are looking for competences. The latter is very important to emerge communities of practice and social learning. Finally this communication space could be a valuable resource for human resource managers als well for recruiting staff. One condition to make the knowledge more transparent is to have the possibility to tag knowledge - the participants of TRAILER project are laking about *tagged instances*. TRAILER project's approach is to define a framework for identifying personal informal knowledge of an individual, a methodology for tagging this knowledge and establish a space for this tagged instances as well as emerging communication channels for making them transparent. The methodological approach of TRAILER project is visualized in figure 2.3. The personal portfolio of informal knowledge is the backbone of an individual's competence level. Around the knowledge portfolio there is the personal learning network (PLN), that contains the resources for informal learning [29]. For defining tagged instances a competence catalog is available to provide predefined categories of informal knowledge. With the interface that gathers informal learning activities which is called informal learning connector (ILC) it is possible to derive a work-flow to achieve the above mentioned objectives of TRAILER project. The results of this projects are the work-flow, mentioned before, as well as a technical implementation of the framework which is the basis for the methodology. It is an open source, web based tool. Once a users has captured a new informal learning activity with the ILC it will be stored in the personal repository of the learner and will be visible to his or her organization (e.g. tutor, employer, project members, etc.). TRAILER follows a similar way to TechScreen and is a close connecting factor for the approach of this thesis. However it provides more a tool to easily bookmark learning content within your personal learning network with the ability to tag it.

It cannot be said that either the formal learning has more advantages than informal learning and vice versa. Moreover both learning concepts result in a different educational objective. Formal learning ensures a certain standard of education and competencies in both quantifiable skills as well as soft skills [23]. Furthermore formal learning systems can be designed to be very efficient and ensure a proper and punctual education in a certain topic. Most companies are focusing on formal learning by arranging training sessions or workshops but they have one major problem: **They do not have any documentation of valuable informal knowledge that**

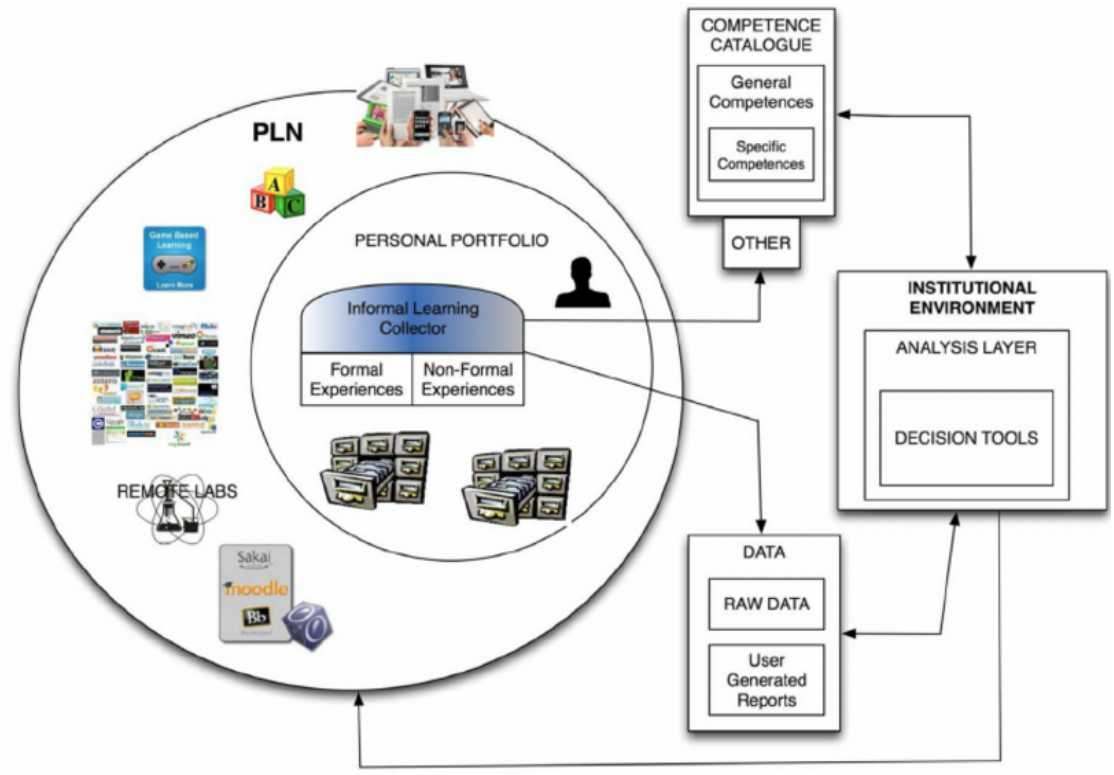


Figure 2.3: TRAILER framework [28]

is available among the employees of the enterprise and can be considered as hidden knowledge [29]. Informal learning can on the opposite ensure a more detailed and in-depth research in particular topics. Furthermore it is much more cost effective. In times of a tense economic situation, companies cut their expenditures on training and education [10]. With informal learning this lack can be compensated although a documentation of available competences within the company is necessary as well as to ensure a proper knowledge exchange process.

Mocker and Spear further define the terms non-formal learning and self-directed learning. Non-formal learning concepts are also defined by the European Community. It describes a learning system where the institution has the control about how to learn but not what. In other words, the learner has the control about the learning objectives but not about the methodology. One can compare that learning type somehow with specialization tracks at master's courses. The boundaries of the learning phase is define by the institution (e.g. university) but the objectives are defined by the student. Finally they mention the self-directed learning type. It allows the learner both, to control the learning means and learning objectives.

2.2 Online communities

Since new Internet based technologies are appearing pretty fast, a lot of different buzzwords appear as well referring to these new Internet trends. “Web 2.0”,” social media”, “social network”, “Internet of things”, “Web community’, “Online community”’, are examples of such buzzwords, just to name but a few. However, my research on that topic revealed that they have one in common: There is no common definition or standardization of these terms. For that reason, my definition of the term online community as a combination of both concepts, social software as well as communities of practice. Considering both of this concepts I call online community. Users of a common interest, using social software trough the Internet for sharing their knowledge and interacting in terms of commit challenges, posting comments and resolutions and tagging other user’s content are part of an online community.

Social software

Online communities and social media platforms are two of the phenomenas, emerged with the rise of the Internet. Different types of platforms are dedicated to different fields of applications. Social media platforms, such as Facebook[1], are very popular to stay in touch with friends or colleagues. Other social media platforms like Xing[2] or LinkedIn[3] are business oriented social networks for professionals. Companies recognized as well, that online communities are very popular for linking people together on a world-wide leve, but they could also be very efficient for intra-organizational knowledge management [13]. Social online platforms could be used as a blog, bulletin board, a wiki or a chat for knowledge sharing. Wikis and knowledge sharing platforms are very common tools for knowledge sharing. The latter will be the basis for the evaluation of the use of digital badges for competence indication. Robert Plant defines an community as

> “a collective group of entities, individuals or organizations that come together either temporarily or permanently through an electronic medium to interact in a common problem or interest space” [2]

Social software and online communities are further delivering all relevant data for competence management and the conclusion to an individual’s skills. Thus social software is nowadays often used to identify hidden knowledge and competence within an organization. Further relevant issues of online communities will be illuminated by social science. The motivation of participating in an online community or virtual community is very similar to the motivation of joing a community of practice [43].

Wikis

Wikis are a very common tool for knowledge sharing among a group of users. They are used either internally within an enterprise or publicly. The most common wiki is the Wikipedia project[4].

[1] http://www.facebook.com
[2] http://www.xing.com
[3] http://www.linkedin.com
[4] http://www.wikipedia.org

It is an open online encyclopedia. The basic principle of a wiki is not a passive consumption of information, moreover it should animate a group of users to a collaborative knowledge exchange [26]. There are existing various wiki software products, based on different technologies. A wiki always consists of several wiki pages which can be easily created and modified by a WYSIWIG (what you see is what you get) editor, that means it requires no HTML or programming skills. Each wiki page is automatically versioned by the wiki software. Moreover it is possible to link between wiki pages and each wiki software contains a full text search. This are the basic features, every wiki software offers [26].

The most important paradigm about wikis is that every contributor is equal. Everyone can add or modify information. From a knowledge management perspective this ensures a permanent quality control and revision of the users community. The efficiency of Wikis in knowledge Management is mostly explained by the following design principles of a wiki (see Table 2.2). This principles are contributing in a working atmosphere and establishing communities of practice based on a voluntary participation without any financial compensation [17].

Knowledge exchange platforms
In addition to Wikis, so called question and answer websites (Q&A sites) emerged recently, particularly dedicated to knowledge sharing. Two very popular representives of that category are Stackoverflow[5] and Yahoo answers[6]. A Q&A site usually works in a way, that a user can raise a question to a particular topic to the community. Whereas Yahoo answers requires to categorize this question among predefined categories, Stackoverflow simply works with keywords. So every question gets tagged with one or more keywords by the inquirer. Once the question has been published to the community, others can submit answers to that questions. Again, other users can review the answers and add comments on them. Moreover it is possible to rate and classify the quality of one's contribution. With Stackoverflow, it is possible to accept an answer, that means the accepted answer was the key for solving the inquirer's problem. Derived from the user-feedback. The reputation of community users will be derived. Stackoverflow uses digital badges as well.

Communities of practice

The term "Communities of Practice" (CoP) was characterized first by Etienne Wenger and Jean Lave in 1991 [19]. It describes a paradigm that supports this new approaches of learning systems. A lot of productivity gets lost within an organization (e.g. university or enterprise) since valuable knowledge is hidden and experts of practical fields of research can not collaborate in an efficient way as the is no communication platform available to bring them together. A definition of a community of practice is:

> "Communities of practice are collaborative, informal networks that support professional practitioners in their efforts to develop shared understandings and engage in work-relevant knowledge building" [19].

[5] http://stackoverflow.com/
[6] https://answers.yahoo.com/

Open	Should a page be found to be incomplete or poorly organized, any reader can edit it as they see fit
Incremental	Pages can cite other pages, including pages that have not been written yet
Organic	The structure and text content of the site is open to editing and evolution
Mundane	A small number of (irregular) text conventions will provide access to the most useful page markup
Universal	The mechanisms of editing and organizing are the same as those of writing so that any writer is automatically an editor and organizer
Overt	The formatted (and printed) output will suggest the input required to reproduce it
Unified	Page names will be drawn from a flat space so that no additional context is required to interpret them
Precise	Pages will be titled with sufficient precision to avoid most name clashes, typically by forming noun phrases
Tolerant	Interpretable (even if undesirable) behavior is preferred to error messages
Observable	Activity within the site can be watched and reviewed by any other visitor to the site
Convergent	Duplication can bed discouraged or removed by finding and citing similar or related content

Table 2.1: Principles of a Wiki [11]

A key concept of Community of Practice is community knowledge [22]. It is characterized by different levels of expertise that are present in the community of practice, resulting in a community knowledge, always larger than personal knowledge. Moreover, even experienced employees can extend incomplete knowledge [22]. Available expert knowledge is an intangible asset within an organization and the formation of Communities of Practice is therefore an important part of an organization's knowledge management strategy. However, Communities of Practice cannot be established from outside, rather they simply emerge once enabled by an convenient organizational knowledge management strategy and working culture [19].

Katerine Bielaczyc and Allan Collins approach in their article "Learning Communities in Classrooms: A Reinceptualization of Educational Practice" the learning effect of a Community of Practice. They say a learning community emerges a culture of learning and knowledge will be shared within the community resulting in a support to the growth of one's individual knowledge [5]. Furthermore, some problems are to complex to be approached by one individual. Within the community it is possible to share and develop joint knowledge to approach new problems. Bielaczyc and Collins defined four characteristics which are mandatory for such a

culture:

1. There must be diversity in the expertise of the communities members.

2. A clearly defined objective to contribute to the community and continuously advance the knowledge

3. An emphasis on learning how to learn

4. Knowledge sharing mechanisms

Digital badges and its application could contribute to all of the four paradigms, mentioned above. They can be considered as indicator for specific skills and knowledge-fields and show up diversity. Furthermore it might help gaining motivation to a CoP's member in contributing and sharing the knowledge. This effect of digital badges to this characteristics, defined by Bielaczyc and Collins, will be evaluated in a later chapter. When an organization focuses on the establishment of Communities of Practice with their knowledge management strategy, they should measure the results and efficiency of their Communities of Practice. Such measurable parameters could be value creation, flow of knowledge or tracking of the learning process [44]. Etienne Wenger, et al. differentiate in their Book "Cultivating communities of practice" between two methods of measurement: (1) stories and (2) systematicity. They argue that story telling in form of case studies is, due to the complexity of the causal relations, a convenient way to reveal if whether there is efficiency in knowledge management with the Community of Practice or not. On the other hand this is difficult to manage since it causes high measuring efforts, it is not quantifiable and it cannot be consolidated. A story is always case-related and enables no complete overview. Thus a different approach is to collect anecdotal evidence systematically [44]. Wenger et all. describe to approaches: (1) the bottom-up systematicity that starts at the community level by identifying all activities and (2) the top-down systematicity that begins at the business strategy or business process level. However digital badges could serve as measurement indicator for that purpose as well.

With the emergence of new computer technologies, such as the World Wide Web (WWW), the classic approach of Communities of practice changed. New forms of Communities of practice raised, the so called online communities of practice respectively virtual communities. Christopher M. Johnson treated this field of research in his paper "A survey of current research on online communities of practice" and noted that there are some structural differences between traditional communities of practice and virtual communities. Of course there are obvious parameters such as different geographical locations and time zones. However there are also cultural differences. Johnsons argues that within a traditional community of practice it is clearly defined who is a member and who not. Moreover they have formal boundaries. This is different in online communities [22]. Online communities are conducted much more loosely. They are organized around an activity and they are getting formed upon a need arises. It's about clustering people with same interests and problems. They must not work together every day both their field of interest overlaps and thus they share knowledge and experience [22] [44]. Virtual communities

are supporting this paradigm even more. They bring people together across geographic boundaries, across the boundaries of organizations as well as across all levels of skills and experience.

Michael Wu describes in his blog a classification of community-related social media, introduced by Brian Solis, digital marketing analyst. Brian Solis his classification "conversation prism". The key message of the conversation prism is that a social (online-) network is an online visualization of already pre-established interpersonal relationships. It has a network structure. In contrast the community is held together by common interests, although there may be pre-existing interpersonal relationship between members. Moreover one can be part of different communities. [46]

2.3 Digital badges

The use of badges as a validation indicator of certain skills or achievements goes back a long way. It has a long tradition in military. They use badges as a visual sign on a soldier's uniform to certify certain skills. Recently this kind of badges have emerged in an online environment in the form of digital badges. Starting in online gaming communities a few years ago, educational institutions and enterprises are using digital badges to indicate a learning process and validating skills and hidden knowledge. New technologies such as Mozilla Open Badges, emerged recently to support this new applications.

Digital badges can provide advantages for online-communities, its members and self-directed learners:

1. **Recognition and skill indication**
   Digital badges are a virtual proof of a skill or particular achievements. They can be issued to certify a certain knowledge, especially hidden knowledge, acquired trough informal learning. Various organizations could issue digital badges upon the earner of the digital badge committed certain artifacts, passed courses and e-learning sessions or has proven his skills in collaborative working. Whereas certificates are common in formal learning with curriculum to prove a positive pass of the course, there is now evidence in informal learning. Digital badges are a resource to provide such evidence, in addition to certificates. For example, the online knowledge sharing platform Stackoverflow allows others to vote the quality of a users postings and contribution. This votes result in different badges which show the reputation of a certain user (see figure 2.4)

2. **Creating a personal learning map**
   Earned badges are publicly shared in the online community of the earner. Others can browse one's digital badge repository and could explore additional knowledge and achievements. With digital badges, everyone is able to see the criteria to receive a certain badge (e.g. show certain experience in collaborative projects, passing different e-learning courses, etc.). This opens one's horizon to new learning and provide a learning map with personal learning targets [16].

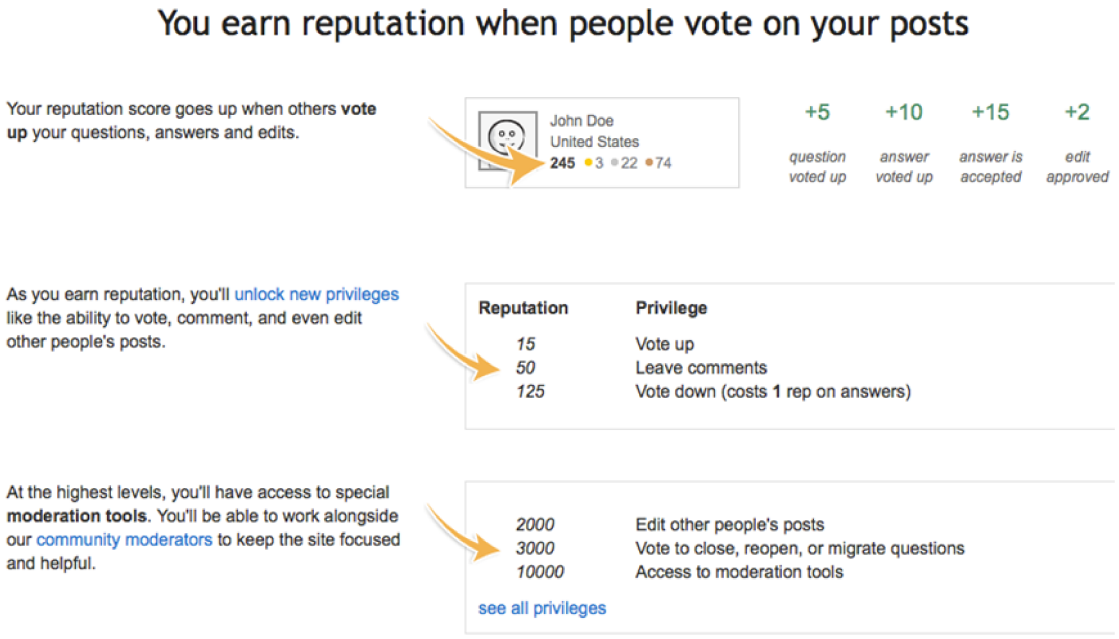


Figure 2.4: Reputation badge schema of stackoverflow [7]

3. **Gaining motivation for collaboration**
   With digital badges it is easier to mine for skilled people. If an organization requires certain expert knowledge for a research project for example, they could define mandatory badges and query the community to find new experts. With this strong social media and social community orientation, ta digital badge platform is also a hotbed for new groups of experts, collaborating together and share knowledge among this expert group.

4. **Motivation to participate within the community**
   New web technologies and paradigms, such as Web 2.0, require a participation of users. This is because one major concept of Web 2.0 is that content is generated by users. Even Web 2.0 is working very good and it can be shown that this user centered approach is working quite will, there is still a high number of passive users [21]. Digital badges offer an advantage to the user community in more directions: Firstly digital badges can be used to measure and document one's contribution. Starting from a beginner level, a user could be motivated to achieve a higher rank in the community. Such incentive schemes have been implemented to a large number of online communities which we will describe later in this chapter. To gain motivation for proactive user contribution, Stackoverflow is issuing separate digital badges for different stages of participation (see figure 2.5).

[7] http://stackoverflow.com/help/reputation
[8] http://stackoverflow.com/help/badges

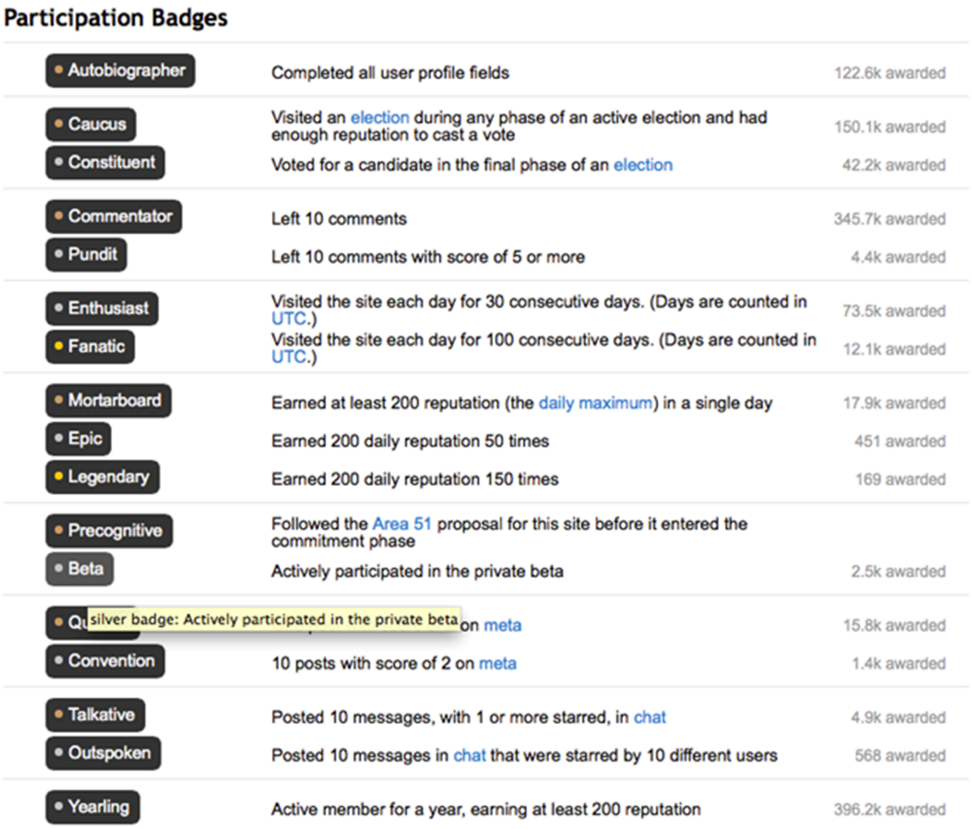


Figure 2.5: Participation badge schema of stackoverflow [8]

A digital badge's lifecycle

The lifecycle of a digital badge starts with the issuing process. The earner of a digital badge could receive a badge upon solving a challenge on a Question & Answer platform, participating in both, online as well as offline training courses, participating in volunteer programs or passing any other kind of assessment. Once one has earned a digital badge, it must be stored. This digital badge repository is hosted in the cloud and consolidates all digital badges of a user, issued from different organization. One example would be a collection of various badges issued during the attendance of different university courses and further badges issued by charitable organizations (e.g. one's volunteer work for the red cross). All these badges are collected in one centralized, cloud-based, repository and available for the user to share. Digital badges can be published in a visible representation on a user's personal profile within a social community, or shared via social media such as Facebook or Xing. Digital badges are then a way to express a person's personality profile and skills. Beside the graphical representation, a digital badge contains always a payload within the PNG file containing Meta-data for validation of the digital badge. Thus it provides the reliability that everyone can validate a user's digital badge against the issuer.

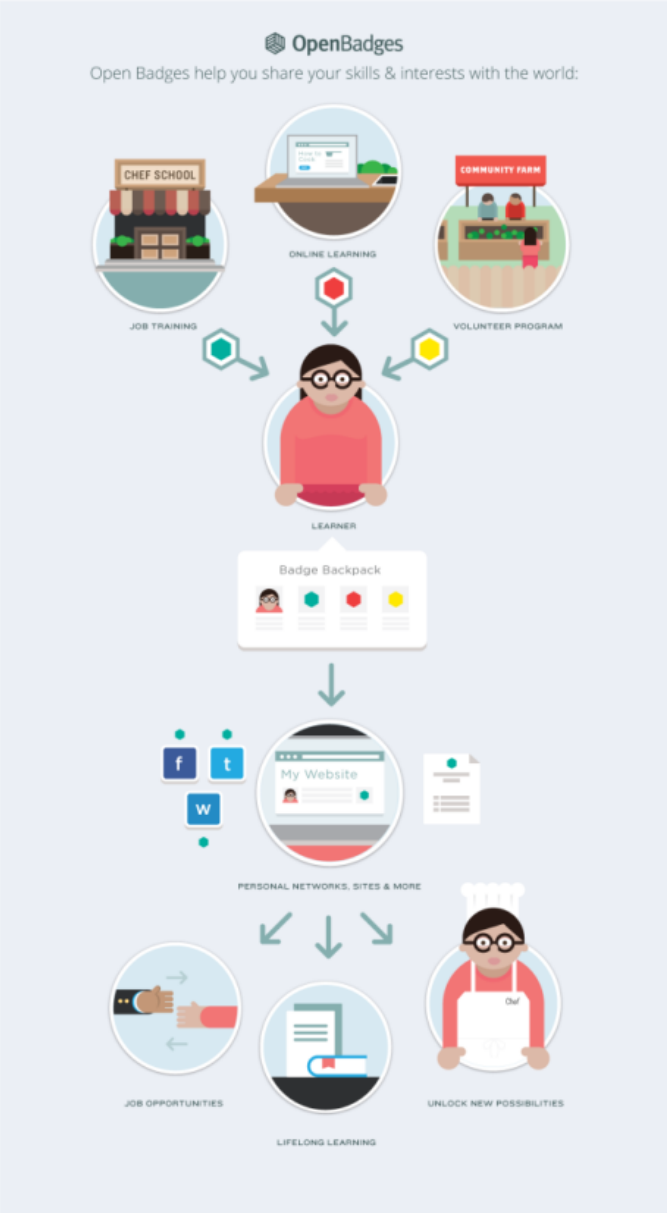


Figure 2.6: A digital badge's lifecycle [9]

Technical standardization

To make the process of collecting, issuing and displaying digital badges more efficient, different digital badge infrastructures emerged. Furthermore, a common standard for the technical representation of a badge was necessary. This standard is implemented by a digital badge in-

[9] https://openbadges.org/get-started/earning-badges/

frastructure as well. This digital badge infrastructures provide the digital badge repository of the earner. It works in a way that the user needs his or her personal account at the digital badge infrastructure (e.g. Mozilla Open Badges) and stores all his earned badges in this online storage. From this storage it is possible to publish all badges and make the reputation visible to the community. On the other side, the digital badge infrastructure provides the process handling of issuing a digital badge. The issuer of a digital badge can interface his infrastructure with the API of the open badge infrastructure and the whole issuing process as well as the allocation of a digital badge is handled trough the open badge infrastructure.

State of the art digital badge implementation

As mentioned above digital badges provide advantages for different aspects of online-communities and learning-platforms. We will discuss a few examples of social software that already uses digital badges for different purposes.

Waze

Waze[10] is, a smartphone app for online traffic management including real-time traffic information. Initially founded as Israel based startup company, it has been acquired by Google in 2013[11]. Users are running the app while they are driving and Waze collects and share real time traffic information with the community. Obviously the quality and accuracy is highly dependent on how much users are online and sharing real-time traffic information as well as points of interest with the community. Thus the aim of Waze is to encourage users to contribute to the community. Based on the mileage of a users and its additional contribution (e.g. indicating a speed camera or road works), the user ascends in his or her rank. Figure 2.7 shows the different ranks of Waze. A high rank unlocks some features of the program, such as changing a user's avatar. Moreover, users with a higher rank can also submit a request for map changes in case of map errors. Waze is using the concept of gamification to engage users to provide information to the community without any monetary compensation [39].

> "Waze has proven to be effective in incentivizing user participation, as more than 50 millions users participate daily as users of and contributors to the traffic map" [15] [39].

Stackoverflow

Stackoverflow initially was a questions and answer platform related to software engineering topics. Users could ask questions about different programming languages (e.g. C#, C++, PHP, Java, etc.) as well as other topics around software engineering (e.g. code versioning, agile software development, testing, etc.). By now, Stackoverflow offers similar sections on its website for other topics such as Photography, use of languages, mathematics, physics, etc. On Stackoverflow, a user can submit a question to the community and every member can post an answer,

[10] https://www.waze.com/

[11] https://en.wikipedia.org/wiki/Waze

Waze Levels (Waze Points Levels)

 **Waze Baby**	Welcome to the world, Wazer! You're a baby now, but not for long... Drive 100 miles to become a Grown up.
 **Waze Grown-Up**	You've matured and can now pick a new Waze mood. To become a Waze Warrior you'll need to seriously ramp up on points...
 **Waze Warrior**	Behold the shield! You've reached the top 10% of high scorers in your region. Maintaining it won't be easy...
 **Waze Knight**	The sword is yours! You've reached the top 4% of high scorers in your region. You're almost Royalty... Keep on looking for point opportunities
 **Waze Royalty**	You've arrived! You're in the top 1% of high scorers in your region. Drive around knowing you're as VIP as they come...

Figure 2.7: Waze ranks [12]

which should ideally solve the requesters problem. Each question is tagged with adequate keywords which are used to categorize a certain problem statement.

Among all submitted answers, the community can vote for the quality of each answer. Additionally a particular answer could be declared as correct answer that led to the solution of the problem. When looking at the idea of Stackoverflow, it is obvious that the platform only works with a strong user community and the readiness of the users to participate without any monetary bonus. Important indicators for platforms, such as Stackoverflow, are the acceptance ratio, ratio of unanswered questions, no-response ratio and the average reaction time. Bosu, et. al. analyzed in their paper "Building Reputation in StackOverflow: An Empirical Investigation" these indicators and analyzed the user behavior as well as their motivation to contribute to the community.

Stackoverflow needs to deal with various challenges and uses digital badges for many reasons. They are using digital badges for both, as a competence indicator as well as to gain motivation for participation to the community (see figure 2.5). The basic principle of the incentive scheme used by Stackoverflow is gamification [9]. This is quite obvious that Stackoverlow is, as any social software, highly dependent on a large user contribution. However Stackoverflow has to consider one further issue related to user contribution: A contribution's quality. Compared to other social software (e.g. in comparison to Waze), Stackoverflow needs not only a large number of users just using the application, it is also crucial to have a high quality in an user's contribution. Empirical analysis revealed that there is a large number of almost 80% of all questions are either rated as poor-quality-question (with a negative user score) or with a user score of zero which will be considered as a question of zero interest of the community [31]. Cavusoglu et. al. conducted an experiment if digital badges have an positive effect on Stackoverflow in terms of the quality of an answer as well as a users motivation to participate. In their paper "Can Gamifi-

cation Motivate Voluntary Contributions? The Case of StackOverflow Q&A Community" they conducted an empirical analysis on the user activity of Stackoverflow. The brief summary of their results is that digital badges are having a significant positive impact on the quality of answers as well as a user's activity. Moreover a fast response time increases the possibility for a good score of a correct answer [7].

Finally it is often less motivation for user's to get awarded only with a certain rank or status within the community simply caused by a certain online activity. Especially when examine the influence and possible contribution of digital badges on informal-learning trough social communities, it is important that digital badges represent something more meaningful.

> "Badges serve several functions in online communities, including goal setting, group affiliation, experience, authority, and identity [...] A significant part of this meaning is as a representation of social prestige. [...] More recently, badges have found prominent use as learning objects, intended to help frame new forms of credentialing, assessment, motivation, and collaboration." [18]

Halavais et. al. performed an empirical study on the social influence on badge acquisition on Stackoverflow. They discussed Stackoverflow's approach of having two types of badges, the general badges and tags. General badges are related to tenure in the community (e.g. representing a certain status, such as rookie or guru) whereas tags are focused on a particular topic (e.g. C# development, PHP development, etc.). Their conclusion is that the social influence, which describes a behavior in which people adopt when enough other group members have adopted, are highly influence by badges. Tags are representing a learning pathway and provide a learning map to a community's member whereas general badges are having a greater community function [18].

It appears that the digital badge approach of Stackoverflow and its scientific studies on it are manly applicable to TechScreen since there are certain similarities. TechScreen is addressing the equal problem domain. It provides a online based Q&A platform for knowledge sharing with a particular focus on computer science. TechScreen can also only work with a contributing user community, submitting inputs of a certain quality level. Moreover it is designed to offer competence management and should engage users for self-directed learning. The state-of-the art discussion, especially on the focus of Stackoverflow, has shown successful examples of how digital badges can significantly increase user contribution in terms of quantity and quality as well as using digital badges for reputation and proof of competencies. Additionally, digital badges are providing advantages for self-directed learning including the personal learning-targets and the learning map. TechScreen has some characteristics, different from Stackoverflow. Firstly it is more focused on the Vienna University of Technology, serving as tool for students and researchers to exchange knowledge as well as mining for experts for certain problem domains withing the community. Therefore the relationships are of a stronger tie compared to Stackoverflow. Secondly it has a stronger link to education and learning strategies. TechScreen is designed as a supplement to formal learning and should extend this curriculum based approach by using self-directed and informal-learning.

State of the art of digital badges in education

Lorena Nisperuza discussed digital badges in education in her Master's Thesis. She evaluates the use and design of digital badges and a digital badge infrastructure for higher education as skill indicator and to better integrate new media such as social communities or e-learning platforms to the classical, curriculum based, formal learning approach. Her conclusion is that digital badges could be an adequate way to support the learning process of a student. However, she also critically noticed, that a student must see an additional, personal, value to develop acceptance of digital bades.

> "Additionally, an important factor in badge motivation is feedback; this lets the students know how they are doing, by creating opportunities for reflection this can improve the participants skills and increase feeling of connection to the learning process." [30]

Razvan Rughinis made a critical reflection in his paper "Talkative Objects in Need of Interpretation. Re-Thinking Digital Badges in Education". His approach is to formulate badge definitions as heuristics. His research revealed a strong context of extrinsic and intrinsic motivation with regards to digital badges. His main concerns are that badges are extrinsic awards that could engage learners because they are excited about that but are not a constant motivator for life-long learning. He describes this behavior wit the model of economy of attention. There is an assumption of limited attention for learning activities: The new exciting grading instrument may attract a learners attraction. However it is a question how long. Learners will focus on badge conditionalities. Following to that, it is important to design those instructions to lead to a valuable learning. The advice of Rughinis is to design so called badge tails as learning paths in longer, winding trajectories. Moreover he mentioned the argument of motivation displacement. He describes this as a situation in which individuals may loose motivation when introducing extrinsic motivations. The concept of Rughinis is to design badges that reach to the future with entitlements for more advanced roles in the learning environment.

Digital badges have been introduced in several educational institutions. One representative case study is the implementation of digital badges at Borders Collage in the United Kingdom which started mid 2012 with a first idea. Later they started a pilot project in study year 2013/2014. The college was using Moodle as e-learning platform, prior to the idea of digital badges. They established a separate e-learning team, operating and maintaining the Moodle platforms as well as running the digital badges related pilot project. This dedicated team did, beside some required technical adoptions to the Moodle platform, the conception of digital badges. Moreover they took over responsibility to train students and tutors and promote the new way of learning evidence among the collage's community as well as summarize the pilot project and evaluate the lessons learned [41]. The defined a bunch of targets when they started with digital badges, including:

- Reduce difficulties to proof evidence of new knowledge.
- Increase e-learning activities and make e-learning sessions more valuable.

- Award e-learning and Moodle best practices and efforts to students and tutors.

At the beginning of the digital badge infrastructure, which has been implemented by using Mozilla's open badges infrastructure, there was doubt among the academic staff. Their concern was that an additional workload is required for processes and activities, related to digital badges. [41] With the available resources of the e-learning team it was able to provide intensive promotion and communication work to convince the academic staff. In addition, gamification was contributing to emerge the new concept. students had the possibility to vote for lecturers and tutors and their intense of using Moodle. A competition raised and academic staff was forced to deal with informal-learning concepts, e-learning and digital badges resulting in exploring new possibilities of teaching. The case study reveled that academic staff favorably accepted the possibility to show their achievements on their Moodle user-profile as well as social media [40].

Similar approaches are described in case-studies of an implementation of digital badges at Khan Academy and MIT. Kahn Academy is a non-profit organization, running a web-based learning platform that covers various fields of research [13]. Lecturers and "content specialists" are providing videos including an e-learning system, featuring online-assessments and a peer-to-peer link between students and tutors. The platform support learning with a personal learning-cockpit for an individuals learning path. Khan Academy uses digital badges for both, motivation as well as to prove passed exams. Like in other digital badge environments, described above, Khan Academy is using badges to keep users motivated and gain competition. For example, there is a "Great Listener Badge" that will be awarded for watching a video lesson of at least 30 minutes duration. Digital badges are also more and more used in traditional building institutions.

> "Traditional colleges and universities are considering badges and other alternative credentials as well. [...] The Massachusetts Institute of Technology announced that it will create MITx, a self-service learning system in which students can take online tests and earn certificates after watching free course materials posted by the university. [47]"

MIT is using digital badges for its e-learning offers at the campus. There is additionally a cooperation with OpenStudy. OpenStudy is a platform that link student together. Across a set of available fields of research, students who are working on a similar topic can easily exchange each other. As part of tis cooperation, there is an agreement that students who are regularly interact with OpenStudy and providing useful content will be awarded with digital badges.

The literature study on existing approaches has revealed that, due to the fact that digital badges are quite new, there are no long-term evaluations available as well as that there is a quite tentative use of digital badges in education. Some universities and colleges did implement digital badges mainly to accelerate the e-learning activities of students and staff. Moreover these digital badges are linked fixed to a criteria for earning the badge, for example after passing a standardized test. Literature study revealed that there is no existing approach of using digital badges as part of the

[13] https://www.khanacademy.org

grading of even to substitute certificates. Digital badges are also not awarded dynamically for specific competences, calculated automatically through knowledge sharing platforms.

2.4 Related platforms and technologies

My master thesis will evaluate the use of digital evaluation for knowledge management platforms. As part of the evaluation, I will apply my concepts of the design to TechScreen, an existing knowledge sharing platform. As part of my evaluation, I made a prototype implementation of a digital badge infrastructure on the example of TechScreen. Since TechScreen is an existing social software, running at Vienna University of Technology, some technological issues have to be considered. Before starting with any implementation it is required to understand the technical- as well as process related architecture of TechScreen including Drupal, its underlaying web development framework. Moreover a platform for creating, issuing, verifying and displaying digital badges is required. In this section I will briefly describe the concepts of TechScreen and Drupal as well as the evaluation and concepts of a feasible digital badge infrastructure.

TechScreen

TechScreen[14] is a web-based knowledge management and sharing tool, developed and running at Vienna University of Technology. It allows a registered user, who could be part of one or more organizations, to commit a challenge on a certain problem. Others of the community cooperate to solve the problem. Each member of the community is able to tag information, to post a solution respectively a solution step and to evaluate other's contributions. The aim of TechScreen is not only to share knowledge on an intra-organizational level but also across the borders of organizations. Since it has been developed in the university environment, one application scenario is the knowledge and competence exchange among different faculties and institutes [14]. Joint research projects could be handled more easily since TechScreen enables competence mining across different organizations

A further feature of TechScreen is competence mining by using machine learning technologies. TechScreen allows a user to create his or her own competence profile, which will be calculated automatically. The two basic concepts for automated competence minig are ontologies and social tagging. Figure 2.8 shows the architecture of TechScreen.

- Ontology
  An ontology is a formal specification of knowledge. Its core concepts are classes, attributes describing classes and relations between classes. TechScreen is using an ontology to describe a knowledge resource. Each knowledge entity is represented as a specific knowledge resource type. Figure 2.9 shows the resource ontology with its different knowledge resource classes. A knowledge resource can either be a document (which will be classified more fine grained by the child nodes of the document knowledge resource type), a reference to a knowledge artifact (e.g. a hyperlink) or a user's contribution (e.g. a

[14] https://techscreen.tuwien.ac.at

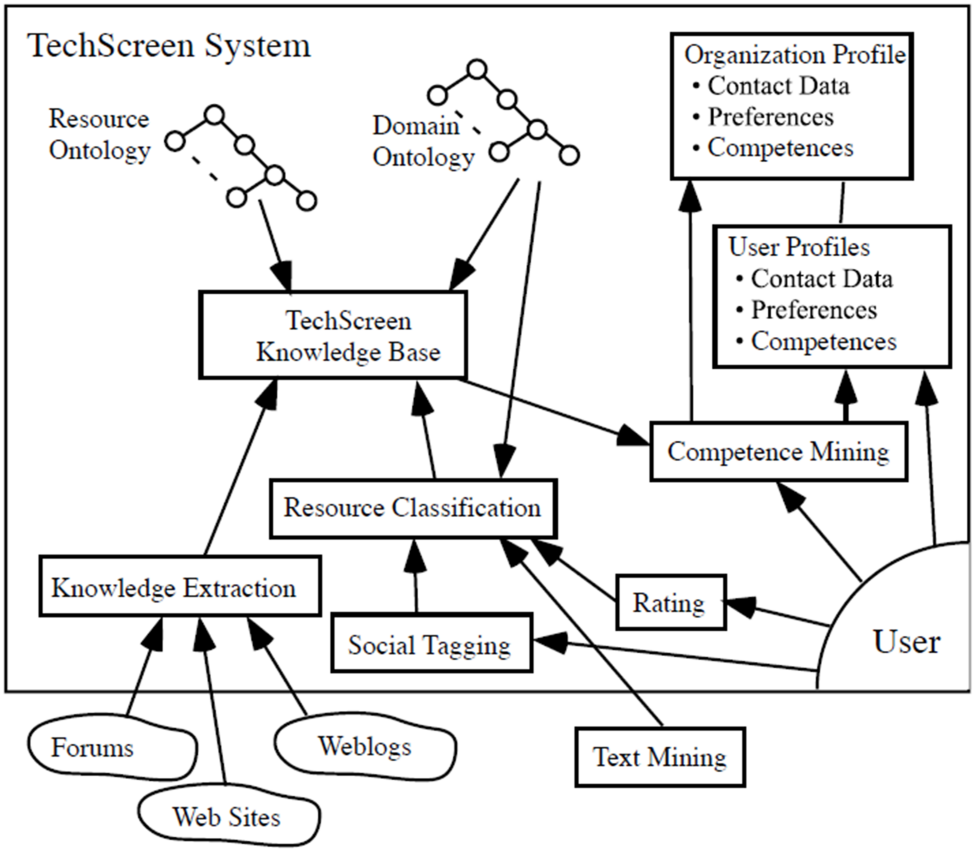


Figure 2.8: Architecture of TechScreen [12]

text-input in the form of a comment, a tag or a solution approach). Beside the ontology of a knowledge resource, a second ontology defines about 140 predefined competences [12]. This competence ontology is the basis for the competence calculation of a particular user and is defined by experts. For the automated and proper classification of a knowledge resource, TechScreen is using text-mining techniques as well as social tagging.

- Social tagging
  Based on the ontology, a knowledge resource can be further characterized by the use of additional meta information (e.g. attributes). Each resource has a a predefined set of standard meta fields (such as date, time, author). However, this meta information can be extended with user specific tags (e.g. keywords) to classify a knowledge resource, in addition to the automatically extracted information [14].

TechScreen is able to automatically calculate and derive a user's competence level. As mentioned above, a competence ontology is used to do a rough subdivision of a contributor's knowledge that can be alleged. However this is only a very global classification of a particular problem

Figure 2.9: Resource ontology of TechScreen [12]

domain and a more fine grain classification is necessary. This is approached by TechScreen with social tagging in addition to the ontological reasoning an text mining [12]. The overall calculation schema of TechScreen is described in figure 2.10

Known limitations

During the analysis of the technical background of TechScreen, we identified the following disadvantages of TechScreen:

- For now, TechScreen cannot be considered as a production-ready platform. It is still in an experimental- respectively prototype phase, resulting in incomplete or erroneous components. Moreover, there are various revisions of the competence ontology, used in different parts of the system.

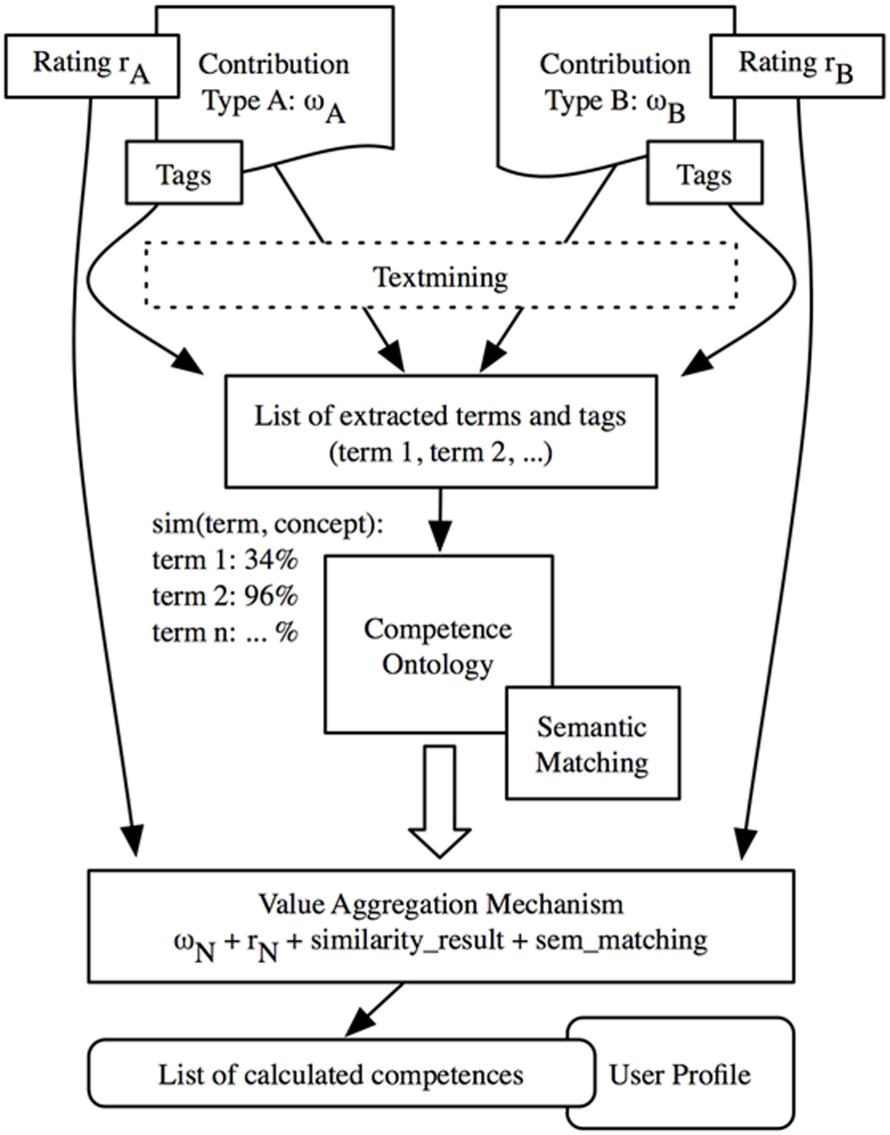


Figure 2.10: TechsScreen competence calculation [12]

- TechScreen is documented very poorly. It is the outcome of different study projects and different parts of the platforms have been designed and developed by different project groups. A joint documentation on both, a technical- as well as process level is not available. That requires a lot of effort to identify where in the process the badge related functions need to be implemented. Moreover it makes migrating to Drupal 7 or higher more complicated. For instance the TechScreen related modules are not documented about the used database model or the required and depended libraries of the Drupal core. The latter could make trouble with updating to a higher Drupal version.

- TechScreen is not used by a large community. It is not very well known across the boundaries of the Knowledge-Management lecture, held by Vienna University of Technology. That makes an evaluation of the underlying competence algorithm not possible for a larger amount of users.

Drupal

Drupal is a PHP based content management system (CMS) framework. It is available under a GPL (open source) license and is the application backend for the TechScreen application. Drupal comes with a basic set of standard functionality and can be extended individually. The figure2.11 shows the architecture of drupal:

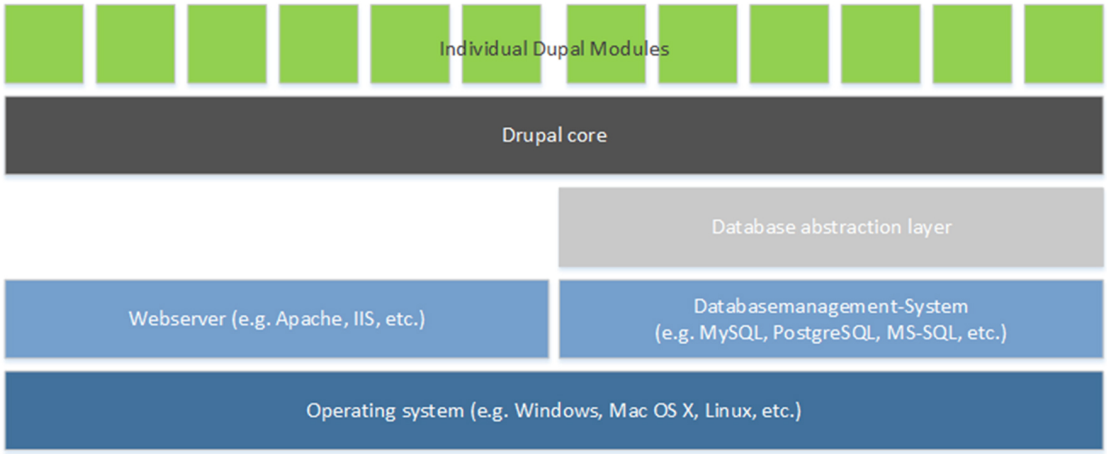


Figure 2.11: Drupal architecture

The core concepts of Drupal are:

- Drupal Core
  The Drupal Core contains a set of standard modules as well as the required backend. It contains necessary program libraries as well as the database abstraction layer and basic features such as user- and session management, localization, template handling, syndication and logging.

- Modules
  All functions are capsulated into modules. It is possible to activate modules as per requirement. The basic features of Drupal are encapsulated into modules as well, located in the Drupal core. If individual functionality is required it is possible to write individual modules. Moreover various modules are publically available to extend the feature-set of drupal.

- Hooks
  A hook is a speical kind of a callback function, allowing other modules to dynamically

load the module of a certain hook and interact with it. This callback functions gets not registered to a listener but they will be created simply by convention.

- Themes
  Drupal supports different template engines to ensure a separation of the content and its representation.

- Nodes
  A node is a generic data object (similar to the class type "object" in Java). Every information (page, blog post, comment, calendar entry, etc.) is of a type node and hierarchically structured. Thus it is also possible to combine content of different content types.

- Blocks
  A block contains information which want to be added on recurring parts of the template. One example could be a user centered menu with individual controls to the user, currently logged in, or a section with the upcoming events of a calendar.

Digital Badge Infrastructures

There are different services available, offering a digital badge infrastructure. The purpose of such a service is firstly the hosting of a persons digital badge collection one has received from different badge issuers in a central repository (e.g. in the cloud). Secondly it provides the issuer of a digital badge the necessary technology to interface the issuer's service with the digital badge infrastructure which handles the issuing process including the assignment of a digital badge to a particular user. The features offered by different digital badge infrastructure services may differ, they will be compared in the next section

Mozilla Open Badges

Open Badges[15] is a project, run by Mozilla, and takes the concept of digital badges further. To ensure a proper workflow, interoperability among different badge issuers as well as a trustworthiness of badges issued certain technical rules have to be considered. All this concepts are part of the Mozilla Open Badges Firstly it starts with a common technical standard. Considering various e-learning platforms, most of them are build on different technologies. Or considering volunteer programs or job trainings, in case they issue any kind of certificate, they all have their individual process of assessment. To avoid individual technical standardizations and data formats, a common standard is necessary. Mozilla Open Badges introduced the Open Badge specification. [38]. The basic concepts for the data structure of a digital badges are assertions and baking. Digital badges, build on the Mozilla Open Badge standard are called open badges.

Secondly, a user needs a central repository to collect and store all of his or her open badges. As part of the Mozilla Open Badge project, there is the particular software component available for this purpose. It is called Mozilla Open Badges Backpack. Mozilla offers a hosted instance

[15] http://openbadges.org/

of the Open Badges Backpack[16]. The backpack does not only stores a user's digital badge but it also enables the user to share and distribute this information (e.g. on social networks, learning platforms, knowledge sharing platforms or to enable new job opportunities).

Concomitantly to the process of issuing, collecting and displaying open bagdes, some further features are part of the Open Badge standard and its implementation. The following enumeration gives an overview of the basic concepts of Open Badges:

1. Assertions
   An assertion is the necessary metadata, describing an open badge. It is a semi-structured text in JSON notation. This meta data will be included into the the png image, representing the badge graphically. This process is called badge baking.

```
{
  "uid": "f2c20",
  "recipient": {
    "type": "email",
    "hashed": true,
    "salt": "deadsea",
    "identity": "sha256$c7ef86405ba71b85acd8e2e95166c4b1114
       48089f2e1599f42fe1bba46e865c5"
  },
  "image": "https://example.org/beths-robot-badge.png",
  "evidence": "https://example.org/beths-robot-work.html",
  "issuedOn": 1359217910,
  "badge": "https://example.org/robotics-badge.json",
  "verify": {
    "type": "hosted",
    "url": "https://example.org/beths-robotics-badge.json"
  }
}
```

```
{
  "name": "Awesome Robotics Badge",
  "description": "For doing awesome things with robots that
      people think is pretty great.",
  "image": "https://example.org/robotics-badge.png",
  "criteria": "https://example.org/robotics-badge.html",
  "tags": ["robots", "awesome"],
  "issuer": "https://example.org/organization.json",
  "alignment": [
    { "name": "CCSS.ELA-Literacy.RST.11-12.3",
```

[16]https://backpack.openbadges.org/

```
10        "url": "http://www.corestandards.org/ELA-Literacy/RST
              /11-12/3",
11        "description": "Follow precisely a complex multistep
              procedure when carrying out experiments, taking
              measurements, or performing technical tasks;
              analyze the specific results based on explanations
               in the text."
12      },
13      { "name": "CCSS.ELA-Literacy.RST.11-12.9",
14        "url": "http://www.corestandards.org/ELA-Literacy/RST
              /11-12/9",
15        "description": " Synthesize information from a range
              of sources (e.g., texts, experiments, simulations)
               into a coherent understanding of a process,
              phenomenon, or concept, resolving conflicting
              information when possible."
16      }
17    ]
18  }
```

2. Badge Baking
   The concept of an open badge's data structure is a structured set of information, describing the digital badge, wrapped in the payload of a PNG image. The PNG image serves as the graphical representation of the open badge. The process of transforming this information to a data structure in JSON notation and integrate it to the PNG image is called, in terms of Mozilla Open Badges, baking. As part of the Mozilla Open Badge implementation, a particular library is provided for this purpose [32].

3. Issuer API
   The issuer API provides features, to easily issue a digital badge. It encapsulates the process of baking a badge and transmit the issued badge to the earner's backpack [37].

4. Displayer API
   The displayer API allows to browse one's open badge repository and to retrieve a particular open badge from the Mozilla Backpack [36]

5. Verification
   The verification component ensures the authenticity of an issued badge. It enables the earner to prove the validity of his or her badges against third parties. Furthermore displayer of digital badges can ensure the validity of a user's digital badge collection. The verification component of Open Badges further supports badge verification, considering an expiry date. That enables an organisation to issue badges which are only valid for a limited period of time.

6. BadgeKIT
   The BadgeKIT is a set of tools, supporting the issuer of open badges during the entire process of issuing a badge. It consists of two parts: The BadgeKIT API and the BadgeKIT webapp. The BadgeKIT webapp implements a set of methods for the issuing process. It contains an API for issuing open badges and submit them to the earner's backpack. Moreover it is possible to use claim codes. This feature allows the earner to call for a badge. This could be on any particular event (e.g. a certain achievement). In addition, the API provides a feature that enables earners to apply for a digital badge and submit an evidence. This pending applications can be assessed by a reviewer and upon a positive result, the badge can be issued. [33] Finally it provides a digital badge management to issue badges on different organizational levels. [34] The BadgeKIT webapp is a user interface on top of the API and offers a tool to create digital badges as well as to issue them. The webapp is an optional component that offers a user interface to all features of the BadgeKIT API, thus it is not necessary to use the BadgeKIT API but it is also possible to interface the BadgeKIT API trough an third party application (e.g. a customized portal of the issuing organization) [35].

Known limitations Mozilla BadgeKIT is either available in the cloud or, as it is open source, it can be obtained from a git repository. Since the BadgeKIT cloud was in the beta testing phase by beginning of 2015, the cloud was only available to a number of selected beta testers. Thus, only the on-premise edition of Mozilla BadgeKIT is feasible for the prototype implementation.

The on-premise edition of BadgeKIT contained some major bugs which caused serious malfunctions on the testing environment, running node.js on Windows 7. In the User API there was firstly some manual code refactoring for bugfixing required, secondly the web based user interface is not working properly after starting the application. After successful login with Mozilla Persona (see figure 2.12), the session handling was not working as the authenticated user has not been recognized. Moreover there have been some browser issues with Mozilla Firefox (see figure 2.13).

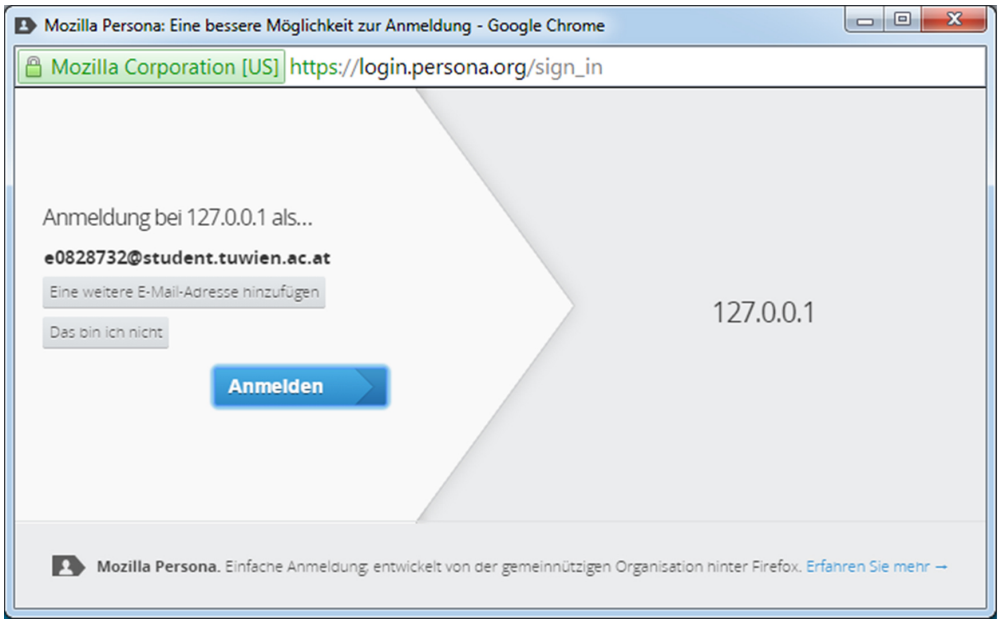


Figure 2.12: Mozilla Persona Login

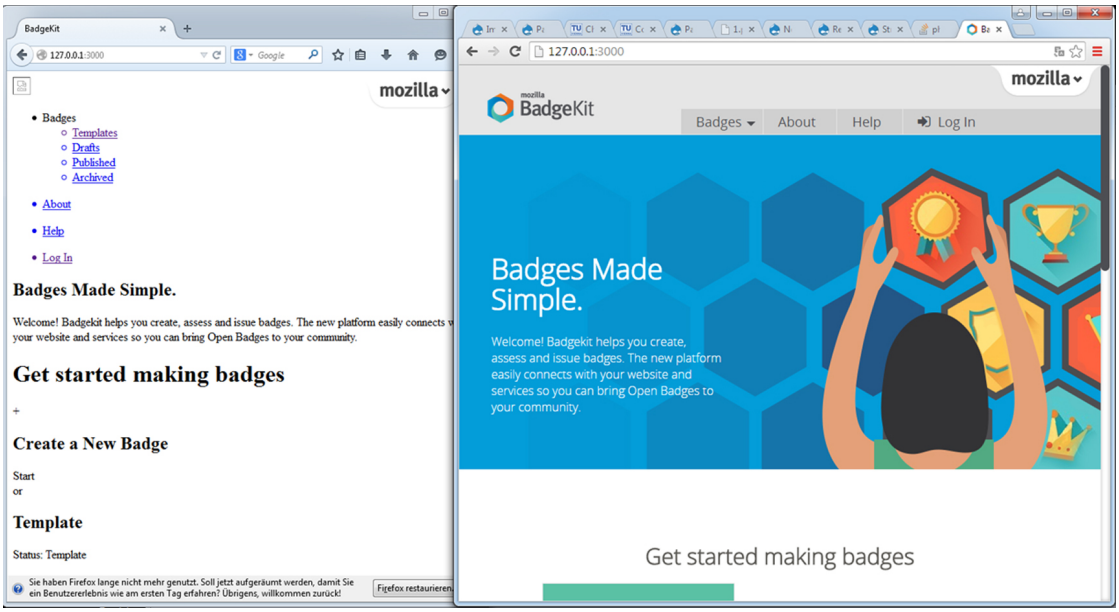


Figure 2.13: BadgeKIT user API rendering issues

CHAPTER 3

Requirements

Based on the expectations of using digital badges in online-communities, explained in chapter 1, we will explain prerequisites as well as requirements to the design of a digital badge system for a knowledge sharing platform. We consider in the requirements as well as in the design, described in the next chapter, the following targets:

(a) Digital badges will have a positive influence on an online-user's motivation for increasing self-directed learning

(b) Digital badges will contribute to a lively online-community as gamification will increase the motivation of users to participate within the community.

(c) Digital badges will make hidden knowledge more visible and is an appropriate instrument to document informal-learning success.

(d) Digital badges are a sign of reputation

(e) In an educational context, digital badges are a novel approach for grading.

To perform an experiment on that research questions, the functional- and non functional requirements including use-cases, different stakeholders and in which scenarios they will use a digital badge system for knowledge sharing platforms, must be defined prior to the design analysis.

3.1 Prerequisites

We consider a state-of-the-art online-community for knowledge sharing, based on recent Internet technologies and the ability to be accessed via a standard web-browser, as an existing part of the concept. We further assume an online-platform that is using a database as backend and provides all required features for knowledge-sharing. As part of the database backend, it provides a user-management and each users needs to sign up prior using the application. Each user

has a personal user profile, containing his or her contact data as well as possible other information such as an avatar, a list of reputation, further information about personal interestes etc. We require this user management including user-profiles for associating a user's badge repository to a particular user. This badge repository will be part of our design and allows one to publish his or her badges trough the personal user profile to the community. The user profile ensures a transparent declaration of earned badges, resulting in a sign of reputation, as well as motivate others to explore new research topic. In addition, a publicly shared badge gallery may gain a competition among learners.

When we consider a feasible online-platform for our purpose, it further shall provide features for social interaction. These features are a comment function, that allow users to interact and discuss on particular topics, as well as social tagging and a voting module. Social tagging is a concept that allows any user to index any kind of Internet resources (e.g. a post, an image, a movie, etc.). A voting module lets a user to vote between a certain range about the quality of a post (for example between 0=poor quality to 5=high quality). These social interaction possibilities are not only required to structure the knowledge within the platform, we consider them as possibility to award a badge on particular events, that certify a user's motivation to participate within the community as well as being interested to discuss about a topic (self-directed learning) and to attest a specific reputation (e.g. moderate a discussion by social tagging).

We will not present any requirement or design part for a feature or process, related to knowledge-sharing. This has to be an existing concept of the knowledge sharing platform. Moreover, this thesis does not cover the part of competence management in such kind of an online-platform. We will focus on how a particular competence may lead to a badge but not how a user's competence will be calculated or derived. A well-conceived competence management is a key issue for the concepts, introduced in this master's thesis. As we want to examine the capabilities of digital badges to prove hidden knowledge and further competencies, acquired trough informal learning. All competencies that can be certified trough this knowledge-sharing platform must be accessible to show a user different learning paths and accelerate self-directed learning.

3.2 Functional requirements

We will distinguish between functional requirements and non-function requirements. In this section we explain all those requirements that leads to particular features having a direct impact to meet the targets of the research issues of this master's thesis. In 3.3 we describe non-functional requirements, which are essential to the ecosystem to work properly.

Badge meta-data Each badge consists of an image as a graphical representation of it (see figure 1.1 on page 3). Additionally, a digital badge shall contain additionally embedded meta-data, describing the badge and its attributes in an machine-recognizable form. This meta-data is an important information to ensure validity and trustworthiness of the badge, especially when the earner of a particular badge wants to share this badge with others like employers for example. Each badge must be able to clearly identify with a unique

name. Further attributes of a badge are a more detailed description including keywords. As knowledge may be valid only for a limited period of time, it must be possible to set an expiration date for a particular badge. To ensure a reliable declaration of knowledge and reputation, the meta-data further contains a reference to the criteria for earning the badge as well as a reference to the evidence of the achievement including details about the issuer of the badge. As part of the meta-data there might be additional, technically required, payload for the signature of a badge, for example.

User profile with badge representation Badges are a sign of reputation. It must give the user a value and a possibility to show his or her badges. Therefore the user profile of the Q&A platform must contain a publicly visible gallery of all badges, earned by a user. This user profile can be accessed by any other member of the community. This transparent declaration and comparison of digital badges, one has earned, is an essential part for gamification and leads to an increase of user motivation for both: selfdirected-learning and pro-actively contribute to the community. Since digital badges shall be a visible sign of reputation, our design will not offer the possibility of hiding earned badges on the user profile. We believe that a large, public badge gallery is a key issue to accelerate the gamification process that leads to a lively user community. However the badge export interface shall allow the user to choose which types of badges shall be exported.

Badge criteria page Literature research has revealed that digital badges are a proper instrument to engage individuals for lifelong, self-directed learning. Thus it is essential that one can define personal learning targets. Digital badges with social communities a motivating factor for individuals to adopt learning targets. A badge criteria is a transparent declaration of the conferral rules of the badge mapping, showing users the criteria for earning a digital badge and target a learning path. This badge criteria page has two functions: First, it shall show a learning path to other user's of the community to identify their missing competencies to achieve the badge. Second, it must be a declaration for others (e.g. an employer or research institute) of the badge in terms of knowledge that is certified by this badge and its meta-data.

Badge export interface Digital badges are a sign of reputation and hidden knowledge. Users require a possibility to share these badges. Beside the badge gallery on the user profile, it shall be possible to share all earned badges with other systems than the knowledge sharing platform respectively other organizations than issuing organization of the digital badge. For privacy reasons, a user must have full control about this process. Thus the badge export will be fully manually and each user can choose which type of badge will be exported to which other system. In an educational context, users must be able to transmit particular badges to other applications within the organization, for example the e-learning system, to lodge these badges as part of a lecture's grading. Furthermore social media platforms, especially dedicated to business contacts, became very popular. As digital badges certify knowledge and skills, the badge export interface enables a user to share this sign of reputation among business contacts and use them for example during a job application.

3.3 Non-functional requirements

We consider non-functional requirements as requirements that are not directly dedicated to meet the targets.

Badge maintenance The question and answer (Q&A) platform has to include a separate administration panel for all badges. Users, having special privileges to perform these tasks, are able to define a new badge. When defining a new badge it is important to assign a name to the badge as well as an image, representing the badge. Moreover an additional description of the badge, a reference to the required criteria to earn the badge and a reference to educational standards this badge aligns to, if any. In the badge maintenance module there is a collection of available badges that can be earned.

Badge mapping For each badge it is required to define conferral rules. The system must provide an intuitive, yet easy-to-use and flexible possibility to define the criteria to earn a particular badge. It must be possible to map competencies of the competence catalog to a badge. In other words a combination of one or more competencies, attested by the Q&A platform should result in a badge. The system shall certify a particular competence in three different levels (beginner, intermediate, expert) based on the experience of the user. This needs to be considered in the badge mapping as well. A second requirement to the badge mapping is to consolidate badges to a super-badge: That means if a user was awarded with particular badges, he or she gets awarded with an additional badge. As any other social community a Q&A platform is dependent on a strong social community. For that reasen, separate types of badges, dedicated to social engagement of user in the community, shall be awarded as well. This badges for social competencies must then also be considered in the badge mapping. Finally a future scenario could be to integrate the badging system with other learning platforms (such as an e-Learning platform) or offline learning activities such as completing an exercise during a lecture. The design of the badge mapping interface must be flexible to be able to integrate future types of criteria.

Verification The trustworthiness of a digital badge is an important issue for the acceptance of digital badges as prove of competences of the earner. Hence it must be ensured that any badge, earned by someone, is protected against manipulations and has not been illegally awarded. Based on that requirement, two parameters are essential to ensure validity. First the algorithms of the issuing process must be reliable. A badge for a certain competency will be issued upon a calculated competence of the Q&A platform. This is a prerequisite of the Q&A platform that all algorithms for detecting knowledge as well as the quality of a post or a user's behavior are tamper-proof. Second, a third party person, viewing a user's badge collection must be sure that this badges have been originally awarded by the organization, mentioned in the badge.

3.4 Use-cases

Personas

Persona is an instrument, originally introduced in user experience design. We will use persona here to define typical groups of stakeholders, their function in the ecosystem and their requirements to the badging system of a Q&A platform. As we focus in this thesis on an educational context, we will highlight the stakeholders also from that perspective

Study commission The study commission defines all mandatory and optional lectures for a certain study program. The compile the curriculum for all study programs. Moreover they are defining the requirements for grading. The study commission has a superior view on all lectures and must approve the use of digital badges, especially for considering them for grading. The requirements for the study commission therefore is reliability and functionality. Especially when using the digital badging system as part of the evaluation criterion, reliability and immutability is a key-requirement

Lecturers Lecturers will use digital badge as part of their performance-appraisal. Hence all badges a particular student has earned need to be visible on a user-friendly user-interface. Additionally, a description of the badge and its conferral-criteria must be available at a glance. As a further recommendation, literature research has proven that promotion and training courses among the academic staff additional contribute to a higher acceptance rate. This is essential for the success and enforcement of digital badges for evaluation of hidden knowledge in the field of education.

Students Students are the beneficiaries of digital badges. They must profit from digital badges from a functional point of view as well. The digital badging system must be integrated in their learning platforms seamlessly. They should have a repository to store their collected badges and publish them to the lecturer for grading. Moreover they should be able to use digital badges for their personal reputation and be able to publish them on social communities such as Facebook, Twitter, Xing or LinkedIn, just to name but a few.

System administrators Each online platform typically has a technical administration interface as well as responsible system administrators for technical maintenance. Following that, a usable administration interface is required. The digital badging system must be flexible to be adopted for further extensions.

Scenarios

Within the context of the concrete example of Vienna University of Technology, there are many different platforms that could issue digital badges. Moreover one could earn additional badges upon the completion of various tasks and other scenarios.

Award new badge This use-case describes the process of how a user will earn a new badge. Since we are using digital badges for both, to certify knowledge as well as soft-skills the

process starts with the event of either a new or improved skill level concerning competences or soft-skills. As part of this use-case, the system must be able to apply different predefined conferral criteria and detect the event when a user fulfills this criteria and is worthy to receive the corresponding badge. Upon the event a user fulfills all criteria of receiving a badge, the system must issue this badge to the user's badge repository.

Self-directed learning Badges of users that someone has earned are publicly visible. Moreover each badge has a transparent conferral rule. This information including an overview of available badges will animate users to explore new topics and engage for self-directed learning.

Badge overview of students Digital badges are a novel approach to benchmark a student's performance. Lecturers may use digital badges as part of the grading criteria. This use-case shall offer lecturers an overview of earned badges of his or her students. The lecturer shall be able to enter a set of students that shall appear in the result list including their badges. Additionally it shall be possible to filter only relevant badges.

Badge export Digital badges shall represent an additional values to its holders, it shall certify knowledge as well as soft-skills and reputations. To offer the holder of those badges an additional value, they shall be able to transfer this badges to an external badge repository as well as social media.

Badge maintenance The badge maintenance use-case contains the process of defining badges and its conferral criteria. The catalog of all available badges will be technically maintained by the system administrator. Hence, the system must provide a particular administration interface to add badges including its meta-data as well as to define conferral rules.

CHAPTER 4

Design and Solution

This chapter describes all underlaying design considerations for the solution approach. Lesson's learned from the state-of-the-art literature research including empirical research as well as the requirements, defined in chapter 3, will be considered for the design study. We will describe different required processes and use wireframes to illustrate the desired implementation of them. Moreover we will define a set of available badges, how badges are awarded and how they can be consolidated (e.g. the achievements of several badges might result in one supper badge).

4.1 Achievements for badges

In our design, we distinct between two types of badges. As proven in different other social software scenarios with regards to digital badges, we will introduce badges associated to soft skills and event participation and badges, associated to personal skills and competencies. We will call them social badges and competence badges. A characteristic of a social badge is that such kind of a badge can be received after a completion of a small task (e.g. attending a lecture or practice a specific role within a project). A social badge can be also awarded for general online activity in terms of online presence within the community, response time on new challenges, quality of a post, just to name but a few. Social badges can also be combined with offline activities or can be awarded during a exercise interview for example. A competence badge in contrast, is a badge that is a prove of skills and knowledge. It will be awarded trough the TechScreen knowledge exchange platform by using its competence calculation algorithms. This machine learning technologies consider various input parameters such as the result of a user post's extracted text in combination with the tags, assigned to a challenge as well as the score of the other user's vote on the quality of the post. The evidence of the solution (e.g. link to an external resource) will be considered as well.

After studying various case studies, there are different approaches of implementing open badges in education. But all of them have one aspect in common: A predefined set of core compe-

tencies. [1] [27]. TechScreen has its own competence ontology, that is used for the classification of each user's competencies, during the process of competence calculation. In case of TechScreen, the competence ontology is quite fine grained. For example we define a badge "Web-Engineering" whereas TechScreen is calculating the competence for a particular web engingeering language or technique, so on a more fine grained level. According to our approach it is more clear and meaningful to issue badges on a more condensed level. TechScreens competence ontology consists of competencies in the field of computer science.

Artificial Intelligence	Algorithms	Functional computer languages
Object oriented computer languages	Procedural languages	Cryptography
Embedded systems	Database systems	Business Intelligence
Knowledge Management	Process Management	Web-Engineering
Usability Engineering	Software Engineering	Software Design
Simulation and Modeling	Software-Testing	
Logic computer languages	Distributed Systems	E-Commerce

Table 4.1: TechScreen's open badges of the category Computer Science

For the prototype implementation, we will issue the open badge in different levels: Beginner, Intermediate, Expert. This shall reflect the competence level. In addition to the above mentioned professional competences, we will define a few personal attributes to be certified with a dedicated badge.

4.2 Badge mapping

Our aim is to design a modular and flexible approach of issuing badges in education. Nevertheless we focus on digital badges for knowledge-sharing platforms in this work, we consider future applications in education as part of the design. To give an example, it could be possible to use this badges as certificates in lectures or as indicator to grade a student in a lecture. Furthermore, as already described, TechScreen is using a dedicated ontology for the competence calculation process. Each contribution to TechScreen (e.g. challenge, solution or comment) will be automatically categorized and the system automatically calculates a competence rate which indicates the skill level of a particular competence. Badges will then be issued based on a user's competencies.

This two factors, the flexibility to integrate other measures than the competence calculation of TechScreen as well as the mapping of a user's competence levels to a badge are requiring a flexible mapping. We present our approach by using wireframes.

Each badge that has been added to the TechScreen platform offers the possibility to define cas-

caded rulesets for the conferral rules of the badge (see figure 4.1). The cascaded rules consists of

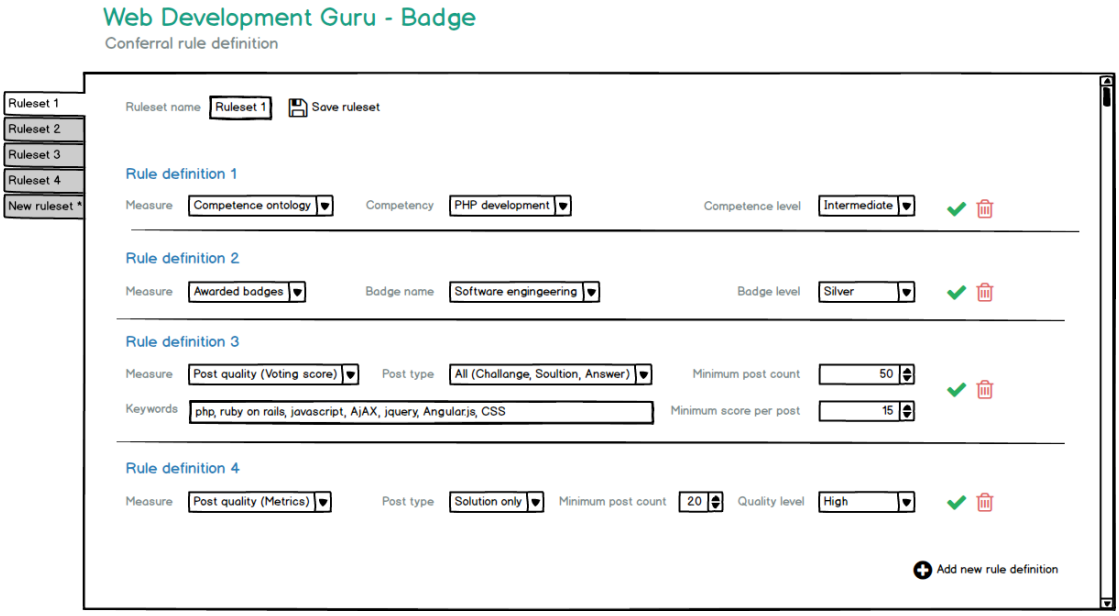


Figure 4.1: Conferral rule definition

n number of rulesets which are linked by a logic OR. Each ruleset consists of i numbers of rule definition. The rule definitions within a ruleset are linked by a logic AND. This badge mapping logic allows different possible path with different requirements for achieving a badge. Within a ruleset, different measures are available to define the rule. These measures are:

Competence ontology
: This measure selects a certain competence that is required to be attested in a user's competence cockpit. In addition it is possible to define a minimum competence level that is required. TechScreen's competence calculation algorithm distinguishes between beginner, intermediate and expert.

Awarded badges
: This measure selects a certain badge that one needs to have in his or her personal badge backpack. When consolidating many badges to a supper badge, the ruleset would consist only of collection of rule definitions of a "awarded badges"-measures.

Post quality (Voting score)
: This measure requires a user to have a certain amount of posts of a certain quality level to be submitted to the community. The quality will be determined by the votes of other users. In addition, it is possible to specify a set of keywords that have to appear in the post to ensure a thematic coherence of the post and the badge. The post quality rule definition can be constrain to a particular type of post (challenge, comment, solution) or a combination of them.

Post quality (Metrics)

As mentioned in chapter 2, there are some approaches for implementing algorithms for automated quality detection of postings in Q&A platforms like Stackoverflow. These machine learning technologies can be implemented as they enable a more quantifiable and objective rating of a post's quality rather than a user's individual and subjective rating. Such a measure can be part of the badge mapping rule definition as well and defines the requirement of a certain amount of posts of a certain quality level.

Social behavior related measures

The badge mapping offers also a set of measures to determine the social behavior of the user and his or her contribution to the community. This measures, that are more related to social badges, are: response time on new challenges, online time per day, number of challenges solved, number of posts rated. These measures can also be combined with a post quality measure. Thus it is possible to define meaningful social badges such as the "Band Manager Badge". Figure 4.2 gives an example of its definition. This badge should express the willingness of a user to react quickly on a new challenge with a proper solution. Thus it consists of a response time measure. However the user, submitting the solution, shall have a reputation to post good solutions in general and shall not receive the badge only on a single event of submitting a solution. Thus, it consists of a second constraint, requiring to have submitted already 20 posts of a high quality in the past.

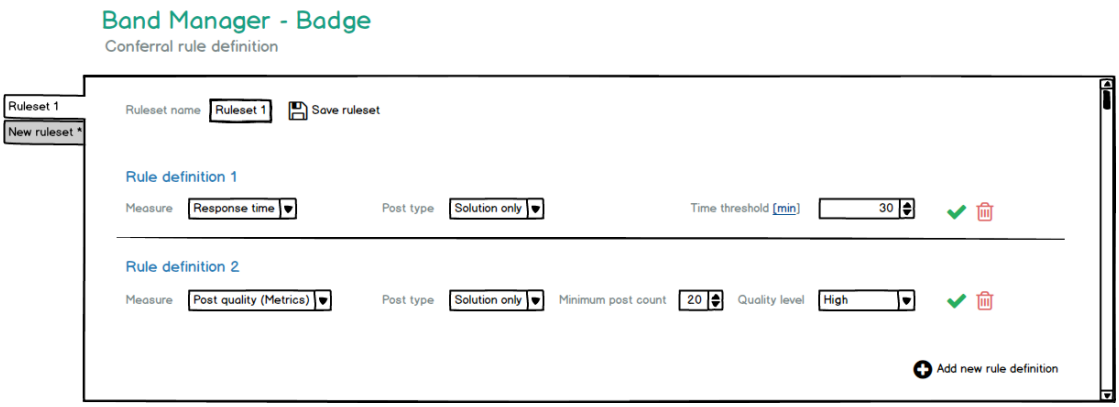


Figure 4.2: Band Manager Badge conferral rule definition

Assigning competence to badges

TechScreen has a set of competences, stored as Drupal taxonomy and representing the competence ontology for the competence calculation. With the badge mapping mechanism, it is possible to create conferral rules for each competence badges, using the competence cockpit of each user. Lets consider the database systems bronze badge: It requires a user to have at least the proven competence in databases and relational databases of a beginner level or an intermediate competence in one particular database management system.

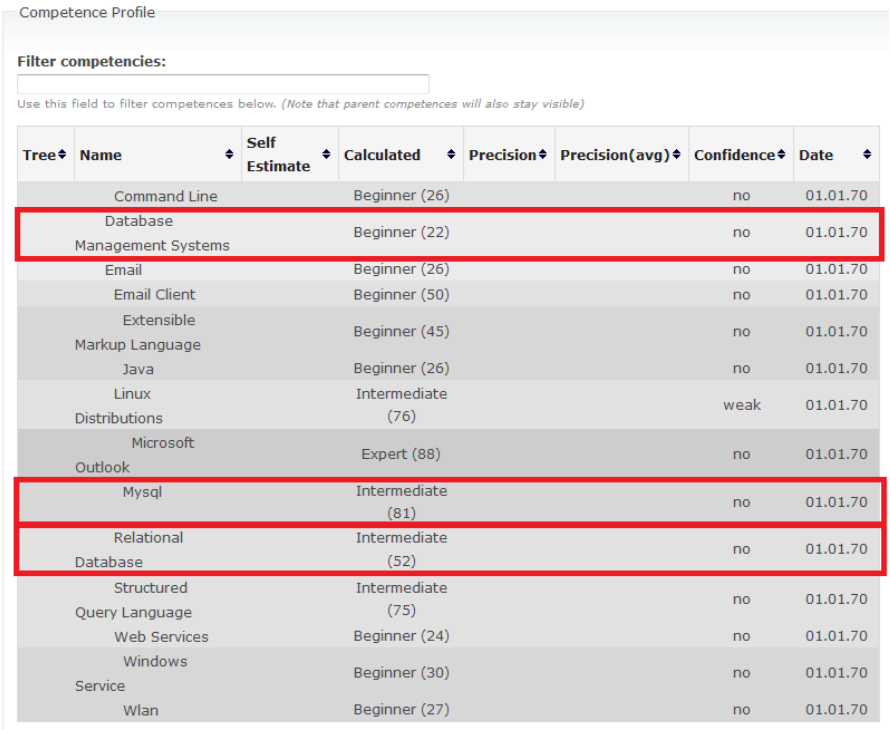


Figure 4.3: TechScreen competence cockpit

Figure 4.3 shows a users competence cockpit in TechScreen. The Q&A platform attests the user competencies in databases and relational databases. In addition there are competencies in MySQL. Therefore the user would be awarded with the database system bronze badge, according to the definition of figure 4.4 and 4.5

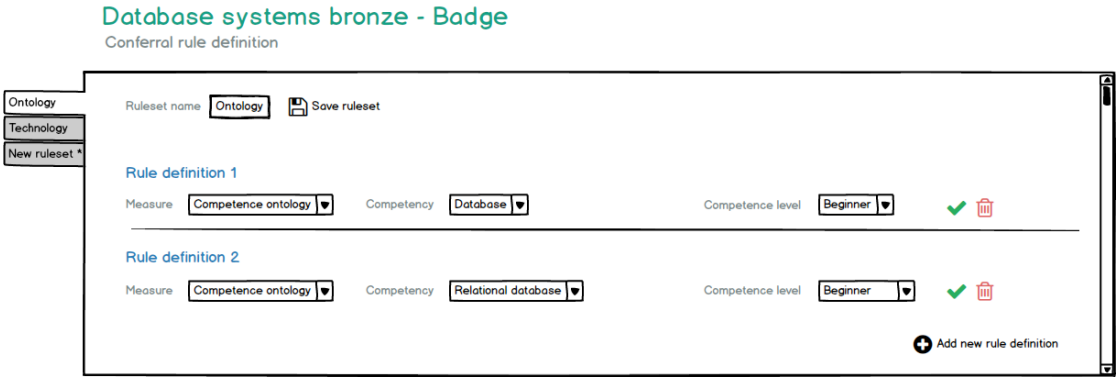


Figure 4.4: Database System Bronze Badge - General ontology ruleset

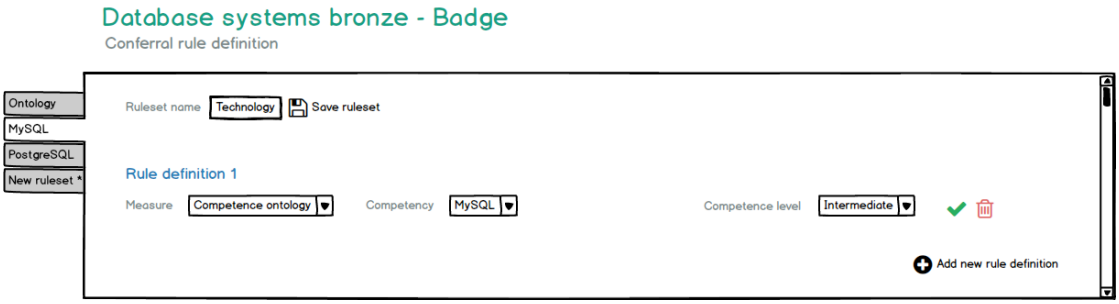


Figure 4.5: Database System Bronze Badge - Technology ontology ruleset

4.3 Badge collection

Our design distinguishes between three types of digital badges.

1. Online badges
2. Activity badges
3. Competence badges

Online- and Activity badges are social badges which shall be awarded by either online activity or contributing content to the community. Knowledge badges shall be awarded upon TechScreen's competence calculation certifies a certain knowledge level to a users. All online- and activity badges are using terms of the music business as name of the different badges

Visual appearance

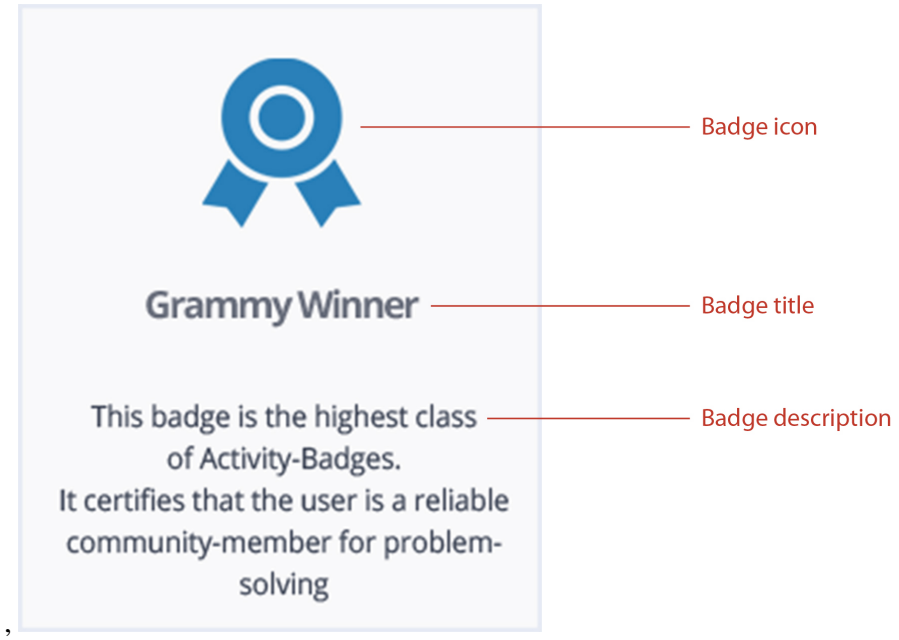
Each badge has an image representation of 250x300px. There is an icon that is unique for each badge and has a different color coding (see figure 4.2 for the color definition), whether is is an online-, activity or competence badge. Figure 4.6 shows the layout of a badge. For the competence badges we use a second color coding of the top-border to indicate the competence level. We will use a bronze tone for the beginner-, a silver tone for the intermediate- and a gold tone for the expert competence level. Table 4.3 shows the defined color tones.

Online badges	Activity badges	Competence badges
#16a085	#2980b9	#8e44ad

Table 4.2: Badge icon color coding

Validity of badges

Each issued badge has a validity of one year. After the badge became invalid, the user can apply for re-issuing the badge upon he still fulfills the awarding criteria.



,

Figure 4.6: Badge layout in TechScreen

Bronze tone	Silver tone	Gold tone
#cd7f32	#bdc3c7	#f1c40f

Table 4.3: Competence level color coding

Online badges

- **One time wounder**
  Badge type
  Social badge

  Badge description
  This badge will be awarded upon a user's login and shall contribute to the motivation of a user to participate to the community. As this badge will be granted immediately when a user starts to use the platform, this badge shall also animate the user to discover the topic of digital badges within the context of the platform as well as the context of self-directed learning.

  Awarding criteria
  At least one login to the knowledge sharing platform.

  Badge appearance

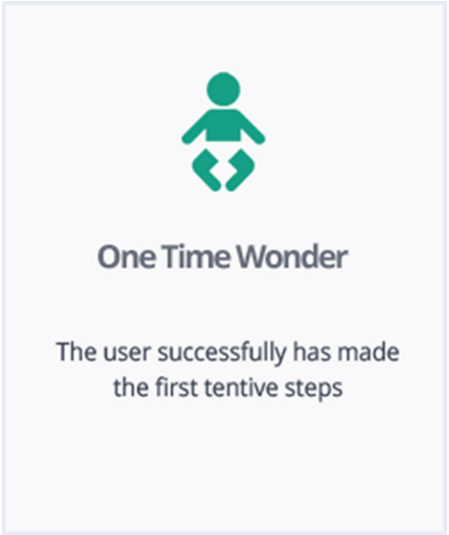


Figure 4.7: One Time Wounder badge

- **Newcomer**
  Badge type
  Social badge

  Badge description
  This badge is a substitute of the “One time wonder” badge when meeting the awarding criteria. The purpose of this badge is to further animate the user to use and login to the platform.

  Awarding criteria
  At least one login per week.

  Badge appearance

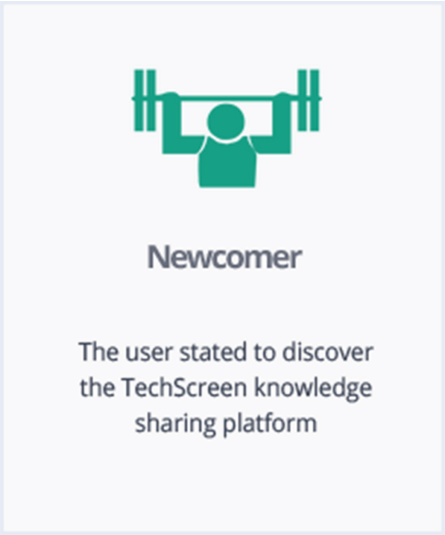


Figure 4.8: Newcomer badge

- **Supporting act**
  Badge type
  Social badge

  Badge description
  This badge honors a regular participation of a user to the social community. It substitutes the “Newcomer” badge and shall motivate users to gain more reputation.

  Awarding criteria
  At least one login during three days of a week.

  Badge appearance

Figure 4.9: Supporting act badge

- **Headliner**
  Badge type
  Social badge

  Badge description
  This badge is a substitute of the “Supporting act” badge and shall certify a heavy online-presence of a particular user. Even it is an online-badge it shall also express some reputation in terms of social behavior. Additionally regular online users are aware of new challenges and facing new topics. Thus, intensive online presence might be an additional driver for animate users for self-directed learning and developing a personal learning map.

  Awarding criteria
  At least one login on minimum four days per week and an average online time of 4 hours within 24 hours on an online day.

  Badge appearance

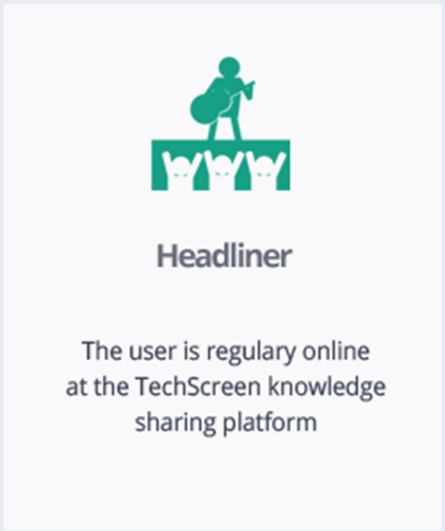


Figure 4.10: Headliner badge

Activity badges

This badges shall state a user’s proactive contribution to the community (e.g. response times to a challenge, number of read challenges per time-period, amount of posts per time-period).

- **Street musician**
  Badge type
  Social badge

  Badge description
  This type of badge shall attest that a user already started to pro-actively participate to the community by either maintain the content or adding new content. Activity badges generally shall motivate users to participate to the social community as well as gaining a competition among users who is more active within the community.

  Awarding criteria
  This badge will be awarded upon a user's activity. This could either be to submit a challenge, to post a comment, to submit a solution or rate at least 10 posts.

  Badge appearance

Figure 4.11: Street musician badge

- **Listener**
  Badge type
  Social badge

  Badge description
  This badge will be awarded upon a user's behavior that only consumes content but never submits any information or knowledge to the social-community. This type of badge shall indicate that someone is using social communities to retrieve information and gain personal knowledge. As this badge may publicly indicate a free-rider behavior it may lead to motivate the earner of that badge to participate more to the community.

  Awarding criteria
  Access to at least 10 comments of solutions with post-count, less than 5, within one month.

  Badge appearance

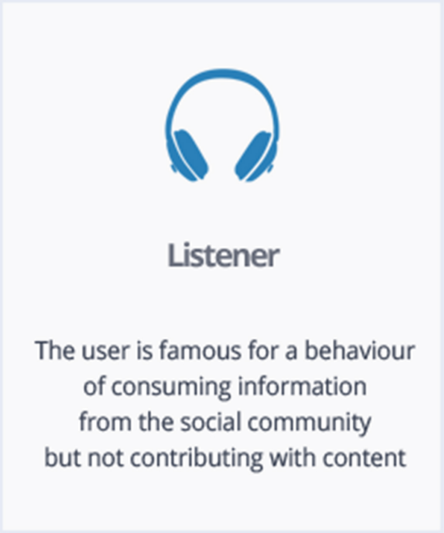


Figure 4.12: Listener badge

- **Songwriter**
  Badge type
  Social badge

  Badge description
  This badge will be awarded when a user is able to correctly solve his or her own challenge. The purpose of this badge is to certify that a users still focuses on persona his or her problem statements by self-learning and the user is willing to share this new knowledge to the community.

  Awarding criteria
  At least five challenges of a five-star voting of at least 10 users that are solved by oneself per year.

  Badge appearance

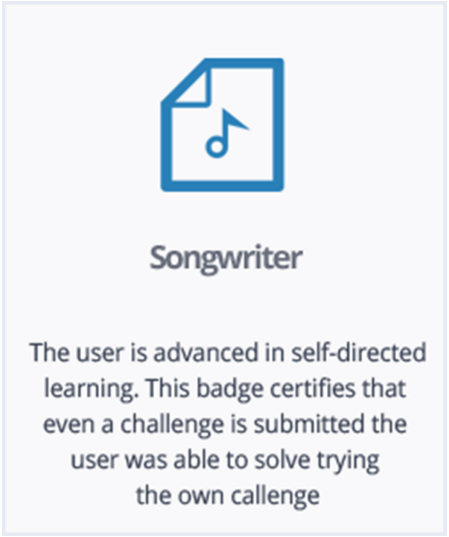


Figure 4.13: Songwriter badge

- **Chart stormer**
  Badge type
  Social badge

  Badge description
  This badge is the precursor of the Grammy winner badge and shall be an evidence that a particular user is interested in problem solving by posting comments of solutions. Moreover it is a sign that the holder of this badge is minded to share knowledge among a social-community

  Awarding criteria
  At least one correct solutions per month and 10 comments per week.

  Badge appearance

Figure 4.14: Chart-Stormer badge

- **Band Manager**
  Badge type
  Social badge

  Badge description
  This badge is an honor for users who are reacting quickly, by providing a correct solution to a challenge withing a very short period of time

  Awarding criteria
  At least twenty correct solutions of high quality within 30 minutes, after the challenge has been submitted.

  Badge appearance

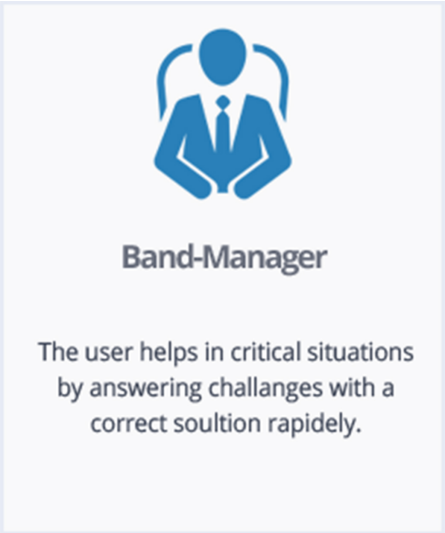


Figure 4.15: Band Manager badge

- **Grammy winner**
  Badge type
  Social badge

  Badge description
  This badge will be awarded to users who are submitting a certain amount of correct solutions within a period of time. This badge shall certify a user's competency on a general level (without defining the type of knowledge) and the willingness to share knowledge and helping others. Moreover it shall contribute to the motivation of a user to participate to the community. Referring to the Grammy award, well known in the music industry for personal efforts in the business, the Grammy winner badge of the knowledge sharing platform will be awarded as great honor for social activity

  Awarding criteria
  At least three correct solutions per week.

  Badge appearance

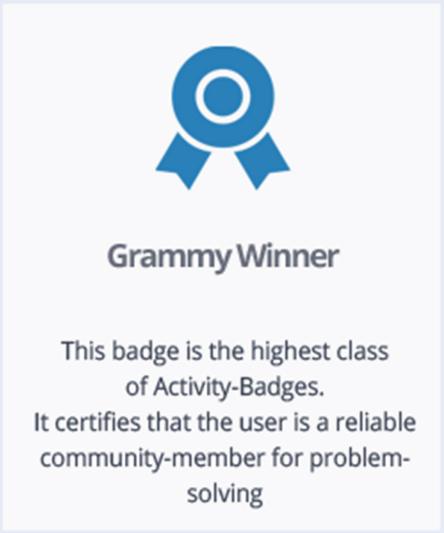


Figure 4.16: Grammy-Winner badge

Competence badges

The competence badges will be awarded upon a certain learning achievement, certifying a particular knowledge and the corresponding level of expertise.

Computer Science Badges

- **Artificial Intelligence**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The "Artificial Intelligence Newcomer" badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in "Artificial Intelligence" of beginner competence level. In case the user has a competence of intermediate level the "Artificial Intelligence Chartbreaker" badge will be issued and substitutes the "Artificial Intelligence Newcomer" badge. The highest level of this series of badges is the "Artificial Intelligence Superstar" badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

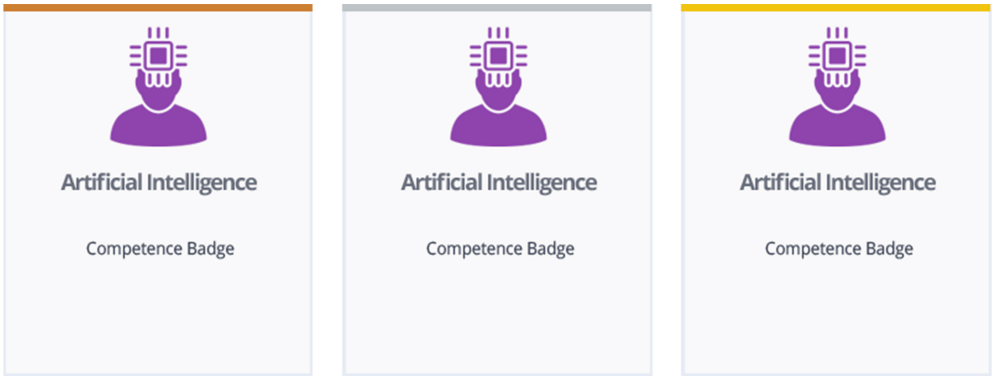


Figure 4.17: Artificial Intelligence competence badge

- **Object oriented computer languages**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Object oriented computer languages Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Object oriented computer languages” of beginner competence level. In case the user has a competence of intermediate level the “Object oriented computer languages Chartbreaker” badge will be issued and substitutes the “Object oriented computer languages Newcomer” badge. The highest level of this series of badges is the “Object oriented computer languages Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

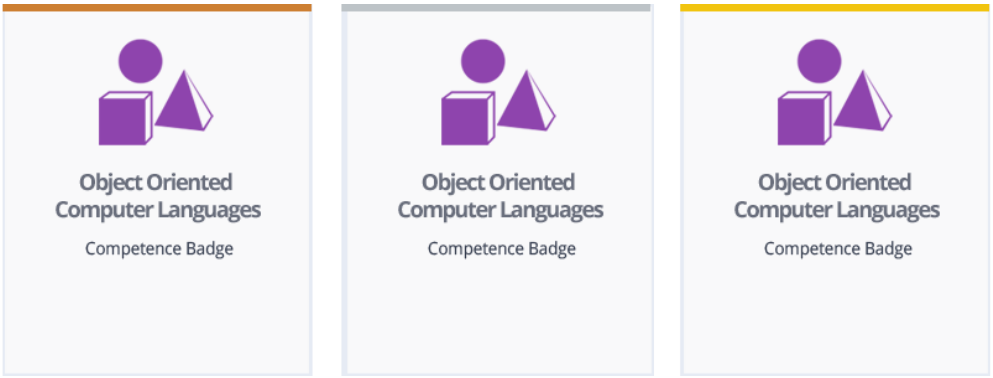


Figure 4.18: Object oriented computer languages competence badge

- **Embedded Systems**
  Badge type
  Competence badge

  There are three different levels of badges available. The “Embedded systems Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Embedded systems” of beginner competence level. In case the user has a competence of intermediate level the “Embedded systems Chartbreaker” badge will be issued and substitutes the “Embedded systems Newcomer” badge. The highest level of this series of badges is the “Embedded systems Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

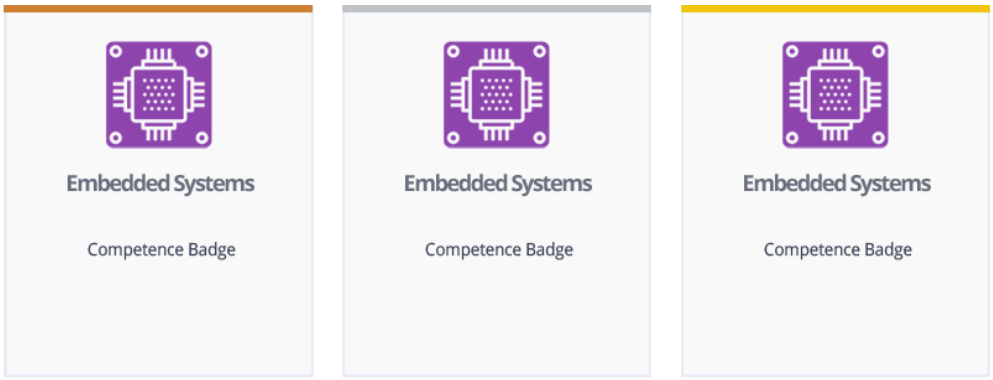


Figure 4.19: Embedded Systems competence badge

- **Knowledge Management**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Knowledge Management Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Knowledge Management” of beginner competence level. In case the user has a competence of intermediate level the “Knowledge Management Chartbreaker” badge will be issued and substitutes the “Knowledge Management Newcomer” badge. The highest level of this series of badges is the “Knowledge Management Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

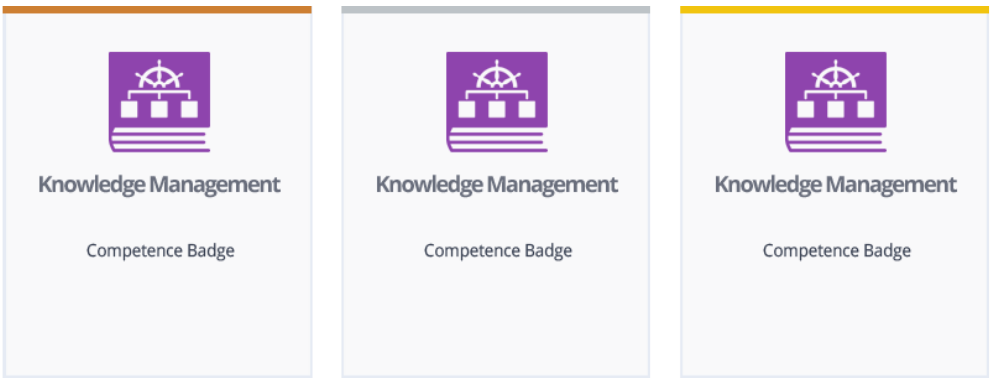


Figure 4.20: Knowledge Management competence badge

- **Usability Engineering**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Usability Engineering Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Usability Engineering” of beginner competence level. In case the user has a competence of intermediate level the “Usability Engineering Chartbreaker” badge will be issued and substitutes the “Usability Engineering Newcomer” badge. The highest level of this series of badges is the “Usability Engineering Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

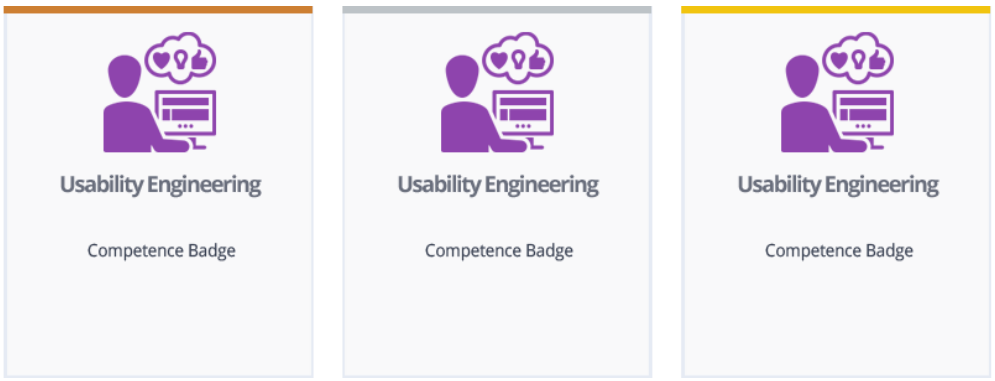


Figure 4.21: Usability Engineering competence badge

- **Simulation and Modeling**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Simulation and Modeling Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Simulation and Modeling” of beginner competence level. In case the user has a competence of intermediate level the “Simulation and Modeling Chartbreaker” badge will be issued and substitutes the “Simulation and Modeling Newcomer” badge. The highest level of this series of badges is the “Simulation and Modeling Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

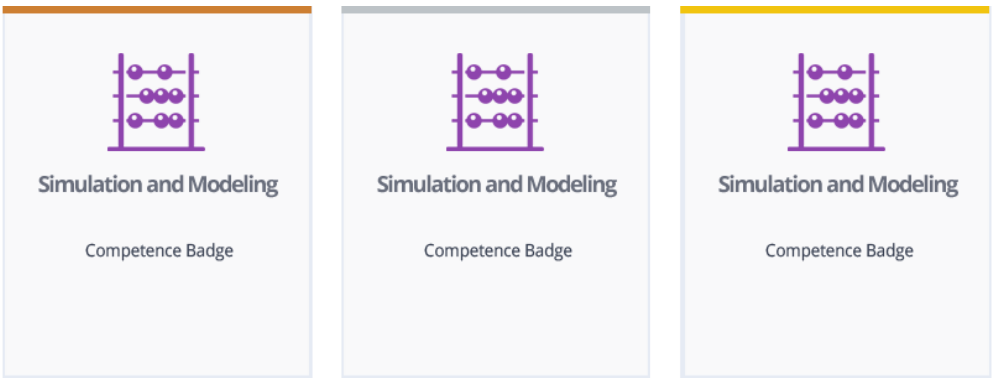


Figure 4.22: Simulation and Modeling competence badge

- **Logic Computer Languages**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Logic computer languages Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Logic computer languages” of beginner competence level. In case the user has a competence of intermediate level the “Logic computer languages Chartbreaker” badge will be issued and substitutes the “Logic computer languages Newcomer” badge. The highest level of this series of badges is the “Logic computer languages Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

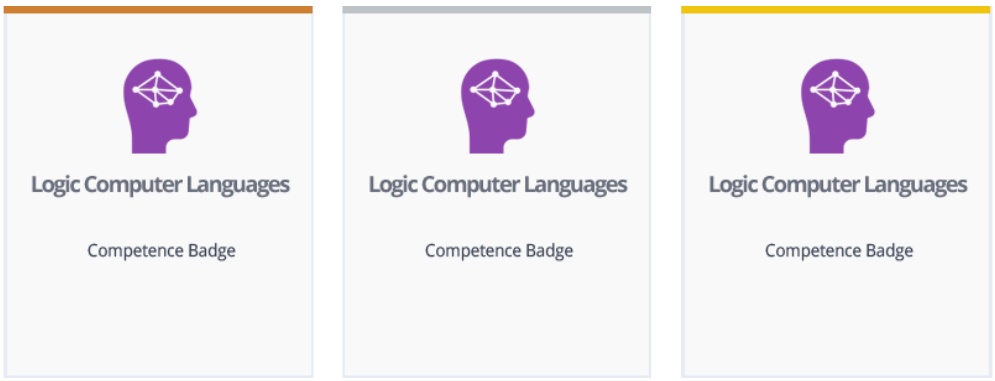


Figure 4.23: Logic Computer Languages competence badge

- **Algorithms**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Algorithms Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Financing” of beginner competence level. In case the user has a competence of intermediate level the “Financing Chartbreaker” badge will be issued and substitutes the “Financing Newcomer” badge. The highest level of this series of badges is the “Financing Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

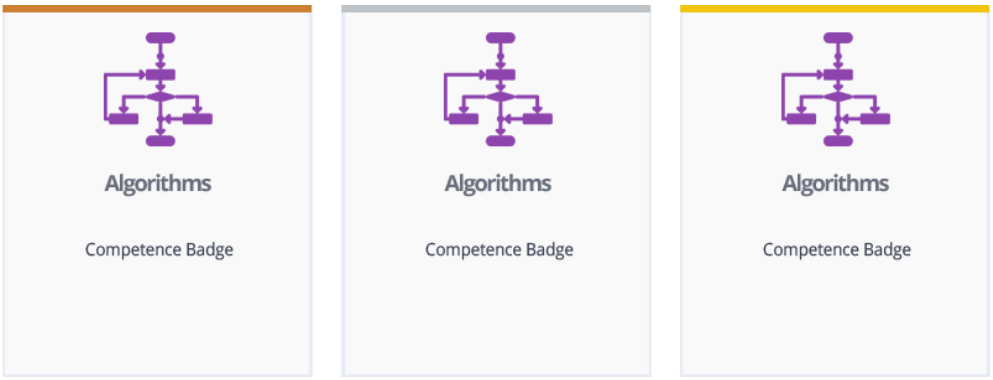


Figure 4.24: Algorithms competence badge

- **Database systems**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Database systems Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Database systems” of beginner competence level. In case the user has a competence of intermediate level the “Database systems Chartbreaker” badge will be issued and substitutes the “Database systems Newcomer” badge. The highest level of this series of badges is the “Database systems Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

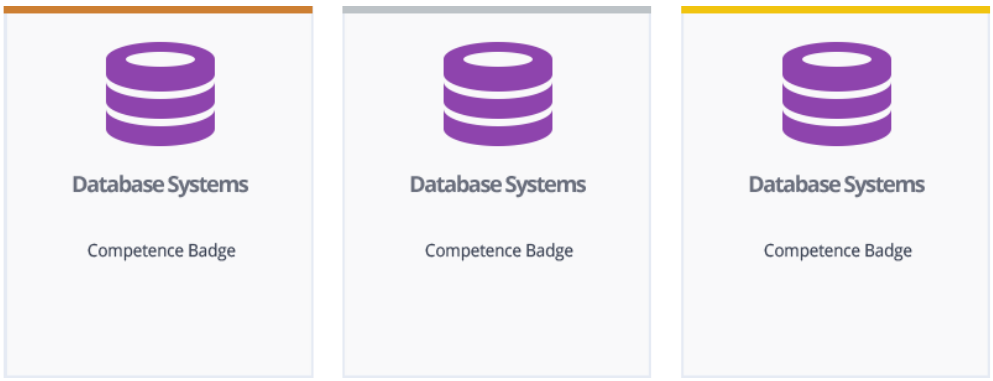


Figure 4.25: Database Systems competence badge

- **Process Management**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Process Management Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Process Management” of beginner competence level. In case the user has a competence of intermediate level the “Process Management Chartbreaker” badge will be issued and substitutes the “Process Management Newcomer” badge. The highest level of this series of badges is the “Process Management Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

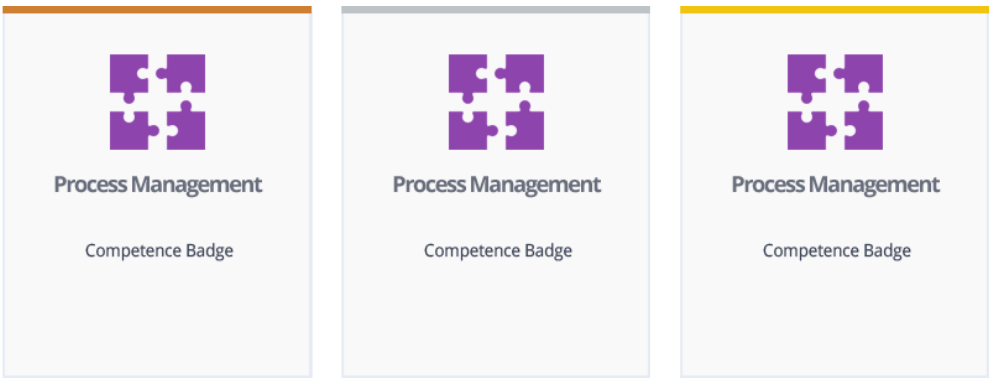


Figure 4.26: Process Management competence badge

- **Software Engineering**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Software Engineering Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Software Engineering” of beginner competence level. In case the user has a competence of intermediate level the “Software Engineering Chartbreaker” badge will be issued and substitutes the “Software Engineering Newcomer” badge. The highest level of this series of badges is the “Software Engineering Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

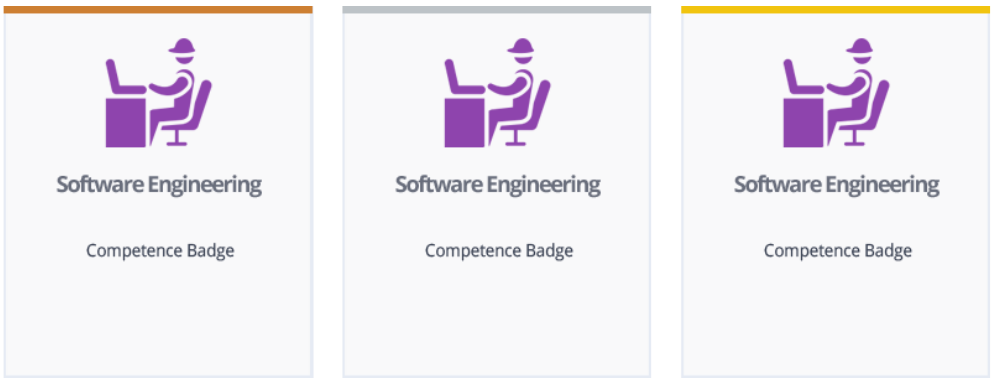


Figure 4.27: Software Engineering competence badge

- **Software Testing**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Software Testing Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Software Testing” of beginner competence level. In case the user has a competence of intermediate level the “Software Testing Chartbreaker” badge will be issued and substitutes the “Software Testing Newcomer” badge. The highest level of this series of badges is the “Software Testing Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

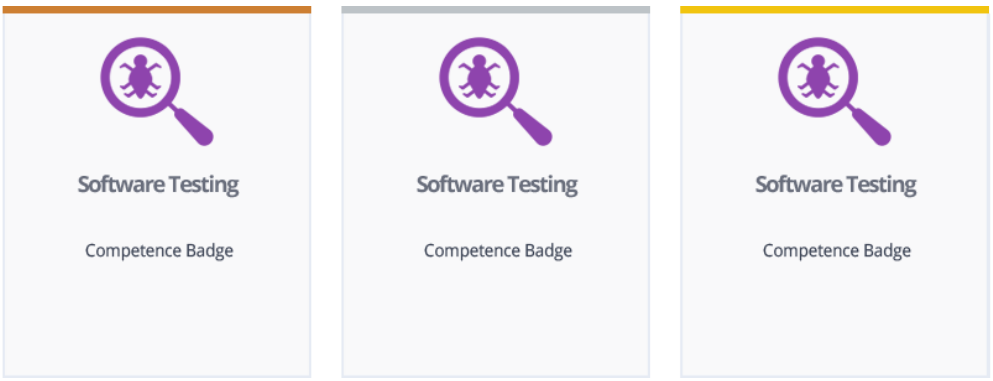


Figure 4.28: Software Testing competence badge

- **Distributed Systems**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Distributed Systems Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Distributed Systems” of beginner competence level. In case the user has a competence of intermediate level the “Distributed Systems Chartbreaker” badge will be issued and substitutes the “Distributed Systems Newcomer” badge. The highest level of this series of badges is the “Distributed Systems Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

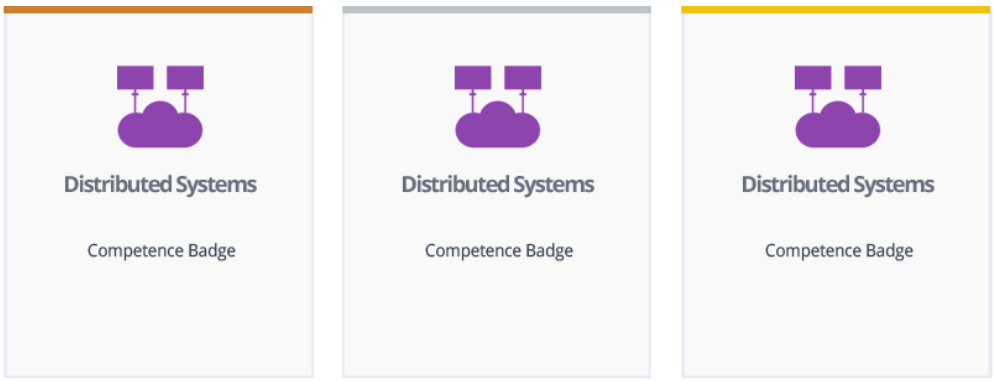


Figure 4.29: Distributed Systems competence badge

- **Cryptography**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Cryptography Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Cryptography” of beginner competence level. In case the user has a competence of intermediate level the “Cryptography Chartbreaker” badge will be issued and substitutes the “Cryptography Newcomer” badge. The highest level of this series of badges is the “Cryptography Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

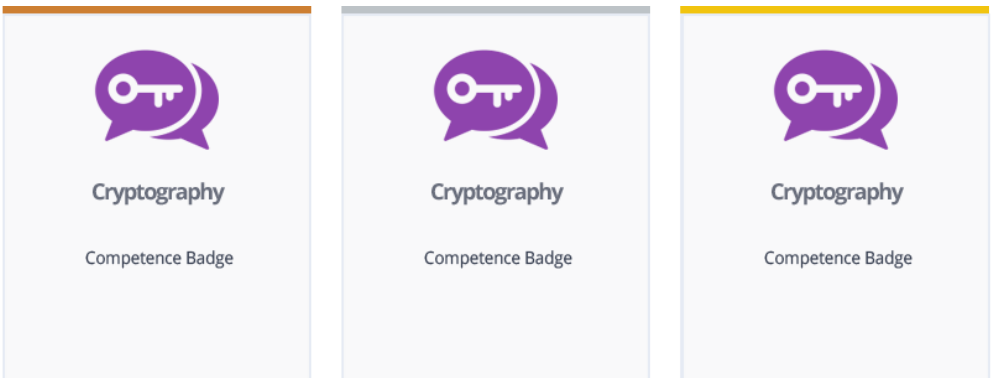


Figure 4.30: Cryptography competence badge

- **Business Intelligence**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Business Intelligence Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Business Intelligence” of beginner competence level. In case the user has a competence of intermediate level the “Business Intelligence Chartbreaker” badge will be issued and substitutes the “Business Intelligence Newcomer” badge. The highest level of this series of badges is the “Business Intelligence Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

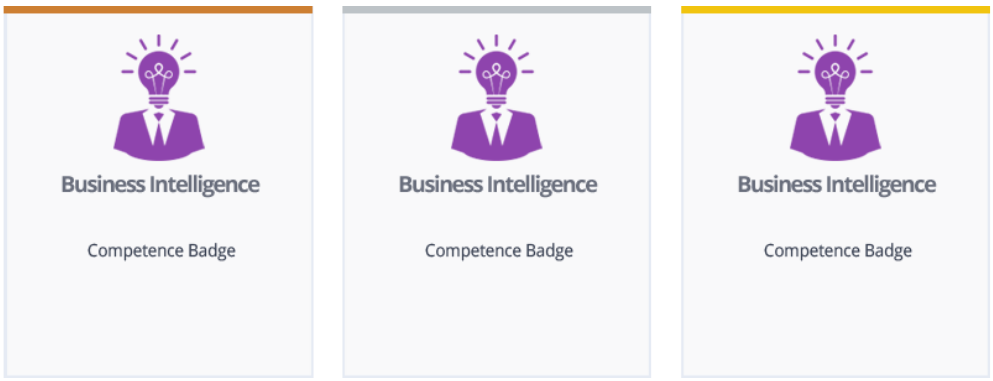


Figure 4.31: Business Intelligence competence badge

- **Web-Engineering**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Web-Engineering Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Web-Engineering” of beginner competence level. In case the user has a competence of intermediate level the “Web-Engineering Chartbreaker” badge will be issued and substitutes the “Web-Engineering Newcomer” badge. The highest level of this series of badges is the “Web-Engineering Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

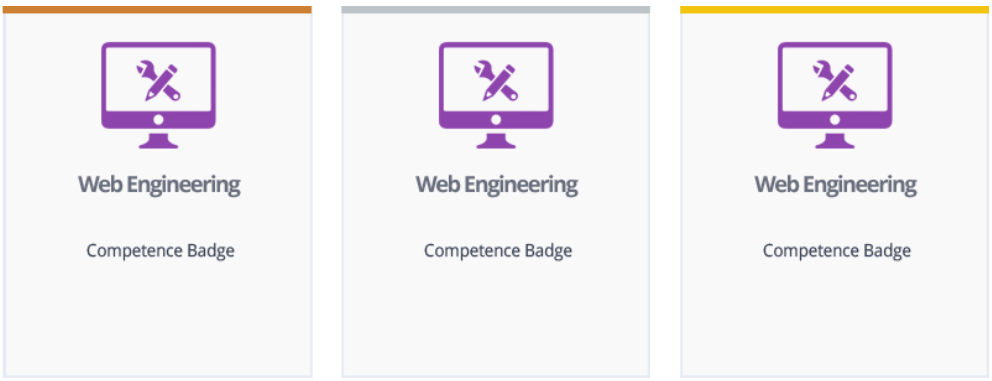


Figure 4.32: Web-Engineering competence badge

- **Software Design**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “Software Design Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “Software Design” of beginner competence level. In case the user has a competence of intermediate level the “Software Design Chartbreaker” badge will be issued and substitutes the “Software Design Newcomer” badge. The highest level of this series of badges is the “Software Design Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

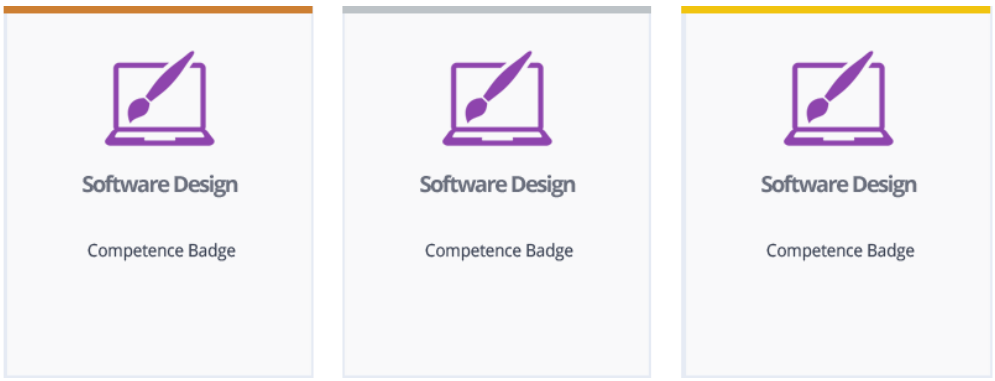


Figure 4.33: Software Design competence badge

- **E-Commerce**
  Badge type
  Competence badge

  Awarding criteria
  There are three different levels of badges available. The “E-Commerce Newcomer” badge is the lowest level and will be awarded upon the competence calculation engine of the knowledge sharing platform certifies a user particular knowledge in “E-Commerce” of beginner competence level. In case the user has a competence of intermediate level the “E-Commerce Chartbreaker” badge will be issued and substitutes the “E-Commerce Newcomer” badge. The highest level of this series of badges is the “E-Commerce Superstar” badge, that substitutes all other badges and will be awarded upon an expert knowledge level.

  Badge appearance

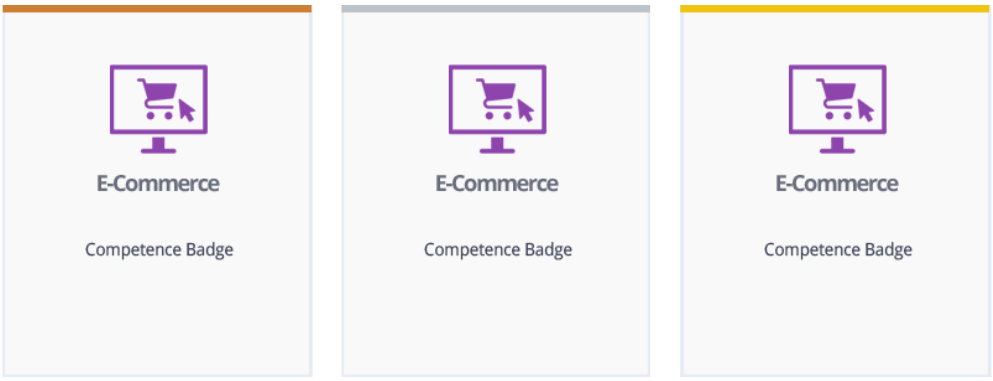


Figure 4.34: E-Commerce competence badge

4.4 Reference implementation

As already described in the related work, the present live instance of TechScreen is not ready to implement digital badges. Thus a separate Drupal 7 instance has been installed. As TechScreen’s core modules are not migrated to Drupal 7 yet, it is not possible to integrate the full competence calculation functionality to this new Drupal instance. However we will show a prototypical approach based on Drupal rules and userpoints. We call our prototype “TechScreen - Digital Badge Edition”, figure 4.35 shows an example of the user profile page including the first, automatically awarded badge upon a users is signing up for the knowledge sharing platform.

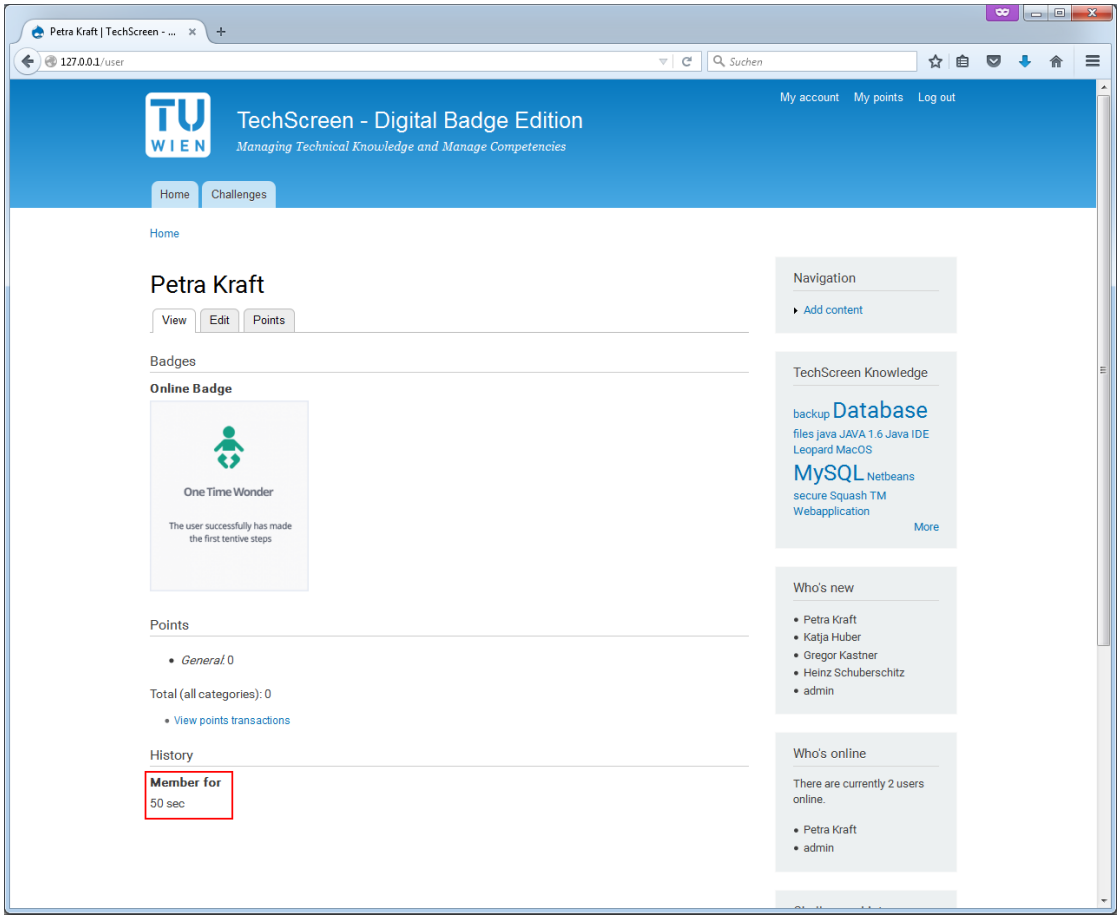


Figure 4.35: TechScreen - Digital Badgde Edition

Software components

For the prototype implementation based on Drupal 7, we used the standard Drupal 7 core, based on version 7.50. Additionally we extended the functionality by using additional Drupal-Modules either in its standard release or in a customized form. We will introduced a set of Drupal modules that are particularly related to our approach of integrating digital badges for informal learning on knowledge-sharing platforms, based on Druplal technology:

User Badges This module enables to define a badge repository on the website. It allows to upload a graphical representation of the badge including a URL of a description of the badge . It further support to issue a badge to a user and extends a user's profile view by the personal badge collection of a particular user. Figure 4.36 shows an user's personal

badge repository.

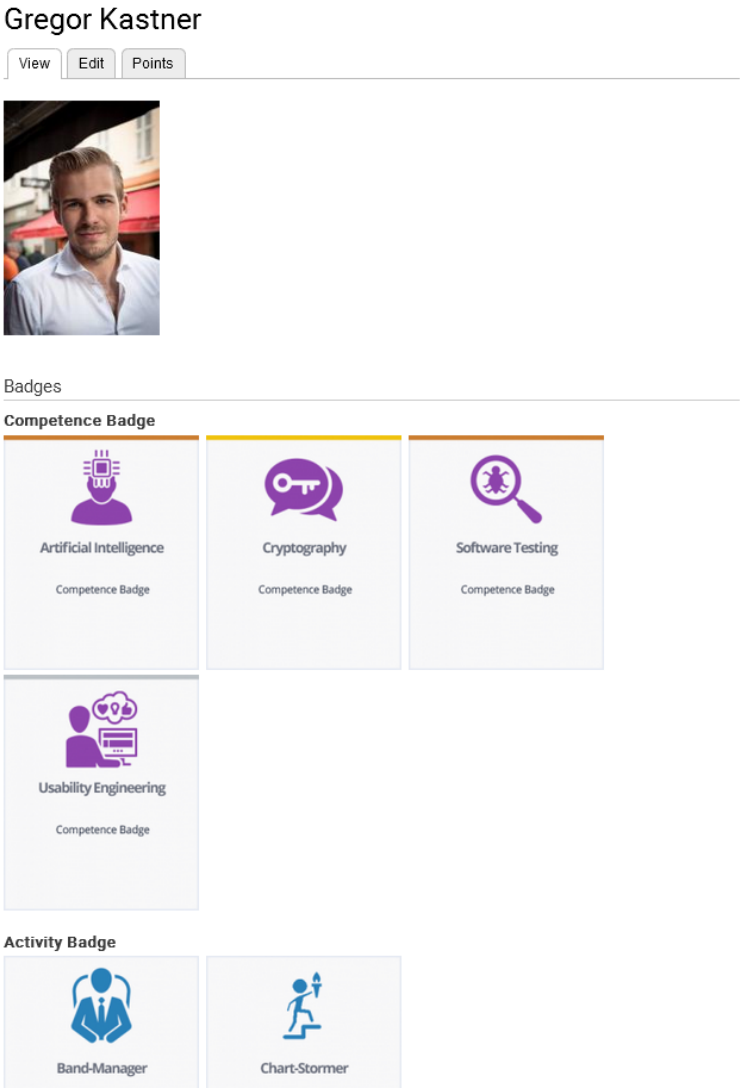


Figure 4.36: User Profile View - Personal Badge repository

Userpoints [1] This module allows to automatically credit a predefined amount of so-called "user-points" to a Drupal user when they perform certain activities, such as posting a challenge, submit a comment or post a solution.

[1] https://www.drupal.org/documentation/modules/userpoints

Userpoints Badges [2] This module allows to assign badges to users as they get certain number of userpoints

Community Tags [3] This module allows that a user can assign tags to a specific content (e.g. challenge). A tag is a set of keywords (spitted by comma) that describes the contend. Tags are important to classify the subject of a certain content and lead further to the competence calculation.

Tag clouds [4] This modules generates a tag cloud to visualize the most common tags (referring to a certain topic of interest). Depending on the relevance, the tags are shown in different font sizes. Figure 4.37 shows the appearance of a tag cloud. The purpose of such a tag cloud, presented at the landing page of TechScreen, is to provide a user an overview of those topics that are discussed mostly at the knowledge sharing platform.

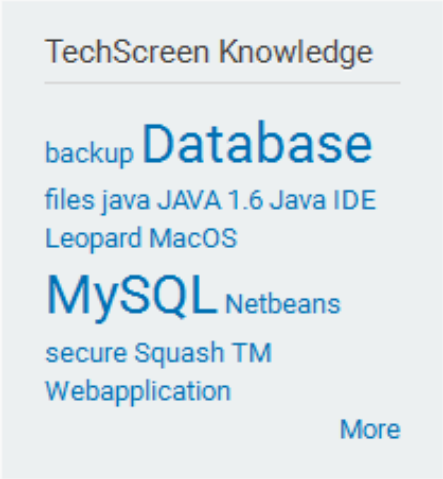


Figure 4.37: Tag cloud

Features

On TechScreen it is possible to browse existing challenges, and one logged in, to submit new challenges or reply to an existing challenge. This comments can be rated trough the userpoints module as well as declared as an solution. Based on the tags, that are associated to the challenge and the rates of the particular posts, TechScreen's algorithm can calculate the the level of expert-knowledge of each user in a particular domain. This calculated data is the basis to award a competency badge.

[2] https://www.drupal.org/project/userpoints_badges
[3] https://www.drupal.org/project/community_tags
[4] https://www.drupal.org/project/tagclouds

As per definition of the conferral rules (described in chapter refDesign and Solution) further badges, such as online badges, may be awarded.

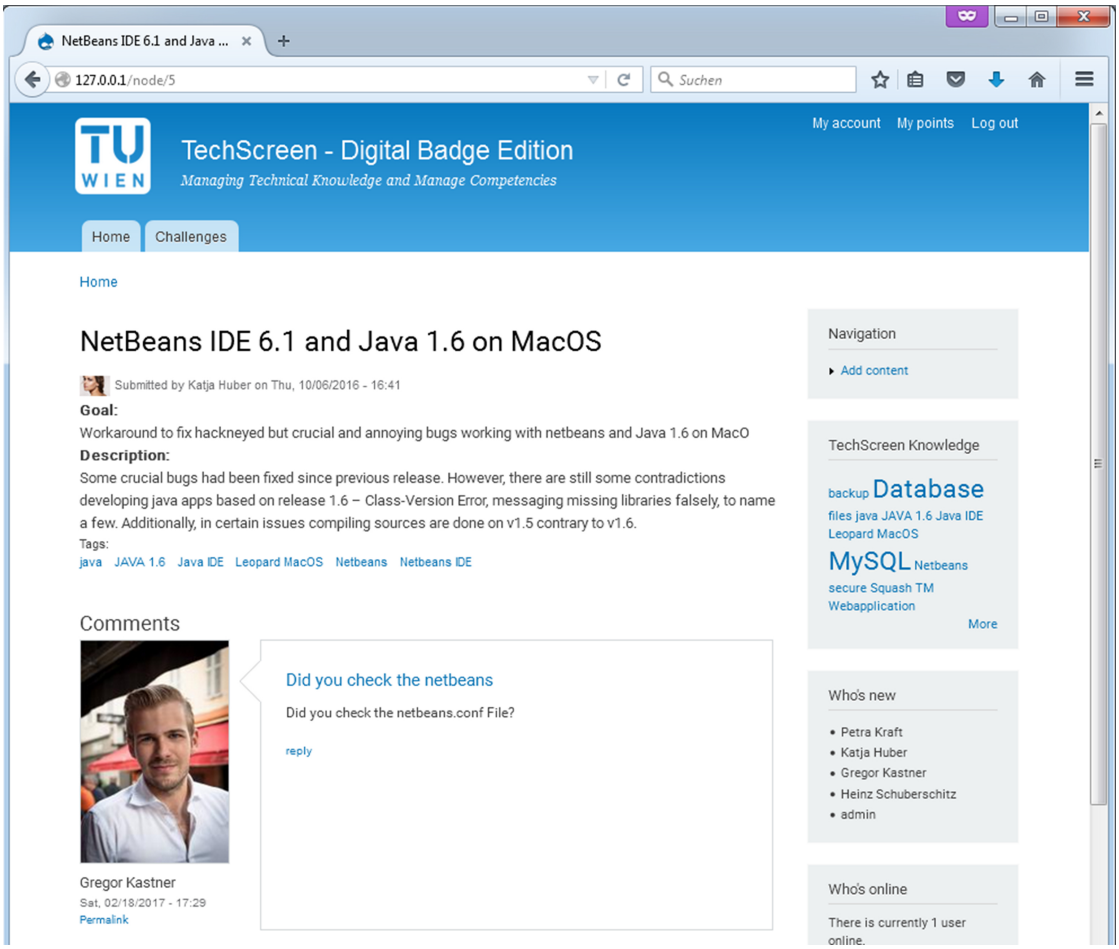


Figure 4.38: Challange in TechScreen

CHAPTER 5

Evaluation

This chapter critically evaluates the proposed concept. We will evaluate the concept by applying the insights and results from preceding studies on social communities and self-directed learning. We further present an evaluation based on an user questionnaire. Obviously some of the initially formulated hypotheses of this mater's thesis can only be fully evaluated trough a long-term study which is not covered by this thesis and has to be considered as future work. However we will describe an evaluation setting.

5.1 Prototype implementation problems

During the implementation phase, we faced certain problems with the underlying technical components, which finally detained us to implement a fully working prototype on the present TechScreen infrastructure. During the design & prototyping phase, TechScreen was running on Drupal 6. As already noticed in chapter 2, Mozilla BadgeKIT is in an early alpha state and during the prototype implementation it turned out that it was not usable. The prototype was using the Open Digital Badging module, a Drupal module for all relevant processes to issue, collect and store digital badges. However this module is only compatible to Dupal 7.

5.2 First evaluation

For the first evaluation of the design, we've used the results of two sources. First, we conducted survey about how students are familiar with digital badges and how they could be used in lectures. Second, we collected the experience of the past five years, since TechScreen is on-line.

Digital badge acceptance

Initially, we conducted a questionnaire about the acceptance and the interest of students about digital badges. For this evaluation we took a sample of 26 students, all of them enrolled to the

Knowledge-management lecture of the master's courses in business informatics. Consequently, the key concept and purpose of digital badges was certainly known by the participants. Each student was asked to answer a set of 12 yes/no questions in terms of digital badges. Table 5.1 shows all questions with the corresponding amount of participants who answered either yes or no.

Question	Yes	No	Depends	No Answer
Do you think that more interactivity would improve your learning in lectures?	12	0	14	0
Would you like to have quizzes in a lecture?	16	10	N/A	0
Would you like to have more discussions in lectures?	18	8	N/A	0
Would you like to have group work in a lecture	12	14	N/A	0
Would you use a laptop to participate in interactive elements of a lecture	21	4	N/A	1
Would you use a smart-phone to participate in interactive elements of a lecture	20	5	N/A	1
Would you check-in to a lecture with social service such as Foursquare?	6	20	N/A	0
Would you like to have digital badges as kind of feedback for achieved solutions?	14	12	N/A	0
Would you like to have digital badges as kind of feedback for participation in discussion?	8	17	N/A	1
Would you like to have digital badges as kind of feedback for a presentation?	14	11	N/A	1
Would you like to have digital badges as kind of feedback for presence in the lecture?	11	14	N/A	1
Would you like to have digital badges as kind of feedback for a question in the lecture?	11	14	N/A	1

Table 5.1: Questionnaire about digital badges among students.

When analyzing the results of the questionnaire, it is evident that interactivity in lectures is appreciated by students. None of the participants of the study answered with No to the question if more interactivity would improve one's personal learning. The majority would make that dependent on the type of lecture. Furthermore there is a clear tendency to computer- and smart-phone aided learning as well as discussions in lectures. When combining both, the use of laptops and social media with the call for discussions in lectures, this is a clear sign that e-learning and on-line-community based learning is important to students. We further saw, that digital badges are not playing an important role to students. Roughly speaking only almost every second see digital badges as convenient instrument. Figure 5.1 gives a more detailed insight into the answers of the participants. The questionnaire contains five questions about the participant's opinion how they see digital badges as an adequate feedback instruments whether for achieved solutions, participation in discussions, presentation, presence in the lecture or questions in the

lecture. Only 11% of the asked students answered to all questions with yes, so would like to have digital badges for all kinds of activities during a lecture. In contrast, 21 % of the sample answered that they don't like digital badges at all as any kind of feedback. The analysis of the response behavior allows the conclusion that students often do not have the imagination how digital badges can be used as feedback in lectures. The question about if students like digital badges as kind of feedback for achieved solutions is 53% answered with yes. This implies that for the application of TechScreen, a question & answer platform where challenges will be solved by the user community, at least every second participant of the study accepts digital badges.

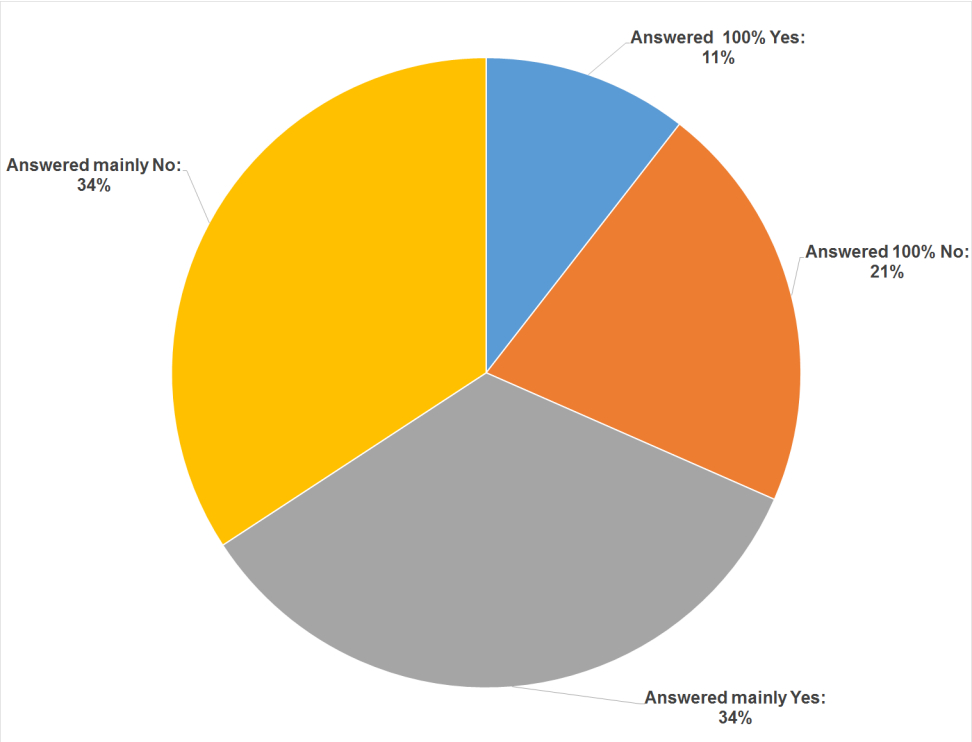


Figure 5.1: Participant's answers to digital badges

TechScreen usage

TechScreen is on-line for more than five years, that allows to derive some information about the user behavior of. TechScreen is used as part of one exercise, every year, in frame of the Knowledge-management course. The statistics of submitted posts reveal that nearly all of them are in context to the exercises of the lecture. The typical task, related to TechScreen, is to post at least three challenges on TechScreen including its solution. As a second part of the exercise, the students must rate the post's quality, among each other. The purpose of this assignment is to introduce the TechScreen platform to students and animate them to use it for further knowledge sharing, also outside this particular lecture. The monitoring of activities on TechScreen shows

that all posts are submitted within the time-frame of the exercise. Furthermore it is evident that there are no returning users, that means after a student completed the exercises he or she does not return to TechScreen to use it further. Since the user accounts of TechScreen are linked to the overall user database of the IT system at Vienna University of Technology, it can be noticed that only students who are enrolled in the lecture are also registered on TechScreen. This fact clearly indicates that it has not yet succeed to introduce TechScreen among the university as platform for sharing knowledge, across various lectures and fields of topics.

Lessons learned

From the findings mentioned before in this chapter, there are a some lessons learned about the required prerequisites to successfully integrate and long-term evaluate how digital badges could be used on knowledge sharing platforms:

1. During the design & evaluation of the toping during this thesis, the OBI (Open Badge Infrastructure) was not very stable. Obviously it is possible to set up an individual infrastructure with a backpack for the user's badges, but since we also want to use the badges also for reputation and job application a stable and well known standardized badge collection platform is required.

2. The knowledge sharing platform (TechScreen in our case) must be a proven and fully tested system. By now, TechScreen should be technically re-factored as we identified some application errors in both, the front-end as well as the back-end. Moreover it should run on a state-of-the-art software platform. By now it is built on Drupal 6, which was substituted by Drupal 7 in 2011.

3. The evaluation revealed, that digital badges are quite a new topic to Internet users. Users with a high Internet affinity sometimes heard about digital badges but are not aware of its capability as indicator for hidden skills and personal learning. This was undergirded by the evaluation of the questionnaire.

5.3 Long-term evaluation

To finally evaluate all hypotheses of this paper, it is required to conduct a long-term study with a large number of participants. We will lean against experience of usability and user acceptance testing. For quantitative studies it is recommended to have a sample of 20 users [1]. To visualize the difference in the behavior of users using digital badges on a knowledge-sharing platform and those users who are not using it, we define two sets of participants with at least 20 users of each, so a total set of at least 40 test participants. The set of probands using digital badges will be further spitted into 10 users, collecting both social badges as well as competence badges, whereas the other 10 users are only collecting competence badges. In total we have three sets:

(A) 20 participants, collecting no badges and are obliged to use TechScreen during the lecture, respectively within the scope of the experiment

[1] https://www.nngroup.com/articles/quantitative-studies-how-many-users/

(B) 10 participants, collecting competence badges only and are obliged to use TechScreen during the lecture, respectively within the scope of the experiment

(C) 10 participants, collecting social- as well as competence badges and are obliged to use TechScreen during the lecture, respectively within the scope of the experiment

Key measures

Based on the hypotheses, defined in chapter 1, there are the following key indicators that have to be evaluated:

1. **Self directed learning indicator**
   How much are digital badges influence the willingness of self-directed learning?

2. **On-line activity indicator**
   How much are digital badges are influencing a user's on-line presence and the participation to the community?

3. **Hidden knowledge indicator**
   How much are digital badges suitable to reveal hidden knowledge?

4. **Reputation indicator**
   How much are digital badges a sign of reputation?

5. **Grading indicator**
   How far are digital badges are a measure for grading?

Experiment - self directed learning indicator

In this experiment we will analyze the hypotheses, whether if digital badges will animate individuals to do more intensive self-directed learning and explore new personal fields of interest. More intensive self-directed learning, driven by digital badges, can be measured :

(i) By comparing the amount of resolutions, posted by the author of the challenge and compare if there is a significant different between proband-set (B) and (C).

(ii) By analyzing the development of a user's personal competence cockpit, separated by proband-set (B) and (C). We suggest to have a particular focus on the gain of new competencies of the probands of set (B) compared to set (C).

(iii) Conduct an questionnaire among all probands and derive whether if probands of set (B) and (C) have the subjective feeling of doing more self-directed learning compared to set (A).

Experiment - on-line activity indicator

In this experiment we analyze the hypotheses, whether if digital badges have an positive impact on a user's on-line presence or not. For this study we suppose a statistic analysis of the probands of set (A), (B) and (C). During the experiment the online-time per user per day and per week will be recorded. Furthermore the number of logins per day and per week will be recorded. The analysis of the different sample-sets allow to draw conclusions if:

(i) The possibility to earn any kind of badges will animate users to be more present to the platform

(ii) A higher on-line presence is only given when the user will be awarded with social badges, specially to on-line activity.

(iii) A fine grained separation of social badges regarding the type of on-line activity will influence a user's behavior (e.g. Listener-Badge vs. Songwriter-Badge).

Experiment - hidden knowledge indicator

Hidden knowledge obviously is a subjective evaluation. However the resulting declaration of hidden knowledge with digital badges shall meet the personal expectations and self-perception of the learner. To evaluate the feasibility of digital badges as hidden knowledge indicator we will use interviews to determine a student's self-perception of the additionally gained knowledge. The evaluation must be done on the example of a lecture with exercises with highly freedom of how a student may solve the challenge. At Vienna University of Technology this could either be "Advanced Software Engineering" or "Workflow Modeling and Process Management". In both cases there are few rules and technology requirements to solve an exercise. This means that students may choose their own technology approach, resulting in additional knowledge-building. TechScreen will be part during the complete lecture and will serve as discussion and knowledge sharing platform.

At the end of the lecture, all students will be interviewed and have to participate in a survey about their personal learning experience. The inquiry sheet will contain all different competence badges that are offered by TechScreen, reflecting the competencies that are part of TechScreen's competence catalog. During the interview, each student has to state in which competence-category he or she has made a gain of knowledge including a self-estimation of the level of competency gain (e.g. beginner, intermediate, expert). After that, TechScreen will issue digital badges based on the competence profile. A comparison of a student's self assessment and the badges he or she received may reveal whether digital badges with TechScreen are an appropriate approach to proof hidden knowledge or not.

Experiment - reputation indicator

The motivation to contribute to a social community and shre knowledge can also be reputation. This reputation can either be valueable as it strengthens one self-esteem or it could also be a valuable indicator for experience and knowledge in one's professional practice. Headhunters

and members of HR-departments could rely on one's badge collection for recruiting for example, or freelancers could proof their knowledge and accelerate their business. There are two ways to perform this evaluation. Firstly, an interview will be conducted to determine if students have the feeling that their reputation at the social community has increased and if other particularly raised questions to someone based on a certain reputation. Also the formation-process of research-groups can be observed and it's members can be asked whether their reputation, expressed by digital badges, played a role

Secondly, the evaluation if digital badges may be a reputation indicator can be done during a long-term study across HR managers. With the emergence of professional social platforms, personnel recruiters often use this platforms to find new employees. An online survey would be an appropriate way to evaluate if the heard about digital badges and if they possibly used them already.

Experiment - grading indicator

As digital badges is a new approach for grading, it has to be introduced to lecturers. We define the introduction and evaluation in two phases: First only a few lectures will be selected to be part of a pilot project to use digital badges as a grading indicator. At the end of a lecture, the lecturer can refer to the badge repository of a student and consider the additionally earned badges for the grading. During this piloting phase, the lecturer has to keep a record about the grading process for each student. On that record, the desired grade based on conventional decision criteria (e.g. results of each exercise, results of oral and written exams, etc.) has to be mentioned. After that, a second round of review will take a student's collection of digital badges into account. Also this additional re-evaluation of a stundet's grading has to be documented on the record including a comparison if the badges earned have an influence on the grading.

After one year pilot project, a further statement is possible. Based on the grading reports it can be determined in how many cases digital badges shifted the grade. Whether there is a significant influence of digital badges on the grading noticeable, it could be applied to a larger number ob lectures and digital badges may be stated as grading indicator in a lecture's description.

CHAPTER 6

Future work

In this chapter we firstly summarize the initial situation of the problem statement as well as lessons learned and secondly discuss further issues.

6.1 Summary

The first part of the thesis was a definition of the scope of the thesis including the hypotheses we want to evaluate. We defined a set of problem statements about digital badges and its possible integration into knowledge sharing platforms. Digital badges recently became one possible incentive for users, contributing to online-communities. On the other hand, knowledge sharing platforms became popular to share experience and expert knowledge among specialists of a certain domain. Stackoverflow is one famous example. Our aim was to present a design to combine the two concepts, digital badges and knowledge sharing platforms. Sharing knowledge on an online platform means one's personal gain of knowledge. We wanted to evaluate if digital badges are an adequate indicator of this hidden knowledge. We further formulated some side questions in chapter one, for example if digital badges are conducing to a larger user activity.

The state of the art evaluation revealed that there are similar concepts of digital badges for knowledge sharing platforms like Stackoverflow but with focus on awarding user participation but not the informal learning success of the users during knowledge sharing.

In chapter three we defined all prerequisites. We took TechScreen as knowledge sharing platform to evaluate an integration of digital badges as competence indicator for its users. The prerequisites describe all requirements to the process also with an outlook to a further application of using digital badges during activities in lectures or as part of the grading of a lecture.

Chapter four describes a design concept, of the issuing and collection process of digital badges and how it can be integrated into the existing concepts of TechScreen. However, since TechScreen is technically not ready to implement a prototype, it is only possible to evaluate this

concept against the prerequisites, and state-of-the-art evaluation. There was also a short-term evaluation about the acceptance of digital badges in education, described in chapter 5. Finally we defined an evaluation scenario for a long-term study.

6.2 Future work

There are four major milestones to go further in the topic.

TechScreen refactoring First it is required to refactor TechScreen. It is still not production ready as it suffers form software bugs and a redundant and inconsistent competence ontology. Moreover it should be upgraded to the latest version of the underlying web-application framework.

Integration of TechScreen to students TechScreen needs to be more present among students. By now it is not very well known. We suggest to integrate TechScreen into various lectures as centralized knowledge sharing platform. Propositioning lectures would be the software engineering lectures. These lectures are groupwork during the entire semester where students are required to realize a software project. The students shall use different new techniques in software engineering, resulting in a lot of questions and technical research required. Students often use Internet sources or internal discussions forums to resolve their challenges. These kind and other similar lectures where students have to research during practice and exercises are ideally suited to introduce TechScreen and push the user count.

Implementation After TechScreen is technically ready, an implementation based on Drupal's Open Digital Badging module is the next step. With this module, users can collect badges and share them on the Mozilla Open Badge infrastructure.

Long-term evaluation As described in the previous chapter, a long-term evaluation is required to evaluate the design and fully answer the hypotheses. We see that digital badges are an appropriate instrument to certify knowledge gained in knowledge sharing platforms and to make hidden skills more visible. User questionnaires prove that there is a general acceptance of students in regards of digital badges. However the effect on a user's online presence, motivation for self-directed learning and how digital badges are a sign or reputation in other parts of one's personal life (e.g. for job application) can only be evaluate after two or three years pilot phase. We further proposed a set of digital digital badges on a more condensed level than TechScreen's competence ontology. It further has to be evaluated if badges shall be more fine grained.

Bibliography

[1] Case study on open badges - university of california, davis sustainable agriculture & food systems. Technical report.

[2] Online communities. *Technology in Society*.

[3] European guidelines for validating non-formal and informal learning. Technical report, CEDEFOP (European Centre for the Development of Vocational Training), 2009.

[4] Andrea Back and Florian Heidecke. *Social Software und Web 2.0 im Unternehmen*, chapter Einfühung, pages 4–6. Oldenburg Wissenschaftsverlag, 2008.

[5] K. Bielaczyc and A. Collins. Learning Communities in Classrooms: A Reconceptualization of Educational Practice. In C. Reigeluth, editor, *Instructional Design Theories and Models.*, pages 269–292. Mahwah, 1999.

[6] Jens Björnavald. Making learning visible: identification, assessment and recognition of non-formal learning. *European Journal on Vocational Training*, 22:24–32, 2001.

[7] Amiangshu Bosu, Christopher S. Corley, Dustin Heaton, Debarshi Chatterji, Jeffrey C. Carver, and Nicholas A. Kraft. Building reputation in stackoverflow: An empirical investigation. In *Proceedings of the 10th Working Conference on Mining Software Repositories*, MSR '13, pages 89–92, Piscataway, NJ, USA, 2013. IEEE Press.

[8] Carla Casilli and Erin Knight. 7 things you should know about badges. *ELI 7 Things You Should Know*, 2012.

[9] Huseyin Cavusoglu, Zhuolun Li, and Ke-Wei Huang. Can gamification motivate voluntary contributions?: The case of stackoverflow q&a community. In *18th ACM Conference on Computer Supported Cooperative Work & Social Computing, CSCW 2015, Vancouver, BC, Canada, March 14-18, 2015, Companion Volume*, pages 171–174, 2015.

[10] Marcia Conner. Learn more with less: Low-cost content. `http://www.fastcompany.com/1107943/learn-more-less-low-cost-content/`, December 2008. Retrieved: 15.07.2014.

[11] Ward Cunningham. ?design principles of wiki: How can so little do so much. Design principles of a Wiki from a knowledge management perspective, 2006.

[12] J. Dorn and M. Hochmeister. Techscreen: Mining competencies in social software. In *The 13th World Multi-Conference on Systemics, Cybernetics and Informatics*, pages 115–126, Orlando, FLA, 2009. International Institute of Informatics and Systemics.

[13] Jürgen Dorn. Knowledge management - introduction. VO Knowledge Management - Lecture slides, 2012.

[14] Jürgen Dorn, Hannes Werthner, and Cristoph Herzog. Techscreen: Networked knowledge management. In *Smart Business Networks*, pages 460 – 470, 2008.

[15] Josef Federman and Max J. Rosenthal. Waze sale signals new growth for israeli high tech. `http://news.yahoo.com/waze-sale-signals-growth-israeli-high-tech-174533585.htmll`, 2013. Retrieved: 18.08.2015.

[16] Alliance for Excellent Education and Mozilla Foundation. Expanding education and workforce opportunities through digital badges.

[17] Jennifer Gonzalez-Reinhart. Wiki and the wiki-way: Beyond a knowledge management solution. Unviversity of Houston, Information Research Center, Februar 2005. 1-22.

[18] A. Halavais, K.H. Kwon, S. Havener, and J. Striker. Badges of friendship: Social influence and badge acquisition on stack overflow. In *System Sciences (HICSS), 2014 47th Hawaii International Conference on*, pages 1607–1615, Jan 2014.

[19] Noriko Hara. *Communities of Practice: Fostering Peer-to-Peer Learning and Informal Knowledge Sharing in the Work Place*. Information Science and Knowledge Management. Springer, 2008.

[20] Alan R. Hevner, Salvatore T. March, Jinsoo Park, and Sudha Ram. Design science in information systems research. *MIS Q.*, 28(1):75–105, March 2004.

[21] Cornelia Jers, Jutta Mayer, Ljewin Scheiko, Michael Schenk, Monika Taddicken, and Christine Uzler. Wie aktiv sind web-2.0-nutzer - entwicklung einer typologie anhand des aktivitätsniveaus der nutzer, 2010. Universität Hohenheim, Jahrestagung der DGPuK 2010 - Medienunnovation.

[22] Christopher M Johnson. A survey of current research on online communities of practice. *The Internet and Higher Education*, 4(1):45 – 60, 2001.

[23] Lynne Koltookian. 8 benefits of formal and informal learning. `http://www.langevin.com/blog/2012/05/10/8-benefits-of-formal-and-informal-learning/`, May 2012. Retrieved: 15.07.2014.

[24] M.C. Pettenati and M. Ranieri. Informal learning theories and tools to support knowledge management in distributed CoPs. In E. Tomadaki and P. Scott, editors, *Innovative Approaches for Learning and Knowledge Sharing: EC-TEL 2006 Workshops Proceedings*, pages 345–355. 2006.

[25] Donald W Mocker and George E Spear. Lifelong learning: Formal, nonformal, informal, and self-directed. information series no. 241. 1982.

[26] Claudia Müller and Norbert Gronau. *Social Software und Web 2.0 im Unternehmen*, chapter Wikis, pages 10–17. Oldenburg Wissenschaftsverlag, 2008.

[27] n/a. Case study on open badges - young adult library services association. Technical report, HASTAC and Mozilla, 2014.

[28] Francisco J. García-Pe nalvo. Trailer (tagging, recognition and acknowledgment of informal learning experiences). Technical report, University of Salamanca (Spain), 2012.

[29] Francisco J. García-Pe nalvo, Alicia García-Holgado, and Juan Cruz-Benito. Formal and informal learning experiences in multicultural scopes. In *Proceedings of the First International Conference on Technological Ecosystem for Enhancing Multiculturality*, TEEM '13, pages 523–527, New York, NY, USA, 2013. ACM.

[30] Lorena Nisperuza. Digital badges in education. Master's thesis, Vienna University of Technology, 2015.

[31] Luca Ponzanelli, Andrea Mocci, Alberto Bacchelli, Michele Lanza, and David Fullerton. Improving low quality stack overflow post detection. In *30th IEEE International Conference on Software Maintenance and Evolution, Victoria, BC, Canada, September 29 - October 3, 2014*, pages 541–544, 2014.

[32] Mozilla Open Badge Project. Badge baking. `https://github.com/mozilla/openbadges/wiki/Badge-Baking`. Retrieved: 26.11.2014.

[33] Mozilla Open Badge Project. Badgekit api - documentation. `https://github.com/mozilla/badgekit-api`. Retrieved: 28.11.2014.

[34] Mozilla Open Badge Project. Badgekit api - wiki. `https://github.com/mozilla/badgekit-api/wiki`. Retrieved: 28.11.2014.

[35] Mozilla Open Badge Project. Badgekit webapp - documentation. `https://github.com/mozilla/openbadges-badgekit`. Retrieved: 28.11.2014.

[36] Mozilla Open Badge Project. Displayer api. `https://github.com/mozilla/openbadges/wiki/Using-the-Displayer-API`. Retrieved: 26.11.2014.

[37] Mozilla Open Badge Project. Issuer api - technical documentation. `https://github.com/mozilla/openbadges/blob/development/docs/apis/issuer_api.md`. Retrieved: 26.11.2014.

[38] Mozilla Open Badge Project. Open badge specification. `https://github.com/openbadges/openbadges-specification`. Retrieved: 26.11.2014.

[39] Francesco Restuccia, Sajal K Das, and Jamie Payton. Incentive mechanisms for participatory sensing: Survey and research challenges. *arXiv preprint arXiv:1502.07687*, 2015.

[40] Suzanne Scott. Open badge adventure at borders college. Technical report, JISC RSC Scotland.

[41] Suzanne Scott. Replacing paper based certification of cpd activities with open badges at borders college. Technical report, JISC RSC Scotland.

[42] Joel Spolsky. Stack overflow launches. http://www.joelonsoftware.com/items/2008/09/15.html. Retrieved: 04.06.2015.

[43] Alexander Stocker and Klaus Tochtermann. *Communities und soziale Netzwerke*, chapter Communities und soziale Netzwerke, pages 64–77. Oldenburg Wissenschaftsverlag, 2008.

[44] Etienne Wenger, Richard Arnold McDermott, and William Snyder. *Cultivating Communities of Practice: A Guide to Managing Knowledge*. NetLibrary Inc. Harvard Business School Press, 2002.

[45] Dietmar Winkler. Einführung in software testen - theoretische hintergründe. VU Software Qualitätssicherung - Lecture slides, 2011.

[46] Michael Wu. Community vs. social network. https://community.lithium.com/t5/Science-of-Social-blog/Community-vs-Social-Network/ba-p/52831. Retrieved: 08.07.2015.

[47] Jeffrey R. Young. 'badges earned online pose challenge to traditional college diplomas. Technical report, The Chronicle of Higher Education, 2012.