

Community KPI-Dashboard

a virtual community evaluation methodology

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Daniel Rubas

to my wonderful family, Elisabeth, Eric, Cornelia and Rafaela

Abstract

This thesis addresses the problem of identifying and measuring success factors of virtual communities. This task is highly relevant since virtual communities are part of today's society and have many different possible applications for enterprises such as involving the customers into the process of developing new products or for marketing to build brand loyalty. But to establish a virtual community can be hard and success is not guaranteed. To increase the success of virtual communities, general success factors as well as key-performance-indicators shall be identified and different designing methods will be described. This thesis analyzes the success factors of famous virtual communities like Stack Overflow or Wikipedia and previous scientific work dealing with this topic. Based on the literature review and a case study about an online community for exchange students at the technical university of Vienna requirements for the ›Community KPI-Dashboard‹ were derived.

The ›Community KPI-Dashboard‹ is a Drupal module to measure and visualize the identified key-performance-indicators for virtual communities based on Drupal. To achieve this, the reports of the ›Community KPI-Dashboard‹ were designed and implemented as far as possible on Drupal core and additional functionality was added using other popular Drupal modules for online communities. The reports generated by the ›Community KPI-Dashboard‹ include measures about activity, audience, content, purposes, roles, quality and views in the community as well as a small social network analysis.

In the end ideas and approaches for further enhancements and development of the ›Community KPI-Dashboard‹ are discussed.

Kurzfassung

Diese Arbeit beschäftigt sich mit der Identifizierung und Messung von Erfolgsfaktoren in virtuellen Gemeinschaften. Diese Problemstellung ist von hoher Relevanz, da virtuelle Gemeinschaften Teil unserer heutigen Gesellschaft sind und auch für Unternehmen viele verschiedene Anwendungsbereiche, wie das Involvieren von Kunden in den Entwicklungsprozess von neuen Produkten oder im Marketing beim Etablieren von Markenloyalität, haben. Aber eine virtuelle Gemeinschaft zu etablieren kann schwierig sein und muss nicht immer mit Erfolg enden.

Um den Erfolg von virtuellen Gemeinschaften zu erhöhen sollen generelle Erfolgsfaktoren als auch Key-Performance-Indikatoren identifiziert und verschiedene Design-Methoden beschrieben werden. Des Weiteren werden die Erfolgsfaktoren von berühmten virtuellen Gemeinschaften, wie Stack Overflow oder Wikipedia, und bisherige wissenschaftliche Literatur zu diesem Thema analysiert. Darauf aufbauend und anhand eines Fallbeispiels über eine virtuelle Gemeinschaft für Austauschstudenten an der technischen Universität Wien wurden Anforderungen für das ›Community KPI-Dashboard‹ abgeleitet.

Das ›Community KPI-Dashboard‹ ist ein Drupal Modul zur Messung und Visualisierung der identifizierten Key-Performance-Indikatoren für auf Drupal basierende virtuelle Gemeinschaften. Um das zu erreichen wurde das ›Community KPI-Dashboard‹ weitgehend auf Drupal Core design und implementiert. Zusätzliche Funktionen wurden basierend auf weiteren populären Drupal Modulen für online Gemeinschaften hinzugefügt. Die Auswertungen des ›Community KPI-Dashboard‹ enthalten Kennwerte über die Aktivitäten, das Publikum, die Inhalte, die Rollen, die Zwecke, die Reichweite und die Qualität der Gemeinschaft so wie eine kleine Social Network Analyse.

Schlussendlich werden Ideen und Ansätze um das ›Community KPI-Dashboard‹ weiterzuentwickeln und zu verbessern präsentiert.

Contents

Abstract	ix
Kurzfassung	xi
Contents	xiii
List of Figures	xv
List of Tables	xvi
1 Introduction	1
1.1 Motivation & Problem Statement	1
1.2 Expected results	2
1.3 Scientific approach	3
1.4 Structure of the Work	3
2 State of the Art	5
2.1 Virtual Communities	5
2.1.1 Definition	5
2.1.2 Types of Virtual Communities	6
2.2 Successful Communities	7
2.2.1 Stack Overflow	7
2.2.2 Wikipedia	9
2.2.3 Quora	10
2.3 Existing Approaches	11
2.3.1 IS success model	11
2.3.2 User Tracking	15
2.3.3 Online Community Framework	16
2.3.4 Social Network Analysis	18
2.4 Software-Frameworks	19
3 Requirements	21
3.1 Case Study - TU International	21
3.1.1 Case Description	21

xiii

3.1.2	Stakeholder	22
3.1.3	Scenario - Exchange Student Incoming	23
3.1.4	Goal Definitions	25
3.1.5	Main Functionalities	25
3.1.6	Mock-Ups & TU International Design	27
3.2	Community KPI-Dashboard	29
3.2.1	Target Community Definition	29
3.2.2	Functional Requirements	30
3.3	Big Picture	31
4	Design and Implementation	35
4.1	Architecture	35
4.2	TU-International Community	36
4.2.1	Preface	36
4.2.2	Roles and Permissions	38
4.2.3	Features	39
4.3	Community KPI-Dashboard	53
4.3.1	Designs & Mock-Ups	53
4.3.2	Prototype	55
4.3.3	Implementation & Code Snippets	56
	Reports	56
	Social Network Analysis	58
4.3.4	Setup of Community KPI-Dashboard	59
5	Evaluation	63
5.1	Activity Tracking	63
5.2	Audience Tracking	65
5.3	Content Tracking	66
5.4	Purpose Tracking	67
5.5	Role Tracking	68
5.6	Social Network Analysis	69
5.7	Quality Tracking	70
5.8	View Tracking	71
6	Conclusion and Future Work	73
6.1	Answers to Research Questions	73
6.2	Limitations & Future Work	76
	Bibliography	77

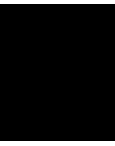
List of Figures

2.1	Badges section of a user profile on Stack Overflow	8
2.2	D&M IS Success Model [7]	12
2.3	Updated D&M IS Success Model [8]	14
2.4	Research model by Lin (2008) [17]	14
2.5	Key components of the online community framework [29]	17
3.1	Cover page	27
3.2	Login screen	28
3.3	Q&A-page	28
3.4	Wiki-page	29
3.5	Big picture	33
4.1	Drupal architecture [4]	36
4.2	Facebook connect	40
4.3	User profile fields	40
4.4	Example user profile	41
4.5	Users with same interests	42
4.6	Prototype of private messaging	43
4.7	Example wiki page of the tu international	44
4.8	Url aliases using pathauto module	44
4.9	Not existing wiki page	45
4.10	Views of q&a-page	47
4.11	Prototype of q&a-page	48
4.12	Prototype of forum	49
4.13	Prototype of surveys	50
4.14	Prototype of surveys 2	51
4.15	Event calendar	52
4.16	Community Dashboard - Audience Tracking	54
4.17	Community Dashboard - Role Tracking	54
4.18	Disabled report	55
4.19	Community Dashboard settings	55
5.1	Created content per hour report	64
5.2	New user report	65
5.3	User interests report	65
5.4	Date filter	66
5.5	New content	67
5.6	Questions and answers report	67
5.7	Top tags report	68

5.8	Settings for role reports	69
5.9	Social network analysis	70
5.10	Top-5 questions report	71
5.11	Top user report	71
5.12	Top views report	72
5.13	Top unique views report	72

List of Tables

2.1	Definitions of ›Virtual Community‹	6
2.2	Comparison of Drupal, Joomla and Wordpress. [21] [25] [33] [6]	20
4.1	Roles and permissions	39
4.2	Overview of ›Community KPI-Dashboards‹reports, their dependencies and required configuration	61



Introduction

1.1 Motivation & Problem Statement

These days virtual communities play a vital part in our society. Like offline communities (classes or project-teams), virtual communities allow people to connect and interact with each other, but online. Virtual communities are used for several applications, one of them is knowledge sharing. [13]

Virtual communities for knowledge sharing especially rely on the cooperation and activeness of their users. If nobody was sharing his or her knowledge with the community, nobody would benefit out of the community. Without benefit from the community there won't be any users.

Nowadays also many enterprises run virtual communities for their customers. Virtual communities can be used in many different ways for enterprises for example product development, where consumers get involved into the development of new products according to the customer needs, or marketing, where virtual communities can help to build brand loyalty and to advertise products. [30] To benefit from their virtual communities enterprises need to motivate users to participate in their communities and to design their communities according to their target customer segment.

The focus of this master thesis lies in the analysis of success factors of virtual communities and how to evaluate them. Evaluating a community in a professional way can help the community leaders to achieve:

- an estimation of health of their community
- identification of well and under-performing parts of their community

- an understanding of the needs of different user-groups and how to receive more attention to potential users for certain user-groups
- an understanding about what is happening in their community through reporting and tracking (content, activities and technical needs)
- comparisons with other communities having the same or similar audiences
- transparency to make the values visible for funders and sponsors

[5]

1.2 Expected results

This work has the goal to describe a methodology, which contains a set of best practices, for virtual communities, the evaluation of virtual communities and the behavior of their users. After the methodology has been defined, a prototype shall be developed, with which it is possible to measure different key-performance-indicators of a virtual community.

Research questions: In the end the following questions should be answered.

- How does a successful virtual community look like?
- What are critical factors on which virtual communities can be evaluated/compared?
- Which methods can be used to make a virtual community more successful?

Hypothesis: The following hypothesis will be verified to support the research questions by giving directions and providing borders for this thesis.

- H1: It is assumed that it is important for successful virtual communities to define a target audience.
- H2: It is assumed that in a successful virtual community all questions are answered accordingly to the questioners needs.
- H3: It is assumed that the average response-time for questions in the community is an important factor for the success of virtual communities.
- H4: It is assumed that digital badges and other indicators of skill in communities motivate the users to share their knowledge.
- H5: It is assumed that the gamification of virtual communities stimulates the knowledge sharing behavior of their users.
- H6: It is assumed that the quality of answers provided by close friends is of higher quality than of unrelated users, since close friends are assumed to care more.

1.3 Scientific approach

The scientific approach of this thesis consists of four parts, which shall contribute that the aims of this paper will be reached.

1. literature review & analysis:

The first part will be a literature review to gather background information about virtual communities, the success-factors of virtual communities and existing evaluation approaches for virtual communities. Furthermore similar existing projects for evaluation of virtual communities will shortly be presented and discussed.

2. description of the methodology:

On the basis of the literature review and the analysis of existing projects a methodology shall be described, which allows to evaluate the critical factors of virtual communities.

3. development of a hands-on scenario

For the identification of requirements and the evaluation of the methodology, as well as for a better understanding a hands-on scenario, about a virtual community for exchange students of a university, will be described.

4. design & development of the evaluation-prototype:

After the first three steps are completed a prototype for measuring the identified key-performance-indicators of a virtual community will be developed. This step includes the identification of the appropriate technology. Depending on the key-performance-indicators additional features will be elaborated and implemented.

1.4 Structure of the Work

A methodology for the evaluation of virtual communities will be developed and presented in this thesis.

- Chapter 2 gives an overview of the state of the art and of already existing projects and approaches in this area. It will take a look into different types of virtual communities and their characteristics and introduce some famous examples of virtual communities. Chapter 2 will also deal with the question how previous researches defined success in relation to virtual communities and if there are already existing approaches of evaluation methods.
- Chapter 3 describes how to plan a virtual community and define goals for it based on a case study about a virtual community for exchange students of the technical university of Vienna. Furthermore the requirements for such a community and for the ›Community KPI-Dashboard‹ are derived from the case study.

- Chapter 4 presents the design and functionality of the ›Community KPI-Dashboard‹ as well as interesting implementation details. Also the design and the development of the evaluation community will be described.
- Chapter 5 evaluates the functionality of the ›Community KPI-Dashboard‹ based on the developed evaluation community.
- Chapter 6 summarizes the answers of the research questions from this thesis and provides further remarks regarding limitations and possible further work in this field of research.

State of the Art

Nowadays there exist a huge amount of online communities while new communities are still generated. To identify general success factors and key-performance-indicators of online communities the following chapter explores literature about virtual communities and evaluation approaches of virtual communities as well as software-frameworks for virtual communities.

2.1 Virtual Communities

As the term virtual community is very widely diversified a short definition of virtual communities will be introduced to this work for thematic demarcation. After the definition the different types of virtual communities and their characteristics will be described.

2.1.1 Definition

Everyone has some kind of idea of what a virtual community or online community might be, but so far there exists no commonly agreed definition of ›Virtual Community‹. This results out of multidisciplinary interest that this topic inspires. [29] What most authors and papers agree on is that virtual communities are an aggregation of Internet users who interact with each other for a longer period of time, with sufficient human feeling, to form webs of personal relationships. [27] [30]

In the following table two definitions of different authors for the term virtual community are presented.

Reference	Definition
Rheingold (2000) [27, p. xx]	›Virtual communities are social aggregations that emerge from the Net when enough people carry on those public discussions long enough, with sufficient human feeling, to form webs of personal relationships in cyberspace.‹
Preece (2006) [24, p. 10]	›An online community consists of: <ul style="list-style-type: none"> • People, who interact socially as they strive to satisfy their own needs or perform special roles, such as leading or moderating. • A shared purpose, such as an interest, need, information exchange, or service that provides a reason for the community. • Policies, in the form of tacit assumptions, protocols, rules and laws that guide people’s interactions. • Computer systems, to support and mediate social interaction and facilitate a sense of togetherness.‹

Table 2.1: Definitions of ›Virtual Community‹

2.1.2 Types of Virtual Communities

Within the huge amount of online communities there are big differences regarding the characteristics of the communities. For example on the one side there is Wikipedia where members created an online encyclopedia by working together. On the other side there is Second life where members are escaping their day to day worries by playing and getting in contact with other users in a virtual world. In the following groupings and arrangements of types of virtual communities presented by different papers and authors will be introduced and described.

- **Based on Purpose**

Regarding Spaulding [30] there are four types in which virtual communities can be divided or purposes for which virtual communities exist.

The main purpose of *transaction-oriented* virtual communities is to bring sellers and buyers together.

E.g. Willhaben, eBay, etc.

At *interest-oriented* communities people with interest or/and knowledge about a certain topic meet for example to discuss or to help each other.

E.g. Dell Community, Stack Overflow, etc.

The functions of *relationship-oriented* communities offer to build, develop and maintain relationships among the community members.

E.g. MySpace, LinkedIn, etc.

Fantasy-oriented communities are supporting the need of personal interaction with others in games and social experimentation in artificial environments.

E.g. World of Warcraft, Second life, etc. [30]

- **Based on participants**

Besides dividing virtual communities on their purpose like Spaulding (2010), virtual communities can also be grouped by the particulars of its members. There are *age-related* virtual communities which are targeting people of certain age-groups such as `www.elderweb.com` or `www.youthactivism.com`. Furthermore there are *gender-related* virtual communities like `www.oxygen.com` or virtual communities reflecting *real communities* where for example the citizens of a village or city can exchange their ideas and discuss certain things regarding their living area for example `www.mymanchester.com`. [14] [3]

2.2 Successful Communities

Since there are many different fields of application for virtual communities, success might be defined differently varying on the subject or cause of a community. This section deals with different communities and their way of having success by shortly presenting some famous and successful communities. It will also be explained how those communities are designed, buildup and what their success factors are.

2.2.1 Stack Overflow

Stack Overflow is a question & answer site for programmers. In 2010, 2 years after Stack Overflow has started, there were 300.000 registered users and more than 7 million monthly visits. Question & answer sites in general have answer rates between 66% and 90%. At Stack Overflow over 92% of the questions about expert topics are answered in a median time of 11 minutes. According to Mamykina (2011) Stack Overflow is very successful because of its reputation system and the strict set of community guidelines that support factual and informational answers. The outcome of this are fast answer times and high answer quality. Those features were a result of the design philosophy and organization encouraged by the founders of Stack Overflow. [19] The paragraph above indicates that in a successful community having fast answer times and high quality answers are part of the success factors which confirms H2 and H3 of this thesis.

At Stack Overflow the design team is strongly involved in controlling the community and debating within it as well. This integration into the community is possible, because the focus of the site is on a single domain in which the design team had prior reputation as community leaders. In comparison to Stack Overflow there are many large self-organizing Q&A sites, where the operators only supply a platform for questioning and answering, but are not involved directly in the community by creating content or moderating. [19] Understanding the motivation of users of a community and what drives them to join in is an important part of starting a virtual community. Communities which have no clear definition of their goals and therefore no definition of what their users want, tend to attract participants with different expectations, who might get frustrated if their expectations are not satisfied. [24] [2] The last paragraph supports H1 of this thesis, that it is important for successful communities to define a target audience.

Mamykina (2011) named the following three factors to be crucial for the success of Stack Overflow:

1. Making competition productive

The founders and the design team of Stack Overflow knew the needs and the driving forces of the software development community, because they were an active part of it. The focus on technical answers was enabled by the Q&A format and the voting system, which together was a strong alternative to the more conversational software forums. The competitive energy of the community was built up by adding gamification. More specific they invented a reputation system, which helped to get users to participate for a longer timeframe, other users in contrast only participated for a short timeframe. The reputation system consists of points which can be earned by the users for example by asking or answering questions. [32] Further users of Stack Overflow can be rewarded with digital badges for being especially helpful to the community for example if a users question gets 2,500 views that user will receive a badge called ›Notable Question‹ which can be seen at his user profile like in figure 2.1. [31] This supports the hypothesis H4 and H5 of this work,

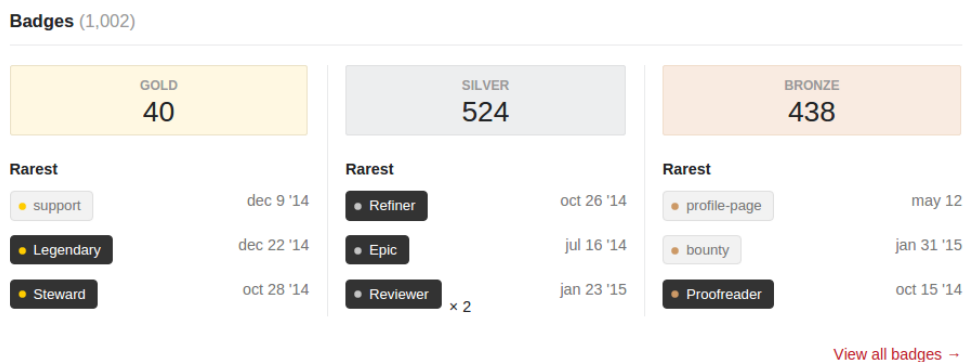


Figure 2.1: Badges section of a user profile on Stack Overflow

that digital badges or other indicators of skill as well as gamification have positive effects on the knowledge sharing behavior of the users.

2. **Credibility in the community**

Since the founders and design team had some kind of leader status and visibility within their community, they already had a critical mass on their side before the site was even launched. This helped ensuring the success of Stack Overflow early on and to get the community's approval for the proposed design as well. Even though many users of the community complain about the missing possibility for discussion and debate, they are sticking to the community and the founders' vision, because they are thankful and acknowledge the benefits resulting of Stack Overflow.

3. **Evolutionary approach to design**

For continuous improvements the design team established a feedback loop including their users. They setup an external forum (`meta.stackoverflow.com`) where the users are able to discuss about the site. This helped the founders to understand the concerns and difficulties of their users and to prioritize feature requests. On `meta.stackoverflow.com` it is possible for users to vote for feature requests like for questions on Stack Overflow. (<http://meta.stackoverflow.com/tags/feature-request/info>) [19]

2.2.2 **Wikipedia**

Wikipedia is an online encyclopedia to which readers can contribute. It was founded in 2001 and grew exponentially over the first years. Today it contains more than 37.5 million pages contributed and maintained by more than 26.5 million users. [37] According to `alexa.com` Wikipedia is consistently ranked in the top ten visited sites on the Internet, which might be seen as success for an online encyclopedia if a huge amount of people are looking for information on your pages. Some studies even proofed that the content of Wikipedia is of comparable quality to traditional encyclopedias. Also vandalism and mistakes are often corrected within a couple of minutes. [15]

Naturally the many members and contributors of its community play an important part for the success of Wikipedia. Kuznetsov [16] tried to find the motivations of the contributors of Wikipedia to spend their time and effort into the community for no payment in return and what role does Wikipedia play in generating these motivations. Following some factors for the success and huge appeal of Wikipedia are listed and explained:

1. **Community**

The technology behind Wikipedia includes many tools that bring Wikipedians together such as ›Community Portals‹ where members with same interests or goals can coordinate tasks and are encouraged to work together. There is also a discussion page for each Wikipedia article where users can talk about different aspects and find out which content might be appropriate or to suggest future work on the

subject. Those portals, discussion pages and other tools motivate users to work together and to meet other members with similar interests. This connection with the other users and the work achieved through cooperation creates the feeling for the single user to be needed by the Wikipedia community.

2. Reputation

Members of Wikipedia create an account for their online identity which represents them in the Wikipedia community. They can design and develop their own user pages. For example many Wikipedians like to include links to articles they have been working on, so that members can learn about each other's interests and levels of expertise. There are also Wikipedia awards for excellent work to which users can be nominated and vote to select a winner. There are also further ways in which great work of Wikipedians can be acknowledged such as ›Featured Articles‹ which are displayed on the front page of Wikipedia or ›Featured Portals‹ where useful portals which are well maintained are listed. Members who contribute to Featured Articles and Featured Portals get a remarkable reputation as their work is rewarded by the community.

3. Autonomy

The technology of Wikipedia stimulates autonomous behavior of its users. Wikipedians have access to all content and are free to edit almost every page they like to. There exists nothing like an authority figure which controls the quantity or quality of contributors. Also Wikipedians never get fired or have to contribute a certain number of articles per time. Naturally there are some regulations since Wikipedia's main function is to be a reliable encyclopedia. For example not all changes are permitted and contributors, who destroyed articles frequently, are not allowed to edit anymore. In addition some articles about controversial topics can get temporarily protected, which means that not everybody is able to edit them. Even though those restrictions are limiting the freedoms of Wikipedians, the general editing process still remains autonomous. [16]

2.2.3 Quora

Quora is an innovative question and answer site, which has a rapidly growing user community since it exited beta status in 2010. While competitors like Yahoo Answers or Google Answers have began to shrink or are already shut down, Quora is still going strong. It differs from its competitors by its basic structure, which includes a social network.

D'Angelo one of the co-founders of Quora once stated that the biggest barrier for sites like Quora is trust and how users can identify high quality answers. To verify why you should trust an answer at Quora much information is provided by the system for example members have to use their real name, they can write a short bio at their profile to prove why they are qualified to answer certain types of questions and users can see which other users voted for which answer. [18]

Wang (2013) [36] indicates that Quora's success is based on the underlying graph structure, especially mentioning the following three graphs:

1. **User Topic Graph**

In Quora users can follow specific topics like ›Technology‹ and ›Startups‹ . New or updated questions about topics an user is following will automatically be pushed to his newsfeed. User topic graphs generate user interest in browsing and answering general questions regarding their topics of interest.

2. **Social Graph**

Users of Quora can follow other users as well, similar to Twitter and receive updates of each other's activities. The user to-user social network attracts views, and leverages social ties to encourage votes and additional high quality answers. In Quora, users who contributed more and good answers tend to have more followers. These well-connected users also gain advantage by having more friends (followers) to answer their questions and vote +1 for their answers.

3. **Related Questions Graph**

The related question graph is one of the core features of Quora which provides an easy way to find other relevant aspects regarding the same question for users. In this graph questions are represented as nodes and the links between the nodes are seen as measure of similarity identified by Quora. [36]

2.3 Existing Approaches

In this section different existing evaluation approaches for virtual communities will be presented and compared. Based on these existing approaches and on the case study described in chapter 3 the functional requirements and key-performance-indicators for the ›Community KPI-Dashboard‹ will be derived.

2.3.1 IS success model

The Information System success model is a holistic approach to describe variables and influences which determine the success of information systems. There is not only one measure to define if an information system is successful or not, there are many. In 1992 the original IS success model groups those measures into six different categories:

- **System Quality**

At the level of System Quality the desired characteristics of information systems which produce the information are examined.

- **Information Quality**

Information quality describes the quality of information product regarding desired characteristics like accuracy, meaningfulness, and timeliness.

- **Use**
Use describes the way the system and its capabilities are used by the users.
 - **User Satisfaction**
User satisfaction describes the level of satisfaction of the users with the information system.
 - **Individual Impact**
Individual Impact describes the effect which the information product has on management's decisions.
 - **Organizational Impact**
Organizational impact describes the influence of the information product on the organizational performance.
- [7, p. 62 & 88]

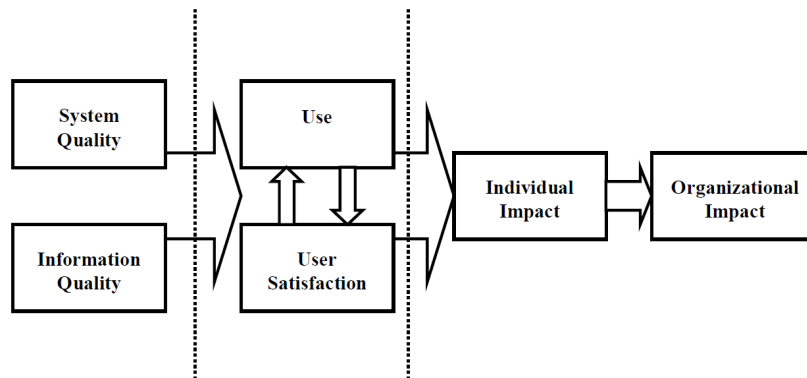


Figure 2.2: D&M IS Success Model [7]

Out of this six different categories many different measures of IS success emerged because different researchers have been laying different focuses depending on their interests.[7] As a result of those many different research studies it is obvious that there is no single measure on the success of information systems that is better than the others. On the other side there are many variables which have been identified to measure success of information systems. So it depends on the objective of the study which success variables you choose. [7]

The article ›Information Systems Success: The Quest for Dependent Variable‹ [7] reviewed 100 studies which attempted to examine success measures for information systems according to those six categories. But out of the 100 studies only 28 tried to measure IS success in more than one success category. 19 used two categories, 8 used three and only one tried to measure variables for success of IS in four of six categories.

A decade later the IS success model was updated by Delone and McLean (2003) based on the review of empirical and conceptual studies and literature about IS success. [22] In

the new updated model the categories in which the measures are divided differ slightly compared to the original model of 1992.

- **System Quality**

System quality is the desirable characteristics of an information system. For example ease of use, system flexibility, system reliability and ease of learning, as well as system features of intuitiveness, sophistication, flexibility and response times.

- **Information Quality**

Information quality describes the desirable characteristics of the system outputs. Those are management reports and web pages. For example relevance, understandability, accuracy, conciseness, completeness, understandability, currency, timeliness and usability.

- **Service Quality**

Service quality measures the quality of the support that system users receive from the IS department and IT support personnel. For example: responsiveness, accuracy, reliability, technical competence, and empathy of the personnel staff. The ›SERVQUAL‹ measure, adapted from the field of marketing, is a popular instrument for measuring IS service quality.

- **System Use**

System use indicates the dimension and manner in which staff and customers utilize the capabilities of an information system. For example amount of use, frequency of use, nature of use, appropriateness of use, extent of use and purpose of use.

- **User Satisfaction**

User satisfaction describes the level of satisfaction of the users with the information system and support services.

- **Net Benefits**

Net benefits describes the extent which information systems are contributing to the success of individuals, groups, organizations, industries, and nations e.g. improved decision-making, improved productivity, increased sales, cost reductions, improved profits, market efficiency, consumer welfare, creation of jobs and economic development. [8]

Lin (2008) tried to adapt the IS success model for virtual community success. The major adaptations affect the variables ›IS use‹ and ›Net Benefits‹. Instead of focusing on ›IS use‹ and ›Net Benefits‹ the ›sense of belonging to a community‹ and the ›need for loyalty to the community‹ is from relevance for virtual communities. If there were no sense of belonging to a virtual community there wouldn't be any involvement and participation. Therefore ›sense of belonging to a community‹ is considered to be an suitable measure of success for virtual communities according to Lin (2008). Loyal members of a virtual community build a stable pool of users. Therefore play an important role when it comes

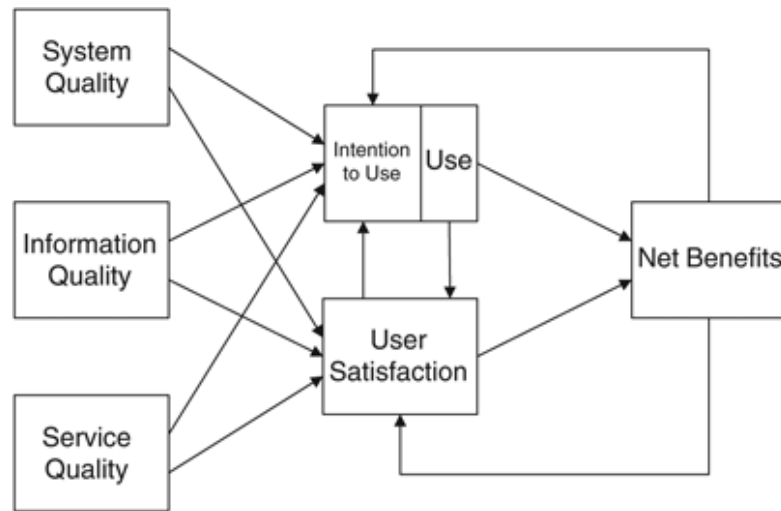


Figure 2.3: Updated D&M IS Success Model [8]

to expanding a community. Lin (2008) describes in her paper that each community has unique characteristics. Therefore member loyalty was considered to be a more suitable parameter for the effectiveness of a virtual community than individual and organizational impact. According to Lin (2008) the ›Social Factors‹ trust and social usefulness lead to the sense of belonging which itself leads to member loyalty. Figure 2.4 shows the resulting

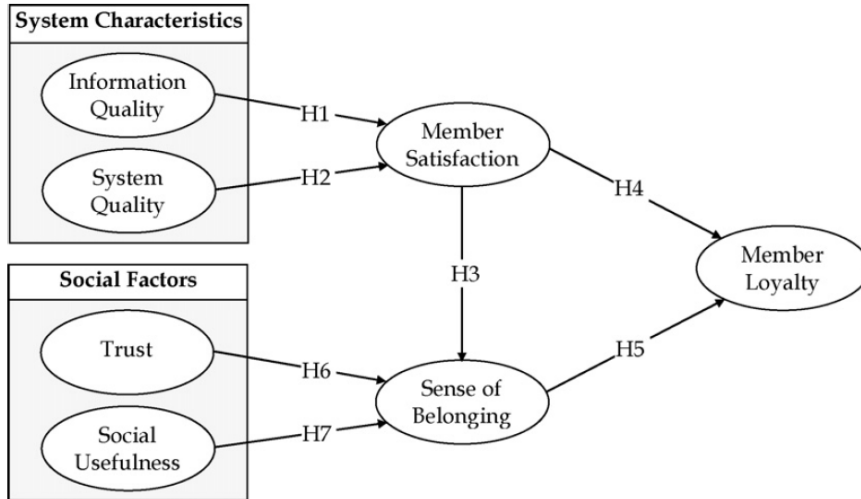


Figure 2.4: Research model by Lin (2008) [17]

research model for successful virtual communities by Lin (2008). Lin's findings point out that there is a positive correlation between member satisfaction, sense of belonging and member loyalty. Furthermore trust shows the strongest influence on the sense of

belonging to a virtual community. [17]

2.3.2 User Tracking

User tracking approaches include online surveys, site analytics or focus groups and can be used for collecting data from the community and to retrieve information out of it. Some questions which can be answered with user tracking are the following:

- What are users doing in the community?
- What are the most favored trends in posts?
- Which way do users contribute in the community? (posting, replying, voting, etc.)
- When and how often do members contribute in the community?
- Do members develop different roles within the community? [5]

To answer those questions simple site analytics by evaluating the traffic and popularity trends of a community can be used. There exist multiple different site analytics applications for free like Google Analytics, FireStats, etc. which can be used for this purpose. A virtual community and its components provide a plurality of raw metrics based on this data evaluations can take place such as:

- amount of topics created, blog posts, messages posted, photos uploaded, etc.
- total number of participants in polls or surveys
- total number of visits
- total number of unique visits
- total number of registered members or users
- average time per visit [5]

Based on the answers to this simple questions you are already able to get an overview about your community and its dynamic. These approaches are the cheapest, but there might be questions which can't be fully explained with a basic user tracking techniques like the following:

- How well is the community doing as a community? Which dimensions of a successful community are achieved through the eyes of the members (such as reducing feelings of isolation)?
- What is each community element contributing to the community as a whole?
- How does the community design impact member use and participation?

- What are the emerging benefits of the community for members?
- What are the emerging cultural norms or themes of the community?
- What kinds of questions are asked while members are doing synchronous activities (e.g., webinars)?
- How is a community progressing over time?
- How is the community doing compared to others? [5]

To answer those more complex questions more complex evaluation approaches have to be used like benchmarking or user content rating tools. In the following paragraph those methods are shortly presented and explained.

- **Benchmarking**

Benchmarking can be used to look how a community is evolving over time or to compare it with other communities. To compare a community with itself, monthly snapshots can be taken of the activity-rates, the user base, etc. For benchmarking against others, 2-3 similar communities regarding audience, purpose, etc. need to be found, so that the data can be compared.

- **User Content Rating Tools**

If the community has relevance on practice, the evaluation of the community quality might be important. A simple method to measure community quality is to use user rating tools, where members can rate the content created by other members. User content rating tools are not only helping community leaders to find out which activities should be continued and which content is beneficial for their membership. But members who are not comfortable with posting or writing can also contribute through user content rating tools in a simple way to the community. There exists the possibility to motivate top contributors to more quality contributions by making their status visible for the community as well e.g. Amazon's Top Reviewer where the users who reviewed articles on Amazon and got helpful votes by other users are honored by the community. [5] [1]

2.3.3 Online Community Framework

The approach of the Online Community Framework (OCF) takes two main aspects into account which form the basis of the framework, ›sociability‹ and ›usability‹. While the aspect of sociability deals with social interactions in virtual communities, the aspect of usability deals mostly with the human-computer interface. Taking the term sociability into account designers of communities are animated to concentrate on the social needs of users first and decide on the software design afterwards. [29]

As we can see in figure 2.5 the sociability part of the online community framework consists of three key components. [24]

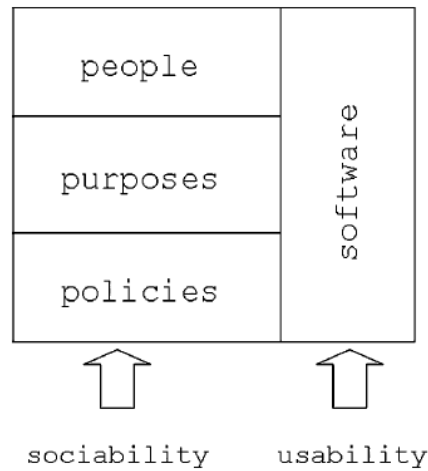


Figure 2.5: Key components of the online community framework [29]

- **Purpose**

For good sociability the community needs a shared focus on some interests, needs, information, services or support, which gives the participants a reason to be part of the community.

- **People**

The members of the community, who interact with each other, have personal, social and organization needs. Those members may take different roles in a virtual community, like leaders, protagonist, comedians, moderators, etc.

- **Policies**

The term policies stands for the language and protocols which guide the member's interactions and leads to the development of folklore and rituals that bring some kind of history and accepted social norms to a community. Besides that more formal policies like registration policies and codes of behavior for moderators may also be needed. Together formal and informal policies and rules form community governance. [24]

Usability in virtual community faces mostly the same issues as most of the other web-based software. But the following four elements are especially important because those items and components are focusing on the software's role as a place for social interaction:

- **Dialog & social interaction support**

Those components include prompts and feedback to support interaction. How easily can commands be executed, avatars be moved, spatial relationships in the environment, etc.

- **Information design**

Information design describes how simple it is to read and understand information concerning the community. Also the elegance of the displayed information is plays a role for the information design.

- **Navigation**

Navigation describes how someone can browse through the community and find the right place or information. Several virtual communities have troubles to avoid inconsistencies with data transfer. Some have also difficulties with the interaction style between the community website and the imported software modules.

- **Access**

The prerequisites to download, run and maintain a virtual community software must be clear. If high bandwidth and state of the art technology are necessary, there should also be a version for low bandwidth in addition e.g. a text only version [24]

Criteria for the evaluation of sociability include the obvious measures like the number of users in a community, the number of messages per unit of time and the satisfaction of the participants. It also includes looser measures like the amount of reciprocity, the number of on-topic messages, trustworthiness and multiple others. To evaluate the usability of an online community measures such as include numbers of errors, productivity, the satisfaction of the participants and others have to be considered. [23]

2.3.4 Social Network Analysis

Another approach for evaluating online communities is to treat them as social networks. The aims of social network analysis are describing the interactions and relations among participating members, identifying the patterns of interactions, and tracing how information flows within the community. Statistics about community participation can provide many insights about the engagement of a community. But it says little about the connections between community members. Social network analysis can be used to explain important social phenomena such as group formation, group cohesion, social roles, personal influence, and overall community health. [5]

The structure of a social network can indicate the usefulness of the network to its members. It can be differentiated between weak ties which usually are only acquaintanceships, strong ties which are people a user really trusts and whose social relationships are strongly overlapping with the one of the user and absent ties if there is no relationship at all between two users. Smaller, tighter networks might be less useful for the individuals of a network (community), than networks with many loose connections. Networks with many weak ties are more open and also more likely to introduce new ideas and opportunities to the users than networks with many redundant connections. So to have access to a larger range of knowledge it is better to have connections to many other individuals of different circles of friends or users, than to have only connections in a group of friends

where the members might already share the same interests and knowledge. [28] [10] [12] The last paragraph indicates that H6 of this thesis must not be true namely that the quality of answers provided by close friends is of higher quality than of unrelated users, since close friends are assumed to care more.

So taking social network analysis into account for evaluating virtual communities, different questions could be examined. For example social network analysis could help to identify who knows who, who might know what or teams and individuals playing central roles in the community. Further the knowledge flow in the community can be tracked to examine: of which users do people seek information and knowledge from? With which users do they share their information and knowledge? [20] Considering those questions can help to identify success factors of an online community for example by showing which users are bringing expert knowledge to the community.

2.4 Software-Frameworks

In the following section three different content-management-system solutions will shortly be presented and compared. In the end the best fitting solution for the purpose of this work will be picked for the evaluation part. The three cms-solutions which will be compared are Drupal, Joomla and Wordpress. They have the biggest market shares from all the cms-solutions listed on www.w3techs.com. [35] All of these three cms-solutions are mainly used to create websites, are written in php and available as free software.

	Drupal	Joomla	Wordpress
Homepage	www.drupal.org	www.joomla.org	www.wordpress.org
Ease of Use	Drupal requires quite some technical expertise to be used, but it is also capable of producing the most advanced sites compared to Joomla and Wordpress.	Joomla is less complex to use than Drupal, but more complex than Wordpress. The installation and setup is relatively simple as well. After a short time it is already possible to create quite complex sites.	To create a website with Wordpress technical experience is not necessary; the setup is intuitive and easy.

Features	Drupal is known for its powerful taxonomy and ability to tag, categorize and organize complex content. Compared to Joomla and Wordpress Drupal is also the most flexible cms.	Joomla is designed to perform as a community platform, with strong social networking features.	The key feature of Wordpress is the ease of use for novices as well as for experts. It's sufficient powerful for web developers or designers to build sites for clients efficiently, which can be managed by the clients themselves afterwards. Wordpress is also known for its extensive selection of themes.
Amount of available plugins or modules	High (more than 26000)	Medium (more than 5000)	High (more than 36000)
Best Use Cases	Complex, advanced and multi-functional sites; sites that need complex data organization; community platform sites for many users; online stores	Quite easy and intuitive usage, with more content and structure flexibility than Wordpress; supports E-commerce, social networking and more.	Ideal for quite simple web sites, such as blogging or news sites and anyone looking for an easy-to-manage website. Easy to expand the functionality of the site with add-ons.
Targeted Users	Web Developers	Web Designers	Beginners

Table 2.2: Comparison of Drupal, Joomla and Wordpress.
[21] [25] [33] [6]

Out of the three content management solutions Wordpress is by far the most popular one. The key-feature of Wordpress, which is mentioned everywhere, is that it is quite simple to setup and to use. But to accomplish the goal of this thesis I am looking for the most powerful and flexible solution that fits the requirements of a community regarding large amount of users and social networking features. Drupal has a much larger amount of modules and offers a great scalability. That's the reason why it was chosen over Joomla for this work.

Requirements

The following chapter describes how to plan a virtual community. The process of having an idea and defining goals for the community will be shortly presented in this chapter using a case study about a virtual community for exchange students of a university as example. Based on the case study the functional requirements of the ›Community KPI-Dashboard‹ are specified and its core functionality will be described.

3.1 Case Study - TU International

This section presents the case study about the hypothetical virtual community tu international. First the case and its characteristics will be described. Then the different stakeholders and their interests and needs are discussed, followed by a more detailed scenario about one of the stakeholders and its life-cycle within the tu international community. Further the goals and main functionality of the tu international are explained. At the end of this section some mock-ups and designs of the community are presented.

3.1.1 Case Description

The Vienna University of Technology is looking for the opportunity to enlarge the internationalization at the university. As part of this program the exchange and mobility services shall be improved.

One of the projects for internationalization is to build an online community for incoming and outgoing exchange students and scientific workers. In this community students who completed their Erasmus Programme in Vienna or abroad as well as scientific workers who have done some research in a foreign country shall be motivated to share their experiences with others. Also students or scientific workers who are still on exchange in Vienna shall be able to interact with other students or scientific workers to help each other with study related problems, but also topics about living and the social life in

Vienna might be interesting for users. The members of the community shall have the possibility to enter their interests into their profile to easily find other members in the community with the same interests. This can help incoming users to find people with the same hobbies to spend time with. Outgoing exchange students might as well use the community during their exchange to get answers about administrative questions like about receiving credits for courses the student is taking abroad. To enable easy access for all the students it should be possible to login to the community with their credentials of the TU Vienna, by authentication via a social-network like Facebook or to sign up with an existing email address.

It might make sense to structure some parts of the community such as the forum into two sub-communities namely incoming and outgoing, because discussion topics of those two target audience groups might differ drastic. Further division of the community based on the users starting semester of exchange, field of study or origin isn't planned and will not be facilitated by the administration team of the community. Nevertheless some kind of sub-communities might develop on its own for example based on forum threads like ›Exchange WS2015/2016‹ or based on tags in questions like ›Business Informatics‹.

For the prototype of the tu international community presented in chapter 4 the community-centered development approach described by Preece (2006) was used. The community-centered development approach takes a look at the community's needs at first and decides about technological and social aspects of the community later on. [24]

3.1.2 Stakeholder

In the following the different stakeholder and possible user groups are presented, describing their needs and problems and how they could benefit out of an international virtual community for the TU Vienna.

- **Exchange Students**

- **Incoming:** are looking for information about Vienna. They need to manage all the administrative tasks like registering at the new university, finding an accommodation or getting a ticket for public transport for the duration of their stay. Incoming students might also be interested in getting to know some of their fellow students in advance or to find students at the university who are sharing interests with them. Furthermore incoming exchange students could profit from knowledge of other incoming exchange students from the past semesters who share their made experiences.
- **Outgoing:** are looking for information about the city they are going to and administrative challenges towards the semester abroad as well. They might want to hear about experiences other students made on their exchange visiting the same country/city to get a deeper insight what they can expect on their stay abroad.

- **Guest Scientists (Incoming & Outgoing):** might have the same requirements to the system as incoming and outgoing exchange student, but the demands for the quality standard of the flat and the activities in the leisure time might differ from those of students, because of age and income differences.
- **Staff of the International Office:** is helping exchange students incoming and outgoing with the planning of their semester or year abroad and during their stay. With the help of a knowledge sharing community like the tu international the staff of the International Office could decrease their workload, by referencing the community to the students to help them finding the right information or by contributing to the community on their own by answering questions where every student with the same question can find it easily.
- **TU Vienna Students:** are looking for a community to enlarge their international network, finding friends of other countries, learning new languages similar to the tandem project, where people with different mother tongue meet up and help each other learning the other ones language or just helping out other students.

3.1.3 Scenario - Exchange Student Incoming

The following scenario is going to describe a possible life-cycle of an incoming exchange student as user of the tu international community.

Stefano comes from Milan (Italy) where he is studying Software Engineering in the bachelors program of the Technical University of Milan. In his leisure time Stefano is playing badminton for a couple of years and likes to visit rock concerts. In the upcoming semester Stefano is going to study in Vienna as part of the Erasmus Programme. To get an overview about his studies abroad he starts planning his semester in April. He already visited the website of the Technical University of Vienna International Office where the first steps are explained and important questions are answered. The International Office does even administer a Facebook-group for incoming exchange students at the TU Vienna for each semester. [34] On the website of the International Office Stefano finds a link to the tu international community for incoming and outgoing students and scientists.

Stefano searches his way through the community and finds interesting information about Vienna and opinions about different topics of students from Vienna and students who have been to Vienna for exchange. To participate in this community he decides to register himself for the tu international. Because Stefano doesn't want to create another account he uses his Facebook profile to register at the tu international community by clicking on the fb-connect button 4.2 on the website of the community. With only one click he setup an own account and to finish the registration he just needs to add the information he likes to his profile. Stefano adds his home town, age, interests and field of research to his profile and finishes the registration process.

After the registration is completed, Stefano looks up a survey about where exchange students can find rooms or accommodations for their stay. He looks up the three platforms with the most votes and easily finds many interesting shared apartments and other possibilities for his stay in Vienna. In the next step Stefano tries to find out how to get from his possible apartments to the technical university of Vienna by public transport and which ticket he should buy. He visits the question & answer site of the community and searches the questions for public transport. The search result offers him many different questions about the public transport in Vienna which help Stefano to understand the public transport system of Vienna and to find out that there is such a thing like a semester ticket for students which allows him to go anywhere and anytime in Vienna by public transport during the whole semester. Because Stefano had the same question and the answer was really helpful for him he gave the question and the helping answer a +1 rating, which indicates how many users found that the question or the answer were useful.

Through the ›interesting user‹ feature of the community Stefano finds out that there are several other students at his university who have already been on exchange in Vienna. He contacts some of them via a private message to meet them face-to-face to get the possibility to get to know the experiences of their time in Vienna. With help of the same feature he finds a fellow student in Vienna who is listing badminton as well as his interests, Stefano asks him via private message if he is interested in playing together sometime.

When the summer holidays are over the time has come and Stefano is moving to Vienna. Thanks to the tu international community he already has got a flat for his stay, the semester ticket for the public transport and some contacts with students at the technical university of Vienna. For the first days in Vienna there are some interesting events listed in the community's event calendar such as the ESN Buddynetwork semester opening party or the TU Vienna welcome day for new students where Stefano is planning to go to meet some people in his new city. But before the semester starts he still needs to find the right lectures for his exchange semester, so he looks in the community if there are some suggestions for English lectures fitting for software engineering students or students who are on exchange. Using the search on the website of the community he finds the proper wiki-section where lectures in English language are listed and linked to the registration system (TISS) of the TU Vienna.

During his time in Vienna Stefano used the community quite frequently for searching, asking or answering questions, voting on surveys or finding interesting upcoming events. When the time of Stefano was over and he moved back to Milan, he decided that the community helped him that much that he wants to share his experiences with it so that other incoming students maybe can profit out of it. So he wrote a report about his stay in Vienna, how he managed administrative tasks, things he really enjoyed doing in Vienna, things he wouldn't do again that way and all the other thoughts he had about his last 6 months and posted it into the experiences section of the incoming-forum of the

community. In the next couple of weeks Stefano got replies to his forum post and some questions of other Italian students who are planning to go on exchange to Vienna which he was happy to answer, but after some months he deactivated his email notifications for the community and stopped visiting it.

3.1.4 Goal Definitions

Out of the project description the project-team for the tu international-community defined the following targets which shall be achieved by and within the community:

- people of the target audiences must be attracted by the community and their benefits
- the main use-cases (finding answers, sharing experiences, discussing problems, searching) must be easy to use
- offering a powerful knowledge source

3.1.5 Main Functionalities

The tu international community shall take care of the needs of the target user groups by offering the right functionalities and structuring the content and the knowledge shared by its users in an organized way so that the right information can easily be found by users. Taking the goals of the technical university of Vienna and the needs of the hypothetical user-groups of the scenarios into account the core functions of the tu international community should contain the following:

- **User Management**

Like almost every website where users generate and modify content a virtual community needs some kind of user management. This includes tasks like login management, permission management as well as personal profiles and private messaging. For authentication the TU-account or social network profiles might be good possibilities, in order that users don't have to register for another platform and maybe scared off by that. Nevertheless the registration using a valid e-mail address shall be possible. Further users shall be able to easily get in touch with other users for example by linking to their social network profile.

- **Wiki**

For the core competencies like lectures at the technical university of Vienna or recognitions of different courses visited abroad a Wiki shall be established where this information is structured and easy to navigate through. The structure shall be preset by the administrators of the community, but users shall be encouraged to add and update information to the Wiki. As example for each field of study a list of lectures could be created and users who have visited equivalent courses on exchange can add those courses to collect the knowledge and make it visible for

upcoming exchange students. If another student finds out that those courses are no longer equivalent some years later and will not be recognized by the university he can add this information easily to the Wiki so that all the users are up-to-date.

- **Surveys**

For some kind of questions or topics, where the users opinion is from relevance like ›best restaurant nearby TU‹ or ›best platform for finding a flat‹, surveys are a good feature to create top 10 lists which collect the knowledge and opinions of the users over time and help new visitors to find relevant information fast. To keep the oversight about the surveys only administrators and moderators shall be able to create new surveys according to the community's needs.

- **Q&A-Site**

Question and answer-sites are a good method for knowledge sharing in communities. Students can ask questions and give answers to questions of others. Questions and also answers can be rated by users regarding their relevance or usefulness. Many platforms like <http://stackoverflow.com/> also make use of digital badges, which can be earned by users for different achievements in the community, to motivate users to contribute e.g. asking a question and accepting an answer. There has to be the possibility to search for questions or keywords to look if the same question has already been answered to prevent redundant questions. To support the users in finding the right questions and answers, related questions based on tags shall be shown at the end of each question. Furthermore the questions which are rated best, meaning they have been very useful can be shown in some kind of ›top 10 useful question list‹ .

- **Forum**

Additionally to the q&a-site a forum shall give students the possibility to discuss about different kind of things, but also to share their experiences with each other. In contrast to a q&a-site a forum must not necessarily be focused on finding right answers. It can be used to share opinions and to discuss about different topics which might be ongoing for a longer timeframe. For example a forum thread could be used ongoing for a whole semester by outgoing exchange students who are sharing their experiences about their adventure abroad with the community, giving other users the possibility to easily respond or discuss about.

- **Event calendar**

The tu international community should contain some kind of event calendar where users can add events or link to events on social media platforms like Facebook which might be interesting for the community such as get-together for Erasmus students in Vienna, events of the ESN Buddynetwork or information events for students who are interested in going on exchange.

3.1.6 Mock-Ups & TU International Design

To get a first idea how the evaluation community tu international is going to look like, regarding the user-interface and the positioning of certain content some mock-ups for the most important features have been created, which can be seen in the following. Figure 3.1

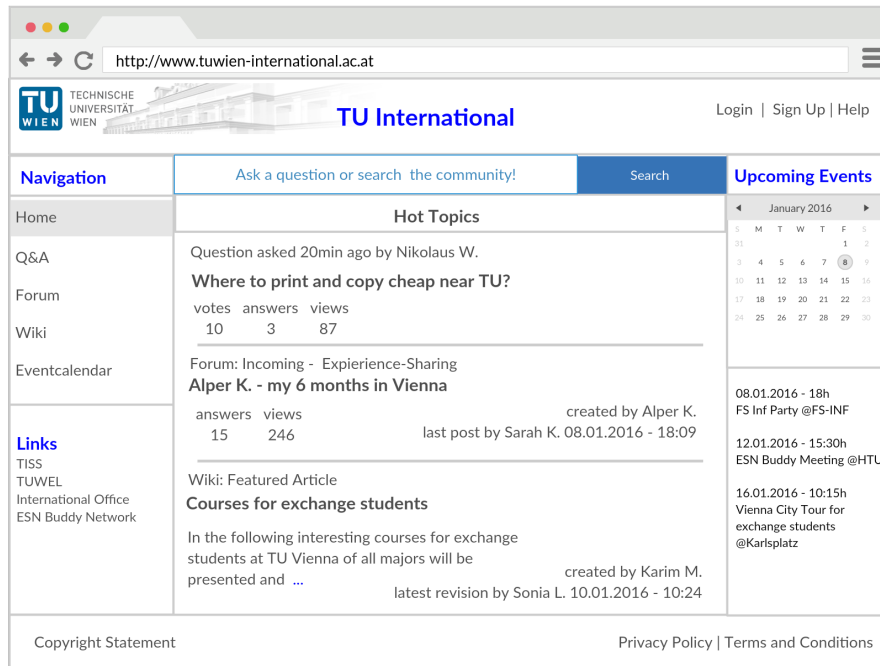


Figure 3.1: Cover page

is showing a design for the cover page, where in the main section the most recent topics and contributions are listed. On the left sidebar the navigation menu and a collection of useful links can be found. On the right side upcoming events of the community's event-calender are listed.

At the login screen 3.2 users should be able to use their social network accounts to login to the community or to create a new account on their own. When a question is viewed in the q&a-section 3.3 there should be shown the rating of the question based on the users, the tags which got attached to the question and the answers. The answers shall also include the rating of the users and show an indicator if the answer was accepted by the author of the question. If possible also related questions based on the tags shall be shown in the right sidebar. The wiki should view the content of the wiki pages 3.4 and be editable for all the authenticated users of the community.

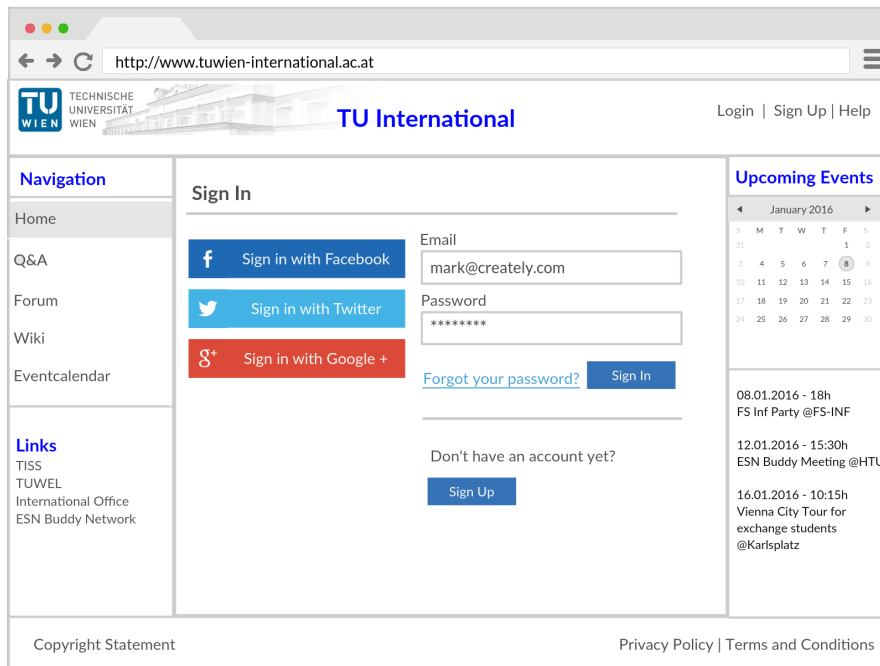


Figure 3.2: Login screen

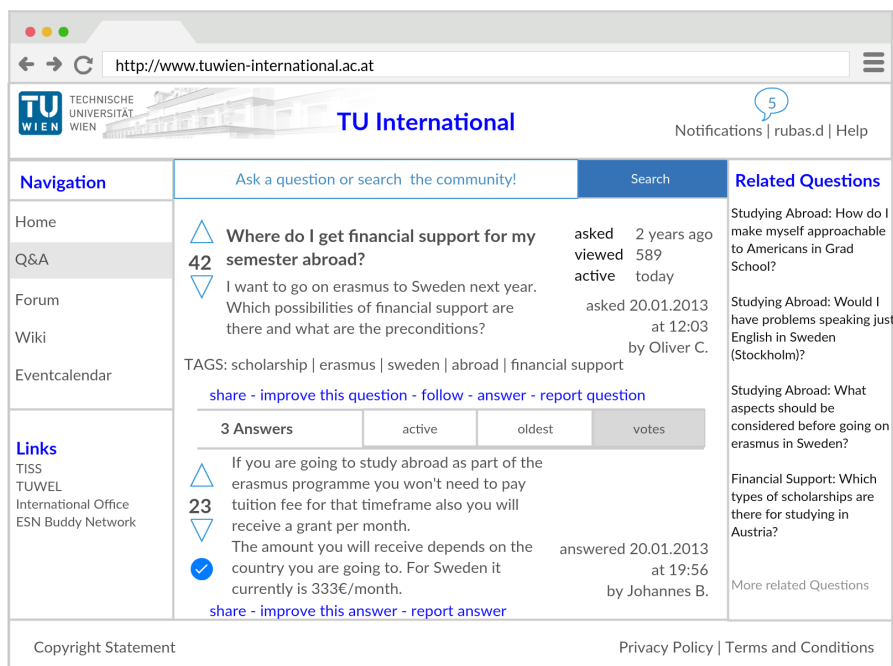


Figure 3.3: Q&A-page

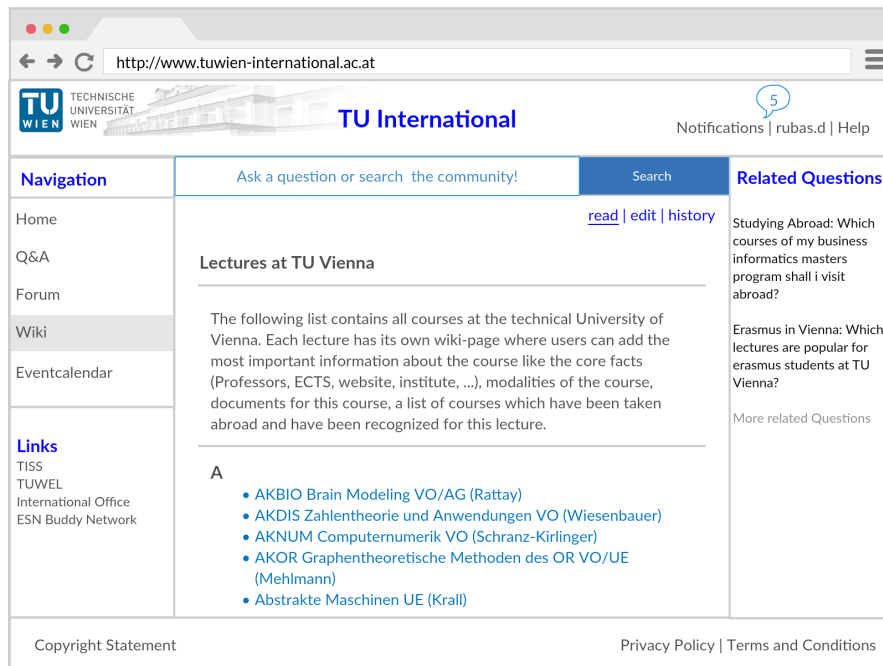


Figure 3.4: Wiki-page

3.2 Community KPI-Dashboard

To support administrators of Drupal communities by showing different key-performance-indicators which have been presented in section 2.3 and other measures about the community. The following paragraphs describe the target communities for which the ›Community KPI-Dashboard‹ shall be developed and the functional requirements for the dashboard based on the case study and the literature review. Details about the design and implementation of the ›Community KPI-Dashboard‹ are presented in chapter 4 while the evaluation of the dashboard takes place in chapter 5.

3.2.1 Target Community Definition

The ›Community KPI-Dashboard‹ will be focused and developed for communities for knowledge sharing purposes like q&a-sites, forums, etc. where the features listed below such as audience tracking or activity tracking might be from interest for the administrator of the community. It shall help keeping the overview of how changes in the community affect the behavior of its users for the administrator team of a virtual community.

3.2.2 Functional Requirements

In this section functional requirements for the ›Community KPI-Dashboard‹ are derived from the case description and presented. Additionally further possible interesting features based on the literature reviewed in the section existing approaches 2.3 are included in the following list.

- **Activity Tracking**

To be able to monitor if certain changes in the community (regarding the user interface, functionality etc.) affect the activity of the members in the community the ›Community KPI-Dashboard‹ should be able to provide information about the amount of new activities in the community such as new forum topics, replies, questions, answers, comments etc. It shall be possible to generate this information for selected timeframes for example last week, last month, last year etc. Furthermore the ›Community KPI-Dashboard‹ should be able to provide reports about the creation time of activities in the community as well as information about the durations (shortest and average) for answers on questions or forum-posts taking different timeframes into account such as last month, last year, forever, etc.

- **Audience Tracking**

To be able to monitor the development of the community's audience its members and for example to compare it with the specified target audience the ›Community KPI-Dashboard‹ should be able to provide information about the amount of (new) members including their registration date and individual parameters of their profiles for example age, gender, origin, job to assign them to different categories.

- **Content Tracking**

To be able to monitor the relation of questions and answers in the community the ›Community KPI-Dashboard‹ should be able to provide information about the amount of un-/answered questions or topics in the community in total and relative numbers. Furthermore the occurrences of certain tags taking the unanswered questions might be from interest to identify areas or topics where users are missing knowledge or motivation to share their knowledge with the community. The same goes for answered questions to identify the areas or topics where many questions occur and users are motivated to help each other.

- **Purpose Tracking**

To be able to monitor if the topics and purposes in the community are changing over time the ›Community KPI-Dashboard‹ should be able to provide information about the amount certain tags are used in the community and to generate reports about the top 10 or top 30 tags used in a certain timeframe. Using these reports administrators can easily get an overview of the current ongoing topics in the community.

- **Role Tracking**

To be able to monitor which roles the members of the community are taking

within the ›Community KPI-Dashboard‹ it should be possible to define different roles which are assigned to all the members according to their contributions and activities in the community. For example a role ›Read Only Users‹ can be defined for users who are registered, have been active in the last semester, but have never contributed actively to the community by asking questions, answering questions or commenting on content. If this role is then applied on the users the administrator of the community can easily get an overview in actual and relative numbers of how many ›Read Only Users‹ in the community exist and who they are.

- **Social Network Analysis**

To be able to monitor which users are interacting with each other the most and if there is some kind of group forming in the community the ›Community KPI-Dashboard‹ should be able to provide reports about frequency of the interaction of users among each other. There shall also be the possibility to compare the profiles of users who interact with each other to check them for similarities.

- **Quality Tracking**

To be able to monitor the quality of the content in the community created by the members the ›Community KPI-Dashboard‹ should be able to provide reports about the information generated by user content rating tools in the community like what are the most interesting/useful questions/topics/posts in the community or which users are generating high valuable content for the community and which users are spamming the community with useless content. There shall be the possibility to display the results of the report in the community so that everyone can see for example the top 10 interesting questions, because they might be interesting for that user as well or that everyone can see the top 10 users regarding the quality of their contributions, because this might motivate others to contribute also in more qualitative way.

- **View Tracking**

To be able to monitor how often content was viewed and how many different users have seen each content the ›Community KPI-Dashboard‹ should be able to provide reports about the total number and the number of unique views of content in the community taking different timeframes into account such as last month, last year, for ever, etc. The total number of views and unique views might also be interesting for the user who asked a question, so it might make sense to show those parameters to the creator of questions.

3.3 Big Picture

During the requirements analysis and idea generation a big picture of the project as mind-map was created. A part of this mindmap can be seen in figure 3.5. It includes ideas about:

- success factors of virtual communities

- the functionality of the tu international community
- potential Drupal modules to implement those functionalities
- potential user-groups of the tu international community
- data which might be interesting of users of the tu international community
- potential kpis which could be measured by the ›Community KPI-Dashboard‹
- potential Drupal modules to lighten the measuring of some kpis

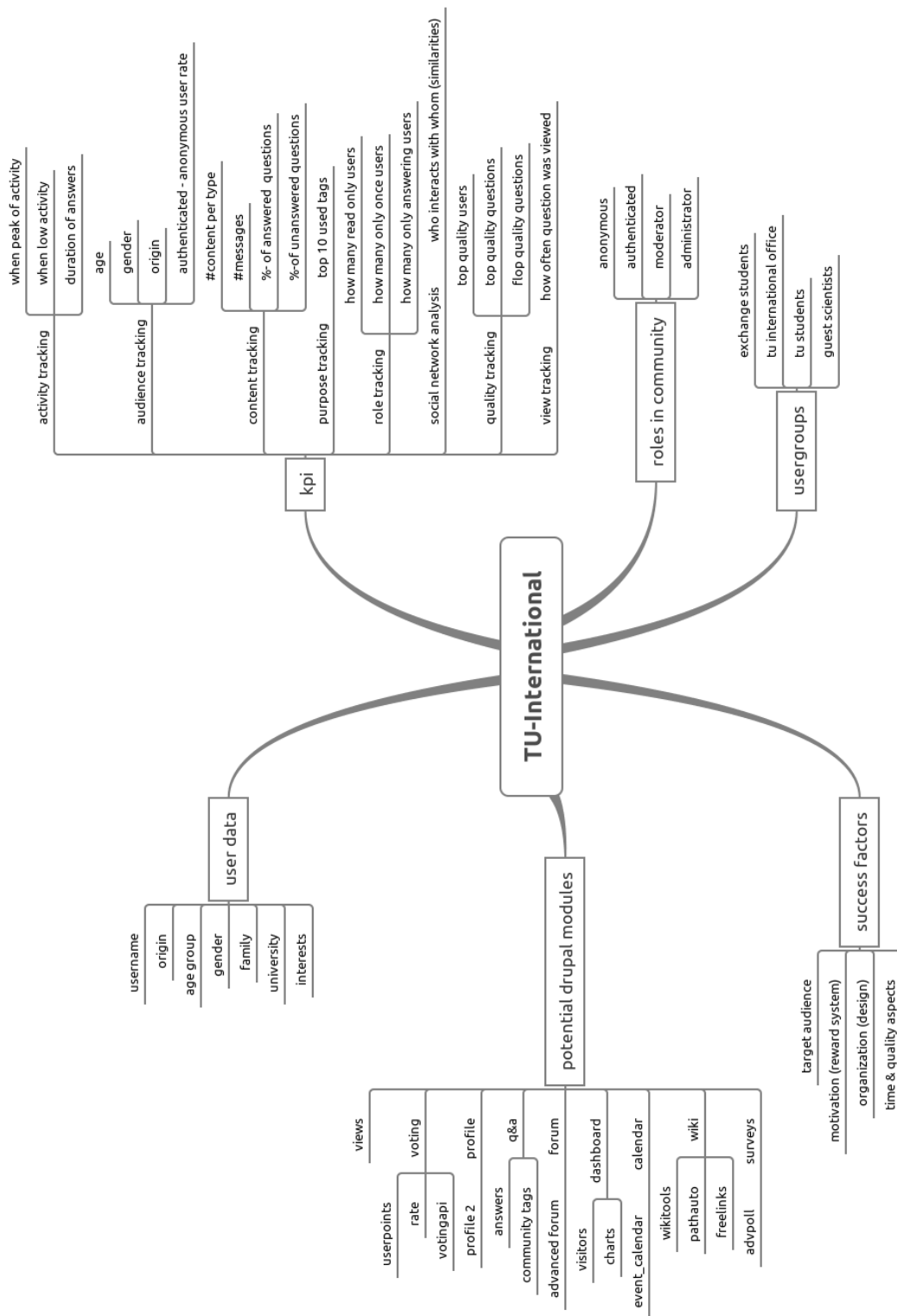


Figure 3.5: Big picture

Design and Implementation

This section presents the architecture of Drupal and the positioning of the ›Community KPI-Dashboard‹ in this architecture. Furthermore the design as well as the implementation of the ›Community KPI-Dashboard‹ module including the dependencies to other Drupal modules and the evaluation community tu international will be described.

4.1 Architecture

For the development of the ›Community KPI-Dashboard‹ the web content management system Drupal was chosen as foundation. Like other content management systems Drupal provides an expandable architecture, where modules can be connected to the Drupal core by using interfaces and APIs. The goal of such modules is to extend Drupal’s capabilities. Most of the time a module just consists of a collection of hook implementations, which are called automatically when Drupal is processing through the request lifecycle. [4] In figure 4.1 an overview of the Drupal architecture is shown. At the end of this chapter the collection of hooks implemented by the ›Community KPI-Dashboard‹ module is listed and some code snippets show how they are used.

The ›Community KPI-Dashboard‹ was implemented as module in the Drupal architecture. Its functions, creating reports and visualizing them for a better understanding of the community, rely on some conditions on the underlying Drupal system. To install and enable the ›Community KPI-Dashboard‹ module, Drupal core needs to be installed and the user must have the necessary permissions for installing and enabling modules. After the ›Community KPI-Dashboard‹ module was installed successfully the module settings can be configured and the selected reports can be shown. Some reports require other modules to be installed. A detailed list about the used modules for the evaluation community and the required modules for the full functionality of the ›Community KPI-Dashboard‹ is located in the section preface 4.2.1. On the basis of Drupal core and

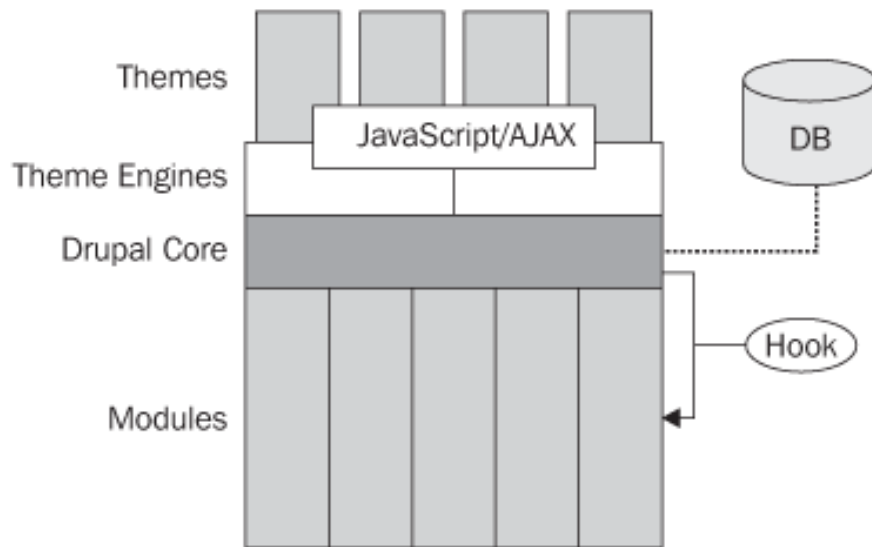


Figure 4.1: Drupal architecture [4]

the supported contributed modules virtual communities, which can be evaluated by the ›Community KPI-Dashboard‹, can easily be built.

The following section describes the setup of the evaluation community and the implementation of its functions.

4.2 TU-International Community

The usual approach for developing and setting up a virtual community with Drupal is the following:

1. setup underlying Drupal system
2. providing user management including different roles and their permissions in the community as well as registration for new users
3. adding required features by installing and configuring suitable modules provided by the Drupal community

4.2.1 Preface

The system is built with Drupal 7.41 using MySQL 5.5.46 and PHP 5.5.9. Besides the core modules the following contributed modules have been used to setup the evaluation community (underlined modules are required by the ›Community KPI-Dashboard‹ for certain reports, for more details see section 4.3.4):

- [Advanced Forum](#)¹: Enables the look and feel of other popular forum software.
- [Advanced Poll](#)²: Allows creation of standard or approval weighted polls with the option to create write-ins, limit by electoral list or present any poll as a block. It takes advantage of the Voting API to track votes with the option to use cookies instead of IP/Authenticated user ids.
- [Answers](#)³: Provides a question & answer service. Users can post questions and other users can answer them.
- [Answers Userpoints](#)⁴: Adds a user reputation system to the Answers service.
- [Best Answer](#)⁵: Enables question authors to select a "Best Answer" to their questions.
- [Calendar](#)⁶: Views plugin to display views containing dates as Calendars.
- [Charts](#)⁷: A charting API for Drupal that provides chart elements and integration with Views.
- [Community Tags](#)⁸: Allows users to 'tag' other users' content. Weighted tag lists or 'tag clouds' are generated for each piece of content to show the popularity of tags.
- [Date](#)⁹: Makes date/time fields available.
- [Event Calendar](#)¹⁰: A module to create and manage events.
- [Facebook OAuth](#)¹¹: Allow users to connect with Facebook and query information.
- [Facebook OAuth Profile2 Integration](#)¹²: Allows to map Facebook profile information to Profile2 fields.
- [Freelinking](#)¹³: A filter that provides flexible, extensible, wiki-style linking of content.
- [Pathauto](#)¹⁴: Provides a mechanism for modules to automatically generate aliases for the content they manage.

¹https://www.drupal.org/project/advanced_forum

²<https://www.drupal.org/project/advpoll>

³<https://www.drupal.org/project/answers>

⁴<https://www.drupal.org/project/aup>

⁵https://www.drupal.org/project/best_answer

⁶<https://www.drupal.org/project/calendar>

⁷<https://www.drupal.org/project/charts>

⁸https://www.drupal.org/project/community_tags

⁹<https://www.drupal.org/project/date>

¹⁰https://www.drupal.org/project/event_calendar

¹¹<https://www.drupal.org/project/fboauth>

¹²https://www.drupal.org/project/fboauth_profile2

¹³<https://www.drupal.org/project/freelinking>

¹⁴<https://www.drupal.org/project/pathauto>

- [Private messages](#)¹⁵: Allow private messages between users.
- [Profile2](#)¹⁶: Supports configurable user profiles.
- [Rate](#)¹⁷: Flexible voting options for nodes and comments.
- [Rules](#)¹⁸: React on events and conditionally evaluate actions.
- [TVI: Taxonomy View Integrator](#)¹⁹: Enables automatic application of views to taxonomy terms and vocabulary.
- [Views](#)²⁰: Create customized lists and queries from your database.
- [Visitors](#)²¹: This module is used for displaying info of visitors.
- [Voting API](#)²²: Provides a shared voting API for other modules.
- [Voting Rules](#)²³: Rules Integration for VotingApi.
- [Wikitoools](#)²⁴: Provides helper functionality to have wiki-like behavior.

4.2.2 Roles and Permissions

Every user in the system can hold several roles. Per default Drupal knows the roles administrator, authenticated user and anonymous user. A visitor to the site changes his or her status from anonymous user to an authenticated user one by logging into the system. Per default no content is visible to an anonymous user of the system. In addition to the Drupal default roles the role ›moderator‹ was added to the community, to allow certain users to modify content in the community without getting administrator permissions for the whole community.

The following list gives a description of the most important permissions in the system. Table 4.1 gives an overview of these permissions granted to each role.

- **View Content**

view content, such as questions, tags, answers, comments, wiki-pages, events, surveys and forum posts of the community

¹⁵<https://www.drupal.org/project/privatemsg>

¹⁶<https://www.drupal.org/project/profile2>

¹⁷<https://www.drupal.org/project/rate>

¹⁸<https://www.drupal.org/project/rules>

¹⁹<https://www.drupal.org/project/tvi>

²⁰<https://www.drupal.org/project/views>

²¹<https://www.drupal.org/project/visitors>

²²<https://www.drupal.org/project/votingapi>

²³https://www.drupal.org/project/voting_rules

²⁴<https://www.drupal.org/project/wikitoools>

- **Search Content**
search through the content of the community
- **Create Content**
create content, such as questions, tags, answers, comments, wiki-pages, events, surveys and forum posts in the community
- **Edit/Delete own Content**
edit or delete content created by the user itself
- **Edit/Delete Content**
edit or delete content created by any user of the community
- **Use ›Community KPI-Dashboard‹**
generating reports with the ›Community KPI-Dashboard‹ and edit its settings and preferences

	Anonymous User	Authenticated User	Moderator	Administrator
View Content	X	X	X	X
Search Content	X	X	X	X
Create Content		X	X	X
Edit/Delete own Content		X	X	X
Edit/Delete Content			X	X
Use ›Community KPI-Dashboard‹				X

Table 4.1: Roles and permissions

4.2.3 Features

In the following the functionality of the tu-international community which was created to evaluate the ›Community KPI-Dashboard‹ and its features will be presented.

- **Users**

To ensure that the features of the ›Community KPI-Dashboard‹ can be evaluated there must be an underlying user management allowing users to create accounts and browse content at the tu international community. In the next paragraphs the implementation of the user management, besides the roles and permissions which have already been explained in section 4.2.2, of the evaluation community will be presented.

At the prototype of the tu international unregistered users have the possibility to view the whole content of the community, but aren't able to contribute to it in anyway. To register the user needs an existing e-mail address or an Facebook account with which he or she can register with only one click on the fb-connect button 4.2 at the website of the community. This feature is enabled through the Facebook OAuth and Facebook OAuth Profile2 Integration module, which automatically imports the e-mail address and other profile properties and matches them to profile2 fields of the Drupal system.



Figure 4.2: Facebook connect

LABEL	WEIGHT	PARENT	MACHINE NAME	FIELD TYPE	WIDGET
Full Name	<input type="text" value="1"/>	- None - ▼	field_full_name	Text	Text field
Origin	<input type="text" value="2"/>	- None - ▼	field_origin	Text	Text field
Interests	<input type="text" value="3"/>	- None - ▼	field_interests	Term reference	Autocomplete term widget (tagging)
Born	<input type="text" value="4"/>	- None - ▼	field_age	List (integer)	Select list
Gender	<input type="text" value="5"/>	- None - ▼	field_gender	List (text)	Check boxes/radio buttons
Field of Study	<input type="text" value="6"/>	- None - ▼	field_field_of_study	List (text)	Check boxes/radio buttons
Bio	<input type="text" value="7"/>	- None - ▼	field_bio	Long text	Text area (multiple rows)

Figure 4.3: User profile fields


Each user of the tu international community has an own profile where he or she is able to add information about him-or herself if he or she likes. Those profiles were

created with the profile2 module and fields for the data of the users were created as you can see in figure 4.3.

A completely filled out user profile can be seen in figure 4.4

rubasd

[View](#)



Points

Total (all categories): 57

Profile

Full Name:
David Rubas

Origin:
Vienna

Interests:
Sports reading cooking politics informatics computer science technology

Born:
1991

Gender:
Male

Field of Study:
Computer Science

Bio:
BSc: Business Informatics University: TU Vienna Sports: Soccer, Hockey, Tennis, Skiing, Hiking TV Series: how to get away with murder, psych

History

Member for
3 months 6 days

[Send this user a private message](#)

Figure 4.4: Example user profile

With help of the information which is put into the users profile it is easy for users

Users with same interests



Username	Picture	Interests
steved		Sports, law, cooking, politics
dummy1		cooking, dumbidumdum
daniel		cooking, Sports, programming, reading, politics
rubasd		Sports, reading, cooking, politics, informatics, computer science, technology
dummy2		cooking, reading, Sports, sailing
maxr		music, law, politics, cooking, sailing

Figure 4.5: Users with same interests

to find people with the same interests, origin or field of studies. If a user for example clicks in his profile on the interest ›cooking‹ a list of other users who also listed cooking as one of their interests is shown like in figure 4.5. This feature was created using the module views, which allows filtering content in the community and provide a structured view to the users.

As on almost every website where users communicate with each other, the module private messages allows users of the community to directly contact other users in private. This feature was implemented by installing the module private messages. Messages can be sent to multiple recipients and optionally may contain a subject.

Madrid

Messages

Read message

Between you and daniel



daniel Jan 20 Delete

Hi David, I saw that you have been on erasmus at Madrid. I am thinking about going on erasmus to Spain as well. May I invite you for a beer after uni some time, so we can talk about the experiences you made in Madrid?

cu, Daniel



You Jan 20 Delete

Hi, Daniel!
Of course I can tell you about my erasmus semester in Madrid.
How about next week after econometrics class?

Reply

Message

Figure 4.6: Prototype of private messaging

- **Wiki**

To enable that users of the tu international can contribute and maintain structured information for example about lectures at the technical university of Vienna a Wiki section was implemented at the evaluation community. Further it allows a better evaluation of the activity and content tracking features of the ›Community KPI-Dashboard‹ if the community contains more different content and content types. The following paragraphs will shortly explain how the Wiki section was created.

Lectures at TU Vienna

The following list contains all courses at the technical university of Vienna. Each lecture has its own wiki-page where users can add the most important information about the course like the core facts (Professors, ECTS, website, institute, ...), modalities of the course, documents for this course, a list of courses which have been taken abroad and have been recognized for this lecture and further interesting details.

A

- Abstrakte Maschinen UE (Krall)
- Advanced Aspects of IT-Law VU (Haslinger, Grechenig)
- Advanced Digital Design VU (Steininger)
- Advanced Distributed Systems VU (Göschka)
- Advanced Internet Security VU (Dabrowski)
- Advanced Software Engineering PR (Grechenig, Biffel)
- Algebra und Diskrete Mathematik VO (Dorfer)
- Algebra und Diskrete Mathematik VO (Gittenberger)

Figure 4.7: Example wiki page of the tu international



Figure 4.8: Url aliases using pathauto module

The wiki of the tu international community was implemented using the following modules:

the wiki can be configured. For example the path of the starting page of the wiki, the content types of wiki nodes or the behavior of the wiki if the user types in a node which does not exist. For the prototype of the tu international the user will be able to create a new node in such a case as you can see in figure 4.9.

As a next step the functionality of linking to usual wiki pages was implemented using the module freelinking, which can be configured that like in other wikis links can be created using a special syntax. For example ›[[lectures|Lectures at TU]]‹ will turn into:

```
<a href="/node/1" title="Lectures at TU"
    class="freelink freelink-lectures freelink-internal">
    Lectures at TU</a>
```

[11]

To accomplish that the URL of wiki pages automatically matches the title of the page instead of for example ›/node/1‹ the module pathauto lets the administrator configure that for certain content types, in this example wiki page, automatically URL aliases are generated. Besides that with the help of pathauto another advantage is achieved, namely users can't create more than one wiki page with the same title. This helps avoiding duplicate wiki pages. [26]

• Q&A-Site

To allow registered users of the tu international to ask and answer questions a q&a-site was created. This also helps to ensure that the ›Community KPI-Dashboards‹ content and quality tracking can be evaluated sufficient. In the following the realization of this q&a-site will be explained.

The Q&A-Site of the evaluation community was created with the following modules:

- Answers
- Answer Userpoints
- Best Answer
- Voting API

The module answers creates the content types ›Question‹ and ›Answer‹ and offers different views which are based on the module view and can be customized or enhanced by the administrator of the Drupal site. The view ›Search & add new Question‹ which is shown in figure 4.10 allows the user to search existing questions before asking his or her own to reduce duplicate questions. The other views like ›Resolved Questions‹ or ›Unanswered Questions‹ list questions where no answer has been accepted by the question author yet or until now no answers exist at all. Figure 4.11 shows the page of a question which has one answer. Through the best answer module the question author has the possibility to accept one answer as best

Check whether your question has already been asked

[All Questions](#) [Search & add new Question](#) [Resolved Questions](#)
[Unresolved Questions](#) [Unanswered Questions](#)

Question

[Search Again](#)

[Continue With Your Question](#)

Question	Post date ▼	Answers
Camur Jus Saluto	2 hours 3 sec	none
Erat Iriure Letalis Lobortis	2 hours 3 sec	3
Si	2 hours 3 sec	none
Acsi	2 hours 3 sec	3
Letalis Vereor	2 hours 3 sec	3
Bene Consequat Dolor Dolus Ideo Tamen	2 hours 3 sec	3
Tego	2 hours 3 sec	1
Pub Quiz near TU	1 day 5 hours	2
Old Exams	2 days 11 hours	1
Library Opening Hours	2 days 11 hours	2

1 2 next › last »

Figure 4.10: Views of q&a-page

answer which resolves the question and is indicated with the yellow ›Best‹ sticker. The voting API allows users to up or down vote questions and answers depending on their opinion if the question or answer was good or useful. The module answer userpoints adds a reputation system to the q&a-site where the administrator of the community can decide how many points are rewarded to users for certain actions like asking or answering a question.

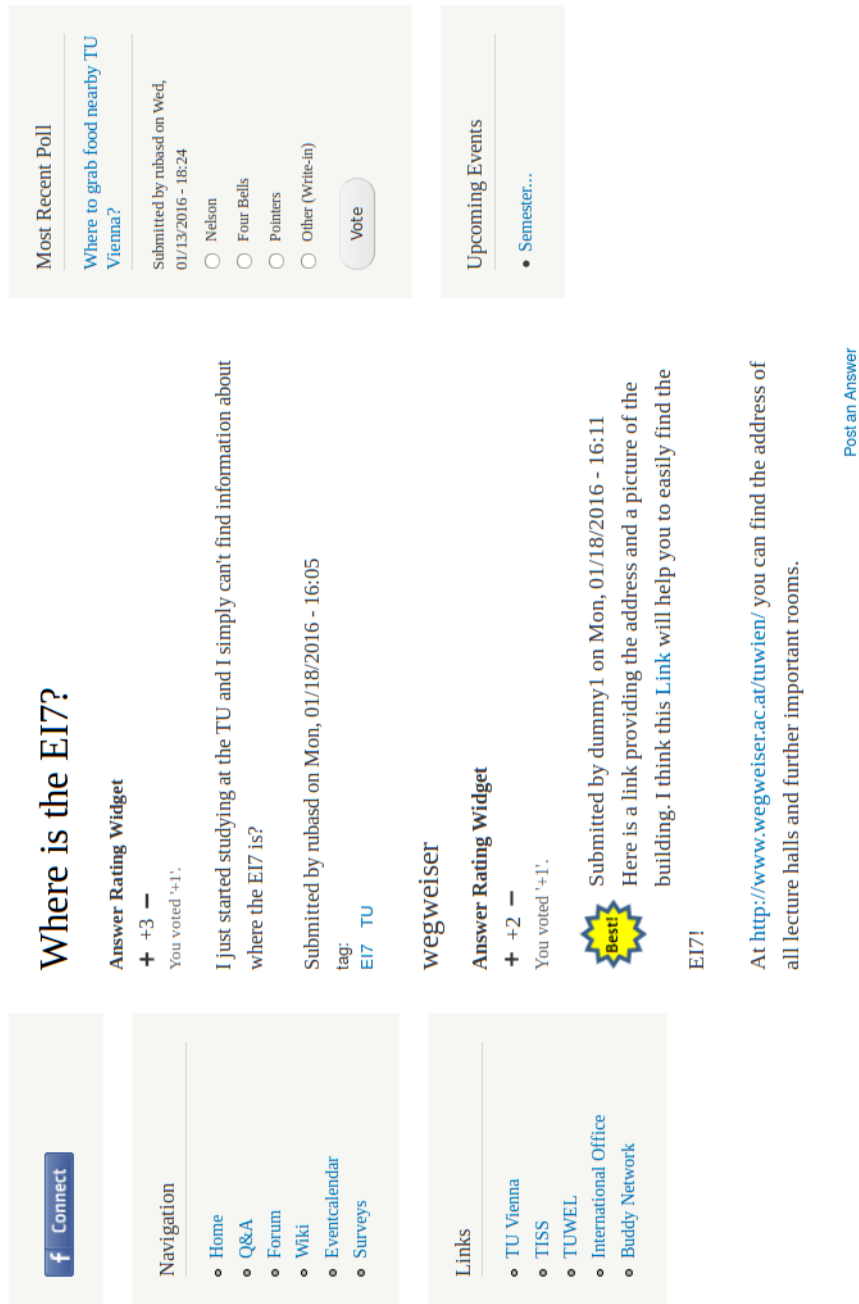


Figure 4.11: Prototype of q&a-page

- **Forum**

To enable that users of the tu international can lead ongoing discussions or share their experiences from abroad with the community a forum section was added to the evaluation community. Additionally it improves the evaluation of some reports of the ›Community KPI-Dashboard‹ if another content type and further content is added to the tu international. The following paragraphs will shortly explain how the forum section was created.

Forums				
	Forum	Topics	Posts	Last post
	General discussion	1 1 new	1	Ea Jumentum Os... by dummy2 01/29/2016 - 10:10
	Outgoing	3 2 new	3	Blog of my 6... by rubasd 5 sec ago
	Incoming	2	3	My 6 months in... by rubasd 50 sec ago

New posts

No new posts

- Forum Tools -

What's Going On?
Currently active users: 1
rubasd
Statistics
Topics: 6, Posts: 7, Users: 6 Welcome to our latest members: steved, dummy1, daniel, rubasd, dummy2

Figure 4.12: Prototype of forum

The forum of the prototype was implemented using the advanced forum module, which builds on and enhances Drupal's core forum module. Administrators can setup the different forums in which users can start topics and reply to posts of other users as known from usual forum software. As we can see in figure 4.12 the currently active users and usage statistics as well as the unread forums and topics are shown by the advanced forum module.

- **Surveys**

To ensure that users of the tu international can vote on surveys which have been created by the community administrators or moderators a survey section was added to the evaluation community. The following section will shortly explain how surveys were implemented for the tu international.

Polls

Create new Survey

Where to grab food nearby TU Vienna?

Submitted by rubasd on Wed, 01/13/2016 - 18:24

- Nelson
- Four Bells
- Pointers
- Other (Write-in)

Vote

Figure 4.13: Prototype of surveys

With the help of the advanced poll module surveys are included in the community. Surveys can be created by moderators and administrators of the community and every authenticated user is able to vote on them as you can see in figure 4.13. The results of surveys are visible to everybody, even anonymous users and are viewed as a bar graph showing the percentage and total number of votes for every option as well as the total number of votes. Figure 4.14 shows the result of a survey of the tu international community. The advanced poll module also allows different setups for surveys. For example the creator of a poll can decide if there shall be certain begin or end dates, or if users shall have the possibility to add their own answering options.

Polls

Create new Survey

Where to grab food nearby TU Vienna?

Submitted by rubasd on Wed, 01/13/2016 - 18:24

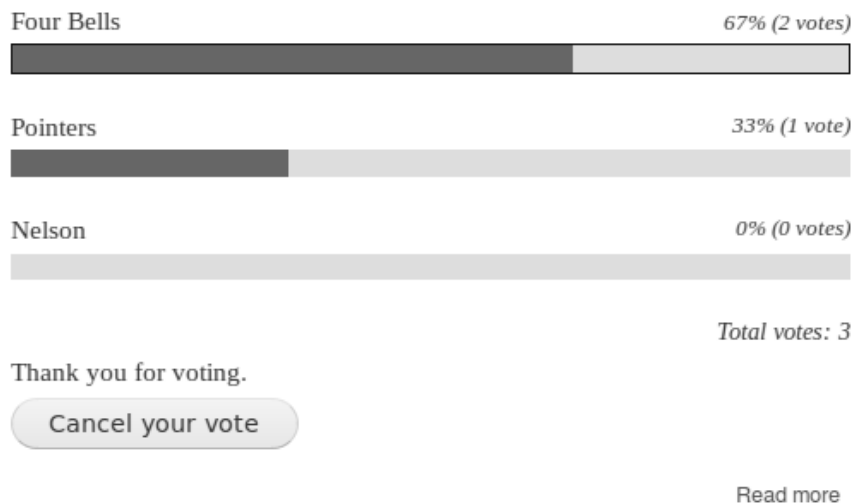


Figure 4.14: Prototype of surveys 2

- **Event calendar**

Users of the tu international should be able to create and view events. Therefore an event calendar section was added to the evaluation community. Further as already mentioned the ›Community KPI-Dashboard‹ reports can be evaluated better if additional content types and further content is added to the tu international. In the following the implementation of the event calendar will shortly be presented.

The event calendar of the community was implemented with the module event calendar. Users can create events, which are visible to the whole community by selecting an event title, a start and optional end date and adding a description of the event. There are different possibilities for displaying the events to the users like per year, per month, per week, per day or upcoming events. Figure 4.15 shows the view of events per month for January.

Event Calendar

Month Week Day Year

Add new Event

January 2016

« Prev Next »

Sun	Mon	Tue	Wed	Thu	Fri	Sat
27	28	29	30	31	1 ESN New Year EDIT	2
3	4	5	6	7	8	9
10	11	12	13 TU Ice Skating EDIT	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30 Semester... EDIT
31	1	2	3	4	5	6

Figure 4.15: Event calendar

4.3 ›Community KPI-Dashboard‹

For the development of the ›Community KPI-Dashboard‹ prototype the following steps have been taken:

1. designing mock-ups of the ›Community KPI-Dashboard‹ (see section 4.3.1)
2. searching proper modules for virtual communities (see section 4.2.1 for a list of suitable virtual community modules in Drupal)
3. setting up an evaluation community (see chapter 3 for requirements and section 4.2 for the description and design of the evaluation community)
4. develop a prototype for the ›Community KPI-Dashboard‹ module (described in the following)
5. evaluate the prototype of the ›Community KPI-Dashboard‹ module on the basis of the evaluation community (see chapter 5)

4.3.1 Designs & Mock-Ups

After defining the functional requirements of the ›Community KPI-Dashboard‹ in chapter 3, in the next step designs and mock-ups have been created to get an first idea of how the user-interface of the module might look like and how the content could be arranged and viewed to the user for a comfortable use.

The first mock-up which can be seen in figure 4.16 shows a design for displaying three reports about the number, age and origin of the visitors belonging to the audience tracking of the dashboard. Users can easily browse through the reports using the vertical tabs on the left side and set the timeframe on which the reports are based in the top bar. The second mock-up which can be seen in figure 4.17 displays a design for the settings of the role tracking. The users of the ›Community KPI-Dashboard‹ have the opportunity to define different roles, name the role and setup the parameters which are filtering the users. Users who fulfill all the defined conditions will be displayed in the resulting report. The horizontal tabs allow the users to instantly switch between the settings of the role tracking and the reports.

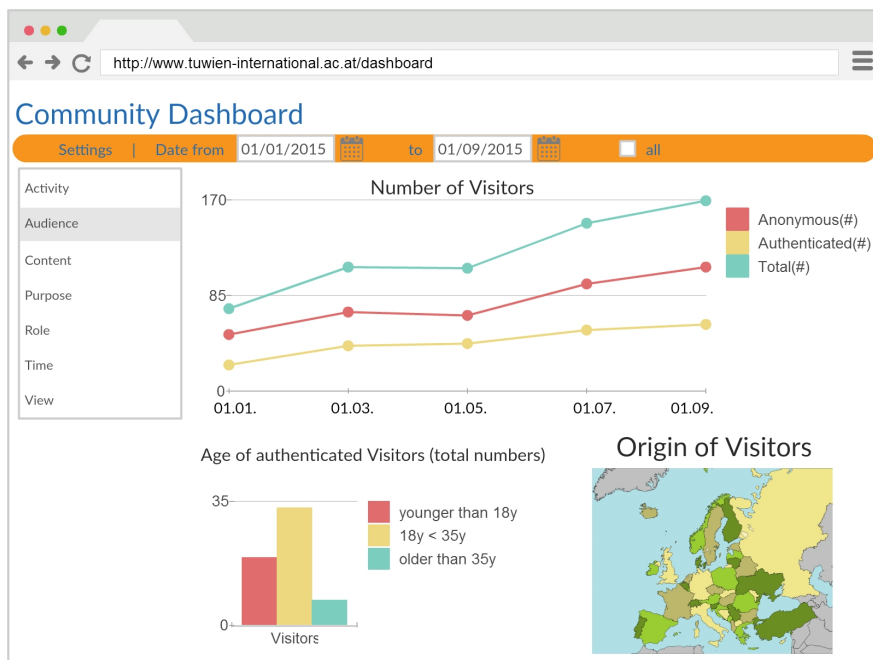


Figure 4.16: Community Dashboard - Audience Tracking

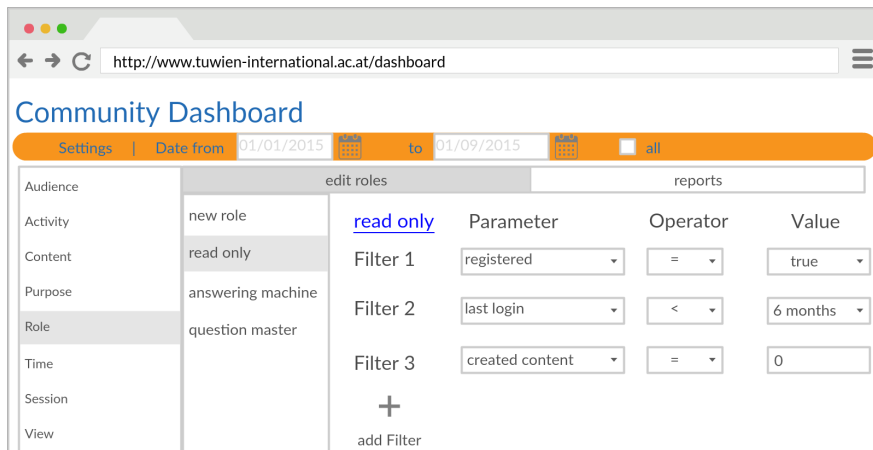


Figure 4.17: Community Dashboard - Role Tracking

4.3.2 Prototype

The ›Community KPI-Dashboard‹ is a Drupal module which focus lies on the analysis and visualization of data of an online community. Those analysis and visualizations are generated by querying the Drupal database with SQL statements. The ›Community KPI-Dashboard‹ allows certain configurations on its settings page, but to make use of all the functionality particular certain Drupal modules have to be installed as well on the system to generate the tables which are necessary to query the database. If certain modules are missing the concerned reports will be disabled in the ›Community KPI-Dashboard‹ and an error message like in figure 4.18 is shown to the user. A list of

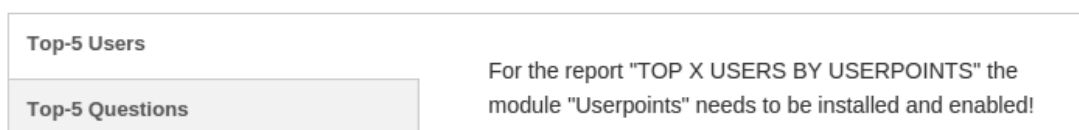


Figure 4.18: Disabled report

all reports of the ›Community KPI-Dashboard‹ and their dependencies to other Drupal modules is presented in section 4.3.4.

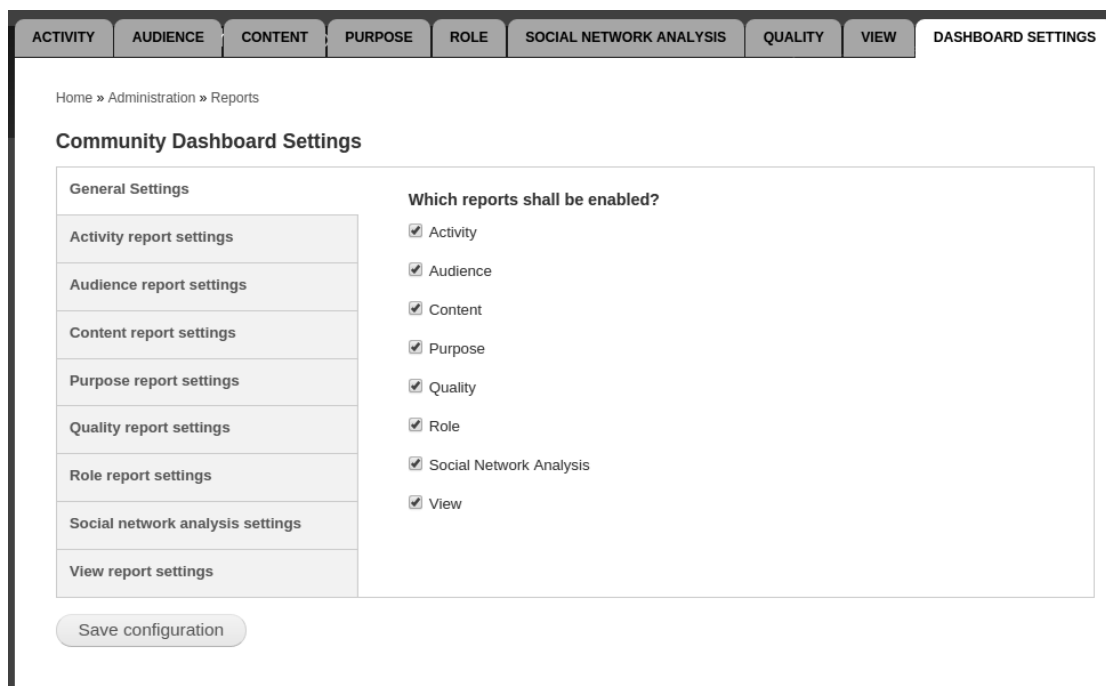


Figure 4.19: Community Dashboard settings

For example some reports which are created by the ›Community KPI-Dashboard‹

generate graphical charts for illustration of the data. To view these visualizations the Drupal module charts needs to be installed. Since many virtual communities provide some kind of question & answer site several reports, which will be presented later on, for this type of content are available with the ›Community KPI-Dashboard‹ if the answers module is installed. In figure 4.19 we see the settings page of the ›Community KPI-Dashboard‹ where the different reports can be enabled and some configurations for each report type can be done.

4.3.3 Implementation & Code Snippets

The ›Community KPI-Dashboard‹ was developed according to the current Drupal coding standards. [9] For the ›Community KPI-Dashboard‹ module the following hooks have been implemented:

- hook_help() - provide online user help
- hook_menu() - allows to define menu items and page callbacks, which easily
- hook_menu_alter() - alter the data being saved to the {menu_router} table after hook_menu is invoked
- hook_form() - display a node editing form

Reports

In the following code pieces of one hook implementation will be shown to get an understanding of the functionality of reports in the ›Community KPI-Dashboard‹ . The following code is the implementation of the hook_form() of Drupal. In the beginning the date-filter and its value is defined. In the next step a vertical tab for the report is created and added to the form. Afterwards the sql string for querying the database is prepared using the begin and end date of the date-filter. Thereafter the result set is fetched from the database and prepared for the output in the table and chart.

```
/**
 * Implements hook_form().
 *
 * Form that displays reports about the ACTIVITY in the community
 */
function activity_form($form, &$form_state)
{
  ...
  //get current date for date filter
  $def = getdate();

  //add date picker for begin date to form
  $form['date_begin'] = array(
    '#type' => 'date',
    '#title' => 'from',
```



```

    '#default_value' => array(
      'year' => $def['year'] - 1,
      'month' => $def['month'],
      'day' => $def['mday']
    )
  );

  //add date picker for end date to form
  $form['date_end'] = array(
    '#type' => 'date',
    '#title' => 'to'
  );

  //add submit button to form to filter for the selected timeframe
  $form['submit_button'] = array(
    '#type' => 'submit',
    '#value' => t('Filter')
  );

  //add vertical tabs to form for navigation
  //through the different activity reports
  $form['activity_reports'] = array(
    '#prefix' => '<h3>' . t('Activity Reports') . '</h3>',
    '#type' => 'vertical_tabs'
  );

  //add tab for report content created per hour
  $form['activity_reports_hour_created'] = array(
    '#type' => 'fieldset',
    '#title' => t('Created Content per Hour'),
    '#collapsible' => TRUE,
    '#group' => 'activity_reports'
  );

  ...

  //define sql-query as prepared statements for the report
  //with begin and end date as parameters
  $sql = "SELECT FROM_UNIXTIME( created, '%H' ) AS Hour_Created,
COUNT( node.nid ) AS Amount, node.type AS Node_Type
FROM node
WHERE FROM_UNIXTIME( created, '%Y%m%d' ) >= :s AND
FROM_UNIXTIME( created, '%Y%m%d' ) <= :e
GROUP BY Node_Type, Hour_Created
ORDER BY Hour_Created, Amount";

  //get and prepare data for the report
  ...

```

```

//create stacked column chart for displaying the data of the report
$hc_chart = array(
  '#type' => 'chart',
  '#chart_type' => 'column',
  '#title' => t('Created Content per Hour'),
  '#stacking' => TRUE
);

//generate data sets for each type for the chart
foreach ($types as $tmp) {
  $data2 = array();
  $data2 = get_24h_array();
  foreach ($rowdata as $r) {
    if ($r[2] == $tmp) {
      $data2[(int) $r[0]] = (int) $r[1];
    }
  }

  $hc_chart[$tmp] = array(
    '#type' => 'chart_data',
    '#title' => t($tmp),
    '#data' => $data2
  );
}

//add chart with data to form
$form['activity_reports_hour_created']['chart'] = $hc_chart;

//add table with data to form
$form['activity_reports_hour_created']['table'] = array(
  '#theme' => 'table',
  '#rows' => $rowdata,
  '#header' => $header
);

```

Social Network Analysis

In the following paragraphs the functionality of the ›Community KPI-Dashboard’s‹ social network analysis will be presented and ideas for further improvements will be described.

The version of the social network analysis developed for this thesis is based on the so called ›network indicator‹, a measure that indicates the frequency of interaction of USER A with USER B. This measure is calculated for the cross product of the users table in the Drupal database. Since the network indicator is no symmetric measure the value for USER A regarding USER B can be different from the value of USER B regarding USER A. The network indicator itself is the sum of comments, messages or answers USER A wrote to USER B or on content of USER B over the last year. If certain types

of interaction shall not be included in the network indicator they can be deselected in the settings of the social network analysis. The visualization of the data is handled in the same way as for reports, described before 4.3.3, and can be seen in section 5.6.

For further improvements the social network analysis could automatically determine weak and strong ties in the community based on previously configured settings. For example administrators could be able to select a certain value which sets the border between weak and strong tie. Additionally the calculation of the network indicator could be improved by adding a time coefficient which determines how much interactions that are older than a certain timeframe shall be weighted. For example comments that have been written over 2 years ago shall only count as 0.3 instead of 1 for the network indicator. Also the possibility of ranking the types of interaction for administrators could be implemented. For example the administrator could determine that writing someone a private message returns a higher network indicator than commenting on someone's content or reading someone's forum posts.

4.3.4 Setup of Community KPI-Dashboard

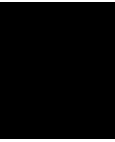
The following section lists all reports of the ›Community KPI-Dashboard‹ and explains which reports need additional contributed Drupal modules or configuration to function correctly. For certain reports graphs are created by the charts module. If the charts module is not installed the reports will be shown correctly but no visualization of the data is created. A list of all contributed modules that have been used for the ›Community KPI-Dashboard‹ and the evaluation community is presented in section 4.2.1.

Report	Description	Dependencies	Configuration
<i>Activity Tracking</i>			
Created Content per Hour	sums up the amount of new content grouped by content type and hour of day	Charts	-
Created Content per Day	sums up the amount of new content grouped by content type and day of week	Charts	-
Created Content per Month	sums up the amount of new content grouped by content type and month of year	Charts	-

Answer Times	calculates median and average of answer times (time from the moment the question was asked until the answer which was selected as best answer was posted)	Answers, Best Answer	-
<i>Audience Tracking</i>			
New Users	sums up the amount of new users grouped by date of registration	Charts	-
User <characteristics>	sums up the amount of occurrences grouped by defined characteristics	Profile2	define which Profile2 field of the users shall be chosen as characteristics
Social Network Analysis	show users with their network indicator and compare users of selected relationship	Answers, Best Answer, Private messages, Voting API	define which types of interaction shall be included
<i>Content Tracking</i>			
New Content	sums up the amount of new content grouped by content type for a certain timeframe	Charts	-
Questions & Answers	shows the number of un-/answered questions as percentage and in total numbers	Answers, Charts	-
Messages	sums up the amount of messages sent grouped by user and in total	Private messages	-
<i>Purpose Tracking</i>			
Top-X Tags	sums up the occurrences of tags used in content and lists the top X	Community Tags, Charts	define X
<i>Quality Tracking</i>			

Top-X Users by Userpoints	shows the amount of userpoints of users and lists the top X	Answers User-points	define X
Top-X Users by Userrating	shows the average rating of users questions and answers and lists the top X	Answers, Voting API	define X
Top-X Questions	shows the rating of questions and lists the top X	Answers, Voting API	define X
Flop-X Questions	shows the rating of questions and lists the worst X	Answers, Voting API	define X
Top-X Answers	shows the rating of answers and lists the top X	Answers, Voting API	define X
<i>Role Tracking</i>			
Role 1-3	lists the users who match the defined filters for role 1-3	-	enable and define role 1-3
<i>View Tracking</i>			
Top-X Pages	shows the number of visits and unique visits of pages and lists the top X	Visitors	define X

Table 4.2: Overview of ›Community KPI-Dashboards‹ reports, their dependencies and required configuration



Evaluation

In order to prove that the prototype of the ›Community KPI-Dashboard‹ enables the described features such as measuring and visualizing the selected key-performance-indicators the prototype was tested manually on the basis of the virtual evaluation community tu international described in chapter 3 and 4. The reports and their results will be presented and implications for the administrators of a virtual community pointed out.

5.1 Activity Tracking

Using the activity tracking of the ›Community KPI-Dashboard‹ the administrator can see when and how much of each content type was generated in the community. The report can be shown for the hours of a day, the days of a week or the months of a year. Figure 5.1 shows a report including a chart presenting how much of each content type at which time of the day was created by users of the community. This report indicates that for the selected timeframe the most activity, in context of new created content, is during afternoon from 4:00pm-6:00pm. Out of this report administrators can conclude different things for their online community such as that in the afternoon more moderation might be needed than during other times of the day.

Another report regarding the activity tracking calculates the average and the median time which it takes for questions to find an appropriate answer. This is assumed to be the timeframe from the moment a question is asked until the moment the answer which was selected as best answer was posted. The average is calculated as arithmetic mean. For administrators of a virtual community an increasing median answer time might indicate a reduction of activity of the users which might imply the need for changes in the community design to motivate users for more contributions to the community.

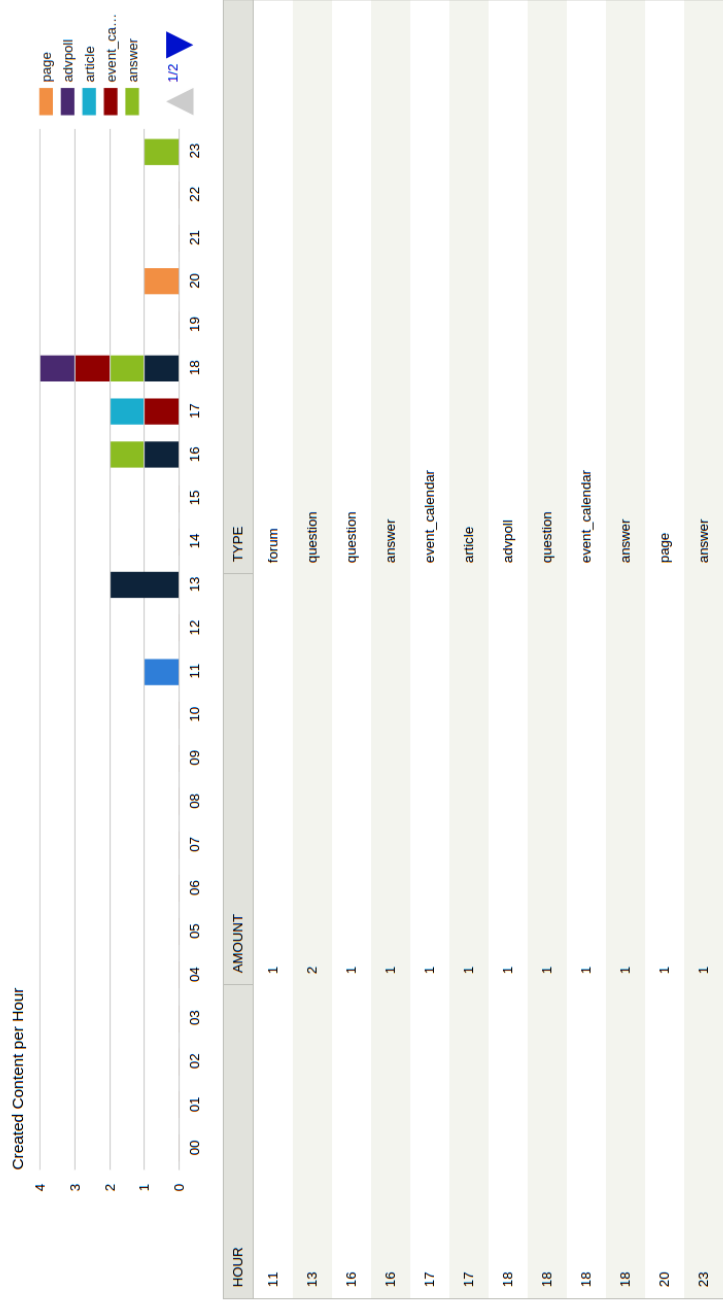


Figure 5.1: Created content per hour report

5.2 Audience Tracking

To get an overview of when new users have registered in the community the new users report, which can be seen in figure 5.2, shows the amount of registered users for the selected time frame grouped per day. This simple report can help to figure out if certain promotions, marketing activities or changes in the community design attracted new users. If there is an increase of new registrations after some online marketing campaign the administrators of an online community might consider prolonging and enhancing this campaign.

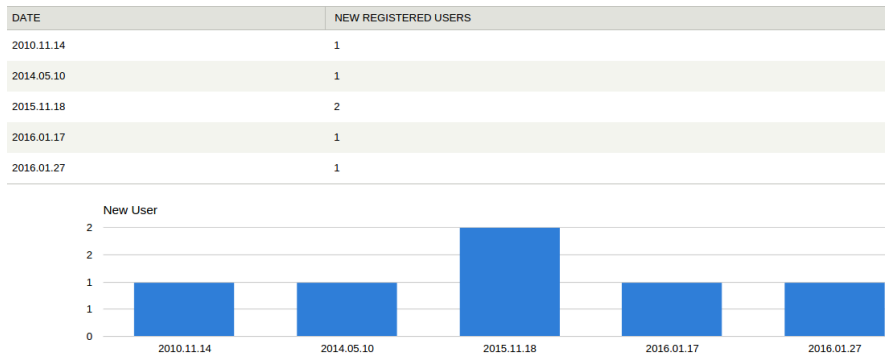


Figure 5.2: New user report

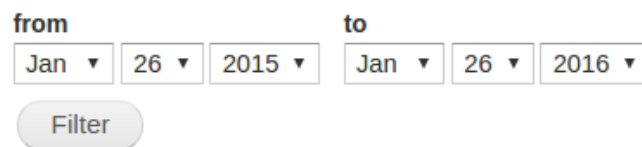
INTEREST	USERS
cooking	6
politics	4
Sports	4
reading	3
law	2
sailing	2
computer science	1
dumbidumdum	1
informatics	1
music	1
programming	1
technology	1

Figure 5.3: User interests report

Furthermore the ›Community KPI-Dashboard‹ allows generating reports about profile2 fields (such as origin, interests, gender, etc. of the tu international community) of community members which gives a good oversight in the audience of the community. For example in figure 5.3 the most common interests among the users of the community are summed up and listed. This report would indicate that even though the tu international is a community for users with a connection to the technical university of Vienna other non-technical interests such as cooking, politics or sports are also strongly represented in the community. As administrator of the tu international this might be interesting for advertisement about cooking classes or sport events on the website or for the creation of new content in the community such as Wiki-pages about sport possibilities near by the TU Vienna.

5.3 Content Tracking

Using the content tracking of the ›Community KPI-Dashboard‹ administrators can see how many nodes of which content type have been created. With the date-filter which is shown in 5.4 the user can choose two dates who define the timeframe for which the report and the corresponding chart is generated.



The image shows a date filter interface. It consists of two date selection groups. The first group is labeled 'from' and contains three dropdown menus: 'Jan', '26', and '2015'. The second group is labeled 'to' and contains three dropdown menus: 'Jan', '26', and '2016'. Below these two groups is a rounded rectangular button labeled 'Filter'.

Figure 5.4: Date filter

The new content report which can be seen in figure 5.5 shows that questions and answers are by far the most popular way of contributing to the evaluation community. Besides finding out the preferred contribution way of the users, with the help of content tracking administrators of an online community can easily find out if new designs or methods in the community stimulate and motivate users to contribute more or if the way of their contributions changed.

Furthermore there exists a report about questions and answers which can be seen in figure 5.6 that shows the amount of answered and unanswered questions as percentage and in total numbers. If the percentage of unanswered questions rises administrators might need to look for the reasons such as duplicate questions, which don't get answered a second time, because of poor community design or users are lacking motivation to share their knowledge and the reputation system needs to be redesigned.

AMOUNT	TYPE
30	answer
19	question
6	forum
5	event_calendar
2	wiki_page
1	comment
1	advpoll
1	page

Content Types



Figure 5.5: New content

Answered Questions

PERCENTAGE	TOTAL
78.9474	15

Unanswered Questions

PERCENTAGE	TOTAL
21.0526	4

Answered Questions



Figure 5.6: Questions and answers report

5.4 Purpose Tracking

To get an overview of the topics which are discussed and keeping the community in motion the top tags report counts the occurrences of every tag and orders them by frequency. In the settings of the ›Community KPI-Dashboard‹ the user can define how many different tags shall be shown in the ranking and set a timeframe by using the date-filter 5.4. Figure 5.7 shows the top-5 tags of the evaluation community. As administrator of the tu international this report would indicate that in the selected timeframe business intelligence, e-commerce and opening hours were the most discussed

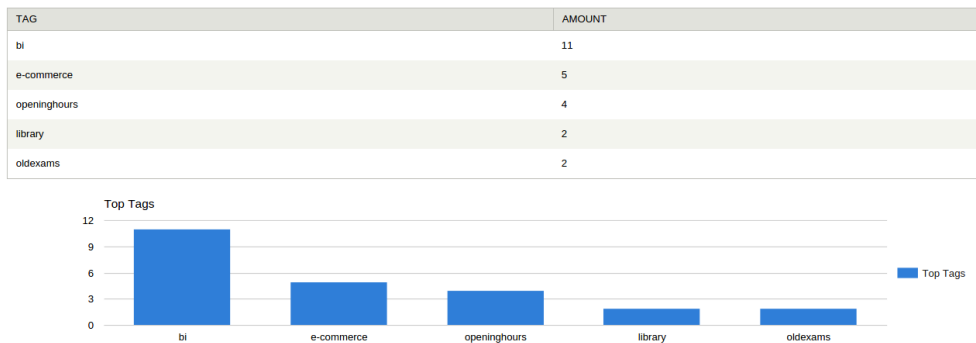


Figure 5.7: Top tags report

or covered topics in the community. If the discussed topics of the community are not desired by the administrators, changes in the community's design or moderation might be needed. For example administrators and moderators could start creating more content about the desired topics to trigger further discussions. If the desired topics are still not appreciated and discussed by the users it might make sense to compare the actual audience with the target audience of the community or to rethink the goals and users that should be attracted.

5.5 Role Tracking

One of the key-features of the ›Community KPI-Dashboard‹ is the so called role tracking where the administrator is able to define certain roles in the community depending on the characteristics of the users. For example figure 5.8 shows the settings for a role named ›Oldie ‹ which will be assigned to all users which match the criteria defined in the settings. In this example that would be all users who have been registered in the community for longer than one year. On the role tracking report page for each report a list with all users who match all the criteria of the certain role is displayed to the administrator.

With the help of this feature community administrators have the possibility to define and determine different roles in the community according to their interests. For example a role ›answering machine‹ could be defined for all users who created more than 50 answers over the last year or a role ›read only users‹ which is applied to all users who never contributed to the community at all but have been active in the last semester. With the help of role tracking it is not only possible to determine which user takes which roles in the community but also to get an overview how many for example ›read only users‹ exist in the community.

General role settings	
read only	
content creator	
oldie	<input type="text" value="oldie"/> Select the name for the third role
	Parameter 1 <input type="text" value="registered"/> Select the first parameter for the third role
	Parameter 1 Operator <input type="text" value="<"/> Select the operator for the first parameter for the third role
	Parameter 1 Value <input type="text" value="4"/> Select the value for the first parameter
	Dates: 0 = 1 week; 1 = 1 month; 2 = 3 months; 3 = 6 months; 4 = 1 year; 5 = 5 years Content: 0 = 0; 1 = 5; 2 = 10; 3 = 25; 4 = 50; 5 = 100

Figure 5.8: Settings for role reports

5.6 Social Network Analysis

Another important feature is the social network analysis. This report analysis how much USER A interacts with USER B based on their activities in the community like writing private messages, answering each other's questions or commenting each other's content or replying to the forum posts of the other user. The more USER A contacts USER B the higher his so called ›Network Indicator‹ gets. The network indicator is not a symmetric measure. In case USER A messages USER B very often, but USER B never answers, the network indicator of USER A for USER B might be very high, but the network indicator of USER B for USER A could be 0.

The social network analysis of the ›Community KPI-Dashboard‹ lists all the network indicators of all users. The administrator of the community can filter the table by searching for users by their username. To discover why certain users might interact with each other the administrator can easily compare their profiles with each other to see if they have the same field of study, same interests or the same origin. The prototype of the social network analysis can be seen in figure 5.9. For the administrator of the tu international it indicates that the users rubasd and steved are the users who are interacting the most with the user daniel. The comparison of the users rubasd and daniel shows that they both study in the field of computer science, have several interests in common and are nearly the same age. These facts might be good indicators why they are interacting that much with each other or even may know each other in person.

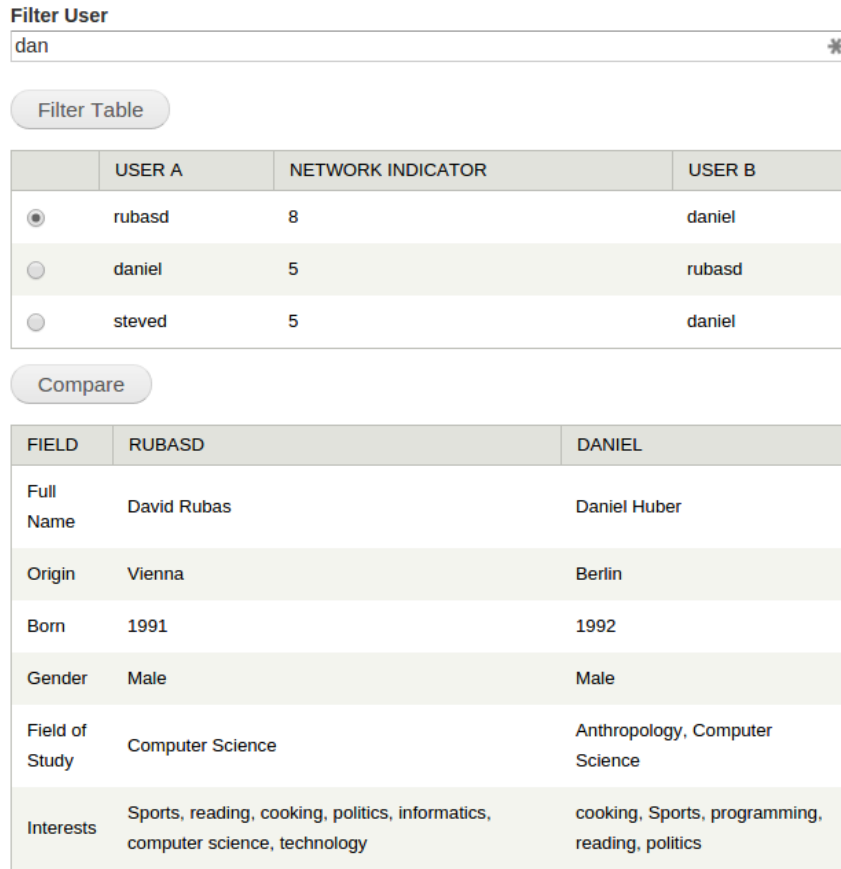


Figure 5.9: Social network analysis

5.7 Quality Tracking

The section quality reports offers insight into which users, questions or answers are contributing the most quality to the community under the assumption that the user or content which gets the most appreciation by the community is of high quality for the community. For example the top-5 questions report for the tu international community, which can be seen in figure 5.10, shows that the question ›Where is the EI7?‹ asked by the user rubasd earned the most appreciation in the community for the selected timeframe using the date-filter 5.4.

Another report of the quality tracking is the top user report, which can be seen in figure 5.11. It shows the users with the most earned points according to the settings of the userpoints module and the users with the highest average rating on their questions and answers. As administrator of the tu international you can see that on the one hand the user rubasd earned the most userpoints, but on the other hand in average the contributions of the user maxr received a higher rating than those of rubasd. Further

QUESTION	RATING	AUTHOR
Where is the EI7?	5	rubasd
Pub Quiz near TU	4	daniel
Old Exams	3	daniel
Camur Jus Saluto	2	maxr
Blandit Consequat Hos Lenis Paratus Pertineo	2	daniel

Figure 5.10: Top-5 questions report

USER	POINTS
rubasd	57
daniel	44
dummy1	35
dummy2	15

USER	AVG. RATING OF USERS QUESTIONS
maxr	2
daniel	1.8
rubasd	1.3333333333333333

Figure 5.11: Top user report

there is the possibility to generate a report about the questions and users with the worst ratings and least points. With the help of this information administrators for example can easily find out which users are not contributing according to the community's needs.

5.8 View Tracking

With the help of view tracking administrators of an online community can easily identify content which attracts many users by showing reports about how often different content in the community was viewed to users. While figure 5.12 shows the total number of

views per site, figure 5.13 lists how many different users have accessed the certain content. These reports give the administrators insights about topics that attract users and which users contribute attractive content to the community. The administrator of the tu

# OF VIEWS	NODE	PATH
170		questions
102	Top rated content	top-rated-points
70	Autocomplete taxonomy	taxonomy/autocomplete/field_tag/pub
45	rubasd	user/1
31	Old Exams	node/18

Figure 5.12: Top views report

international community sees in the top views report 5.12 that the page ›questions‹ , where all questions are listed, has with 170 views by far the most of all pages. Further the top unique views report, which can be seen in figure 5.13, shows that the page ›questions‹ was viewed by four different users, but the page ›top-rated-points‹ , which lists up the content with the best ratings, has seven unique views, therefore was visited by seven different users. As administrator of the tu international you could conclude that even though the page ›questions‹ is visited more often the page ›top-rated-content‹ attracts more users.

# OF UNIQUE VIEWS	NODE	PATH
7	Top rated content	top-rated-points
5	Autocomplete taxonomy	taxonomy/autocomplete/field_interests/spo
5	Pub Quiz near TU	node/19
4		questions
4	Old Exams	node/18

Figure 5.13: Top unique views report

Conclusion and Future Work

The following chapter shall give an overview about the results regarding the research questions of this thesis. Furthermore the limitations of this work will be explained and an outlook for further improvements in future work will be presented.

6.1 Answers to Research Questions

Q.1: How does a successful virtual community look like?

The analysis of success in virtual communities in general and of the three chosen successful online communities Stack Overflow, Wikipedia and Quora in chapter 2 provided the information based on which the first research question will be answered and the hypothesis of this thesis will be verified or disproved.

According to literature a successful virtual community has clear goal definitions for example about the audience which shall be targeted or topics that shall be discussed in the community. Further the target audience of a successful community has a commonality, something which brings them together like a community in real life. This can either be a shared purpose for example an interest which all participants are sharing, or some shared characteristics of its members such as age-related communities or virtual communities for people living in the same city. Additionally successful virtual communities stimulate the motivation of users with the help of good community design. More details about good community designs are described in the answer to Q.3.

Hypothesis:

- ✓ ... indicates that the following hypothesis was supported / proved in this work.
- X ... indicates that the following hypothesis was not supported / disproved in this work.

Studying literature about successful virtual communities proofed the importance of defining a target audience for the success of virtual communities. It is pointed out that communities which have no clear defined target audience and goals attract users with very diverging expectations who might get disappointed or frustrated if their expectations are not met in the community. This might result in conflicts between users in the community or the loss of community members. [24] [2]

✓ - H1: It is assumed that it is important for successful virtual communities to define a target audience.

According to Mamykina (2011) the fast answer times and the high answer quality play an important role in the huge success of Stack Overflow. Both characteristics were achieved by the community's design and organization which was encouraged by the founders of Stack Overflow. From which I can conclude that both sufficient high answer quality according to the questioners needs and fast response-time are important factors for successful virtual communities. [19]

✓ - H2: It is assumed that in a successful virtual community all questions are answered accordingly to the questioners needs.

✓ H3: It is assumed that the average response-time for questions in the community is an important factor for the success of virtual communities.

The literature of chapter 2 also indicates that gamification like the reputation system of Stack Overflow encourages users to participate more actively in communities than they would without such a system. Furthermore the goal of earning rewards like digital badges or trophies that are used in many virtual communities stimulates the knowledge sharing behavior of the users. [16] [19]

✓ - H4: It is assumed that digital badges and other indicators of skill in communities motivate the users to share their knowledge.

✓ - H5: It is assumed that the gamification of virtual communities stimulates the knowledge sharing behavior of their users.

As stated by Scott (2013) small and tight networks must not provide a better output for users than a network of many weak ties, because small groups of friends might have similar knowledge and interests and therefore might not be able to help each other as someone from outside the network could by giving new information and knowledge. This disproves H6 of this thesis. [28]

X - H6: It is assumed that the quality of answers provided by close friends is of higher quality than of unrelated users, since close friends are assumed to care more.

Q.2: What are critical factors on which virtual communities can be evaluated / compared?

In principal a virtual community is a website and therefore it can be analyzed and evaluated like other websites, but there are also aspects which are not covered by traditional website analytics, because in virtual communities users are actively contributing and shaping the content of the website and the site itself. Based on the literature about the evaluation of virtual communities and critical factors that can be measured which has been analyzed in section 2.3. the foundations of this methodology have been designed.

The following list contains some examples of key-performance-indicators for virtual communities.

- number of created content (like questions, answers, forum threads, forum posts, comments, etc.) by users in certain timeframes
- bounce-rate
- most popular tags
- peaks/lows of activity of the users
- average answer time on questions
- percentage of answered questions

Furthermore there exist different topics on which virtual communities can be evaluated and compared which cannot be put in concrete measures like key-performance-indicators. These topics include the flow of knowledge and information inside a community, relations inside a community or group forming which can be examined with social network analysis. Besides that privacy and data security issues might be from further interests for evaluation and comparisons of online communities.

Q.3: Which methods can be used to make a virtual community more successful?

For some of the users the community aspect, to help others and to get help of others, might be enough to contribute active to a community. Nevertheless many communities are using technology to motivate their users to get active by providing different types of reputation that can be earned by the users. Some examples for these methods are the voting and digital badges system of Stack Overflow, the featured articles or featured portals approach of Wikipedia or the graph-based design of Quora including a personal user feed about questions the user is interested in, which all have been presented in section 2.2.

6.2 Limitations & Future Work

Whether the thesis has reached its goals, there were some unavoidable limitations. Since a live evaluation of the tu international community as well as the ›Community KPI-Dashboard‹ was not feasible in the timeframe of this thesis only prototypes have been developed and tested manually. Although the key-performance-indicators are calculated as expected and the reports work properly, nothing can simulate the performance of a system when going live.

For future work in this field of study the module could be enhanced with additional reports and supporting further modules for generating reports. For example a more detailed social network analysis could be implemented, where the user's knowledge domains get analyzed based on tags of his or her created content. Additionally other features like benchmarking or other ways of comparing communities among each others could be evaluated and added to the ›Community KPI-Dashboard‹. Furthermore the prototype of the tu international community could go live to see how the potential users are reacting on its features and are using them. With the help of the ›Community KPI-Dashboard‹ the activities and events happening in the tu international community can be monitored and improvements at the setup of the community based on the reports of the dashboard can be done.

Additionally the module should be offered to different existing virtual communities for testing and evaluating its application in real world scenarios. The claim, that this framework supports the development of successful virtual communities and helps to get a deeper insight into them must be based on scientific research.

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