Ludwig-Maximilians-Universität München
Institut für Informatik
Lehr- und Forschungseinheit Programmier- und Modellierungssprachen

Bachelorarbeit

Designing an Interface for Citizen Science Platforms Ensuring a Good User Experience

Dehn Giuliana

Verantw. Hochschullehrer	Prof. Dr. François Bry
Betreuer	Dr. Clemens Schefels,
	Martin Bogner
Abgabe am	19. Januar 2017

Erklärung

Ich erkläre hiermit, dass ich die vorliegende Arbeit selbstständig angefertigt, alle Zitate als solche kenntlich gemacht sowie alle benutzten Quellen und Hilfsmittel angegeben habe.

München, 19. Januar 2017

Giuliana Dehn

Zusammenfassung

Das Engagement von Freiwilligen auf Citizen Science Plattformen wird in hohem Maße durch eine intuitive und motivierende Nutzerschnittstelle beeinflusst. In dieser Arbeit wird ein Designansatz für kollaborative Citizen Science Plattformen, die Mitwirkende in mehreren Stadien des wissenschaftlichen Forschungsprozesses einbeziehen, entworfen. Der Ansatz bietet Designkonzepte, die eine gute Benutzererfahrung gewährleisten und damit einen modernen Wissenschaftsprozess, der von professionellen Wissenschaftlern und Laien durchgeführt wird, unterstützen. Auf der Grundlage der Citizen Science Plattform ARTizen, die einen Rahmen für eine kollaborative Datenanalyse der Kunstgeschichte bietet, wird durch eine Implementierung die Realisierbarkeit des Designansatzes dargelegt.

Abstract

The engagement of volunteers on Citizen Science platforms can considerably be influenced by an intuitive and motivating user interface. This thesis elaborates on a design approach for collaborative Citizen Science platforms that involve their contributors during multiple stages of the scientific research process. The approach provides design concepts, which ensure a good user experience and therefore support a modern science process carried out by professional scientists and lay people. Based on the Citizen Science platform ARTizen, which provides a framework for a collaborative data analysis of art history, an implementation demonstrates the feasibility of the design approach.

Acknowledgements

First, I would like to express my gratitude to Dr. Clemens Schefels and Martin Bogner who followed my progress with enthusiasm and provided me with helpful advice. Many of their ideas enriched the work on this thesis.

I am also deeply grateful to Prof. Dr. François Bry for his helpful suggestions as well as his inspiring comments and great interest in the topic.

Finally, I would like to thank my family who supported me, not only through this thesis, and my boyfriend Veit who I can always count on.

Contents

1 Introduction

By having people with limited experience in scientific research working together with experienced professional scientists to study scientific problems, Citizen Science (CS) represents a considerable supplement to traditional science [1]. CS meets the needs of science research, as well as science education [2]. While encouraging science, it also raises awareness for scientific concerns among a broader audience.

In times of fast technological developments, where information technology and web-enabled devices became ubiquitous, CS platforms provide a great potential for spreading a modern concept of science. While the number of these platforms grows, the competition between CS projects has also increased, and it becomes more difficult to attract enough volunteers. As investigated by Nov et al. [3], many CS platforms suffer from irregular patterns of participation. In order to avoid this irregular behavior, motivational aspects of the platform have to be enhanced. Concepts of a good user experience and design are important to attract and engage contributors [4]. When developing a design concept for CS platforms, it is important to distinguish existing CS platforms.

Scientific investigations include many processes, steps, or tasks in which the public can be involved through CS projects. Nevertheless, most CS platforms benefit from volunteers completing tasks in early stages of research, such as collecting or encoding data. *ARTizen* is one of the few CS platforms that involve their contributors in multiple stages of the research process. It is a platform providing an environment to develop and discuss findings based on data of the image tagging platform *ARTigo*[1]. This thesis elaborates on a design approach for CS platforms while ensuring a good user experience. It refers to platforms supporting multiple steps of a scientific process – starting with research questions, followed by deeper investigations, leading to findings and conclusions.

This thesis consists of a theoretical design approach, as well as a practical implementation part. Chapter 2 describes related work, followed by a deeper understanding of CS platforms (Chapter 3). The elaborated design approach establishing a basis for the implementation part is presented in Chapter 4. Chapter 5 introduces the platform, which will be visually revised in Chapter 6. The thesis will be completed with a conclusion (Chapter 7) and future work (Chapter 8).

[1] https://www.artigo.org/

2 Related Work

The following sections will give a deeper understanding of some fundamental principles and terms used in this thesis. The first term to discuss is user experience, playing a leading role for the design approach of this thesis.

2.1 User Experience

The term user experience – introduced by Don Norman and his colleagues [5] in 1995 – describes all aspects of the user's experience when interacting with a product, service, environment, or facility. Thus, both a coffee machine and a call center can deliver user experience. Since this thesis deals with online platforms, user experience will be considered with the focus on computer-based systems.

In the past decades, user experience has grown into an important design discipline that continues to mature and evolve [6]. This movement results from the growing market of applications, websites[2] and other computer-based systems [7]. In the fast-paced world of today people use many different products and applications without a permanent commitment. Therefore, it is essential to engage users by providing them with an interface ensuring a good user experience. The key of success is not just about the functionality and technology of a product. In order to distinguish from the competition, a product has to be intuitive, exciting and fun to use. It should not be delivered without focusing on its interface. This was proved many times in the past. The *N-Gage* mobile phone by *Nokia* is a famous design faux pas examples [8]. Although the concept of a phone combined with a gaming console met the spirit of the time, the clumsiness of its design led to a failure of the whole product.

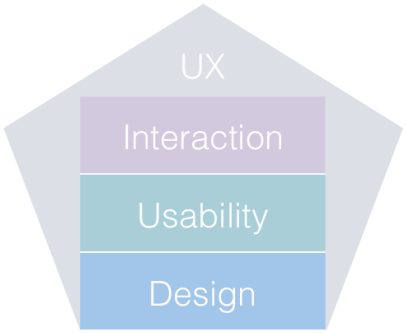

Figure 2.1: The three elements of user experience (UX).

[2]There are over one billion websites on the world wide web today (internetlivestats.com/total-number-of-websites/. Accessed: 2016-31-08).

User experience takes a broader view, looking at the individual's entire interaction, as well as their feelings and expectations. It combines design, usability and interaction (Figure 2.1). **Design** is fundamental for user experience. It deals with the visual appearance of a user interface making decisions about color schemes, fonts and other static elements of an interface. It furthermore includes graphic design of for instance logos and icons. An appealing design is essential but not sufficient for user satisfaction [7]. **Usability** builds upon design (Figure 2.1). A usable web interface attaches importance to the user's needs. It meets their expectations by following design conventions and building an intuitive interface. Scientific literature on this topic is sparse, often outdated and overly theoretical. A greater help in this case are web design conventions published by web designers or companies dealing with this topic, for example [9, 10, 11]. According to the *International Organization for Standardization*[3], usability can be measured by three different factors: effectiveness (the ability of users to complete tasks using the system, and the quality of their output), efficiency (the level of resource consumed in performing tasks) and satisfaction (users' subjective reactions to using the system). **Interaction** is the third element required to provide a good user experience (Figure 2.1). It refers to the active operation of a surface, for instance, when the user is clicking a button or hovering over a text container. Interaction should subconsciously deliver enjoyment but never overwhelm the user.

When does user experience become relevant?

Within milliseconds people make up their mind about strangers. The same phenomenon can be observed when a user visits a website for the first time. According to a study by Tuch et al. [12], it takes 17 to 50 milliseconds to pass esthetic judgments about websites. Another study [13], examining how strong design influences trust and mistrust of online health sites, underlines the importance of design making up 94% of the first impression. Based on this first impression users decide whether to stay on a website or to leave it. In order to keep a user on a website, the first impression has to be convincing. Tuch et al. [12] address that a simple and clear design more likely leads to a positive first impression. Users can easily identify structures and orientate themselves. After the first milliseconds have passed, user experience becomes relevant. The user starts to navigate and interact with the website - apart from design, usability and interaction now gain importance.

Besides user experience this thesis also focuses on CS. The next chapter gives a deeper insight into CS, its development and its relevance today.

[3]ISO 9241-11 standards.

2.2 Citizen Science

Is CS an achievement of hobby-researchers or is it a serious and reasonable science? This is a typical thought that comes to mind, when people think about CS. But of course there is science beyond science, as Peter Finke, an expert for CS, names it. CS describes public participation within the scientific research [14].

In order to understand the meaning of CS, it is necessary to be aware of the history of science. Until the end of the 18th century CS was the convention while going to university was a privilege that only few persons could benefit from [15]. Of course it was normal that the entire society accumulated and elaborated knowledge, not only those who completed higher education. With the 19th and 20th century various modern universities were established worldwide and higher education became available to the masses. Scientific work was increasingly carried out by experts and a parallelism between CS and *traditional science* (science performed through higher educated people) evolved [14]. Science is an accumulation of knowledge regardless of where it comes from. Educational institutions such as universities, academies or scientific associations promote the quality of science. They are no requirement to science [16]. Unlike most authors writing about CS, Finke discusses the interplay of CS and *traditional science*. CS is on no account inferior science, but rather another form of science. According to him, this form of science is independent of educational institutions and the bureaucracy they often involve. Among other things CS benefits from the knowledge of people with pronounced interests in a certain field, who often have considerable practical experience. The practical orientation has become determinative for CS [16].

Charles Darwin is often mentioned as one of the leading figures in terms of CS. The British researcher studied theology and medicine but he was always fascinated and inspired by nature. He joined an association of citizens interested in natural history. Thanks to this community and to his extensive self-studies, he revolutionized our comprehension of nature. Thus, Charles Darwin was s professional and citizen scientist at the same time. Back the term CS did not exist. In 1938 Lancelot Thomas Hogben, a British experimental zoologist, medical statistician and writer, published a book called *science for the citizen* [17]. In this book he already expresses first thoughts of CS *avant la lettre*.

> *The further progress of science depends on how far the scientific worker and his fellow citizens co-operate with one another in applying scientific knowledge to the satisfaction of the common needs of mankind. Before discussing the first question it is important to clarify a distinction which is commonly taken for granted. The separation of human societies into*

> *social classes which enjoy abundant leisure or are deprived of it, has encouraged a superficial and arbitrary division of science into two branches, pure and applied. [...] Pure and applied science are not independent social phenomena. They are inextricably related as shoot and root in the process of healthy growth. Growing science is the unity of theory and practice. [17]*

Hogben notes that the separation of the society into two classes – the academic and the bourgeois – is an arbitrary division of science. He emphasizes the importance of cooperation between applied and pure science. In the last years the term CS became fashionable. It was added to the Oxford Dictionary in June 2014, which certainly revived discussions about CS [18]. Finke [14] criticizes the view on CS, which dominates until today. According to him, the knowledge of lay people is still underestimate and not really taken serious. Until today, skepticism about the quality of lay-knowledge is disseminated [19, 20]. Due to missing confidence, most CS projects benefit from the public supporting early stages of the scientific research only. Voluteers often collect big amounts of data which still requires monitoring and evaluation.

2.3 Collaborative Online Platforms

> *The Internet is [...] a mechanism for information dissemination, and a medium for collaboration and interaction between individuals [...] without regard for geographic location. [21]*

Collaborative online platforms reflect the original idea of the Internet. They consist of communication, collaboration, and productivity. Everybody can share ideas on these platforms, as well as extract information and knowledge from them. Collaborative online platforms make use of collective intelligence, which is a well-investigated research field. The popular book *The Wisdom of Crowds* by Surowiecki [22] vividly describes the incident that a group of people can achieve better results than any individual of the group could, even if one member of the group is more intelligent, than the remaining individuals. Surowiecki also emphasizes the importance of diversity to *wise crowds*, as different opinions expand the range of possible solutions proposed.

In parts collaborative online platforms have similar characteristics. They support teamwork and provide an environment to share information with other users. Nevertheless, every collaborative platform has own characteristics. To differentiate these platforms an overview (Table 2.1) of some common collaborative platforms was created. Defining their differences represents a demanding challenge since some platforms resemble others and functionalities overlap.

Table 2.1: Collaborative Online Platforms

Platform	Description	Examples
Creative Communities	Creative social media platforms focusing on the generated content.	Abduzeedo, Behance, Cargo, Dribbble, Dropr, Ello, EyeEm, Flickr, Krop, Printerest
Learning Platforms	Platforms letting user learn new skills, practice and improve them.	Codecademy, Coursera, Duolingo, Lecturio, Treehouse, Udacity
Networking Platforms	Some kind of social bookmark in which content is being linked through interests and relationships. Based on the user's social interactions and network new content is being recommended.	Digg, Diigo, StumbleUpon
Professional Collaboration Tools	Team and project management software that makes it easy to organize, manage and track projects from a central location. They facilitate collaboration and accelerate working processes.	Asana, Azendoo, IBM Connections, Open-Xchange, Podio, Samepage, Trello, Yammer
Social Media	It allows users to share thoughts, photos, videos, news and other content with different people. Social media provides the opportunity to take social interaction to deeper levels [23, 24].	Facebook, LinkedIn, Nextdoor, Twitter, Xing, ASKfm
Support/Discussion Forums	Platforms, where questions are asked, advice is shared and user discuss interesting topics. They collect a wealth of solutions to problems and often unit an engaged community.	gutefrage.net, Quora, Stack Overflow, wer-weiss-was, zhidao.baidu
Wikis	Volunteer members can add, delete, and change the generated open-source content while working on collaborative projects. Wikis are non-profit organizations in an educational context [23].	H-Soz-Kult, Wikipedia

3 Citizen Science Platforms

Bonny et al. [25] created a model describing three different categories of CS projects depending on how many steps of the scientific process are being covered by a project and how much control participants have over these steps. According to Bonny et al., ***contributory projects*** denote projects which are usually initiated by scientists asking questions that require data-collection over wide geographic areas and/or over long periods of time. Members of these projects normally follow guidelines predetermined by scientists who then analyze the collected data. ***Collaborative projects*** describe CS projects having members of the public collect data but also help to refine project design, analyze data, or disseminate findings. ***Co-created projects*** are CS projects involving citizen scientists in multiple steps of the scientific process.

CS platforms provide structured online frameworks for these different CS projects. The following chapter gives a deeper understanding of the development of CS platforms and the challenges they face nowadays.

3.1 Development of Citizen Science Platforms

As Eric Bonabeau [26] explains, our brain avoids complexity in order to respond quickly and ensure survival. This is the reason why our evolved decision heuristics have certain limitations. The Internet gives us the possibility to access more data and receive accurate responses in a short time [26], which also revolutionized CS. Moreover, the Internet facilitated the communication between individuals contributing to CS projects [27]. Angelika Zahrnt and Mark Hörstermann [16] affirm that a good communication is essential to an exemplary CS project. The Internet opened further opportunities by increasing the scope of potential volunteers [27]. CS platforms simplify the coordination, unlike CS offline projects, where collaboration has to be coordinated without a platform's support. Most existing CS platforms[4] provide an environment for *contributory projects* while benefiting from volunteers accumulating large amounts of data [28, 29, 30]. Only few CS platforms give an environment to *co-created projects* encouraging participants to take part in multiple steps of the scientific process rather than supporting data collection only. While previous CS researches have focused on how to design an effective data collection and capturing interface, this thesis explores a design approach based on platforms covering multiple aspects of the scientific inquiry. Contributors of these platforms work collaboratively on a scientific process – starting with research questions followed by deeper investigations leading to findings and conclusions. Lay people as well as scientists participate in these kinds of platforms.

[4] for example: http://feederwatch.org/, https://talk.galaxyzoo.org/, http://bigbughunt.com/.

3.2 Challenges of Citizen Science Platforms

According to Nov et al. [3], CS platforms are founded upon two pillars: On the one hand the **technological pillar**, which means developing a computer system to manage a CS online project and on the other hand the **motivational pillar**, which means attracting and retaining people who would be willing to contribute their skills, time, and effort for a scientific cause [3]. Both pillars are fundamental for a successful CS platform. While the technological pillar is responsible for a functional framework enabling for example communication and a central coordination [31], this thesis focuses on the second pillar – the motivational pillar. In order to realize the motivational pillar a range of aspects has to be considered: The surface of a CS platform plays a very important role, as it represents the interface between contributor and the project. Concepts of good user experience and a highly motivating design are important to attract many participants [4]. Since participants of CS projects work voluntarily, they are free to choose their degree of commitment and contribution [16]. Contributors commit themselves through own motivation. Nevertheless, CS projects do not run by themselves. Volunteer participants always have the choice whether or not to contribute. They tend to quickly reduce or even stop their contribution as soon as their motivation decreases. This implies that the motivation of a volunteer participant has to be kept at a high level. The main interaction point of a contributor is the platform's interface. Therefore, a user-centric, exciting and fun interface can be significant for the user's intrinsic motivation [4]. This for instance defers in the case of university portals. Students will use them, no matter how intuitive the interaction or how appealing the design is. So, in order to design a successful CS online project, among other aspects the interface of the platform has to be appealing to the contributors and has to meet their expectations — even more then on other platforms [4].

All sorts of CS projects are facing the described challenges. Of course CS platforms providing a framework for multiple stages of research, such as ARTizen, also deal with these concerns. Therefore a motivational interface for *co-created CS projects* will be elaborated in the following Chapter.

4 Design Approach for Citizen Science Platforms

This chapter investigates details about how to design a platform supporting *co-created CS projects* that motivate and engage contributors. As mentioned above, several papers examine how to structure CS platforms benefitting from the data collection by volunteers. Although these CS platforms differ from platforms supporting *co-created CS projects*, some of their general design concepts can be assumed to platforms supporting *co-created projects*. For instance according to Jannett et al. [30], users should be able to understand what a CS project is about within a few minutes. In order to achieve this, Jannett et al. suggest to avoid overload by reducing text and to structure information making it easier to understand the project's intention. Additionally the remaining pages should also avoid unnecessary features and text [30]. Using a platform and interacting with it should be self-explanatory, while the integration of tutorials or videos can accelerate comprehension and explain scientific concepts [30].

The following approach refers to projects, where volunteers (lay people and scientist) conduct science by analyzing data in a collaborative framework within a given structure. These platforms supporting *co-created CS projects* require an individual design approach since they include other functional elements that for example allow users to discuss findings, providing analysis tools and supporting collaboration. This approach provides a design concept for intuitive platforms supporting *co-created CS projects* while ensuring a good user experience.

People prefer to work with elements they already know, as these elements reduce the time required to become familiar with their functionality [32]. Therefore following certain conventions and rules during the design process of a CS platform can increase reliability and lead to more user confidence and trust. [32]. Since the amount of platforms supporting *co-created CS projects* on the Internet is limited, this approach attempts to include design conventions of collaborative platforms in general as they share many functionalities and concepts with platforms supporting *co-created CS projects*. The combinations of familiar functional elements from various collaborative platforms (Table 2.1) result an interface of platforms supporting *co-created CS projects* while ensuring user experience and user satisfaction. Functional elements from existing collaborative online platforms are for example timelines, search functionalities, user profiles and user groups. People immediately understand the purpose of these components and know how to interact and work with them.

Each of the following sections will represent one component that can typically be found in well-known collaborative online platforms. The set of components discussed

in this section consists of basic elements and capabilities supporting collaboration. These components usually do not refer to a single, but can rather be found in different environments. The section of every component will be divided into three paragraphs:

- General description, including detailed characteristics and annotations of the component
- Occurrence in well-known platforms, including an example where the described component can be found
- Relevance, including how the component is related to CS platforms

4.1 Groups

Description

It is natural that users of social networks tend to form groups, as observed by Girvan and Newman [33]. Teams or groups of online users intensify the feeling of solidarity on any platform. They usually gather people with similar interest or same goals. Usually messages can be uploaded and shared to a group [34]. While certain groups are managed and controlled by a user appointed as the group's moderator, others are unrestricted giving every member same responsibilities [34]. Moreover, organized teams with well defined roles, tasks and scheduling help to structure collaborative work, which can increase the team's efficiency significantly [35].

Example

The photo sharing platform *Flickr*[5] represents a creative, interacting online community providing an environment for producing, sharing, viewing and repurposing content while participating in a social scene [36]. They have more than 112 million users distributed over 63 different countries[6]. The complex social aspects of *Flickr* and the use of social features such as groups (Figure 4.1) open new opportunities for discovering images [37, 38]. *Flickr* users join 4.62 groups on average [34]. These groups are self organized [36] and have three different degrees of public accessibility: public, public with invitations, or private. A group consists of a photo pool, discussions and descriptions. Every group has an overview page including latest discussions, top contributions and other information. A group also shows a map marked with locations of the uploaded photos. In conclusion, *Flickr* has implemented the group feature exemplary, showing latest contributions and relevant photos using a simple design.

[5] https://www.flickr.com/

[6] http://expandedramblings.com/index.php/flickr-stats/ Accessed: 2016-23-09.

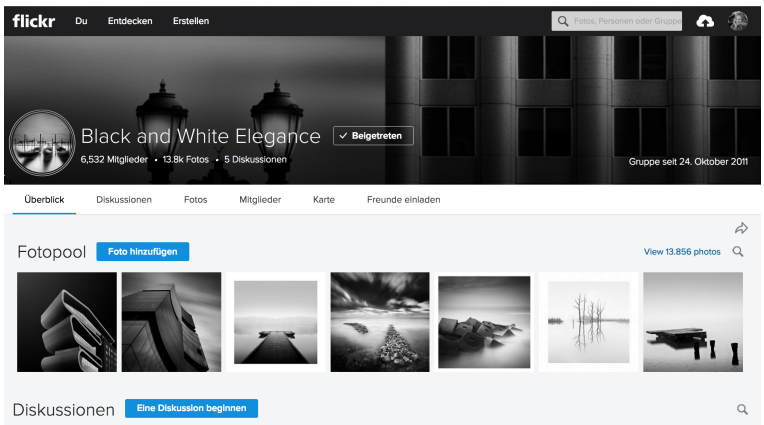

Figure 4.1: *Flickr* group.

Relevance

The power of CS is not result of single individuals working in isolation, but of volunteers working together in groups and achieving useful results [39]. User groups on CS platforms reinforce collaborative work and help to categorize scientific topics. It is useful to have different research groups each working on a scientific problem. The ability of creating private groups on CS platform is important since scientists tend to be cautious sharing ideas in an early stage of research. They want to ensure accuracy and precision of their contributions before making them available to the public.

4.2 Progress and Gamification

Description

Keeping the users informed about their personal progress can be a very motivating mechanism. According to Amabile et al. [40], satisfaction and motivation is directly correlated to progress. Many platforms – especially learning platforms – such as *Duolingo*[7] or *Memrise*[8], reward activity and progress with motivational gamification elements. For example, they use digital awards and leaderboards to visualize progress. Gamification describes the use of game design elements in a non-gaming context [41]. It is also a promising mechanism to increase the user's effectiveness [29].

Example

A successful visualization of progress can be found on the language-learning platform *Duolingo* (Figure 4.2). *Duolingo* is a free learning platform, where users progress through lessons in order to learn a foreign language [42]. According to a survey by Vesselinov et al. [43], 87.9% of the users enjoy learning Spanish with *Duolingo* and 78.8% are satisfied with it, which is a huge success.

[7] https://en.duolingo.com/
[8] https://www.memrise.com/

Duolingo motivates the users by permanently keeping them updated about their progressing skills showed through various visualizations. For instance, Figure 4.2 shows a bar, which demonstrates how far the user worked through a lesson, whereas Figure 4.3 shows the daily progress of a student. When a user hovers over a data point, it gets bigger and shows the exact achieved points. These chances of discovering effects make it fun to interact with *Duolingo's* interface. Furthermore, the platform implemented leaderboards where users can compare progress with their friends' progress.

Figure 4.2: Progress bar on *Duolingo*.

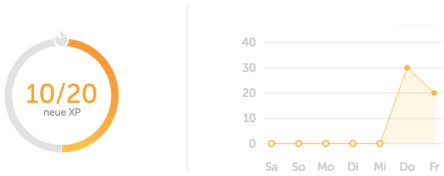

Figure 4.3: Daily progress on *Duolingo*.

Relevance

Keeping users informed about their achievements can be useful for CS platforms in order to motivate a continuous contribution. While gamification elements usually engage users in a gaming environment, they can also help to increase contribution in favor of more serious interfaces [29]. Gamification enhances user experience, as well as user engagement [41], which makes it a mechanism keeping motivation high. The platform *Foldit*[9] is not only a gamified citizen science platform, but rather a citizen science game. They developed a multiplayer online game, where players have to fold proteins into a chemically stable configuration, helping scientists to optimize proteins [44]. Additional to the opportunities gamification provides, unsolved challenges, such as integrating fun gaming-elements while ensuring quality of scientific data, have to be mentioned [45]. Boeser et al. note that gamification should on no account have an adverse effect on the data's quality. Especially scientists have concerns that quality and analysis suffer and people may not take a gamified CS platform seriously [45]. But how can be made sure that these are unjustified concerns? Quality defects can be avoided using build-in repetition elements, for example by having multiple contributors confirm new findings before they are accepted. This process could be achieved through *games with a purpose*, which are games benefiting from human-based computation in order to achieve an objective [46]]. It is very challenging to meet the preferences of every user type when integrating gamification elements [29]. There are users who prefer a

[9] https://fold.it/

more serious look and others who prefer a game-like interface. Finding ways to have a single interaction experience that appeals to both groups is a worthwhile goal [29].

4.3 Appreciation

Description

Feedback is essential in pursuing goals [47] not only through progress visualization but also through social appreciation. Barbara Moschner [48] released a publication about motivation for volunteer work where she examines altruistic and egoistic motives. Among other things she identified satisfaction of needs as a motivational factor. According to Moschner, social appreciation is an example for this satisfaction of needs reinforcing self-esteem. Within online platforms social appreciation can be received in different ways. The classic method is the like or favor button expressing a positive feedback to a specific content.

Example

Table 4.1 shows an overview of icons evaluating posts and content on collaborative online platforms. The icons are usually displayed in combination with a number representing how many users completed the corresponding action. Positive feedback can be seen as success, which leads to pride and a good feeling [48].

Relevance

Allowing social feedback to contributions of CS platforms is essential to intensify the interaction among users. Due to the fact that CS platforms host professional scientific content a heart icon, as it can be found on the *Digg*[10] platform, may be inappropriate. Furthermore, it is important to remind users why their task is important [30]. This can be done on a separate page explaining the projects goal or on a screen popping up after a contribution was uploaded.

4.4 User Profiles

Description

Nowadays, user profiles are virtually ubiquitous since people want customized environments and access services from different devices. For example the streaming service *Netflix*[11] provides a logged-in user with personalized movie and series recommendations. Or the social bookmarking service *Digg* provides

[10] http://digg.com/
[11] https://www.netflix.com/

Table 4.1: social reactions

Platform	Icon	Description
Behance	26	Expresses how many users viewed a post.
Digg	4	Describes how many users like a post.
Digg		Shows that a user saved a post or not.
Duolingo	3	Describes how often users ranked a post. Arrow up represents positive votes, arrow down negative votes. The more positive votes are counted, the higher the post displays.
Dribbble	12	Expresses how often users commented on a post. Can be positive or negative.
Flickr		Shows that a user favors an image post or not.
StumbleUpon		Describes that a user likes a post.
Twitter	7	Shows that a tweet has been retweeted.

its users with personalized news feeds based on the users interests. User profiles make it possible to identify a user no matter which device is being used and to provide him with his familiar environment.

Despite the advantages offered by profiles various users are cautious with providing personal data [49]. Therefore, privacy issues should not be forgotten while implementing user profiles. Additionally, it is important that users have the possibility to change their profiles anytime.

Since many people rather turn away than complete a registration, users should not be forced to create a profile in order to see a platform's content or integrated features. A similar phenomenon can be seen in context with e-commerce sites. As described in an article by the Nielsen Norman Group[12], the most common complaints within e-commerce usability research concerns registration [50]. Reasons for this include that some people dislike registration in general and are frustrated with remembering usernames and passwords for every sites they visit, while others associate registration with receiving unwanted emails. Guest users who receive access to content and features of a platform often register as soon as they feel comfortable with a website. Allowing guest user access to a platform is a great way to encourage participation of new volunteers on CS platforms [50].

Example

The business oriented social network *Xing*[13] accomplished the presentation of online profiles in an exemplary way (Figure 4.4). The main information about the user and his status become visible at a glance. Further facts are shown on several menu taps. The whole can see the activity of a user, which motivates him to keep activity high.

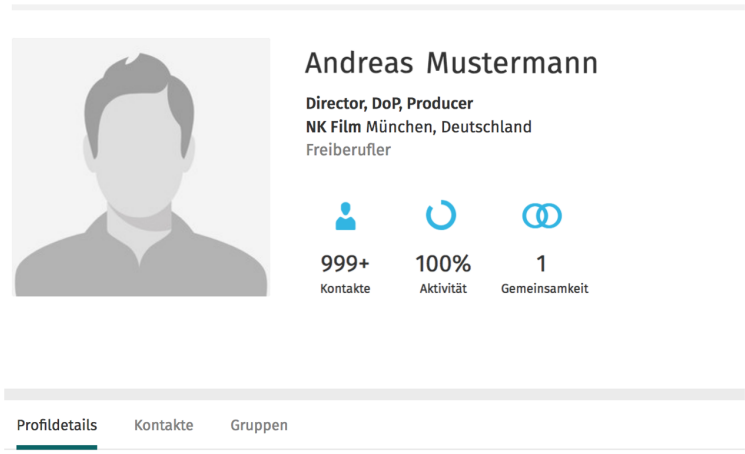

Figure 4.4: *Xing* profile.

[12] American computer user interface and user experience consulting firm.
[13] https://www.xing.com/app/startpage

Relevance

In terms of collaborative platforms Zhang and Dran [51] identified participant accounts as a satisfaction-factor. Nevertheless, many CS platforms enabling user profiles also allow to explore a project on an anonymous level without registration, but making some functionality inaccessible for them. Zhang and Dran mention *Galaxy Zoo*[14] and *Old Weather*[15], famous CS platforms, as examples where anonymous users are not listed in the leaderboards and are excluded from discussing findings. In fact, user profiles on CS platforms help track who developed an idea or contribution. Rotman et al. [52] investigated that volunteers of CS platforms are motivated by a complex framework of factors that are strongly affected by personal interests as well as external factors, such as attribution and acknowledgment. Listing the initial author and every author being involved in an article can motivate contributors, as they are proud of their results and receive public recognition for their achievements [52]. By means of profiles, citizen scientists can become organized research groups.

4.5 Communication

Description

Communication is essential to an interacting online community. People can interact, share ideas and respond to each other through private messages, or public discussion panels. Forums and chat tools help facilitate a sense of community and reinforce engagement by supporting further interactions between participants [53]. While chat tools and private messaging provide users with the opportunity of immediate contact to specific people, forums are a good way of discussing more general content [53]. Support and discussion forums are usually structured into different topics which are discussed by various users. The interface plays a major role on how people relate to each other and how they interact [35].

Example

A German support community implemented a clearly presented public discussion panel (Figure 4.5). The community *wer-weiss-was*[16] is a forum, where experts and other users can exchange knowledge, ask questions and discuss topics. *Wer-weiss-was* implemented a well-structured site classified into different topics. Thanks to its simple interface and the exemplary structure the platform is easy to understand. An overview shows the previously posted questions. This overview can be filtered by topicality, popularity and topic. Each

[14] https://www.galaxyzoo.org/?lang=en
[15] https://www.oldweather.org/
[16] http://wer-weiss-was.de/

question preview consists of three lines of text, a heading and a topic. Small icons show how many users visited a question and how many commented on it. The right upper side shows who the author is and when it was published. If somebody is interested in a question, this person can proceed to the whole discussion, which shows more details and comments.

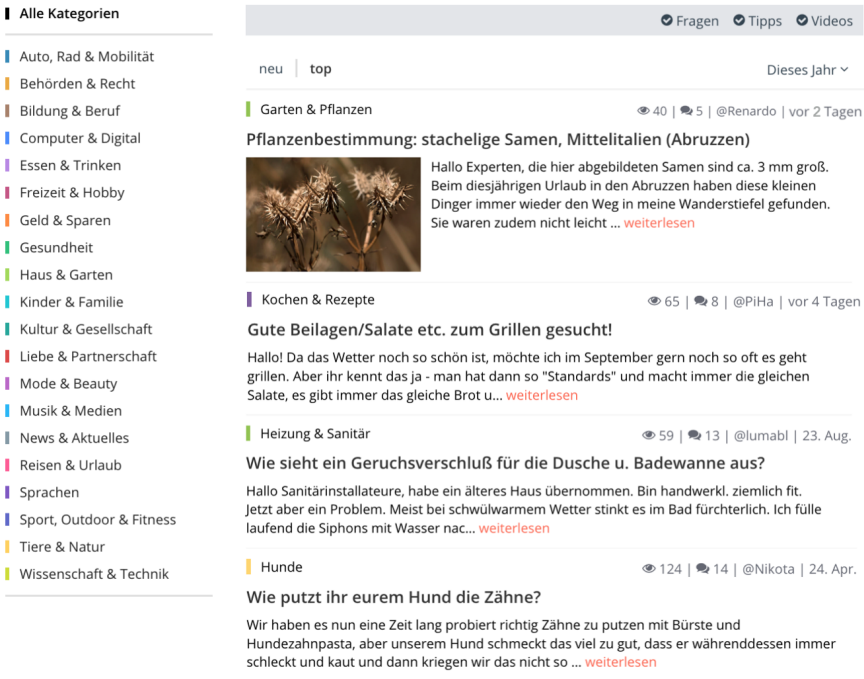

Figure 4.5: Question overview of *wer-weiss-was.de*

Relevance

Initiators of CS platforms should not neglect the importance of establishing a community of volunteers who share opinions, interact regularly, possibly using social media outlets and work collectively towards a common goal [3]. An interacting community requires that participants communicate. Given the fact that CS platforms work at a scientific level, the interaction between participants should be professional. Since public discussion panels are rather impersonal in contrast to personal messaging, they may be more suitable for the implementation of communication on CS platforms. In fact, public discussions keep science transparent, which can strengthens its credibility. Furthermore, users could use discussion panels to provide platform members with regular update information about projects [53].

4.6 Articles

Description

Collaborative online platforms visualize their produced content in different ways. For example, *Twitter*[17] displays the content through posts, called *Tweets*. The professional collaboration tool *Trello*[18] shows the visualization through so-called boards that contain lists of cards structuring the content. Another method for the visualization of content are articles: formatted text about a certain topic which is being generated by one or more users.

Example

Wikipedia[19] is an encyclopedia being generated and edited collaboratively [54]. It has become one of the most successful Internet experiments in collaborative knowledge [55]. The idea is that any user, even those without an account, can change and create articles, which are immediately viewable to every visitor. Although vandalism, inaccuracies, user disputes, and other quality issues do exist on *Wikipedia*, most of the content is of high quality, as discovered by the journalist Jim Giles [56]. The good structured versioning and editing system (Figure 4.6) provides the ability to track the status of articles, review individual changes, discuss issues and edit articles. The system stores every version of an article edited, so that no content can be permanently lost [54]. Figure 4.6 shows the editing view of an article on *Wikipedia*. It is similar to any editor's interface, which makes interaction intuitive. The *View history* tab shows all article versions allowing users to filter and compare them.

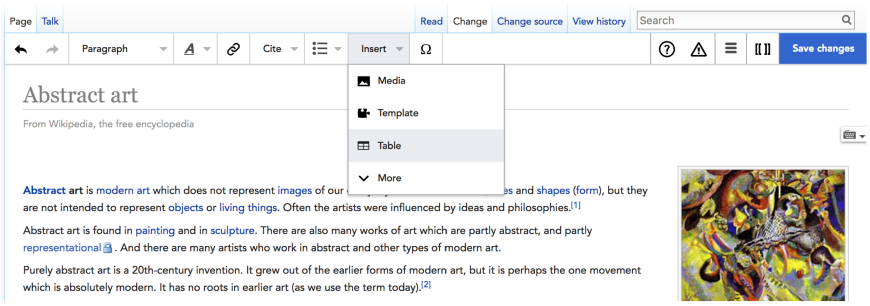

Figure 4.6: Editing *Wikipedia* Articles.

Relevance

Articles, as they are described in the last paragraph, are a good way to structure scientific contributions on CS platforms. Similar to *Wikipedia*, CS platforms aim to collaboratively generate scientific knowledge.

[17] https://twitter.com/
[18] https://trello.com/
[19] https://en.wikipedia.org/wiki/Wikipedia

4.7 Levels of Contribution and Responsibility

Description

Contribution within projects differ from one individual another. For instance, some people are willing to accept supervision while contributing, whereas others see themselves as mentors or coaches shaping an organizational direction. These different types of contributions are described in the model *The Four Stages of Contribution* based on the research of Gene Dalton and Paul Thompson [57]. The model refers to the different stages of contribution within organizations. According to Dalton and Thompson, organizations need every stage of contribution: individuals supporting others and learning through them (stage 1), individuals establishing and applying expertise (stage 2), individuals guiding, coordinating others (stage 3) and individuals supervising and shaping organizational direction. Of course it is possible to increase one's impact and influence over time if it corresponds to the objective of the organization [57]. Outsourcing parts of a platform's maintenance by transferring responsibility to its members reduces the operator's tasks and at the same time ensures levels of responsibility. For instance co-option, the mechanism where certain members of a group decide upon additional memberships, is a process giving more responsibility to members of online platforms.

Example

Allowing different levels of contribution is necessary for collaborative projects. This is an important insight gained by the study of Nov et al. [3]. Many contributors want to start on a low level granularity and increasingly proceed to more demanding responsibilities. A few community-based projects, such as the open source platform *Wikipedia*, have realized this a long time ago. They allow interested contributors to progress in the ladder of responsibilities[20]. For instance, any visitor of *Wikipedia*, as long as they are not blocked, can edit articles. A user with a *Wikipedia* account who has been registered for four days or longer and has made at least ten edits gains the ability to move articles and to edit semi-protected articles. Another level of responsibility is the administrator. Administrators have been approved by the community, and have access to some significant administrative tools: they have the possibility to delete articles, block accounts or IP addresses and edit fully protected articles.

Relevance

CS platforms can also benefit from different levels of contribution and responsibility. To keep the administrative overhead of a CS platform low, users have to propose interesting research questions and organize topics and groups them-

[20] https://en.wikipedia.org/wiki/Wikipedia:About

selves. People contributing frequently for a long time are more reliable to a platform then others. After a period of qualitative work members should be able to increase their impact and influence. For example they can become group leaders, with the ability to create new research groups or to remove members working against the platform's aim. Currently, volunteer user of CS projects are often restricted in their scope [3]. The governance and decision making is usually left in the hands of scientists managing the projects. For instance volunteers of the CS project *FeederWatch*[21] can only contribute by counting birds they see at their feeders from November through early April. The collected data helps scientists track broad scale movements of winter bird populations and long-term trends in bird distribution and abundance. Nov et al. [3] affirm that greater empowerment of volunteers will be inevitable as digital citizen science develops, and the competition over volunteer resource increases.

4.8 Topicality

Description

Zhang and von Dran [51] identified up-to-date information on websites as a satisfying feature. People want to know about breaking news. Therefore, displaying current development is essential to keep users engaged. Current news or content of a platform can be shown in different ways. For example, *Netvibes*[22], a dashboard to follow the news feed of social networks or online news, provides different methods to sort the incoming content. It is possible to display the news feed of each source separately, classified into self-generated categories or without any categorization. Social media timelines, however, usually display the latest content without any categorization. A single stream keeps users on the latest state of postings. The postings are sorted in reverse chronological order with the most recent contributions shown first. Estes et al. [58] observed that although some people prefer content which is sorted by source, the time-ordered stream predominantly matches user expectations. Moreover, users usually do not seek past posts that they might have missed, but they are satisfied reading only the latest information [58].

Example

The popular microblogging platform *Twitter*[23] is one of the most popular platforms providing users with news. An important characteristic of the platform is its real-time nature [59]. Once logged-in, *Twitter's* frontpage shows recently

[21] http://feederwatch.org/
[22] http://www.netvibes.com/en
[23] https://twitter.com/

posted content in its timeline (Figure 4.7). A user can control which content is being displayed on the timeline by following other *Twitter* accounts. The timeline is sorted by topicality. A *Tweet* includes the time it was published and the author. *Tweets* that have been *retweeted* by another person have a small icon highlighting the post.

Figure 4.7: Timeline on Twitter.

Relevance

Contributors of CS platforms want to stay up-to-date, especially when they contribute to a certain project. Therefore, it is useful for CS platforms to integrate a timeline showing recent contributions. The timeline should also allow a categorization by research topics, enabling users who are only interested in the development of a specific topic to see its development at a glance.

4.9 Further Development and Outlook

The different elements elaborated in this chapter represent functional components of platforms supporting *co-created CS projects*. This list can be extended by additional components. In case of an extension, the design process would proceed analogously: other collaborative platforms with similar components have to be identified. If design patterns and conventions relating to this components can be found, they should be applied and best practices should be followed while implementing these functional elements in the context of platforms supporting *co-created CS projects*.

Usually the interface of a platform is designed during its conceptualization. This is assumed in terms of this design approach referring to platforms supporting *co-created CS projects*. For each CS project the general design approach possibly has to be adapted in order to individually improve the platform. Before the approach can be applied to a platform its initial state has to be examined: whether the platform is currently being conceptualized or whether it already exists, which components the platform requires or whether functionalities have to be improved.

The next chapter introduces ARTizen, the CS platform that was the motivation for this thesis. ARTizen's visual revision (Chapter 4) will demonstrate this design approach applied to a concrete example.

5 The ARTizen Platform

ARTizen is an already existing CS platform [60]. This means that many functional components described within the design approach are already implemented. Therefore, the existing components and functionalities need to be improved rather than created. The interface requires further development in order to create an intuitive platform, meeting user expectations. Revising ARTigo's interface requires understanding its concept and objectives. In the following sections these two issues are addressed.

5.1 Concept and Objectives

ARTizen is a CS platform providing a framework for a collaborative analysis of art history by means of data science. The platform allows contribution to any volunteer who is interested in investigating art history, sharing ideas with the public and discussing them. It is a user-generated content platform, motivating contribution to an online CS project.

Figure 5.1 shows the basic structure of ARTizen. **Users** of the platform can sign up and create a profile or visit the platform anonymous. Among other things user profiles help to identify a user and provide a personalized environment, as described in Section 4.4. Logged-in users can become members of projects in which a group of people works collaboratively on a research question (see Section 4.1). Users who have gained trust and responsibility on ARTizen can even start new projects, choosing a title and a related research question. A project called *natural phenomena* could for instance respond to the question whether natural phenomena are reflected in the art of an era. Moreover, it is important to mention that projects can be private or public, enabling users to ensure accuracy and precision of their findings before publication (see Section 4.1). Public as well as private projects are visible to everybody. Any user with a profile can join public projects, whereas private projects require a confirmed membership request. Working on a project's research question means analyzing data followed by a development of findings and conclusions. This process is being elaborated within contributions. Contributions can be compared to *Wikipedia* articles, which are described in Section 4.6. A significant difference is that a user can only write contributions to a project after becoming a member of this project. A project can have various contributions that produce the main content of ARTizen. Furthermore, users can **comment** on contributions, which is an essential feature ensuring a dynamic and collaborative development of findings. ARTizen even provides the possibility to include external data from applications, such as ARTigo and the Analytics Center. The next section introduces the applications supporting ARTizen.

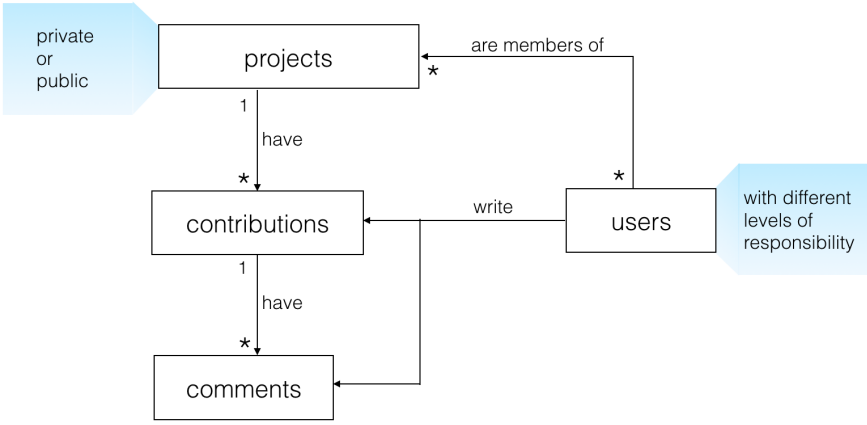

Figure 5.1: The structure of ARTizen.

5.2 Supporting Applications

ARTigo is a social image tagging platform initiated by several institutes of the University of Munich [61]. The platform was developed in order to build a semantic search engine for rediscovering artwork by their semantic tags. It includes a huge database of artworks including more than 65,000 images with most of the artworks coming from the long 19th century. The Britain historian Eric Hobsbawm defines this time as the period between 1789 and 1914, dominated by the age of the revolution [62], the age of capital [63] and the age of empire [63]. Although technological possibilities of describing the content of images are still limited, ARTigo found a possibility to create semantic tags referring to its artworks by means of human computation and gamification. Due to volunteers playing games with a purpose (see Section 4.2), the stock of semantic tags on ARTigo increases. Users of ARTigo benefit from the semantic image search engine that is constantly improving through their tags. The growing amount of games on the platform collects diverse tags characterizing ARTigo's images.

Analytics Center is a first attempt to enable data science on ARTigo's tag data, as described by Florian Hoidn [64]. It allows users to draw conclusions about artistic trends within certain eras and identify clusters or interesting associations and similarities between motives [64]. The Analytics Center represents a query interface to the tags stored in ARTigo's database. It offers the following five different query interfaces:

- *Frequency Graphs*
  A frequency graph indicates the frequency of a requested tag. The request can contain logical operators such as *and* or *without* which makes more specific requests possible. The result of an example query can be seen in Figure 5.2.

- *Poisson Overdispersion*
  The Poisson overdispersion reflects whether a tag is significant or not. The results are either presented on a time series plot or as an overall value.

- *Association Rules*
  The associative rule $X \Rightarrow Y$ indicates the probability that images tagged with set X are also tagged with set Y.

- *Neighborhood Analysis*
  The Neighborhood Analysis indicates the similarity of tags to the queried tags. It is represented in a vector space. The closer tags are in the vector space the more similar they are.

- *Clustering*
  Clustering detects a set of tags contained in a cluster with the queried tag. The tags do not necessarily have to be similar, they are only part of the same cluster.

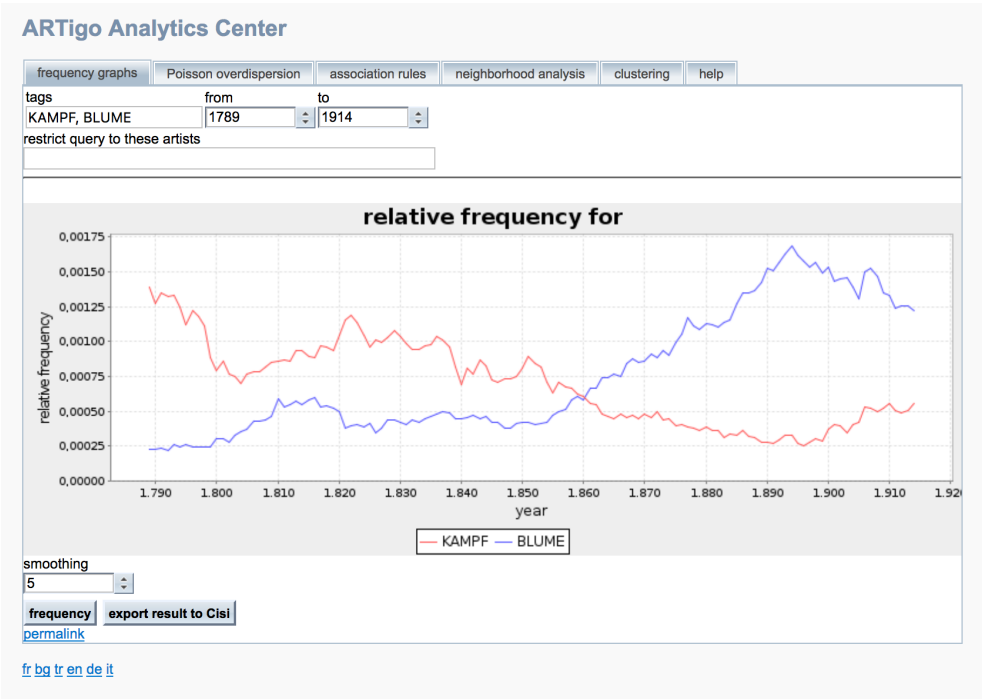

Figure 5.2: The Frequency Graph of ARTigo's Analytics Center showing the query for the German tags *Kampf* and *Blume* (battle and flower).

Interesting findings related to ARTigo's database can be gained by employing the Analytics Center. These findings can be captured developed and discussed on ARTizen. The platform attempts to transfer the CS spirit already presented during the tag creation process of the ARTigo games [60].

5.3 WordPress Architecture

ARTizen is realized through *WordPress*, a widespread *CMS* on the Internet. *WordPress* uses a number of different programming languages and standards, with *PHP* covering most of the code. *PHP* is a server side programming language powering about 82% of all web pages [65]. Besides *PHP*, *WordPress* also uses *HTML*, *CSS* and *JavaScript*. *HTML* is responsible for the site's structure, whereas *CSS* is a style sheet language designing the structure given by the *HTML* code.

WordPress is a powerful tool to develop all kinds of websites. It is roughly organized as follows: each site is displayed by a template file. Templates are invoked by themes, which can be downloaded from various online sources or developed individually. They can also be modified or extended. *WordPress* themes interact with plugins which can add functionality or new features to a *WordPress* website.

While this chapter provided a general overview of ARTizen, the following chapter's aim is to present ARTizen's interface revision.

6 ARTizen: Implementation

As mentioned previously, many components described within the design approach are already implemented in ARTizen. Therefore, only their appearance and presentation have to be modified and improved in order to ensure user experience. Some pages of the platform needed complete reimplementation, while other pages could be improved by minor changes. This implementation focuses on those components found within pages that are frequently visited by users or that offer access points to other pages and thereby have a greater impact on the platform's user experience.

This chapter in particular describes the major changes made during ARTizen's revision. Adjustments such as removing redundant text and incorrect terminology, adding a new font, changing the size property of certain images in the database, ensuring browser compatibility, enhancing *CSS* elements on the entire site and other minor issues are not going to be addressed any further. Nevertheless, these changes have contributed to a uniform look and feel of the platform and to a much better overall user experience.

6.1 Overview pages

One of the major changes while redesigning ARTizen's user interface are the overview pages: the contribution overview, the project overview and the member overview. The overview pages share same style elements but nevertheless, they are clearly distinguishable from each other. The visual distinction of the different types of overview pages is of great importance since it simplifies user orientation. The user immediately memorizes the appearance of each overview page and therefore does not confuse the platform's components.

Contribution

Figure 6.1 shows the initial contribution overview that can be reached through the main navigation bar. The contributions are listed with their properties, such as author or title, split into columns. Although the list is very clear, it seems outdated and does not appeal.

The new contribution overview (Figure 6.2) was inspired by various post overviews of creative sites, such as *Behance*[24] or *Dribbble*[25]. Each box within the overview represents a contribution including its properties, starting with the contribution's title followed by the project in which it was published and its project image. Furthermore, each contribution box shows how much feedback and reactions the contribution caused: two icons depicted on the bottom right side

[24] https://www.behance.net/
[25] https://dribbble.com/

of each box are indicated with numbers. The number next to the star declares how many users favor the contribution, whereas the number next to the speech bubble declares how often the contribution has been commented on. If the number counts zero, the icons are not colored. Enabling users to express positive feedback to content on CS platforms help to convey the feeling of appreciation, as examined in the design approach (see Section 4.3). This, however, increases user motivation. The contributions in the overview can be sorted by various properties: for example by project, author or title. The previous design approach (Section 4.2) emphasizes the importance of an interface that appeals to both: users preferring a simple look and those preferring a more creative appearance. As there may be users preferring the original overview page, this rather technical view is still accessible by clicking the list icon next to the grid icon in the upper right corner. The grey background indicates whether the grid or list view is active.

Project

The initial project overview is shown in Figure 6.3. It includes a simple list, which can be presented in a more user friendly and creative way. Furthermore, the list wastes a lot of space in the middle of each line.

The new project overview (Figure 6.4) resembles the contribution overview. Each box of this overview represents a project containing an image and further details about the project. The project image floats to the left side of the box, whereas the right side shows details about the project. If a user is logged-in, a button is shown allowing to join or leave a project. If the *leave project* button is pressed, this decision has to be confirmed within a pop-up window. The number beside the star on the right side of the box indicates how many users favor the project.

Member

The last initial overview page (member overview) is shown in Figure 6.5. It resembles the simple list of the initial project overview. The member overview has been re-implemented for the same reasons as the project overview.

Figure 6.6 shows the new member overview. Each box includes a profile image, a name and the moment of the member's latest activity. As long as the screen is wider than 755 pixels, the member boxes are displayed in three different columns.

Most *WordPress* overview pages are realized through *PHP* files displaying an array of content in a loop. These loop files are invoked by template files. This mechanism

is also used to display ARTizen's contribution, project and member overview. The loops extract the required data from the database and display it in place of each template tag. A template tag is simply code that extracts data from the database. Editing loops can be realized in different ways. With small adjustments it is common to use so-called hooks. *WordPress* hooks allow adapting themes or plugins using short snippets of code without modifying the original files. For instance the *loop_end* action hook fires after the last post of the *WordPress* loop is processed. If the basic loop-structure needs to be changed, the usage of hooks is not sufficient. In this case the default loop needs to be replaced by a complete new loop implementation. When implementing a new, individual loop, developer need to pay attention to hooks within the original code. Some plugins or functions rely to these default hooks. If they are not integrated into the new code, functionalities may stop working or the whole site may crash. ARTizen's new loop files mainly contain a combination of *PHP* and *HTML* code. The *HTML* code refers to many well-considered *CSS* classes. Some effects are achieved by *CSS* and *JavaScript*. These are only visible while interacting with the interface. A detailed description about these effects can be found in Section 6.5. As previously mentioned, contributions can be sorted by various properties. The sort functionality was realized by passing variables via *URL*. The page stores the *orderBy* variable and a variable indicating the sorting order ascending or descending. The default order is by latest activity. In order to customize the number of contributions per page the loop query had to be adjusted.

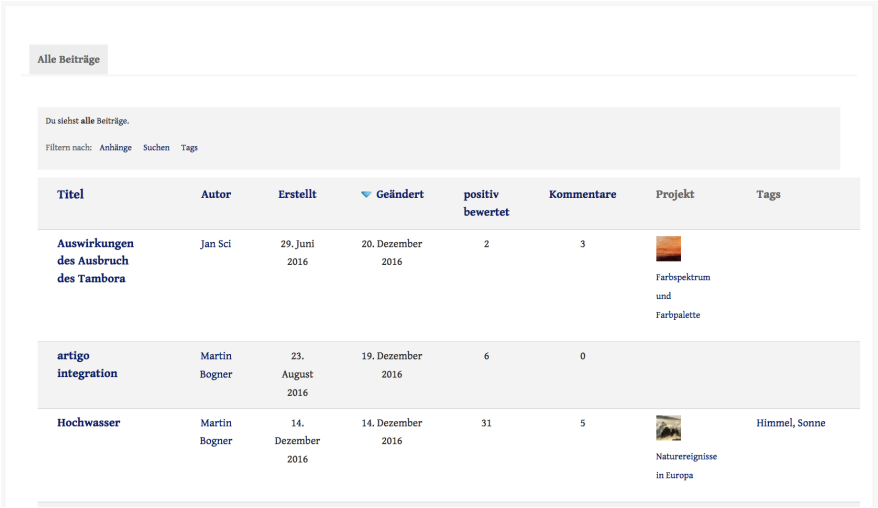

Figure 6.1: Initial contribution overview of ARTizen.

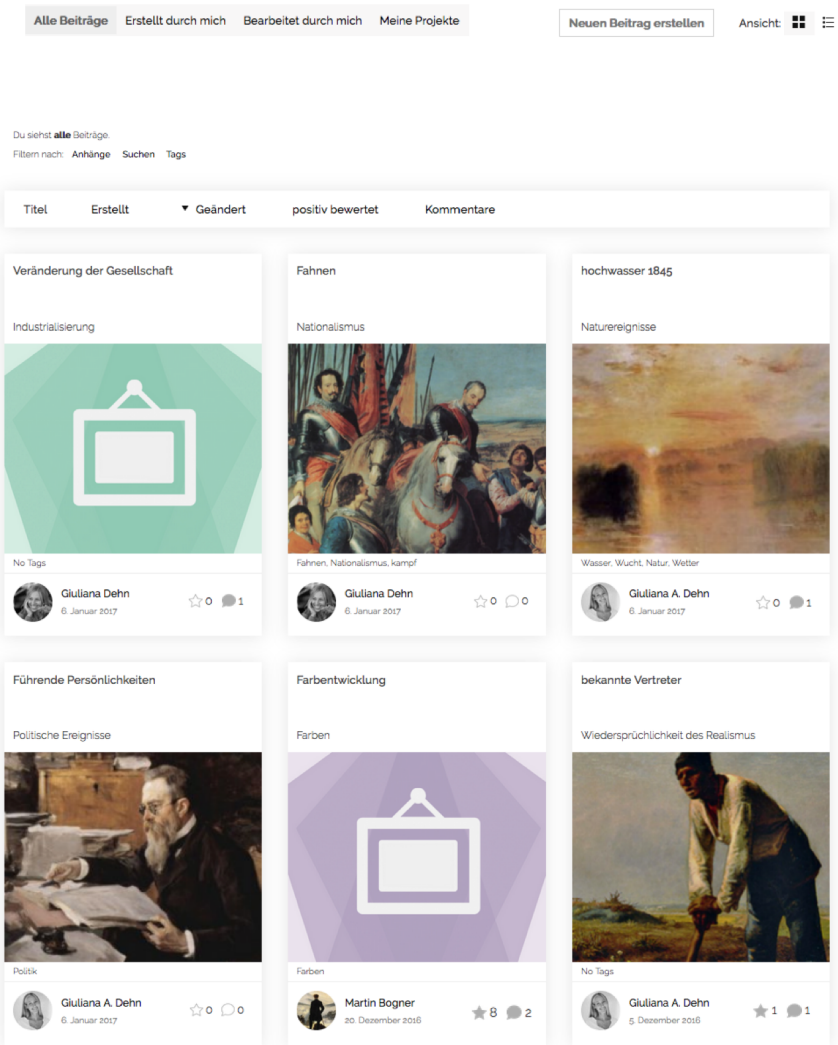

Figure 6.2: Contribution overview of ARTizen.

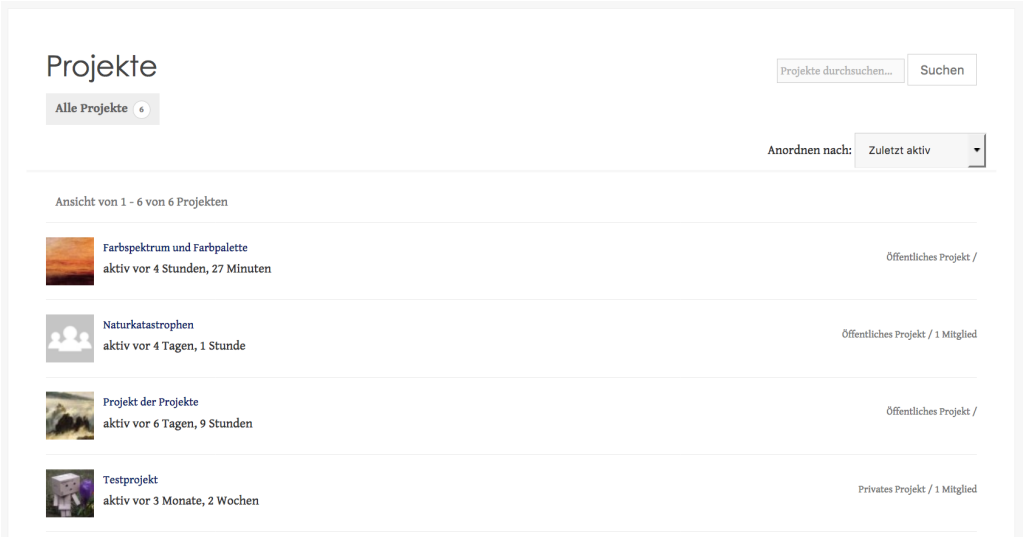

Figure 6.3: Initial project overview of ARTizen.

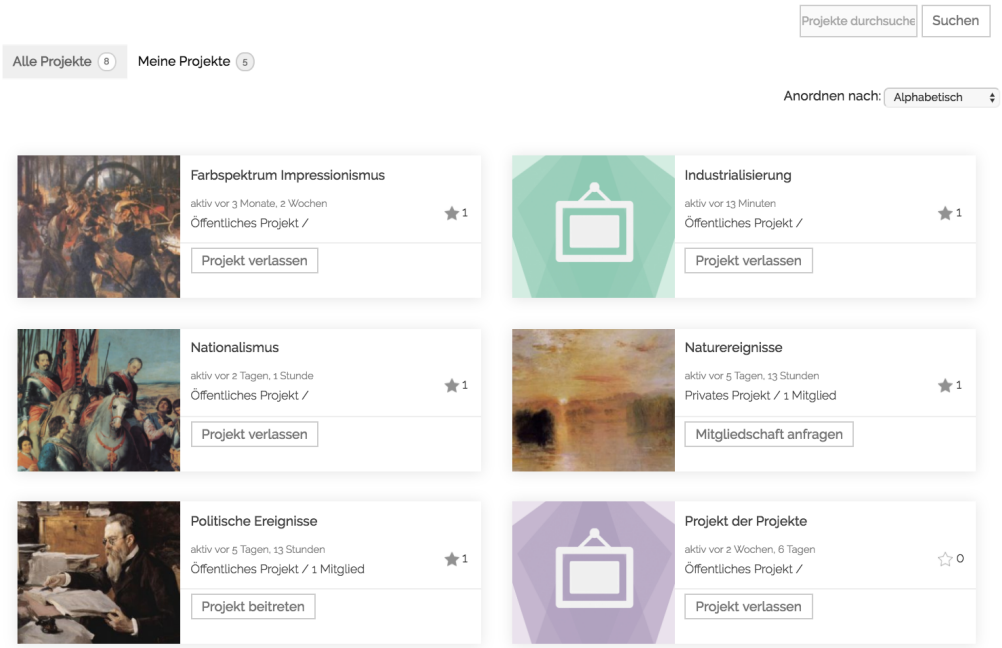

Figure 6.4: Project overview of a logged-in user of ARTizen.

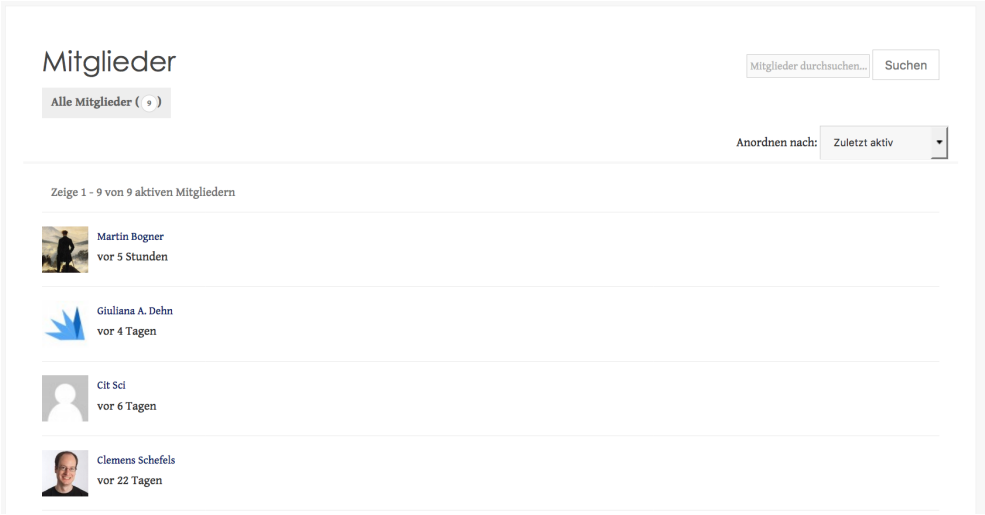

Figure 6.5: Initial member overview of ARTizen.

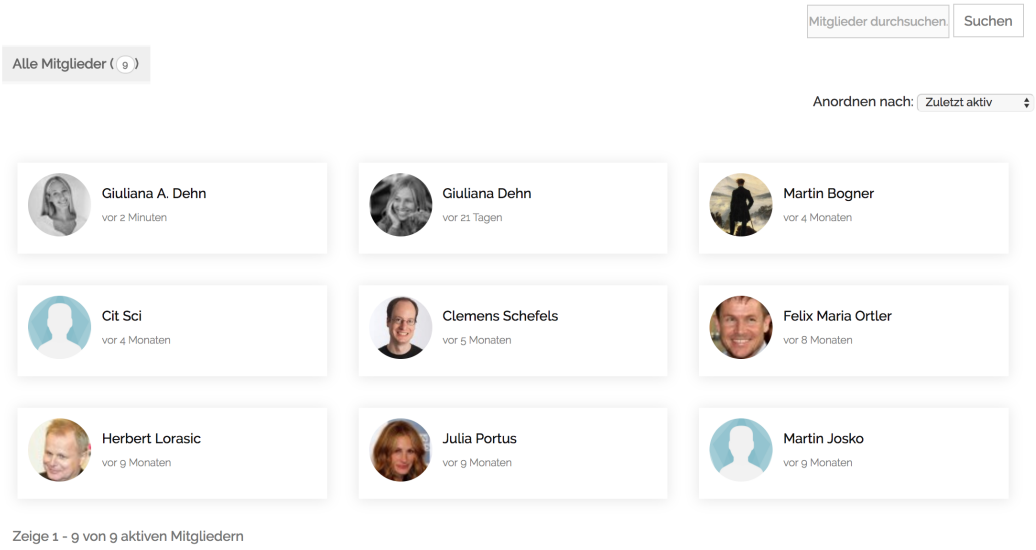

Figure 6.6: Member overview of ARTizen.

6.2 Static Pages

ARTizen includes a few static pages, which, for example, provide information about the project or explain the platform's workflow. These static pages are all structured in a visually homogeneous way.

Homepage

A person who visits ARTizen will initially be led to the homepage. Since the original homepage already represented a suitable access point to the platform, only minor adjustments were made in order to matches the design of the remaining pages (Figure 6.7). As outlined in the design approach (see Chapter 4) the first impression is elementary for user experience. The homepage should avoid overload and offer links which lead to sites describing the platform's project.

The Platform

The page describing the platform can be accessed through the main navigation bar or by using a link on the homepage. It explains ARTizen's idea and intention. It also emphasizes that the platform needs the help of volunteers to succeed in its objectives. As described within the design approach (see Section 4.3), it is important to explain the great importance of the volunteer work in order to make the platform's contributors feel appreciated.

Participate

The *participate* page can also be reached through the main navigation menu or through a link on the homepage. This page gives the user a comprehension of the platform's functionality. The idea is to upload tutorials and/or instructions to this area explaining ARTizen's workflow.

Netiquette

The *netiquette* page which is shown by Figure 6.8 is structured identically as the *participate* and *platform* pages. The netiquette page outlines rules of conduct to ensure a respectful interaction between the users.

The static pages on ARTizen are build using template files written in *HTML* and *PHP*. They can easily be edited by changing their template file in ARTizen's backend and by modifying the code of the relevant template file within the active template folder.

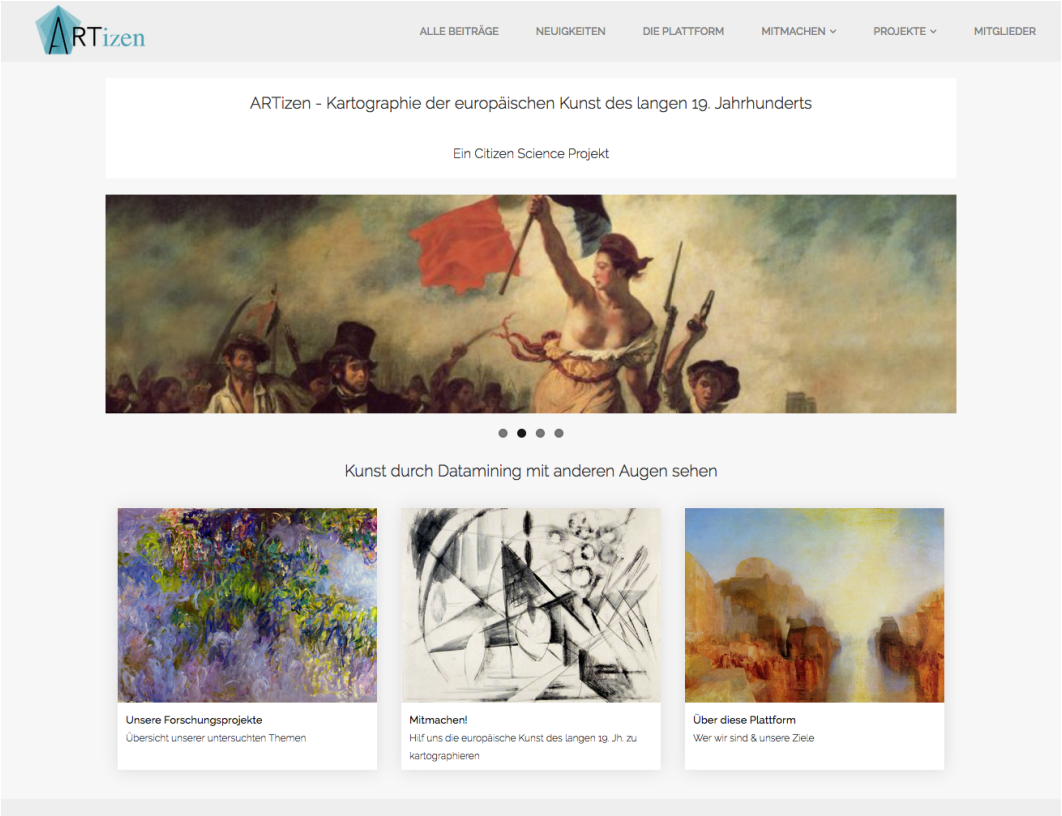

Figure 6.7: ARTizen's homepage.

Figure 6.8: ARTizen's netiquette page.

6.3 Login

The initial login screen hardly differed from the default *WordPress* login screen. In terms of the platform's revision the login interface was modified in order to match the remaining pages. The current screen can be seen in Figure 6.9. Moreover, the *login* and the *register* button were initially in the upper left corner. These buttons are now shown in the upper right corner since this is where users would expect them to be[26].

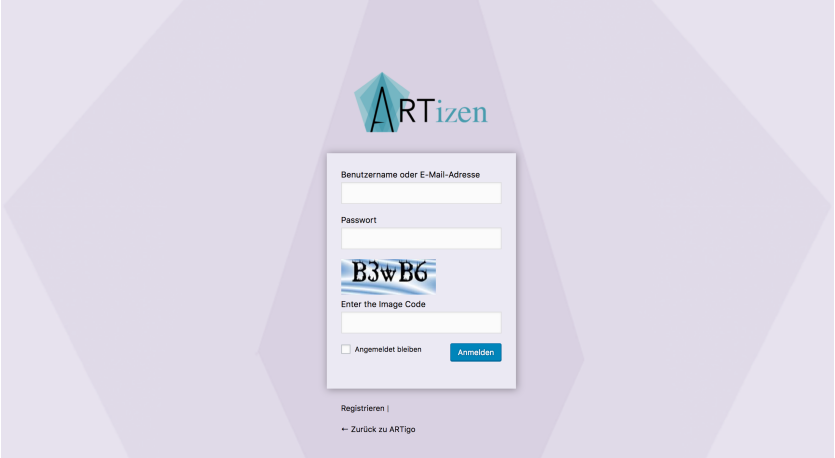

Figure 6.9: ARTizen's login screen-

6.4 Graphic Design

To increase the recognition value of ARTizen a website favicon was designed. The idea was to create something artistic and creative representing the site. A blue diamond (Figure 6.10, 6.11) emerged as result of this work.

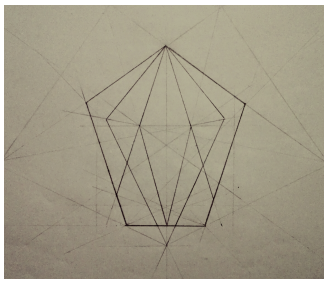

Figure 6.10: Final sketch ARTizen icon.

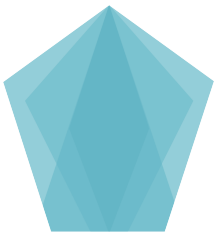

Figure 6.11: ARTizen icon.

The diamond is also integrated to the platform's logo complying the "A" of ARTizen (Figure 6.12). The letters of the logo resemble the letters of the ARTigo logo, which expresses a connection between those two platforms. It is also used as the login background image, as shown in Figure 6.9.

[26]compare with common social media platforms such as: Facebook, Twitter, Flickr, etc. .

Figure 6.12: ARTizen logo.

Moreover, the diamond was used as a basis for the sites placeholder images. If a user does not upload a profile image, he will receive the diamond avatar image which can be seen in Figure 6.13.

Figure 6.13: ARTizen's placeholder image for users.

A project without a cover image also receives a diamond avatar – with the difference that this avatar can adopt different colors (Figure 6.14). A square sum based on a project's title decides which avatar is displayed. This calculating process simplifies the programming effort considerably since no additional color parameter has to be stored for each project. The project's title represents a good computational basis, as it usually does not change. If a title changes nevertheless, a new color indicates this development. The different colors also lead to a clearer interface because the project images play an important role in the contribution overview (Figure 6.2) where colors help to recognize coherence at a glance.

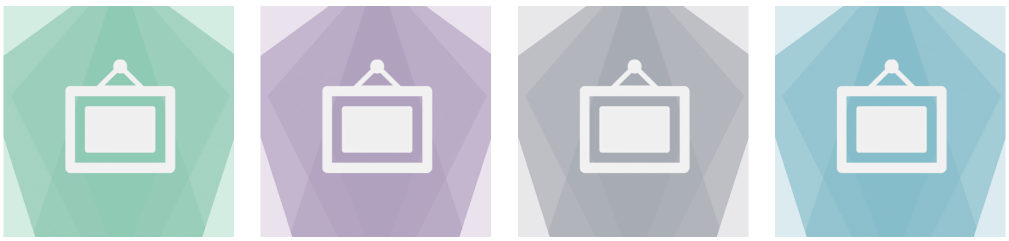

Figure 6.14: ARTizen's placeholder images for projects.

6.5 Dynamic Interaction

An enjoyable interaction with the interface of a web page is essential for user experience. On the one hand the interface has to be intuitive, simple and easy to understand, but on the other hand it is nice to surprise the user with small animation effects. These effects should never overstrain the user rather than subconsciously transmit a fun experience.

In terms of ARTizen's revision a few effects to certain images were added. If a user hovers over these images, they get lighter and smoothly scale up to 104 %. This effect is added to project images within the overview pages and to a few images that can be found within the static pages. Other images and icons, such as profile images or the speech bubble icon and the favor icon from the contribution overview page, merely change their brightness on hover. Another effect implemented during the platform's revision is the *hideMe* effect. This effect achieves a scroll related animation letting each content box of an overview pages appear when one third of the box would be visible. This creates a dynamic scroll sense on the pages that motivates the users to explore the content. The effect is implement with the aid of *JavaScript* and *jQuery*. *JQuery* currently is one of the most popular *JavaScript* libraries [66]. The open source library helps developer to create animations, handle events, and develop *Ajax* applications while supporting the mainly used browsers[27] [67].

6.6 Navigation

ARTizen is a platform where findings are not only shared but also gained and developed. It is a working environment that requires easy interaction and navigation, so that users can work on their projects efficiently. It is essential that users can quickly orientate themselves and navigate to desired pages.

The platform's main navigation is a classic horizontal navigation bar sticking to the top of the website. The menu points float to the right side, whereas and the left side is filled with the sites logo. Clicking the logo navigates the user to the homepage. The main navigation includes a few drop-down menu points which can easily be expanded when required. Plain Colors are chosen to keep the site harmonious. Horizontal navigation bars are possibly the most common menus, which ensure intuitive interaction. ARTizen's original main navigation was displayed after a big header image covering space at the top of the page. In order to keep the site simple and to preserve the top space for the main navigation the initial header was removed.

[27] Chrome, Edge, Firefox, Safari, Current and Opera.

6.7 Responsive Design

Mobile devices have become increasingly popular in recent years. According to StatCouter [68], a research company that tracks Internet usage based on more than three million global websites, 51.3% of all web visits in October 2016 came from mobile devices compared to 48.7% coming from desktops. Mobile Internet usage exceeds desktop for the first time. This development requires responsive design enabling a single website to adapt layouts of different devices [69]. Responsive design leads to a more satisfying experience for users [69]. ARTizen required additional *CSS* code referencing to different screen sizes in order to adapt to mobile devices and tablets. Figure 6.15 shows ARTizen screenshots on different sized mobile devices.

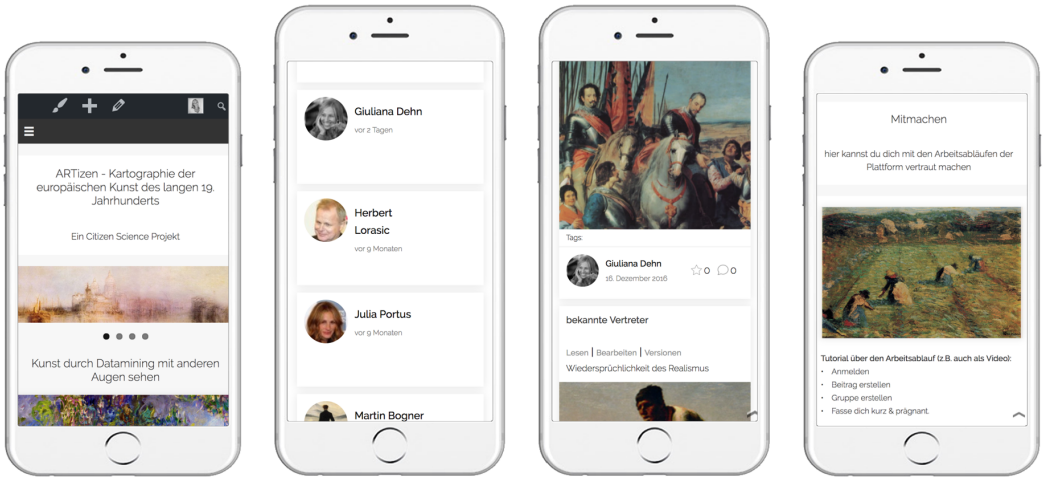

Figure 6.15: ARTizen screenshots on different sized screens.

7 Conclusion

This thesis provides a detailed design approach for CS platforms that involve their contributors during multiple stages of the scientific research process. The developed approach can improve existing CS platforms as well as support the design of new CS platforms. An implementation of the theoretical concepts based on ARTizen makes them more comprehensible and emphasizes the flexibility of the presented approach.

In conclusion, the investigation has shown that it is very difficult to create a general design approach ideally applicable to any CS platform since every CS project has individual resources, requirements and objectives. It is rather important to convey a concept which can be adapted to individual cases.

8 Future Work

It is important to be aware of the continuous process of adjustments while implementing a complex online platform. The technical components should always be state-of-the-art. In the context of ARTizen this implies that after a *WordPress* upload plugins should immediately be adjusted in order to ensure a smooth and bug free interaction within the platform. Furthermore, it is essential to observe how the platform is adopted by its users and whether some functionalities are not used, or if others require revision.

As stated in Section 4.4, mobile devices have become very popular in recent years therefore the implementation of a mobile version of ARTizen or even a mobile application in order to reach a wider audience of participants [27] should be focused on.

Another arising research topic involves how to draw the greatest attention for CS platforms. This requires a detailed examination of the project's target group. Social media communities have a high potential for spreading project ideas and receiving attention by a wide audience. Christine Robson [39] investigates how social networks can be used for recruitment and promotion of a citizen science projects. Her results are based on a series of campaigns promoting the CS platform *Creek Watch*, including a participation campaign through local organizations, and a social networking campaign through Facebook and Twitter. According to Robson, social media campaign represents a worthwhile method to increase the awareness of a project and reach participation goals.

References

[1] Jeffrey P. Cohn. Citizen science: Can volunteers do real research? *BioScience*, 58(3):107–192, 2008.

[2] M. Jordan Raddick, Georgia Bracey, Karen Carney, Geza Gyuk, Kirk Borne, John Wallin, Suzanne Jacoby, and Adler Planetarium. Citizen science: status and research directions for the coming decade. *AGB Stars and Related Phenomenastro 2010: The Astronomy and Astrophysics Decadal Survey*, 2010:46P, 2009.

[3] Oded Nov, Ofer Arazy, and David Anderson. Dusting for science: motivation and participation of digital citizen science volunteers. In *Proceedings of the 2011 iConference*, pages 68–74. ACM, 2011.

[4] Nathan R. Prestopnik and Kevin Crowston. Citizen science system assemblages: understanding the technologies that support crowdsourced science. In *Proceedings of the 2012 iConference*, pages 168–176. ACM, 2012.

[5] Tom Steward. Econsultancy. Usability or user experience - what's the difference ? https://econsultancy.com/blog/2321-usability-or-user-experience-what-s-the-difference/. Accessed: 2016-27-07.

[6] Marc Hassenzahl and Noam Tractinsky. User experience-a research agenda. *Behaviour & information technology*, 25(2):91–97, 2006.

[7] Ping Zhang, Ruth V. Small, Gisela M. von Dran, and Silvia Barcellos. Websites that satisfy users: A theoretical framework for web user interface design and evaluation. In *Systems Sciences, 1999. HICSS-32. Proceedings of the 32nd Annual Hawaii International Conference on*, pages 8–pp. IEEE, 1999.

[8] The Wall Street Journal. Five classic nokias we loved—and two we didn't. http://blogs.wsj.com/tech-europe/2013/09/03/five-classic-nokias-we-loved-and-two-we-didnt/, 2013. Accessed: 2017-10-1.

[9] HTC. 7 web design conventions you should never break. http://blog.htc.ca/2013/09/03/web-design-conventions/, 2013. Accessed: 2017-10-1.

[10] Netaccountant. 10 web design conventions that will make your website as good as amazon.com. http://netaccountant.net/website-design-for-accountants/web-design-conventions/, 2010. Accessed: 2017-10-1.

[11] Browser statistics. https://www.orbitmedia.com/blog/web-design-standards/, 2017. Accessed: 2017-10-1.

[12] Alexandre N. Tuch, Eva E. Presslaber, Markus StöCklin, Klaus Opwis, and Javier A. Bargas-Avila. The role of visual complexity and prototypicality regarding first impression of websites: Working towards understanding aesthetic judgments. *International Journal of Human-Computer Studies*, 70(11):794–811, 2012.

[13] Elizabeth Sillence, Pam Briggs, Lesley Fishwick, and Peter Harris. Trust and mistrust of online health sites. pages 663–670, 2004.

[14] Peter Finke and Ervin Laszlo. *Citizen Science: Das unterschätzte Wissen der Laien.* oekom, 2014.

[15] Paul F. Grendler. *The Universities of the Renaissance and Reformation.* Renaissance Quarterly, Vol. 57, No. 1 , pp. 1-42, The University of Chicago Press on behalf of the Renaissance Society of America, 2004.

[16] Peter (HRSG.) Finke. *Freie Bürger Freie Forschung - Die Wissenschaft Verlässt den Elfenbeinturm.* oekom, 2015.

[17] Lancelot Thomas Hogben, James Francis Horrabin, and Richard Palmer. Science for the citizen. 1938.

[18] Oxford Dictionary. New words notes june 2014. http://public.oed.com/the-oed-today/recent-updates-to-the-oed/previous-updates/june-2014-update/new-words-notes-june-2014/. Accessed: 2016-23-07.

[19] Bruno Latour and Steve Woolgar. *Laboratory life: The construction of scientific facts.* Princeton University Press, 2013.

[20] Hauke Riesch and Clive Potter. Citizen science as seen by scientists: Methodological, epistemological and ethical dimensions. *Public Understanding of Science*, 2013.

[21] Barry M. Leiner, Vinton G. Cerf, David D. Clark, Robert E. Kahn, Leonard Kleinrock, Daniel C. Lynch, Jon Postel, Larry G. Roberts, and Stephen Wolff. A brief history of the internet. *ACM SIGCOMM Computer Communication Review*, 39(5):22–31, 2009.

[22] James Surowiecki. *The wisdom of crowds.* Anchor, 2005.

[23] Derek E. Baird and Mercedes Fisher. Neomillennial user experience design strategies: Utilizing social networking media to support "always on" learning styles. *Journal of educational technology systems*, 34(1):5–32, 2005.

[24] Varinder Taprial and Priya Kanwar. *Understanding social media.* Bookboon, 2012.

[25] Rick Bonney, Heidi Ballard, Rebecca Jordan, Ellen McCallie, Tina Phillips, Jennifer Shirk, and Candie C. Wilderman. Public participation in scientific research: Defining the field and assessing its potential for informal science education. a caise inquiry group report. *Online Submission*, 2009.

[26] Eric Bonabeau. Decisions 2.0: The power of collective intelligence. http://sloanreview.mit.edu/article/decisions-20-the-power-of-collective-intelligence/, 2009. Accessed: 2016-24-08.

[27] Greg Newman, Andrea Wiggins, Alycia Crall, Eric Graham, Sarah Newman, and Kevin Crowston. The future of citizen science: emerging technologies and shifting paradigms. *Frontiers in Ecology and the Environment*, 10(6):298–304, 2012.

[28] Sunyoung Kim, Christine Robson, Thomas Zimmerman, Jeffrey Pierce, and Eben M. Haber. Creek watch: pairing usefulness and usability for successful citizen science. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 2011.

[29] Anne Bowser, D. Hansen, and J. Preece. Gamifying citizen science: Lessons and future directions. In *Workshop on Designing Gamification: Creating Gameful and Playful Experiences*, 2013.

[30] Charlene Jennett and Anna L. Cox. Eight guidelines for designing virtual citizen science projects. In *Second AAAI Conference on Human Computation and Crowdsourcing*, 2014.

[31] Peter (HRSG.) Finke. *Freie Bürger Freie Forschung - Die Wissenschaft Verlässt den Elfenbeinturm*. oekom, 2015.

[32] Vitaly Friedman. 10 principles of effective web design. *Smashing Magazine*, 31, 2008.

[33] Michelle Girvan and Mark EJ Newman. Community structure in social and biological networks. *Proceedings of the national academy of sciences*, 99(12):7821–7826, 2002.

[34] Alan Mislove, Massimiliano Marcon, Krishna P. Gummadi, Peter Druschel, and Bobby Bhattacharjee. Measurement and analysis of online social networks. In *Proceedings of the 7th ACM SIGCOMM conference on Internet measurement*, pages 29–42. ACM, 2007.

[35] Nancy Yen-wen Cheng. Approaches to design collaboration research. *Automation in Construction*, 12(6):715–723, 2003.

[36] Radu Andrei Negoescu and Daniel Gatica-Perez. Analyzing flickr groups. In *Proceedings of the 2008 international conference on Content-based image and video retrieval*, pages 417–426. ACM, 2008.

[37] Cameron Marlow, Mor Naaman, Danah Boyd, and Marc Davis. Ht06, tagging paper, taxonomy, flickr, academic article, to read. In *Proceedings of the seventeenth conference on Hypertext and hypermedia*, pages 31–40. ACM, 2006.

[38] Lyndon Kennedy, Mor Naaman, Shane Ahern, Rahul Nair, and Tye Rattenbury. How flickr helps us make sense of the world: context and content in community-contributed media collections. In *Proceedings of the 15th ACM international conference on Multimedia*, pages 631–640. ACM, 2007.

[39] Christine Robson. Using mobile technology and social networking to crowdsource citizen science. 2012.

[40] Teresa Amabile and Steven J. Kramer. The power of small wins. https://hbr.org/2011/05/the-power-of-small-wins. Accessed: 2016-23-07.

[41] Sebastian Deterding, Dan Dixon, Rilla Khaled, and Lennart Nacke. From game design elements to gamefulness: defining gamification. In *Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments*, pages 9–15. ACM, 2011.

[42] Ailsa Marion Randall and Bc Veronika Jašková. Duolingo as a new language-learning website and its contribution to e-learning education. 2014.

[43] Roumen Vesselinov and John Grego. Duolingo effectiveness study. *City University of New York, USA*, 2012.

[44] Rhiju Das and David Baker. Automated de novo prediction of native-like rna tertiary structures. *Proceedings of the National Academy of Sciences*, 104(37), 2007.

[45] Aaron D. Mason, Georgios Michalakidis, and Paul J Krause. Tiger nation: Empowering citizen scientists. In *2012 6th IEEE International Conference on Digital Ecosystems and Technologies (DEST)*, pages 1–5. IEEE, 2012.

[46] Luis Von Ahn and Laura Dabbish. Designing games with a purpose. *Communications of the ACM*, 51(8):58–67, 2008.

[47] Ayelet Fishbach, Tal Eyal, and Stacey R. Finkelstein. How positive and negative feedback motivate goal pursuit. *Social and Personality Psychology Compass*, 4(8):517–530, 2010.

[48] Barbara Moschner. Altruismus und egoismus was motiviert zum ehrenamt? *Bielefeld 2000plus–Forschungsprojekte zur Region, Diskussionspapier*, 2002.

[49] Paavo Kotinurmi. Citeseer. User profiles and their management, 2001.

[50] Amy Schade. Don't force users to register before they can buy. https://www.nngroup.com/articles/optional-registration/, 2015. Accessed: 2016-19-09.

[51] Ping Zhang and Gisela M. Von Dran. Satisfiers and dissatisfiers: A two-factor model for website design and evaluation. *Journal of the American society for information science*, 51(14), 2000.

[52] Dana Rotman, Jenny Preece, Jen Hammock, Kezee Procita, Derek Hansen, Cynthia Parr, Darcy Lewis, and David Jacobs. Dynamic changes in motivation in collaborative citizen-science projects. In *Proceedings of the ACM 2012 conference on Computer Supported Cooperative Work*, pages 217–226. ACM, 2012.

[53] Ioanna Iacovides, Charlene Jennett, Cassandra Cornish-Trestrail, and Anna L. Cox. Do games attract or sustain engagement in citizen science?: a study of volunteer motivations. In *CHI'13 Extended Abstracts on Human Factors in Computing Systems*. ACM, 2013.

[54] Andrew Lih. Wikipedia as participatory journalism: Reliable sources? metrics for evaluating collaborative media as a news resource. *Nature*, 2004.

[55] Aniket Kittur, Bongwon Suh, Bryan A. Pendleton, and Ed H. Chi. He says, she says: conflict and coordination in wikipedia. In *Proceedings of the SIGCHI conference on Human factors in computing systems*, pages 453–462. ACM, 2007.

[56] Jim Giles. Internet encyclopaedias go head to head. *Nature*, 438(7070):900–901, 2005.

[57] Paul Terry, Alan Graden, and Ed Haltrecht. *The New Four Stages^{TM} of Contribution Research*. 2014.

[58] Janelle Estes, Amy Schade, and Jakob Nielsen. Social media user experience. *California, USA: Nielsen Norman Group. Retrieved October*, 2009.

[59] Takeshi Sakaki, Makoto Okazaki, and Yutaka Matsuo. Earthquake shakes twitter users: real-time event detection by social sensors. In *Proceedings of the 19th international conference on World wide web*, pages 851–860. ACM, 2010.

[60] Martin Bogner. Conception and implementation of a collaborative data science platform. 2016.

[61] Christoph Wieser, François Bry, Alexandre Bérard, and Richard Lagrange. Artigo: Building an artwork search engine with games and higher-order latent semantic analysis. Ludwig Maximilians University of Munich, National Institute of Applied Sciences Rennes, 2013.

[62] Eric Hobsbawm. *The age of revolution: Europe 1789-1848.* Weidenfeld & Nicolson, 1969.

[63] Eric Hobsbawm. *Age of Empire: 1875-1914.* Hachette UK, 2010.

[64] Florian Hoidn. *The Analytics Center: Devising a citizen science data mining tool for the ARTigo image tagging project.* Bachelor's Thesis, Ludwig Maximilians University of Munich, 2014.

[65] W3techs. Usage of server-side programming languages for websites. https://w3techs.com/technologies/overview/programming_language/all, 2016. Accessed: 2016-16-12.

[66] JavaScripting. The definitive source of the best JavaScript libraries, frameworks, and plugins. https://www.javascripting.com/view/jquery, 2017. Accessed: 2017-12-1.

[67] W3schools. Browser statistics. http://www.w3schools.com/browsers/, 2017. Accessed: 2017-10-1.

[68] StatCounter. Mobile and tablet internet usage exceeds desktop for first time worldwide. http://gs.statcounter.com/press/mobile-and-tablet-internet-usage-exceeds-desktop-for-first-time-worldwide, 2016. Accessed: 2017-12-1.

[69] Brett S Gardner. Responsive web design: Enriching the user experience. *Sigma Journal: Inside the Digital Ecosystem*, 11(1):13–19, 2011.