Design, Implementation and Evaluation of an Anti-Phishing Education App

Design, Implementatierung und Evaluierung einer Anti-Phishing Education App

Master-Thesis von Clemens Bergmann und Gamze Canova

Januar 2014

TECHNISCHE UNIVERSITÄT DARMSTADT

SECUSO
SECURITY · USABILITY · SOCIETY

Design, Implementation and Evaluation of an Anti-Phishing Education App
Design, Implementatierung und Evaluierung einer Anti-Phishing Education App

Vorgelegte Master-Thesis von Clemens Bergmann und Gamze Canova

1. Gutachten: Professor Dr. Melanie Volkamer
2. Gutachten: Arne Renkema-Padmos

Tag der Einreichung:

Erklärung zur Master-Thesis

Hiermit versichere ich, die vorliegende Master-Thesis ohne Hilfe Dritter nur mit den angegebenen Quellen und Hilfsmitteln angefertigt zu haben. Alle Stellen, die aus Quellen entnommen wurden, sind als solche kenntlich gemacht. Diese Arbeit hat in gleicher oder ähnlicher Form noch keiner Prüfungsbehörde vorgelegen.

Darmstadt, den January 25, 2014

(C. Bergmann)

Erklärung zur Master-Thesis

Hiermit versichere ich, die vorliegende Master-Thesis ohne Hilfe Dritter nur mit den angegebenen Quellen und Hilfsmitteln angefertigt zu haben. Alle Stellen, die aus Quellen entnommen wurden, sind als solche kenntlich gemacht. Diese Arbeit hat in gleicher oder ähnlicher Form noch keiner Prüfungsbehörde vorgelegen.

Darmstadt, den January 25, 2014

(G. Canova)

Contents

Abstract

More and more scammers discover the Internet as a convenient place for their criminal activities. For instance, they send Internet users spoofed e-mails or publish fraud websites which prompt users to enter their confidential data. This kind of Internet fraud is referred to as phishing. For a victim of a phishing attack the consequences can be of economic as well as private nature. In addtion to technical solutions, user education about the dangers of the Internet is a key part of a strategy to combat phishing. Our master thesis aims at developing a smartphone app, which makes important information and tips available to its users, so that users fall for phishing attacks more rarely in future. For this purpose, the app alerts the user regarding known methods of attackers and helps him to internalize this by practicing.

1 Introduction

This chapter introduces the target of this work, which is to design, implement and evaluate an educational app. The app is supposed to help unexperienced users to detect phishing attacks. At first we are going to motivate the benefit of our work and how we envision our approach to achieve our goal. Specifically, we will first motivate why countering phishing is necessary by exploring the consequences and statistics of phishing. Subsequently, we will reason why there is a need for an anti-phishing education app, instead of, for example, a further technical solution or a computer-based educational approach. Then, we define our specific objectives and finally, we provide an overview of the following chapters.

1.1 Motivation

Nowadays, a world without Internet is unimaginable for most people in developed countries. As an example, 83% of Germany's population have Internet access **??**. However, it is undeniable that with the great benefits of the Internet also come great threats. One major issue of today's digitalized world is spam in general and phishing in detail.

Phishing is a form of fraud to lure confidential information from users, cf. Section subsubsection 2.1.1. The goal of the attacker is to impersonate the user in online systems. This can be used to access corporate systems, damage the users reputation or simply steal money from him. Usually, phishing happens through fake websites which imitate the original ones. On these so called phishing websites the users are asked to enter their personal or account data. In this section we elaborate on the importance of countering such phishing attacks with the aid of user education.

1.1.1 Consequences of Phishing

Falling for a phishing attack has several consequences for the fooled person as well as for the target company or organization. In the following some of these consequences are briefly illustrated.

Identity Theft Phishing is the practice of tricking users to disclose their personal data. That is to say, a possible consequence of falling for a phishing attack is identity theft [35]. With the data unknowingly provided by the victims, the attacker can impersonate them on their behalf. For example, he can do online shopping or transfer money to his account on behalf of his victims. In a corporate scenario the attacker might even gain access to secured systems by attacking an administrator. When the attacker has access to these systems he might be able to collect customer data. Therefore not only users who are subject to phishing attacks can be affected by the attack, but also the institutions, organizations, companies and also their customers.

Financial Loss Financial loss can be the result of users' banking accounts being plundered or increased support costs for the targeted institutions due to their customers who fell for an attack [63, 45].

Reputational Damage Moreover, the targeted institutions may sustain a damaged reputation caused by customers falling victim for phishing attacks [45, 68].

Displeased Customers Customers who actually became a victim of such a phishing attack will be displeased about the money or account loss and the resulting efforts they have to make in consequence of such an attack. Furthermore, they will tell other people about this displeasant experience.

Loss of Trust Ultimately, these victims will lose their trust in the institution targeted by the phisher [68]. Moreover, they might lose confidence in eCommerce operations and the Internet in general.

1.1.2 Statistics of Phishing

Phishing is also reflected by many statistics of various reports. According to the Anti-Phishing Working Group (APWG) approximately 40,000 unique phishing websites are detected each month [31]. Statistics published by Kaspersky Lab, a well-respected provider for IT security solutions, state that from year 2011-2012 to 2012-2013 the number of attacked users increased by about 87%. While in 2011-2012 the number of users, who were subject to phishing attacks, was 19.9 million, in 2012-2013 the numbers climbed up to 37.3 million. Every day about 100,000 Internet users are victims of phishing attacks, which is twice as many compared to the previous period of 2011-2012. An immense increase can also be observed in the number of unique sources (i. e. IPs) of attacks, which has tripled from 2012 to 2013 [40]. The amount of target institutions also rose. While in 2011 the APWG counted about 500 target institutions, in the fist quarter of 2013 720 target institutions were identified [30]. Finally, RSA and ECM estimate worldwide costs caused by phishing at about $1.5 billion for the year 2012 [63].

We are aware that such statistics might be inherently biased [50]. The problem is, there are several ways to inteperet collected data. Hence, every party might assess their data with respect to their interests. Yet, we believe that the education of end users is an important step towards countering phishing. Ultimately, more reliable and accurate statistcs would required in order to evaluate the effectiveness of all the proposed countermeasures against phishing. Next, we reason the importance of anti-phishing education in general and specifically the need for a mobile app for this purpose.

1.1.3 Technical Solutions to Counter Phishing

Several technical solutions to counter phishing have already been suggested in literature [61]. As a matter of fact, these approaches are not flawless. In the following some of these approaches are briefly summarized.

Spam filters Commonly, the phisher sends out a tremendous volume of emails to random users which contain links to fake websites. According to Dr. Dobb's, for example, every day 500 million phishing e-mails arrive in user inboxes [64]. There the users are lured to disclose their personal data. Consequently, one possible countermeasure to stop phishing is to filter these e-mails before they even reach the receiver. Various approaches for such spam filters already exist [9, 14, 23], but spam filters also have their drawbacks. First, spam filters might be abused for an invisible form fo censorship. Second, a spam filter needs to be installed and applied to the users' e-mail accounts. When using an e-mail service the service provider is generally not allowed to access the users' e-mail without their permission. Therefore, spam filters only apply to users that actively enable them. Third, phishers are constantly improving their techniques to circumvent current spam filters. Consequently, such filters can not assure 100% accuracy. Finally, the strength of the filter controls the amount of false positives and negatives. On the one hand it is possible that phishing e-mails can make it through these filters and might harm the user (false negatives). On the other hand there are legitimate e-mails which may not reach the user (false positives). This might result in a user's loss of confidence, which in turn can result in the user not applying the spam filter anymore [53].

Blacklists Fake websites are a common way for phishers to get at users' data. Thus, another alternative to protect potentially endagered users from phishing attacks is to restrict the access to such phishing websites with the aid of so called blacklists. Here, the browsers hold a list of revealed phishing websites. If a requested URL is contained in such a blacklist the access to this website can be restricted or the user can be warned about the phishing website. Several blacklisting approaches have been suggested in literature [43, 79]. The major downside of blacklists is that most of them work reactively. That is to say, there is a certain time frame where phishing websites are active without being blacklisted. In this time frame users can access these website without being warned or restricted and thus are vulnerable to fall for the attack. To resolve this problem multiple dynamic and predictive approaches have been proposed to restrict and/or warn the user from accessing phishing websites [60, 52, 44]. Nevertheless, there is no flawless blacklisting approach, as there are always malicious websites which can bypass such protective systems (false negatives). Also, similar to spam,

blacklists may contain false positives, and they can also be abused for censorship. Moreover, these systems require a high effort to maintain, since a regular and realtime update is inevitable in order to make the system effective [61]. Furthermore, there is the weakest link in the security chain: there exist users who are very often unsure about what to do when getting such security warnings [7]. As a matter of fact, in case of disregard of these warnings such systems are useless for those who ignore them.

Visual distinction A further technical approach against phishing is the automatic visual distinction of phishing websites from legitimate ones. For this purpose it is necessary to identify maliciously duplicated websites mainly based on visual similarities [42]. Various solutions can be found in literature to approach this [15, 16, 78]. However, there is no foolproof solution. In particular, if approaches mainly rely on visual similarities many of them will fail if the phishing website is not a duplicate of the original site. Moreover, phishers will always be able to adapt to sophisticated solutions in order to bypass these security levels. Of course a phisher's adaption to circumvent such solutions must be profitable for him, i.e. it must happen fast enough with reasonable costs. On the other hand, some website providers allow the user to customize some visual elements of the website to distinguish it from faked websites. In the end as always the human factor plays a major role here: such techniques will remain of no use for users who keep misunderstanding or ignoring the provided visual indicators.

Takedown Commonly, hosting providers are urged to take down revealed malicious websites by certain parties: banks, other organizations or specialized takedown companies, for example [49]. The removal of phishing websites is an effective solution, since it implicitly solves the aforementioned problem, where users ignore security warnings: a removed website cannot trick a user into entering sensitive data. However, this approach - similar to the blacklist one - cannot defeat phishing entirely, since it is not fast enough [49]. During the uptime of the fraudulent website falling for it remains a threat.

In conclusion, there are two major issues of existing techniques. First, technical solutions do not assure 100% accuracy. There is always the potential of false positives and false negatives. Furthermore, attackers can always invent new, more sophisticated deceptions that bypass current prevention systems. The attackers are always first in row, i. e. they create a deception technique and once it is captured and resolved by detection systems, they simply create a new technique or adapt the old one so that it is no longer detected. The second major problem with these approaches is the user behavior. As already indicated above users tend to overlook or intendedly ignore security warnings. If the user behavior does not change such approaches will in fact remain unhelpful. The problem here is that users primarily use the Internet for purposes such as online shopping, online banking, communicating with relatives and friends etc. Aspects related to security are not of their primary interest when being online or they just implicitly assume the system to be secure. Another factor for overlooking and ignoring these warnings is the lack of security awareness of the users. Some users are just not aware of how easy it is for even unexperienced attackers to duplicate a website and send out fake e-mails. Even if users are aware that there is a certain degree of threat in the Internet, people tend to think the probability that they will face such an attack is very low and that it will not happen to them, until it actually happens to them. In summary, pure technical solutions cannot guarantee 100% protection. On the other hand, in the end the users themselves fall into the traps of the attackers. Thus, in our point of view a further key step against phishing is to change the user behavior by increasing the security awareness of the users and educating them how to protect themselves against such traps.

1.1.4 Anti-Phishing Education on the Smartphone

There are several reasons why we chose to educate users on the smartphone.

Mobility and Size The main characteristic of a smartphone is that it is mobile and smaller than the well-known desktop computers. As a consequence there is less space on the screen. Many browsers, for example, generally hide their address bars due to the lack of space. With the address bar, the URL and other potential security indicators are hidden.

Distraction Caused by Mobility There is also the fact that users often use their smartphones while on the move, for example, when walking or during a train or a bus ride. These circumstances include distractions from the environment

which are unavoidable. These distractions obviously will influence the user's attentiveness. Hence, smartphone users are even more vulnerable to phishing attacks than the traditional desktop user. This is also indicated by a report of 2011 [10], which says that mobile users are three times more likely to access phishing websites than desktop users. This might also be influenced by the fact that mobile mail clients effectively provide no way to check the validity of a incoming mail.

High Number of Smartphone Users In addition, given that the majority of the people use a smartphone on a regular basis in Spain, Germany, Italy, France and the UK [18], there is a need for the protection of smartphone users.

Benefits of Education on the Smartphone Educating the user on the smartphone provides two major benefits. First, the user can use the app on the move. Thus, the app is accessible outside of the user's desktop environment. The app can be used during train or bus rides, while waiting for a friend or while waiting for any other appointment. The app can be started and continued any time as a sideline or just to bridge time, so that probably more users would be willing to use it. Second, it is easy to transfer the knowledge of smartphones to desktop computers as the screen is bigger and the URL is easy to find. Transferring knowledge from desktop computers to smartphones, on the other hand, is not that simple.

1.2 Goals

We begin with stating our primary goals of this thesis and describe them in more depth subsequently. The major goals of this thesis is to educate the user about phishing so that he is less likely to fall for fake webpages. This is an addition and not an alternative to technical solutions to counter phishing. We think that that the following steps are important to achieve this goal.

1. Increasing the users' security awareness
2. Educate the user with the skills to identify phishing websites.

As already indicated in the previous section the lack of a user's security awareness seems to be a major issue concerning his security-related behavior. For this reason we want to raise the users' security awareness by demonstrating within our app that faking e-mail senders and content is very easy. Additionally, we want to make them aware that links do not necessarily lead to the target website the link displays to the user. This should happen at the beginning of the app so that the user realizes that the threat of the Internet is prevalent and that he needs to learn to protect himself. Furthermore, the user should practically experience these aspects and not only be told, since being told will not suffice to motivate the user to go on with the app. Moreover, besides technical solutions, valuable information has to be made available to the user. In particular, we want to qualify our app users to detect phishing URLs so they can distinguish phishing websites from legitimate ones. For the app we focus on educating the user. Increasing the security awareness is a minor introductory part of the app.

1.3 Outline

This thesis consists of ... main chapters: .... Their purpose is as follows:
Chapter 1 motivates this work. ..
Chapter 2 ...
Chapter 3 ...
...
Chapter ... finally summarizes this work and provides an outlook on future work.

2 Background

The objective of this chapter is to provide the required background knowledge for our further design elaborations. Afer providing some background to phishing in general we introduce the different phishing learning techniques we have found in literature. For better readability and comprehensibility we divided the available techniques into the content, i.e. what exactly is the user told, and the used media, i.e. how is the user told something about this topic.

2.1 Phishing in General

2.1.1 Abstract Definition of Phishing

The goal of this work is helping users to distinguish phishing websites from legitimate ones. Since phishing is important in the scope of this work, we are going to define the term first [35]. In fact, phishing is a term that is used by many people in different contexts. Therefore, the following definition is intendedly kept abstract in order to cover all possible scenarios of phishing. At the end of this chapter we will state our concrete definition of phsihing considered in this work.

"Phishing is the practice of obtaining confidential information from users and describes a form of identitfy theft. Targeted confidential information includes, but is not limited to, user names, passwords, social security numbers, credit card numbers, account information, and other personal information. "

2.1.2 Phishing Techniques

There are various possibilities how phishers can obtain users' confidential information. In the following we describe phishing techniques that can be distinguished [35, 58]. ITTC Report on Online Identity Theft Technology and Countermeasures

Deceptive Phishing In deceptive phishing social engineering plays a key role. Here, users are lured to disclose their confidential data directly to the phisher without being aware of it. A typical scenario is the unsuspecting user receiving an e-mail from an institution he trusts. In fact, this e-mail is malicious and links to a fake website, where the phisher intends to steal the user's data by capturing the fields the user enters trustfully. Once the phisher obtains the user's data, he is able to impersonate the victim's identity and benefit from this.

Malware-Based Phishing As the term already reveals, malware-based phishing embraces some kind of malicious software running on the user's computer. There are several ways of infecting the user's computer with such malware. Social engineering techniques can be used to convince the user to open malicious e-mail attachments or download malevolent files from a website. Another possibility is to exploit security vulnerabilities. Once the malware resides on the target, various technologies can be utilized to get at the users' data. Keyloggers and screenloggers, for example, track users' data input and send relevant information to a phishing server. Recent research has shown that mobile phone Operating systems are as vulnerable to such attacks as desktop systems. Another way is to make use of so-called web trojans, which appear when users intend to log in. While the user thinks he is logging in on a website of his trust, the entered information is actually transmitted to the phisher.

DNS Based Phishing This kind of phishing is also referred to as pharming and includes the manipulation of a system's host file or domain name system. These kinds of tampering result in returning a fraudulent IP address for URL requests and thus leading the user to a malicious website, even though the URL of a legitimate website had been entered. As a consequence the unaware user enters his credentials into this fake website and the attacker obtains these and can misuse them. These attacks are almost impossible to detect for the user.

Man-in-the-Middle Phishing In this form of attack the phisher positions himself between the legitimate website and the user. The user's data input is delivered to the phisher, where he stores the information and then forwards it to the legitimate website. Responses are also forwarded back to the user so that the interference of the phisher does not affect the user's interactions. The gained sensitive information can then be sold or misused in any other way. As everything works as usual for the user, it is very difficult for him to detect such an attack.

Content Injection Phishing Content injection phishing refers to the practice of embedding additional harmful content into legitimate websites. This content can, for example, be malvolent code to log users' sensitive information and deliver the input to the phishing server. Well-known types of content injection phishing include, for example, cross-site scripting. Cross-site scripting vulnerabilities result from a web application's usage of content from external sources, such as search

terms, auctions or user reviews of a product. This type of data supply can be misused and instead of delivering the expected kind of data malicious scripts can be injected.

Search Engine Phishing Other phishing attempts involve search engines. Here, websites with offers for fake low cost products and/or services are legitimately indexed with search engines. Thus, users reach these websites when using the search engine. These offers then lure the user to buy those fake products which in turn leads to the disclosure of their sensitive information, such as the credit card number, to the phisher.

2.1.3 Phishing Attack Channels

These days several attack channels exist that can be exploited by phishers to reach their victims. This section introduces possible attack channels [62, 58].

E-Mail E-Mail spoofing is a common way for a phisher to reach his victims. These e-mails usually imitate renowned institutions, organizations, companies or banks the recipients trust. They usually contain a text which will deceive the recepient into doing what it says. Typically a link to a malicious website, whose look and feel is almost identical to the original one, is included. On the malicious website the user is lured to enter his sensitive data which is captured by the phisher. Other alternatives are embedded forms in an email where a user fills in his data directly instead of being forwarded to a website. Finally, sometimes users are even asked to directly send back their confidential data.

SMS An alternative to acquire confidential user data is making use of cell phone text messages. As with e-mails, the text message may contain a link to a fake website, where the user is induced to divulge his sensitive information. The user may also be asked to send back the information directly. Another possibility is to be asked to call back a fraudulent telephone number indicated in the text message. This number usually leads to an automated voice response system which is intended to gain the confidential information from the calling user. This form of phishing is also referred to as smishing, derived from the two terms “SMS” and “phishing”.

Instant Messaging In this attack the user receives an instant message from one of his friends. However, the user does not know that his friend’s account has been compromised by a phisher. The message usually contains a link to a website asking the user for his instant messenger account information (user name and password). As the link came from a friend many users do not expect something harmful behind this and thus enter their credentials. When the phisher acquires the user’s credentials he can continue playing this game with the friends of the newly derived user’s instant messaging account, which has just been compromised.

Online Social Networks Using online social networks is similar to using instant messaging services. However, online social networks provide additional valuable information to the phisher. With the aid of user profiles and pinboard entries etc. he can make his baits even more credible and trustworthy. Consequently, the likelihood for his targets to get phished increases.

Voice Phishing A further possibility for a phisher is to send out spoofed e-mails asking the victim to call back the telephone number indicated in the e-mail. To deceive the user, the phisher as usual claims to be from a legitimate and trustworthy institution or organization. The number in the e-mail commonly leads to a voice response system by which the user is tricked to disclose confidential information. Alternatively, the phisher can directly call the user and lure him into divulging his senstitive information. Voice-over-IP (VoIP) further facilitates these kinds of attacks. It makes them easy to execute and inexpensive. Voice Phishing is also referred to as Vishing.

2.1.4 Variations of Phishing

In the course of time different variations of phishing have evolved. This section deals with some of these variations that can be found in literature.

Mass Phishing Here, for example, the phisher sends out a tremendous amount of spoofed e-mails to random users. These e-mails usually link to the phisher's fake website where he tricks his victims to disclose their credentials. In this variation the phisher is not forced or even able to customize the mail to the attacked user. He tries to formulate the mail so that it might fit most users and accepts that some users might not fall for it. The principle of mass attacks is very common and effective, since sending e-mails and setting up websites is almost of no cost and effort nowadays. Even if not all phishing e-mails make it through the spam filters or are not opened: sending out a tremendous amount of spoofed e-mails evidently results in a high amount of victims, not in relative, but in absolute numbers. For example, there exist estimations of 156 million phishing e-mails being sent out daily. Only 16 million of these e-mails win the fight against spam filters. The half of these are opened. 800,000 users of these 8 million e-mail recipients actually click on the contained link and still 80,000 users take the bait according to the estimations [65].

Spear Phishing Unlike mass phishing attacks, spear phishing mainly aims at sensitive information like business secrets, intellectual property or even military secrets. While in mass phishing attacks, spoofed e-mails are sent to millions of random users, spear phishing targets specific individuals resp. groups within organizations to acquire sensitive information. In order to make a deceptive request more credible and personal, knowledge of the targeted individuals and organizations is used. Usually, victims of spear phishing receive e-mails with a malicious attachment and are lured to download it [75]. As sharing documents via e-mail is normal in an organization this does usually not arouse suspicion if the e-mail is from a known person with a legitimate context. This makes spear phishing attacks very hard to detect[75, 33].

Whaling Whaling is a specific form of spear phishing. The target distinguishes whaling from spear phishing. While spear phishing aims at specific individuals or groups within organizations, whaling attacks are after high-level targets, such as senior executives or other leaders in positions of influence [27].

In the following section we will summarize the scope of the term phishing for this work.

2.1.5 Scope of Phishing in Our Analysis

In the previous sections we have introduced numerous phishing techniques, attack channels as well as phishing variations. As there are more ways of how phishing can be understood, we have to constrain the scope of the term phishing for this work. In literature most of the time phishing is described as the act of gaining sensitive information with the aid of fake websites which trick unsuspecting users into disclosing their credentials [70, 31, 40]. This type of attack is the mostly observed one and is a form of deceptive phishing. For this reason we have decided to focus on deceptive phishing. As aforementioned, phishing websites can be distributed in several ways, including but not limited to e-mail, SMS, or online social networks. Since we set our focus on the analysis of URLs when visiting the website, it does not matter where these links originate from. Any attack channel distributing a link to a fake website will be covered by our approach. However we, and the user should, know that by mere clicking the link to come to the website some information might already be send to the phisher. This includes the validity and activeness of the communication path (e-mail address, phone number, OSN account) and additional information (browser information). We have to accept this because checking the link beforehand is not possible in most situations and also very different, depending on communication path and used software. Finally, there are three variations of phishing we have introduced. Our main focus is the mass phishing attack, since this is the common one. However, if any spear phishing or whaling attack should involve fake websites, this would be covered by our approach as well. Not that we have restricted our understanding of phishing, the next section provides our concrete definition of phishing for the scope of this thesis.

2.1.6 Concrete Definition of Phishing

In the following we present a concrete definition which encompasses our understanding of phishing for the scope of this work:

"Phishing is the practice of obtaining confidential information from users and describes a form of identitfy theft. This attack exploits a user's trust rather than system vulnerabilities. More specifically, the user is fooled into believing that he is

communicating with a party he trusts and lured into divulging confidential data. This usually happens through phishing websites which look deceptively similar to the originals. Targeted confidential information includes, but is not limited to, user names, passwords, social security numbers, credit card numbers, account information, and other personal information. "

2.2 Phishing Learning Techniques

This section deals with different learning techniques used for phishing education in previous work. For better readability and comprehensibility we divided the related work into two categories: the *content*, i.e. what the user is taught, and the *medium*, i.e. how the user is taught. These two categories can be further divided into several classes. In the following, we are going to provide an overview of these classes, before we provide specific examples of previous work in the next chapter.

2.2.1 Content Classification

The content classification deals with the concrete content of learning which is communicated to the user. The objective of this section is to introduce the different classes of learning content that we identified in previous work.

General Knowledge Transfer Renowned and targeted websites, such as PayPal, eBay or Microsoft provide general and superficial information about phishing [47, 57, 22]. Usually, they deal with questions like what is phishing, how does phishing happen, what the symptoms of phishing are and how to report phishing attempts. Providing the user only with text to the topic of phishing makes it possible to communicate any kind of content, so that the learning objectives can get as complex as one wishes. However, it is likely that users do not like reading too much, especially when it gets complex and difficult to comprehend. Of course the user's willigness to read a lot of complex text about computer security also depends on the user's motivation.

E-Mail Based Knowledge In this class of content, the user is told about the "anatomy" of phishing e-mails [76, 72]. Particularly, they are informed about what kind of hints in an e-mail give indications for a phishing attempt. Indications for a phishing e-mail can be impersonal salutation, requesting personal and confidential information as well as exerting pressure and threatening the user with, for example, account closure. The benefit of detecting phishing attempts before even clicking on a link in an e-mail is that the user would not confirm the existence and active usage of his e-mail address to the phisher. More importantly, the user would not unknownlingly download malicious software. The problem with the e-mail based approach is that detecting phishing e-mails by looking at their content becomes more and more difficult [48, 73]. Even if today still many phishing e-mails exhibit the obvious characteristic of having no personal salutation or being urgent and threatening, we observe a growing number of phishing e-mails that do not make these mistakes and it is likely that these obvious hints will not remain in future.

URL Based Knowledge Sending spoofed e-mails with links to fake websites is a common trick of phishers. On the target website then, the user is lured to disclosing his credentials. Thus, detecting such fake websites is another possibility to protect oneself against phishing. Here the user is taught to distinguish phishing URLs from legitimate ones [70, 6]. Links to phishing websites are not only distributed by phishing e-mails. Such links can be spread via any communication channel, such as online social networks or SMS. It is even possible to land on a phishing website by just browsing the web. In these situations knowing how to distinguish phishing URLs from valid ones will help whereas knowledge about phishing e-mails in general will not. The problem with this approach is that as soon as the DNS or host file is attacked even for experts it will get difficult to distinguish a phishing website from the legitimate one (cf. DNS Based Phishing in Section subsubsection 2.1.2). Also, it is unlikely that the user is checking the URL after each click. So the user must develop a strategy when to check the URL (e.g. before entering personal data) and when not.

2.2.2 Medium Classification

The learning medium describes how the learning content is communicated to the user. The objective of this section is to introduce the different classes of learning media that we identified in previous work.

Simple Text The simplest way of transferring knowledge to the user is to just provide text about it. Written language is the most researched kind of medium and generations over generations pedagogues have researched and improved this medium. Alone in this medium there are multiple genres and subgenres which all might be used to transfer knowledge. The main problem is that in modern time many people see the simple text as old fashioned and prefer more interactive learning approaches.

Game Based Learning Game based learning tries to communicate the learning content vividly and playfully through a game. Such a game usually has a "background story" and a "mission" the user has to accomplish [70, 76]. The game design is important and depends on the target group. Previous work in the area of phishing, for example, has focused on a fish as starring role in their game, cf. Section **??**. This might work well for a target group of young age, but will most likely not be appealing to a larger audience. This is also reflected by our prestudy, cf. Section section 6.

Quiz Based Learning The quiz based approach is a type of a game which relies on a question-answer cycle without using a specific background story [56]. The advantage of a quiz based approach is that it seems more appropriate for adults and thus will likely be appealing to a larger audience.

Comparison Based Learning A further way to teach users is to let them compare legitimate websites, URLs, or e-mails, with fake ones. Here the user has to decide which of the shown examples are the secure ones [74]. We believe that this form of learning would increase the user awareness, as with this approach one could visualize to the user how difficult it can be to distinguish an original from a fake, especially when they appear almost identical. On the contrary, this way of learning does not reflect the reality, which is a major drawback in our point of view. In real life the user does not have the luxury of chosing between two options, he has only one and has to decide whether this option is trustful or not.

Emdedded Learning The aim of embedded learning is to educate the user on the topic of phishing during his every day life. For this reason the user is sent simulated phishing e-mails. In case the user falls for this simulated phishing attempt he is notified and gets more information regarding phishing and how to protect himself [36, 39]. This approach benefits from the so called "teachable moment". The moment the user realizes that he has almost become a victim to a phishing attack, he will be highly motivated to prevent this happening again and thus be highly receptive for input related to this topic. The teachable moment itself will not suffice to make the user stay on and consult the educational page, though. For example, there was a study in Germany to assess the effectiveness of CMU/APWG's landing page. During the study they found that people just closed the window immediately after or shortly after landing on the educational page without reading on, because they thought they were on the wrong website and were not aware that they landed on an educational site. Even if with an effective landing page, the missing positive feedback is a major flaw of this strategy in our opinion. The user is only notified in case of a mistake and not in case he has successfully discarded the simulated phishing e-mail. A further problem is raised with the implementation of such an approach. Legal issues will arise when sending simulated phishing e-mails which claim to come from a reputable vendor, such as an online shop.

We believe that a mixture of the game and quiz based approach is the best way to go in order to create an incentive for the users. Regarding the content which will be communicated to the user we decided to focus on detecting phishing URLs for the reasons explored in this section.

3 Related Work

In the previous section we have introduced the different classes of learning contents and communication media. Furthermore, we have decided to go for the game/quiz based approach while focusing on URL based knowledge. This section summarizes concrete examples of previous work on anti-phishing education. For each class we have previously introduced at least one example is illustrated. We especially elaborate on the game and URL based approach as this is the path we take. Moreover, we state in which way our work is to be distinguished from previous work.

3.1 Game and URL Based Approaches

Anti-Phishing Phil [70] is a game based approach. The three objectives of this game are the following: (1) learn to detect phishing URLs, (2) learn where to look for indications in browsers for trustworthy/untrustworthy websites, and (3) learn

to use search engines to find legitimate websites. The major focus, however, is set on the detection of phishing URLs. The main character of the game is a little fish, named Phil, who has to grow to a big fish by eating worms. These worms can either be good, i.e. real worms, or bad, i.e. fake worms, with which fishers try to hook the fish off the sea. Good worms of the game are associated with URLs of legitimate websites, while bad worms are associated with the URLs of phishing websites. Phil's task is to feed on legitimate URLs only. He must reject phishing URLs to grow to a big and healthy fish. The game consists of four rounds in total, each round endures two minutes. For correct actions Phil is rewarded with a certain amount of points. If Phil falsely rejects a legitimate URL, he is slightly penalized by having the time left decremented for a couple of seconds. However, if Phil eats a phishing URL he is severely penalized by losing one of three lives. In this way, the authors try to simulate the extent of the real world effects of their behavior, i.e. in reality rejecting a valid URL is not as bad as trusting a phishing URL. Each round the focus of deception techniques is shifted and phishing URLs get more difficult to identify. In the first round the users get introduced to IP address URLs. The second round mainly deals with deceptive subdomain URLs, where the brand name occurs in the subdomain. In the third round, the users are taught about similar and deceptive domains. In the last round finally, the user has to deal with all kinds of deceptions he has dealt with so far. The information material provided to the user is delivered by so called training messages. Anti-Phishing Phil features four kinds of training messages. First, the user gets direct feedback during the game, whether the answer he has given is correct or not and why. Second, the user has the possibility to receive help in case he needs it. In this case, Phil's experienced father will give a tip. Third, at the end of each round a score sheet is displayed, which summarizes the user's answers, whether they were correct or wrong, and why they were correct or wrong. Finally, there are anti-phishing tips in-between the rounds.

To evaluate the effectiveness of the game the authors conducted a between-subjects experiment with three training conditions, represented by three groups: (1) existing training material, e.g. from eBay or Microsoft, (2) anti-phishing tutorials which were created based on the game, and (3) the game itself. Each group had to decide on ten websites (in total 20) about their authenticity before and after the training step. The results showed that the participants in the game condition performed better than those in the other two conditions. All in all, we believe that the approach is a good step towards user education and features many good aspects. In the first place, the game based approach is an attractive incentive for the user to be educated. Furthermore, the training messages are kept short and simple. Finally, the training messages, especially the ones of help during the game and the score sheet after each round are very valuable. Due to time restrictions we cannot integrate those kind of messages.

On the other hand, we believe that this approach has some flaws and thus is not optimal for user education. Even though using a fish as main character for this game is a funny idea, we do not think that this is an appropriate solution for adults. This is also reflected by the results of our phishing survey, cf. Section section 6. Therefore, we will not use a fish as our main character. Our approach will rather be a combination of a game, which includes lives and points, and a quiz, where users are required to answer questions directly, without any background story. As aforementioned, the training messages are simple and easy to understand, however, we are afraid that the phrasing is too vague. For example, for IP address URLs Anti-Phishing Phil displays the following alert message to the user: "Don't trust URLs with all numbers in the front". For subdomain attacks the following wording is used "Don't be fooled by the word ebay.com in there, this site belongs to ttps.us". These kind of messages are susceptible to misinterpretation. Another downside we see, which is ultimately related to the vague formulations, is that the user is not concretely explained how he has to parse the URL in order to make healthy decisions on the authenticity of such. Here again he is only told that the most important part of the URL is between the "https://" and "/" and that the name of the website is the text right before the "/". In our point of view this is a imprecise phrasing and there is a lack of emphasizing the importance of the domain, which we do in our solution. Finally, the game does not cover some spoofing techniques, which are still relevant in our opinion and thus is covered by us (cf. Section subsubsection 7.4.1). For example, the difference between http and https is not introduced, as well as the fact that https websites can also be phishing websites. Furthermore, the game does not explicitly mention that the domain name, the host or even the entire URL can be part of the path to fool the user. Finally, there are different ways of making use of deceptive domains, which were not explicitly covered by Anti-Phishing Phil. For example, homograph attacks (cf. Section subsubsection 7.4.1), typos and scrambled letters should be distinguished in order to exemplify how mean and hard to detect such URL spoofing techniques can be.

More work has been done in this area. However, most approaches are similar to Anti-Phishing Phil [5, 6].

3.2 Game/Quiz and E-Mail Based Approaches

Anti-Phishing Phyllis [76] is a game based approach and focuses on teaching the user to detect a variety of phishing traps in e-mails. These include, for example, fake links, attractive offers, urgent requests, or malicious attachments. The main character of this game is a fish named Phyllis. Phyllis has to decide whether potential traps (marked with red bubbles) in an e-mail he is shown are real phishing traps or are harmless by disarming or ignoring them. The playing user gets hints during the game and direct feedback on his actions. Another quiz and e-mail based approach is provided SonicWALL [72]. The user is shown e-mails consecutively and has to decide whether the displayed e-mail is legitimate or not. The user does not receive direct feedback on his decisions. At the end he receives an overview of the answers he has given and whether they were correct. If the user wants to know why his answer was correct or wrong he has to click on a link to get this information. As aforementioned, teaching users to detect phishing e-mails before even giving them the possibility to land on phishing websites has the advantage that they do not confirm the activeness of their e-mail address, and more importantly, do not have the chance to accidentally download malicious software. However, as phishing e-mails become more and more sophisticated, i.e. convincing and credible, and since phishing websites are also reachable via other communication channels, such as SMS, online social networks or just surfing in the Internet, we decided against the e-mail based approach.

3.3 General Knowledge Transfer With Embedded Learning

There are several proposals in literature for embedded learning [37, 39, 1]. One of these is a solution proposed by Jansson et al. where simulated phishing e-mails with links to fake websites or malicious download attachments are sent out to users [37]. The moment a user falls for a trap of these simulated e-mails he receives a notification informing him that he could have fallen for a real phishing attempt. Also, the e-mail includes a link to a website with a training program with general information and tips on how to detect phishing and malicious attachments. After consulting the training program the user is asked to complete a questionnaire in order to verify whether he understood the content of the training program. A very similar approach, the so called PhishGuru [39], is proposed by Kumaraguru. Another possibility is to leave out the step where simulated phishing e-mails are sent to users. Instead actual phishing e-mails are utilized. For example, the APWG and Carnegie University's CyLab Usable Privacy and Security Laboratory (CUPS) work on the project "Phishing Education Landing Page" [29]. The moment a user clicks on a link of a real phishing website which has already been taken down, i.e. the moment the user behaves riskily, he is redirected to the anti-phishing landing page. There he is told that he had almost become a victim of phishing and provided with educational material to this topic. Finally, there is an approach where the intervention does not happen after clicking on a dangerous link, but while surfing [1]. When the user lands on a blacklisted phishing website and is about to disclose his sensitive data (i.e. presses the submit button) the system interferes: the user is warned and given tips on how to detect phishing websites (e.g. abstract information on the detection of spoofed URLs). All of these solutions benefit from the so called teachable moment, the moment the users place themselves at risk by either clicking on a link in a (simulated) phishing e-mail or by submitting sensitive information to blacklisted phishing websites. This moment of risk presents a teachable moment for those who almost fell for such a trap. For this reason giving the warnings, hints, and training to the user in this moment will most likely result in higher motivation and retention so that the tips are more likely to help avoid similar dangers in future. A downside of these approaches is that they do only give negative feedback to the user. Consequently, the user is not "rewarded" when he rejects to click on a phishing link or to submit data on a phishing website, which is an important thing to do in our view. Moreover, the amount of information provided on such an educational website should be reasonable, i.e. the user should not be flooded with information. Otherwise he will not retain or even consult everything. To overcome these issues, a reasonable consideration for future work might be to combine embedded learning with another approach, for example, playing an educational game. In this way positive feedback can be included and the information can be transferred bit by bit to the user. For example, the website the user is redirected to might contain just the most important information, just enough to motivate the user to click on the provided link to an educational game, for instance our app, in case the user is interested in gaining in-depth insight on this topic. For now, we do not follow this approach since the step of sending simulated phishing e-mails to users raises legal issues.

3.4 Comparison and URL Based Approach

Symantec offers a "race to stay safe" [74], where the user is shown two snapshots of two websites, while one website is a fake and the other is a legitimate one. Within very short time the user has to compare the snapshots and decide which way is the safe one to go. The focus of this training is set on the URL and address bar. We believe that such an approach is likely to increase the user awareness of how deceptively similar phishing websites can be to the original ones. However, the approach of comparing two websites is not realistic enough, since the user does not have two websites and does not have the option to choose between them in reality. This is why we did not decide for the comparison based approach. However, adding time pressure to our approach, i.e. simulating a real life situation, is an aspect which might be worth to consider for future work.

3.5 General Knowledge Transfer With Quizzes

There exist online quizzes where the user is asked general questions to the topic of phishing [8, 56]. The design of these online quizzes is based on the association of phishing with fishing. That is to say, here again a fish is the main character of the quiz, which we do not find appropriate for adult users. Moreover, the number and variety of the questions asked in these quizzes are very restricted. Even if the examples of the quiz based approaches are not optimal for user education, we think that this approach is the most appropriate one for adults as target group.

3.6 Further Game Based Approaches On Other Computer Security Topics

Besides the proposals for user education on the specific topic of phishing, there exist a variety of other approaches aiming at educating the everyday user on general or other specific topics of computer security. Auction Hero [17], for example, is a simulation game which covers different topics of computer security, amongst other phishing. Its aim is to help users make more secure decisions in the Internet by modeling their regular Internet behavior. Real life is simulated by making security a secondary goal of the game, like it usually is the case with end users. The primary goal of the user, who is a trader, is to build and sell robots, and earn enough money and reputation to ultimately become an "Auction Hero". As in reality, the trader has to pay attention to various security risks, such as weak account passwords, out-dated antivirus software as well as phishing. Phishing, in particular, is dealt with as follows: the playing user receives e-mails within the game. While some of them are legitimate others are not (for example, an e-mail saying that the user has won an auction for an item on which he has never bidden). The e-mails include links to websites where the user is asked to enter his in-game login data. An ultimate consequence of disclosing data to a phishing website is that the user will suffer loss of money and reputation. Also, an explanatory warning will be displayed. The user is taught about typical characteristics of phishing, potential consequences of falling for them, and how to deal with phishing attempts. This approach has the major benefit of simulating actual online behavior and thus provides a realistic context for the user. Additionally, the user does not only learn about phishing, but other security related aspects, such as having strong passwords and keeping antivirus software up-to-date. On the other, our aim is not to develop a multi purpose application, but rather to focus on phishing attacks in detail. Targeting multiple security related topics means that the taught content needs to be constrained, otherwise retaining the learnt content will be difficult. Additionally, as security is a secondary goal and multiple security aspects are reflected in the game the user will have to play it for a long term in order to obtain helpful knowledge, especially for the purposes of detecting phishing attacks. Therefore, we want to focus on phishing attacks in detail instead of giving the user an overview of security topics which have to be considered when using the Internet. There exists a variety of other online games and quizzes covering miscellaneous topics of computer security. "Mission Laptop Security", for example, is a quiz based approach where the user's mission is to transport a laptop to a specific destination in a secure manner [55]. During his trip, the user is asked several questions about how to act in different situations. The mission can only be completed if the user gives enough correct answers. Another game covers the topic of network security [54]. Hackers, represented by little red men, are surrounding the user's WLAN area. By clicking on a hacker man a question appears. When the user gives the correct answer, this specific hacker man disappears. When the user gives an incorrect answer all red men come closer to the user's computer in the center of the WLAN area. Others have diverged from computer based games and rather suggested a physical card game primarily intended to increase the users' awareness of needs and challenges related to computer security in general [21].

4 Focus

This chapter deals with the focus of this work. First we describe, what aspects and scenarios will be covered by our app. Subsequently, we summarize the system requirements and what assumptions we had to make. Finally, the limitations of our work are stated.

4.1 Coverage

Deceptive Phishing as Phishing Technique Within the scope of this work we focus on deceptive phishing. In particular, we target the detection of phishing websites resp. phishing URLs.

Several Attack Channels We focus on the detection of spoofed websites resp. phishing URLs. Phishing websites can be reached in several ways. Links to fake websites are usually distributed via e-mails, instant messages or online social networks. However, they can also be spread via SMS or even phone calls. Ultimately, a phishing website can also be reached by just surfing in the Internet. As a consequence, our approach covers all attack channels, as long as the user is tricked to divulging sensitive information via a phishing website.

Mass Phishing as Variation of Phishing We cover in particular mass phishing, as already stated in Section subsubsection 2.1.5. However, the URL checking can be applied in case of any variant, as long as the attack includes a website which lures the user to type in his credentials.

Game and Quiz Based Learning as Communication Medium As already discussed in Section **??** we have decided to develop a quiz game to create an incentive for the users and at the same time reach a large audience.

URL Based Knowledge as Learning Content The advantages of telling the user what to pay attention to within e-mails are the following: if the user recognizes the phishing e-mail before clicking on a link he does not even get onto a fake website where he could be lured to divulge his credentials. This also would mean, that the user would not be forwarded to a page where a malicious download might be started. On the other hand, these fake e-mails become more and more sophisticated and thus it becomes harder to distinguish them from legitimate ones [48, 73]. Additionally, e-mail is not the only attack channel where links to phishing websites can be distributed. Those links are also spread via instant messaging systems, online social networks, or SMS, where the messages would differ from those in e-mails. Moreover, phishing websites can also be reached by surfing [40], where the e-mail based knowledge approach would completely fail. For these reasons we decided to focus on communicating URL based knowledge to the user. This way, the disadvantages of e-mail based knowledge are mitigated. Furthermore, we believe that URL based knowledge gives the most reliable hint regarding its "belonging", i.e. whether a URL in fact belongs to a legitimate website or not.

"After Click" URL Analysis We have decided to consider the "after click" scenario for the following reasons: Firstly, we cannot hinder users from clicking on links and make them type in the whole URL into the address bar. This is too effortful, especially on smartphones, and thus will not be followed by them. Secondly, many links contain redirects. Such redirects are not recognizable before the click. A further problem the "before click" scenario raises is that the stock e-mail client of Android does not provide the functionality of viewing the destination URL before clicking on it. The only way to have a look at the URL before clicking on it is to make a long press onto the link, copy it into the clipboard, paste it somewhere else and then analyze it. Then, after the analysis the URL has to be sent to the browser. However, as this is also involves too much effort, no user will follow such a suggestion. Finally, even if there are many other e-mail clients which offer viewing the destination URL via long press only, we believe that this should not be communicated to the user for two reasons. Firstly, we do not know how many Android users actually make use of the stock e-mail client, which does not offer this functionality. Secondly, and most importantly, this functionality has the potential to mislead the user. A drawback of the URL destination preview is that the end of it is cut in case the URL is too long. Well-crafted URLs might thus look legitimate even though they are not because the most important part of the URL was cut out. For example, the subdomains of the URL can be long and well-crafted so that a legitimate looking subdomain is exactly at the end of the preview. This will cause the user think, that the subdomain at the end of the preview is the domain of the URL. Ultimately, the user will trust this URL even he should not. For the reasons explained above we have decided to consider

the "after click" scenario. This approach suffers the disadvantage that users might click on a link which has a download of malware behind it. Also the visit of the linked phishing website might show the phisher that the used Mail-Address is valid and active and this can result in further attacks on this Mail address. Also the mere request and display of the phishing webpage might provide additional information to the phisher or even expose the user to attacks. For now, we consider this as future work, as there is no possibility to detect the real target of a link before clicking it.

Considered Browser As a matter of fact, the user is only communicated general browser skills which can be transferred to any other browser. Nevertheless, when the user gets browser screenshots, for example, we made use of the Android standard browser to be sure that most users are familiar with the pictures they are shown.

4.2 System Requirements

In the following we are listing the system requirements which need to be met for the final app.

Android Today the mobile phone market is split between two major competitors. Android (81.0%) and iOS (12.9%) [34]. We have decided to develop an app for the Android operation system as there are more users and we believe we have greater freedom here compared to an iOS app. The publication of an iOS app, for example, is connected with more requirements, which is not the case for Android apps [12, 11]. This allows us to implement and test an android app more quickly and cost effective then on iOS.

Version Our original intention was to develop an Android app for version 4.0 and upward. However, during the app development we have encountered that about 24% of all Android users still have Android 2.3.3 to 2.3.7 [4]. For this reason we have decided to modify the code so that these users can also install and use our app.

4.3 Assumptions

We have to make some assumptions about the system the user uses. If one or more of these are not met the user, disregarding of his skill, is not able to detect when he is target of an attack.

Secure DNS We have to be sure that DNS is not under the control of the attacker. Our approach is to show the user how to identify phishing by analysing the URL of the shown page. This is of no use if the Phisher can control the DNS system of the user. This includes local host files and all used DNS servers.

Secure Smartphone Also we have to assume that the system of the user is in a secure state. This means that the attacker is not able to e.g. replace the browser or read the users input.

Secure SSL For a Man-in-the-middle it is possible to interfere with the send or received data and to collect the user data directly. Therefore we warn the user that he should not enter personal data in non-HTTPS pages. But even in HTTPS environments we can not be sure of the servers identity when SSL is not secure. We are aware that recent events show that there are a multitude of SSL providers which fail to ensure that certificates are only handed to legitimate users or do this on purpose. When SSL is not secure the user has no practical possiblity to detect a Man-in-the-middle attack.

4.4 Limitations of Our Approach

In addition to the general assumptions we make because of the total inability of the user to detect phishing if one of these assumptions are not met. There are also limitations of our approach that result in the target group for our app. The targeted user is not a computer expert and has no time nor interest to analyze the shown webpage throughly before entering data. Therefore we don't tell the user about possible attacks that an experienced user might find.

Cross-Site Scripting Cross-Site Scripting (XSS) is an a attack where the attacker enters code into a legitimate webpage. For a later viewer of this page this form seems to be legitimate content of the attacked webpage and he might be lured to enter personal data in this area. Depending on attacked webpage this can not be detected by the user. This is a vulnerability of the attacked webpage and can be prevented by checking user input. Therefore we think that preventing this attack is in the responsibility of the website owner.

URL Hiding Techniques Most modern mobile phones have small screens. Therefore most browser hide away the URL-bar when the user views a webpage to gain additional screen real estate. The URL-bar is shown only when the user scrolls up beyond the top of the page. There is a possible attack where the attacker prevents the user from scrolling all the way up and instead displays a fake URL-bar with a fake URL. A problem that the attacker must solve is that mobile browser look very diffently and this must be reflected by the fake URL-bar. This problem is not easy to solve and it is today not needed for the attacker to do such sophisticated attacks because enough users fall for the simple attacks. We think this is the reason that this attack is not yet seen in the wild. Therefore we don't consider this attack.

5 Target Group

5.1 Target Group definition

In this section we want to describe the targeted users for our app. The main condition that must be met is that they can learn something from our app. That means they are skilled enough to use the app and not to skilled so that they already know everything that the app tells them. In detail this is modelized by the following conditions.

Attackabilty The first precondition is that all our users must meet is that they are possible targets for phishing. This means they must use the Internet. They also should use the Internet often enough and have a common trust in the web so that they are in general willing to enter their personal data. [24]

Android users The second precondition is that they should use a android smartphone. Our evaluation shows that the app is also usable by iOS users but they are not the target group because they can not use the app on a regular basis.

Language The informative parts of our app are texts and they are written in german. This means the target user should be able to read german texts.

Motivation The distribution plan for this app is to put it on the google play store and hope that users download and install it. Therefore the target user must be willing to learn something about the Internet. [24] shows that some Internet users are so sure about their knowledge that they are not willing to learn something. We will not be able to reach these users.

5.2 Projection to Population

After we have roughly decided what our target group is we wanted to be sure that we don't rule out to much of the population with these preconditions. This means it is of no use to produce a app that is, after all, only of use for 1 % of the population. To proof this we looked at a big survey done by SINUS-Instituts Heidelberg in behalf of Deutschen Instituts für Vertrauen und Sicherheit im Internet (DIVSI). This survey first looked at 60 persons in detail and found seven types of Internet users. Thereafter they tried to apply the findings to the whole german population by interviewing 2,000 representative persons. We tried to match our preconditions to these groups. Following is our evaluation for each group[24].

Digital Souveräne This group moves naturally in the Internet and is therefore exposed to phishing. They also often use smartphones. We rule them out because because they think that they already know the problems of the Internet so they need to be trained. Therefore they will probably never download the app.

Effizienzorientierte Performer This group matches our preconditions because they are using the Internet naturally as well as smartphones. In contrast to the previous group the are interested in learning something new and see their own learning in an investment into the future. To target this group we should show that you can learn something from this app.

Figure 1: Internet Milleus as defined by DIVSI

Unbekümmerte Hedonisten This group is also native in the digital worlds but in contrast to the before mentioned groups are not aware of the problems and frauds therein. When they are aware of the problems they seek to secure themselves with automated software and are not interested in investing time therein. Therefore they are not motivated to use our app.

Postmaterielle Skeptiker This group is interested in the Internet and uses it frequently. On the other hand they are aware that there are problems and frauds. As they are interested in information in the Internet especially from official sources they might download our app. To target this group we should clearly state that this app is from an university.

Verantwortungsbedachte Etablierte This group uses the Internet regulary and also use smartphones. They are exspecially interested in using protection software and actively search information in the Internet. The users of this group don't think that they could protect themselves from the dangers of the Internet and actively seek to change this. Therefore they mostlikely will find the app. To target this group we should clearly state that this app protects the user.

Ordnungsfordernde Internet-Laien These users are using the Internet very infrequently. Because of this they are very careful when using the Internet and normally don't enter personal data. Therefore it is not likely that they will use the app. Also they mostly don't have smartphones.

Internetferne Verunsicherte These users don't use the Internet. Therefore they are not exposed to phishing threads.

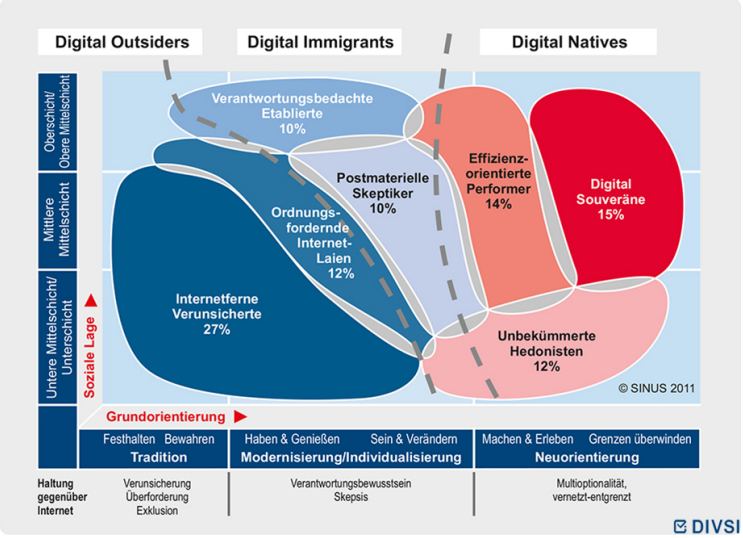


Figure 2: Internet Milleus as defined by DIVSI

In Conclusion we consider *Verantwortungsbedachte Etablierte* (10%), *Postmaterielle Skeptiker* (10%), *Effizienzorientierte Performer* (14%). In total these are 34% of the german population.

6 Phishing Survey

Before elaborating on the concrete app design we ran a small phishing survey. To the best of our knowledge there do not exist other surveys which resemble ours and additionally were conducted in Germany. This chapter deals with the main objectives of the survey. Furthermore, it provides some details and finally presents the results and evaluates the questionnaire.

6.1 Main Objectives

Our main objectives of this survey were twofold:

1. **Awareness and Knowledge** One goal of the survey was to comprehend what exactly Internet users understand under phishing. With a Likert scale we furthermore tried to figure out how they evaluate their on knowledge on the topic of Internet security.

2. **Preferences of Users** Another purpose of the survey was to get an idea of the users' preferences with regard to an educational app. For example, they were asked whether they found a quiz based game appropriate for learning purposes.

6.2 Survey Details

This section provides some details about our questionnaire, how we distributed it and how we filtered the surveys in order to consider our target group for the results and evaluation.

SURVEY IN APPENDIX???

6.2.1 Questionnaire

In the following we present the structure of our questionnaire and the function of each section.

1. **General Information** In this section the participant is asked to provide information regarding his gender, age, his professional qualification as well as his field of study or work. The main purpose of this section is to exclude participants which do not fit into our target group.

2. **Internet Usage** Here, the participant is asked how often he uses the Internet, whether he owns a smartphone and which applications he uses on his desktop computer and which ones he uses on his smartphone. This section is intended to give us an overview of the users' Internet usage and helps us to exclude participants who do not fit into our target group.

3. **Self-Assessment** In this part of the survey, the participant has to indicate how much he agrees to the presented statements with the aid of a Likert scale. The statements mainly refer to their self-assessment regaring their knowledge about Internet security. For example, they have to assess, whether they think they have enough knowledge, to avoid the dangers of the Internet or whether they think it is easy for them to distinguish legitimate e-mails from fake ones. This section is partially based on Likert scale statements used by DIVSI **..ADD REF**

4. **Phishing** Here, the participant gets concrete questions to the topic of phishing. In particular, he is asked which services and which user information are endangered by phishing attacks. This section purposes to find out what the participants know about and think of phishing.

5. **Anti-Phishing App** This section asks the user for his preferences regarding an anti-phishing education app. With the aid of a Likert scale he is requested to assess, for example, whether the would like having a game with a fish, or whether he finds a text-based approach meaningful as well as whether he would have fun with a question-answer quiz game.

6. **Further Survey Progress** In this part of the survey the user can provide us his e-mail address in case he wants to get information about the further progress of the survey or would like to test the app.

6.2.2 Distribution

In total 251 persons participated in our survey. We set up an online survey as well as asked students to fill out our printed survey. In the following we briefly explain our distribution process.

Printed Survey To reach participants for our printed survey we contacted multiple professors and asked them whether we could have 10 minutes of their lecture time to have their students fill out our printed survey. Moreover, we asked our friends and parents whether they can ask their friends, colleague or customers to fill out the questionnaire.

Online Survey The online survey was mainly distributed digitally. We contacted our friends and asked them to participate in the survey. We also demanded to forward the link to their friends so we could reach a wider range of people.

6.2.3 Filtering for Evaluation

Table 1 summarizes what kind of answers we used in order to exclude participants from the survey who do not fit into our target group.

In the succeeding section we present and evaluate the results of the study. With the filtering above we had 169 remaining participants who were considered for the evaluation.

6.3 Results and Evaluation

The study yielded interesting results which should be considered when designing an anti-phishing education app, either for this work, or if not possible due to time constraints in future work. This section outlines the results of the study.

General Information The ratio of our male and female survey participants was more or less balanced. 40.83% of the users were female and 56.80% of them were male. The remaining 2.37% did not indicate any gender. The average age of our participants is 27.59, the youngest participants are 19 years old, the oldest are 63 years old. Most of the survey participators, 48.52%, obtained a university degree. 24.85% of them do not have any professional qualification (yet). 17.75% did an apprenticeship and the remaining participants had a master craftsman certificate or did not indicate any professional qualification in the survey.

High Rate of Android Users The majority of the participants were Android users. In total about 60% of the study participants use an Android smartphone. The remaining 40% are iOS users. This result additionally supports our decision for the implementation of an Android application.

High Internet Usage Frequency 51.48% of the users are online several times a day. Another 30.18% indicated that they are online even constantly. As a consequence, over 80% of the survey participants are frequently online. This is depicted in Figure Figure 3 Being online is always connected with being attackable and vulnerable to dangers of the Internet, such as phishing attacks, while the extent of the vulnerability of course depends on the expertise of the person being online. However, the more often a user is in the Internet, the more likely it is that he will experience a phishing attempt.

Usage Distribution of Internet Applications Figures Figure 4 and Figure 5 summarize the usage distribution of Internert applications on a desktop computer and on smartphones. Almost all participants, 99.41%, make use of e-mails on their desktop computer. 88.76% of the smartphone owners use their e-mail application on the smartphone, which is still a high percentage. As we have previously mentioned, cf. Section subsubsection 2.1.3, e-mail is a common attack channel for phishing attempts. Consequently, all users of e-mail applications as well as users of webmail on mobile phones are potentially endangered by phishing attacks. The same applies to participants using browsers. A common way to trick users to disclose their confidential information is the use of fake websites. These websites can be reached by clicking on a link in an e-mail, SMS or in online social networks or instant messaging systems as well as by simply surfing in the Internet. About 80% of all considered participants make use of desktop or smartphone browsers. Furthermore, it is conspicuous that banking is far less used on the smartphones compared to desktop computers. While about 74.56% of the participants make use of online banking on the desktop computer, only 26.63% make use of it on their smartphones, which is however still a quarter of the participants. The question to ask here is if these users use the browser for the online banking or if they use apps provided by their bank. Regardless of the answer to this question, these users might be more likely to react to phishing e-mails, claiming to come from their bank, on their smartphone compared to other users who manage their financial arrangements on a desktop computer and thus are less likely to access a phishing website, cf. Section subsubsection 1.1.4. To sum it up, all the categories of applications are used by the participants, on their smartphones as well as on their desktop computers. For this reason, all of these application categories should be reflected in the choice of the example URLs for the final app. For future work, one could argue to put the focus on URLs from specific categories (also those which were not considered for the study), depending on the usage distribution.

Self-Assessment - Knowledge to avoid dangers of Internet With a Likert scale the participants had to indicate how much they agreed with the following statement: “I have enough knowledge to avoid the dangers of the Internet”. 18.34% of the participants strongly agree with this self-assessing statement. Further 45.56% agree with the statement and only

Question	Filtering
Age	We consider all adults ranging from 18 - 65 years.
Gender	We do not exclude any gender.
Professional qualification	The participant does not have to exhibit a specific professional qualification to be considered for the results and evaluation.
Field of study/work	Students, employees or employers in the field of computer science or electrical engineering are filtered out as they do not belong to our target group.
Frequency of Internet usage	Participants who have indicated “rarely” as the answer to this question do not belong to our target group and thus are filtered out.
Used Internet applications	The listed applications include, for example, browser, e-mail, shopping as well as banking. Any service of the Internet is potentially endangered by phishing. For this reason we do not use this question to filter out participants.
Owning a smartphone	With the app we particularly target smartphoner owners. For this reason participants who do not own any kind of smartphone are filtered out.
Used smartphone applications in the Internet	The listed applications include, for example, browser, e-mail, shopping as well as banking. Any service of the Internet, especially on a smartphone, is potentially endangered by phishing. For this reason we do not use this question to filter out participants.
Number of received commercial e-mails per week	We do not filter out any participant with this question.
Number of received e-mails asking for personal data	We do not filter out any participant with this question.
User reads up on topics related to dangers in the Internet	Participants who have chosen “no” as answer are filtered out. We specifically target users who are interested in getting safer in the Internet. As the participants who have indicated “no” do not seem to have any interest in doing so, they will most likely do not show interest in our app. For this reason we regard them as not belonging to our target group and exclude them from the analysis and evaluation.
Section to self-assessment regaring their knowledge about Internet security	We do not filter out any participant with these statements.
Section to questions concretely related to phishing	We do not filter out any participant with these statements.
Section to preferences for an anti-phishing education app	We do not filter out any participant with these statements.

Table 1: Filtering rules for the phishing survey

about 13% disagree or strongly disagree with this statement. As a consequence the majority of the participants were quite confident that they could avoid the security-related risks raised by the Internet.

Self-Assessment - Distinguish legitimate from illegitimate e-mails With a Likert scale the participants had to indicate how much they agreed with the following statement: "I find it easy to distinguish legitimate e-mails from fake ones". Here, 37.23% of the participators strongly agreed with the statement and even 50% of them agreed with it. Only about 8% of the participant did not agree or strongly disagreed with this statement. This arouses the suspicion that the users are not aware of how easy it is to spoof the "from" field of an e-mail or to create credible message contents which in fact may persuade the receiver to be trustful.

Self-Assessment - Trust to e-mails from known parties With a Likert scale the participants had to indicate how much they agreed with the following statement: "I trust e-mails which come from persons I know". The majority of the participants trust e-mails which come from persons they know. Approximately 20% strongly agreed and approximately 57% agreed with this statement. Only about 2% strongly disagreed and approximately 5% of the participants disagreed with this statement. This again shows, that most of the participants are not aware that spoofing the "from field" of an e-mail is very easy. These users are likely to react to e-mails which claim to be, for example, from friends. Such e-mails may contain links to the download of malware or malicious websites.

Self-Assessment - Internet security is only related to financial applications With a Likert scale the participants had to indicate how much they agreed with the following statement: "Internet security is only related to financial applications". The answers to this statement showed that the majority of the participants are aware that security related issues in the Internet do not solely concern financial applications. 49.7% of the users strongly disagreed with this statement and another 24.26% disagreed. Only about 10% of the participators agreed or strongly agreed with this statement and about 14% indicated "neither nor" as an answer. Even though most users seem to be aware that Internet risks do not only concern financial applications, the ones who are not aware that, phishing for example, can also occur in online social networks, should be enlightened about this. To do this, originally, our plan was to display the consequences of falling for a certain phishing website (phishing URL). In this way, the user could have learnt what his loss could have been, if he had fallen for such an attack in reality. This would have contributed to his awareness that security issues in the Internet, in this particular case phishing, are not necessarily related to financial loss only. Due to lack of time we could not realize this approach, so it is something which should be considered in future work.

Services endangered by phishing Figure Figure 6 summarizes the results for this question. All in all, we can observe that the participants agree that phishing can actually occur related to any service. The users agree (97.04%) that especially the e-mail service is endangered by phishing. Also they see the browser with fake websites (70.41%), online banking (83.43%) as well as social networks (74.56%) as endangered. Still about 40% consider various media (audio and video) services as well as online games as endangered. These services are in fact not targeted as often as other services in the Internet, however they are potential targets and should be communicated to the user, for example, with the aid of the choice of the URLs to decide on.

Data endangered by phishing Figure Figure 7 outlines the results of this question and illustrates that the participants agree that any kind of data is potentially endangered by phishing attacks. 90.53% of the participants are of the opinion that login data is endangered by phishing. About 89% agree that credit card information as well as personal data is endangered, too. Finally, 76.33% of the participants consider PINs and TANs endangered. Consequently, there does not seem to be a major necessity in enlightening users in this area.

Preferences for an education app todo. evtl nochmal aufteilen

7 Teaching and Learning Content

In this section we will describe and elaborate on different teaching and learning contents which can potentially be communicated to the user. At the same time we will reason our decision whether to communicate the specific content or not.

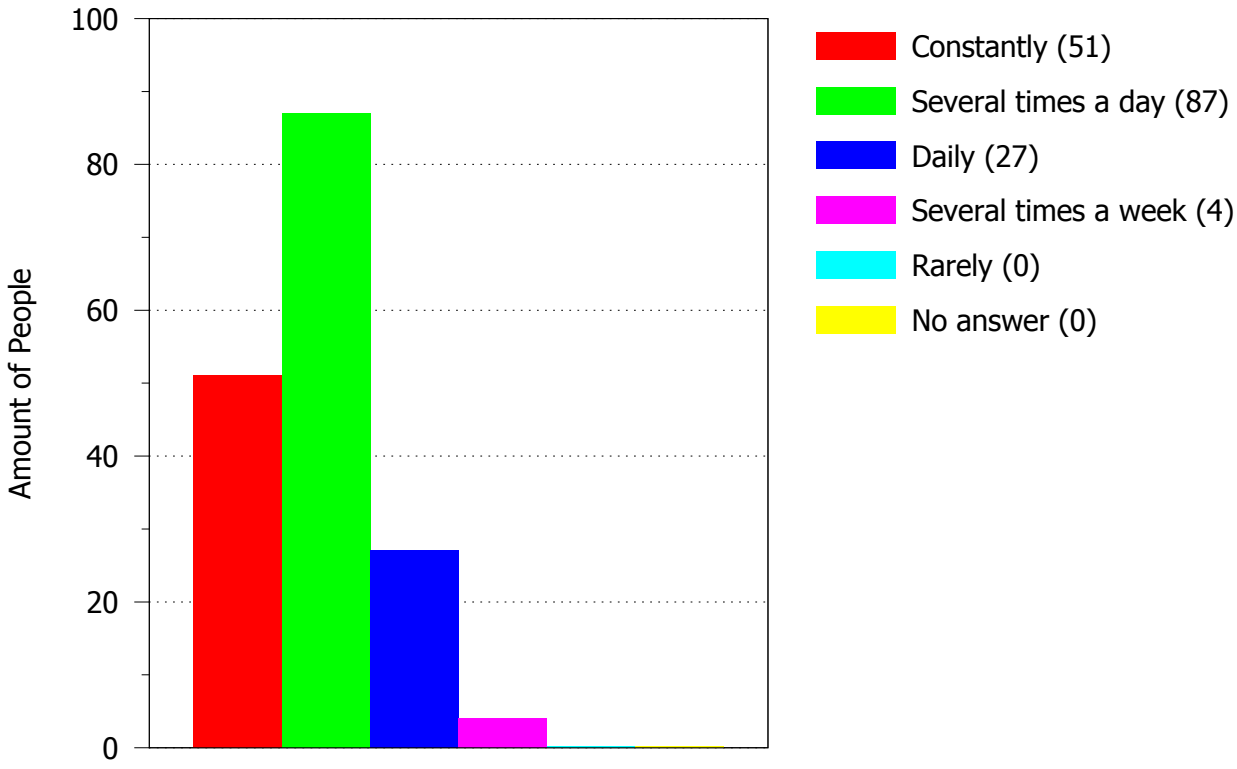


Figure 3: Frequency of Internet Usage

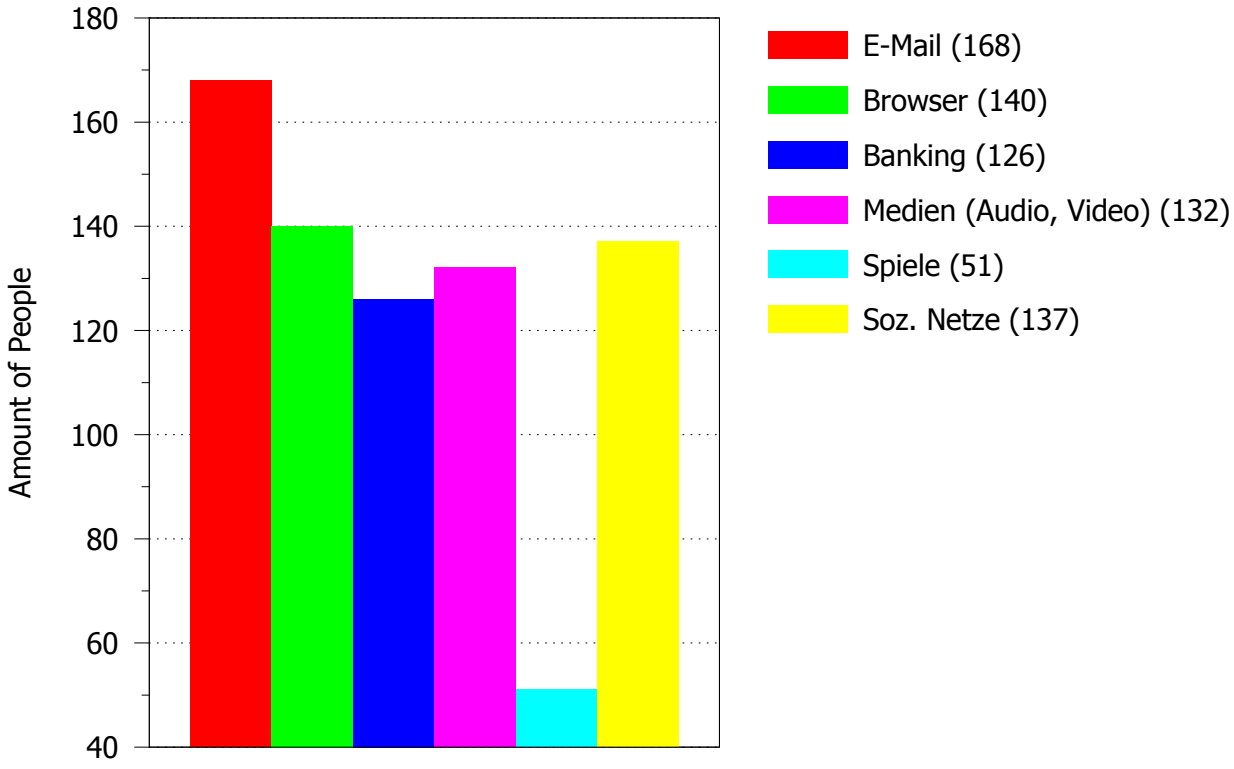


Figure 4: Usage of Internet Applications on Desktop Computers

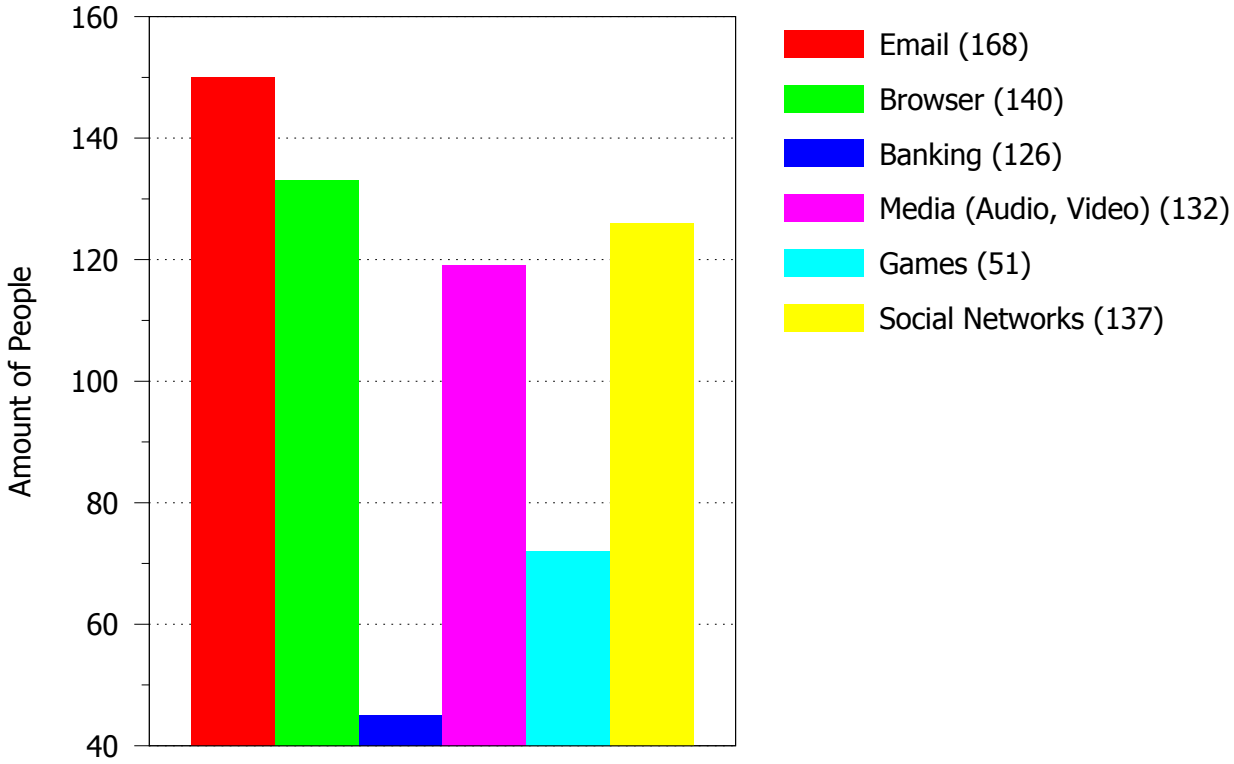


Figure 5: Usage of Internet Applications on Smartphones

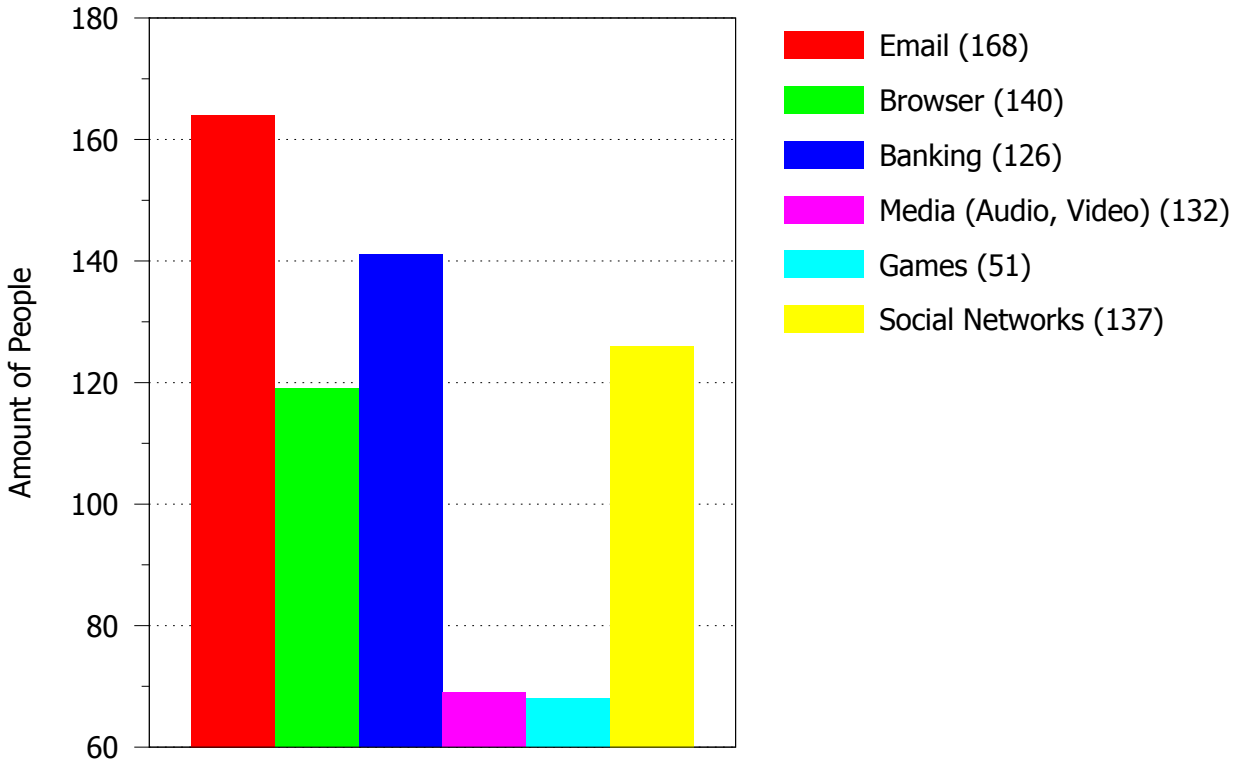


Figure 6: Services Endangered By Phishing

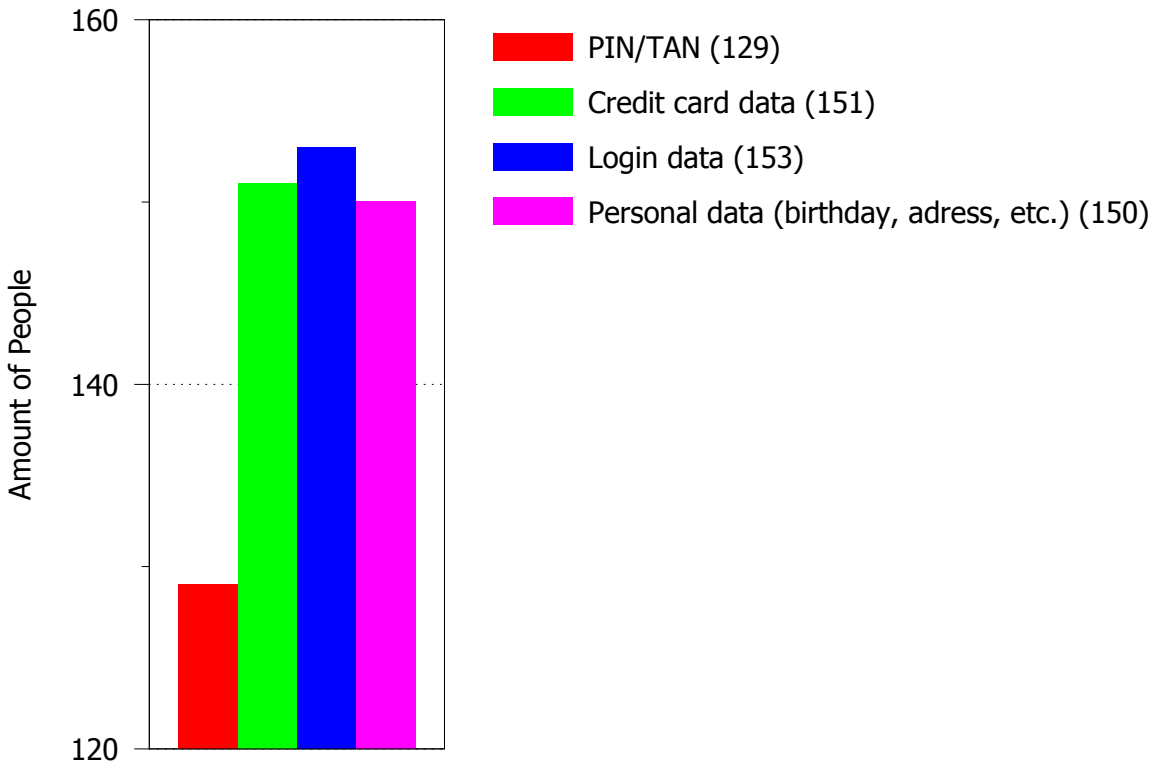


Figure 7: Data Endangered By Phishing

7.1 E-Mail Spoofing

The first thing we tell the user in the app is that they can not trust in Mail and the sender of them. This is exspecially important [24] found out that 85% of the internet users use E-Mail to communicate but only 14% have concerns about security regarding mail communication.

This is a problem because in contrast to public believe e-mail is in no way secured against fraud. There are three main facts that we need to transport to the user:

From Field The first misbelife is that the from-field is in some way secured. In reality it must be considered a plaintext field. The problem is that most modern mail-clients used by most users hide this fact away from the user. Therefore we show the user with an example that anyone can send mail from any from-address.

E-Mail Content We also have to show the user that the content of the mail is totally in the control of the sender. Nobody prevents the attacker from sending mails that look exactly like the once send out by a legitimate sender.

Links in E-Mails The third information that most users are not aware of is that Links in general and Mail-Links in detail could link to any page. This means that a Link showing an URL does not need to link to that url.

To show the user these facts we have introduced the first part of the app. We commonly refer to this part as the "awareness part" because it is there to increase the users awareness of the problem of Email spoofing and internet fraud. In this part we first introduce the problem. Thereafter the user is presented with a form that allows them to enter a sender and a target E-Mail address and a free text. When the user submits this form we send out a Mail that has the sender and the receiver that the user entered. The body of the mail contains a common introduction and the users free text. It also contains a link that seems to go to a common webpage but instead links back to the app. The template for this mail can be found in Appendix Appendix A.

7.2 Smartphone limitation

As already discussed in Section subsubsection 1.1.4 smartphones have several limitations, such as the small screen size. This section deals with the detection of phishing on the smartphone and the related limitations. More particularly, we will briefly explain in which ways URLs can be checked with the smartphone and what kind of problems these operations raise. Based on this we decided whether to communicate this kind of URL checking to the user or not.

Invisible Address Bar Due to lack of space most of the smartphone browsers hide the address bar [3] and use this won space for the web content. By doing this, not only potential security indicators are made invisible, but also the URL that indicates with which website the user is actually interacting. In order to make the address bar re-appear the user generally has to scroll to the top of the whole website. The fact that the address bar containing the important information of the URL is generally hidden must be communicated to the user. Most of the users will probably know that they can access the address bar by scrolling to the top of the website. However, for those who might not know how to deal with that an introduction is inevitable.

Analyze Complete URL Via Address Bar Finding the address bar will not suffice for a reasonable URL analysis. Here again, the small screen size makes it is impossible to view the complete URL without any further action. Specifically, it is necessary to first tap the URL address text and then scroll the pointer to the left and right for the URL analysis. Without learning these steps a reliable URL checking is not possible. Therefore, these operations steps have to be communicated to the user.

Show URL Before Click Many mobile e-mail clients provide the functionality of showing the URL a link leads to when touching and holding the link. However, the Android stock e-mail app, for example, does not provide this functionality. This operation is generally available in smartphone browsers for links on websites while surfing. Yet, one should keep in mind that it might happen that the complete URL cannot be displayed on this preview in case it is too long. Consequently, as discussed in Section subsection 4.1, deceiving the user with well-crafted, illegitimate URLs becomes possible. In that section we have already extensively discussed the benefits and drawbacks of teaching the user how to preview the destination URL and have decided against it.

Copy and Paste URL Previewing the destination URL raises flaws, such as there is no guarantee that every mobile e-mail client provides this functionality and deception remains possible. An alternative to the preview functionality is the copy and paste functionality. When touching and holding a link, additional to the URL preview, the option "copy URL" is available. Upon selecting this option the destination URL is copied to the clipboard. Now the user may paste the destination URL to any editor or even the address bar itself in order to analyze the it *before* submitting. In case the URL was pasted directly into the address bar, left and right scrolling must further be applied for the analysis. Also, the user must be careful not to submit the URL before checking it, otherwise he also just could have clicked on the link and checked the URL afterwards. Analyzing the URL in a separate editor would mean to re-paste the URL into the address bar afterwards and then submit it. We believe that either of these steps are of too high effort and thus would not be followed by the users. Also, the user would not be able to see the "real" target in case there is a redirect included. Hence, this kind of possible operation will not be communicated to the user.

7.3 URL Structure

The URL is a complex construct. In order to correctly analyze a URL and decide whether it is a spoofed or not it is necessary to understand the structure of it. An attacker use brands which are familiar to the user in any part of a URL in order to deceive him. Therefore, especially, the identification of the domain in a given URL is a key aspect which must be aimed at with the app. We will teach the user about the most important parts of a URL, the protocol (http vs. https), the host with its domain and the path (we do not distinguish the directory, filename or query parameters of the URL path).

7.4 Phishing URLs

As aforementioned, we focus on teaching the user how to analyze a given URL and to decide on it whether it belongs to a legitimate or illegitimate website. In order to distinguish legitimate URLs from phishing URLs it is necessary to analyze existent phishing URLs regarding how the URLs are spoofed in order to deceive the users. For the analysis of phishing URLs we chose the database of PhishTank.

PhishTank is a free community site where people can submit, verify and view phishing data. It provides an API which makes all PhishTank data accessible. Organizations such as Yahoo, Kaspersky Lab and Mcafee use the data submitted by PhishTank [59]. A further deciding reason to choose PhishTank as our phishing URL database was that Kaspersky Lab itself recommended us to make use of it for our URL analysis. For the phishing URL analysis we made use of the URL categories which had been identified by the authors of Anti-Phishing Phil [70] as a starting point. To these belong IP address URLs, subdomain URLs as well as similar and deceptive domain URLs. With these given categories we tried to assign the PhishTank URLs to the available categories. When no category suited the URL to be assigned, we generated a new category, to which the URL could then be assigned to. In addition we found various categories mentioned in literature, which we also included to our categories, even if we could not find any explicit example URL in the PhishTank database. In the following the identified URL categories are explained.

7.4.1 Phishing URL Categorization

URLs are complex and many users do not know how exactly they have to be interpreted. For example, users can be convinced about the authenticity of an URL when it contains the brand name anywhere. Phishers exploit this lack of knowledge in different way. In the following we present the identified spoofing attacks on URLs. All spoofing attacks are covered by the app unless noted otherwise.

Subdomain Phishers make use of subdomains which are very similar or even identical to the domains of the spoofed target institutions. For example, they register a domain “xyz.com” and use “paypal” in their subdomain, resulting in a URL such as “http://www.paypal.xyz.com/webapps/”. This makes the users believe that they are on a legitimate website.

IP Address Sometimes phishers do not even bother registering any domain at all. In this case, the URL to the phisher’s fake website contains an IP address.

Nonsense Domain We frequently encountered URLs which had registered quite nonsense as their domain. The domain names ranged from random letters to domain names like “marketstreetchippy. com”. Sometimes other parts of the URL contained the brand name, but sometimes there was no clue in the URL about to where it is actually leading.

Trustworthy, But Unrelated Domain Some URLs are very well-crafted. When reading them they appear meaningful and trustworthy. This is particularly accomplished by making use of domain names which sound very trustworthy, for example, “account-information. com”, “secure-login. de” or “security-update. com”. If the URL additionally contains the brand name of the target institution somewhere in the URL the user is easily deceived.

Similar and Deceptive Domains Another possibility to fool users with a spoofed URL is to use URLs which look like the original ones, but have a slight difference. For example, phishers register domains which resemble the targeted domain, but has a typo. To spoof “paypal. com”, for instance, the attacker might register “paypel. com”. Another approach is to use a modification of the original domain. The modified domain contains the brand name in some form. For example, “facebook-login. com” can be registered in order to fake “facebook. com”. Finally, the attacker can scramble letters of the original domain, which can be very hard to detect at first sight.

Homograph Attack The homograph attack exploits character resemblance. Here characters are replaced by other characters which look very similar to the replaced one. For example, an attacker might replace a “w” within a genuine domain with “vv” and register it. An even more advanced way is to replace characters of the genuine domain with characters from other langauge sets, such as Cryllic languages, where the characters will look almost identical [25]. The letter case is indistinguishable for the human eye in many cases and is partially a technical issue. Here, browser vendors should be

encouraged to indicate when there are international characters. For this reason only cases that are distinguishable by the human eye are covered by the educational app.

Tiny URLs A tiny URL service is used to convert a long URL into a short one. Due to their shortness tiny URL are very comfortable to use and easy-to-type. There seemed to be a trend of using tiny URLs for phishing in 2009, in particular in instant messaging services. Tiny URLs usually do not give a hint about the target website and users do not tend to be suspicious about receiving such links from a "friend" what made the use of it quite popular [41]. Tiny URLs redirect the tiny URL to the actual long URL. As we consider the "analyze URL after-click" scenario for the user education, there is no need of the tiny URL to be covered by the app.

Cloaked URLs Other phishers integrate an "@" into the URL so that domain names become difficult to understand and the actual destination of a link becomes "cloaked"[2]. For example, the URL http://paypal. com@google. com/ is redirected to http://google. com. As we consider the "analyze URL after-click" scenario for the user education, there is no need of the tiny URL to be covered by the app.

7.4.2 Problems With URLs

There arise two major problems with the detection of phishing attacks based on the URL which are stated below. The succeeding sections elaborate on these problems and outline how we handle these problems.

1. Some legitimate URLs feature characteristics of phishing URLs.
2. We cannot assure that the users know all website vendors of our URLs (whether legitimate or phish).

Legitimate But Phishy Looking URLs

We wanted to find out to what extent phishing URL categories apply to authentic websites. For this purpose we browsed the web and looked at legitimate websites, too. In detail, we visited and clicked through websites of the top 50 banks [80] and top 50 online shops in Germany [13]. While surfing on these websites we have recognized that it occasionally may happen that a legitimate URL features the characteristic of a phishing URL. This is particularly the case for the category of similar and deceptive domains. There exist sites of vendors which make use of similar domains, instead of never changing the domain and using, for example, subdomains. An example is the website of the Commerzbank. When surfing on Commerzbank's website the domain is "commerzbank.de". As soon as the user is on the online banking part of the website the domain changes to "commerzbanking.de". The same happens on a PayPal website. The regular website features the domain "paypal.com". However, paypal also has a site, where the domain is "paypal-viewpoints.com" By our definition, "commerzbanking.de" and "paypal-viewpoints.com" would be a phishing website.

We have decided to address this problem by adding a section of final remarks to the app. In this section we tell the user that there might be domains which are similar to domains they are familiar with and not necessarily are phishes. We still strongly recommend the user to directly contact the vendor before submitting data to such websites. The reason why we do not address this problem in the according level is that we do not want to degrade the user's attention by telling him that similar domains might still be legitimate. We do not consider it an issue that the user is told about this later in the app, since it is better to reject a legitimate URL than trusting a phishing URL.

Unknown Website Vendors

Even our efforts of mainly making use of URLs from widely known website vendors there is still the issue of the possibility that a user does not know all vendors and thus the respective URL. One approach to address this problem is that the user has to indicate which websites he knows with the aid of a long check box, for example. We decided against this approach for two reasons: First, if a user does only know two website vendors, the list of available URLs will be quite short. In such a case the game experience would degrade significantly. Second, and more importantly, we cannot expect the users to go through a large list of vendors and let them decide whether they know them or not. This kind of configuration would substantially decrease the usability of our app. Currently, we have to let the user learn new vendors.

This should not be a big issue. By making mistakes and/or giving correct answers to unknown URLs, i.e. domains, the user will eventually learn whether a given domain is legitimate or not. For future work, one might consider to add a "I don't know" button. In this case the user would virtually skip this URL and be explained whether it is a phish or not and why it is so.

7.5 General Recommended Behavior

In addition to these facts that we specially address in the app there are some things that we want to tell the user that are helpful when using the internet in general.

Do Not Download Attachment Many users download or even open files that they receive via mail rather unchecked. This is related to the problem that they trust the from-field of the Mail. It is crucial to tell them that downloading or even opening a unknown file might infect their system. However, for this work we consider this as out of scope and leave it open for future work.

Data Economy The goal of this app is to prevent that the data of the user is phished. The first step towards this goal is to teach the user to enter his data as rarely as possible. The idea behind this is not only phishing website might use the users' data in a way that he did not intend. This is considered out of scope and remains as a problem to be targeted in future work.

Date Entry Via Https We should also tell the user that he should only enter data via HTTPS. When the user is entering data via HTTP there are basically two problems. First the user can no longer be sure that he really talks to the person he want's to talk to. This is captured by our precodition that DNS is assumed to be secure. Secondly even if he really talks to the legitimate target site he can not be sure that an attacker is not wiretapping the communication. Therefore the data that is send over plain HTTP can be considered lost. This teaching content will be part of our app, cf. Section subsection 8.5.

7.6 Browser Security Indicators

As a matter for fact, there is a major lack of mobile browser security indicators [3, 10]. Besides the lack of such indicators there is also the problem of inconsistencies among the mobile as well as desktop browsers. This section deals with the security indicators of the Android standard browser which the user might potentially be told about. Ultimately, our decision was not to tell anything about these security indicators, since they are too inconsistent even among the standard browser, depending on the device and Android version it is installed on.

Https Padlock The padlock in the browser chrome is a security indicator for the usage of https. All Android standard browsers on various devices we have examined have a padlock on SSL secured pages. Also, one should consider that there are illegitimate as well as legitimate websites where a padlock is part of the web content. Therefore, it is important to teach the users to look for the padlock in the browser chrome to verify that the site they visit is SSL secured, when they enter confidential data. However, some browsers additionally make use of so called favicons, small website icons. The danger of using such a favicon is that a phisher could use the image of a padlock [10] in order to deceive the user. Moreover, the padlock with/without favicon combinations appear in different ways. While a part of the standard browsers installed on various devices and Android versions we have examined only feature a padlock in case of https websites and no favicon at all, others make always use of favicons. In the latter case, if https is used the padlock is either displayed right next to the favicon or overlaps it . Due to the variety of possible combinations as well as the deception potential in combination with favicons we decided not to tell the user about the padlock.

Touch Padlock Touching the padlock of an SSL secured website leads to an alert dialog with information about the website. One part of this information is the complete URL of the website the user is currently on. In this case, it would become possible to view and analyze the complete URL without tapping the address bar and scrolling to the left and right. For *some* browsers which additionally make use of favicons, the above described feature is always applicable. That means, the alert dialog with the complete URL can also be consulted on websites which do not use https. Yet, there are

also browsers where neither clicking on a padlock nor on a favicon is possible. Hence, we will stick to our approach, where the user is explained how to analyze the URL directly in the address bar.

Certificate Verification Tapping on the padlock icon results in an alert dialog where the user can select to view the certificate details ("show certificate"). Upon selecting this option details about the certificate will be displayed. On the hand, while examining Android's standard browser on various devices and versions we have encountered that clicking on the padlock is not always possible. Hence, in these cases a validation of the certificate is not possible as well. On the other hand, we consider the validation of certificates as out of scope for this work. Therefore, this is an aspect which is not covered by our app.

7.7 Conclusion

This section briefly summarizes the above described learning contents which will be addressed by our app.

1. E-mail spoofing
    a) Do not trust sender
    b) Do not trust content
    c) Target URL of a link is not necessarily the displayed one
2. Invisible address bar
    a) Access address bar
    b) View complete URL
3. URL structure
4. Phishing URL categories
    a) Subdomain attack
    b) IP address attack
    c) Nonsense domain
    d) Trustworthy sounding, but unrelated domain
    e) Similar and deceptive domain
    f) Homograph attack
5. General Recommended Behavior
    a) Data entry via HTTPS only

8 Approach for Our Anti-Phishing Education App

This chapter presents our final approach for the Anti-Phishing Education App. In the following sections we will elaborate on the app design in detail.

8.1 App Design

We have decided to divide our education app into two main parts. The first part of the education app is intended to increase the user awareness. The second part of the app then covers the actual educational part. The following enumeration summarizes the functions of our twofold app structure.

1. **Awareness Part** The first part of the education app is intended to increase the user awareness regarding how easy it is to spoof e-mails and mislead users with such fake messages. This part is supposed to motivate the user to do something to counter the danger of the Internet, in this particular case, against phishing.

    a) **Receive Fake E-Mail** We want to illustrate to the user how easy it is to spoof the "from" field of an e-mail as well as the content of this e-mail. For this purpose the user has to send a fake e-mail with an arbitrary sender address of his choice to himself. The user will also have the option to type in a free text. Upon submitting the form the user will receive an e-mail with the e-mail address he had indicated as sender. The free text will also be part of the received e-mail. We believe that the user will be very surprised about how easy even he himself could send a fake e-mail. The user will learn that he cannot fully trust the "from" field and the content of the e-mails he is receiving.

    b) **Linktext Unequal Target URL** The awareness part of the app is also supposed to show the user that he cannot trust the texts of a link he is clicking on. To illustrate this, the user is asked to click on a link with the text "https://www. google. de/". Clicking on this link, the user will expect to land on the Google website, what will not happen. In fact, the user is linked back to our app, where he is told that link texts are not trustful as well.

    c) **Fake Website** Finally, the user is told that creating a copy of a website is also very easy. He is told that a reliable way to decide whether a website is a fake or not is to analyze the URL of the website he is visiting. He is also told that this app focuses on exactly this.

2. **Educational Part** The second part of the app covers the actual educational part. Here, the user is learning about various spoofing techniques of the attacker.

    a) **Information Material** The second part of the app is divided into levels of increasing difficulty. Here the user is first taught how to access and analyze the URL of the web browser. Subsequently, the user learns about the general structure of a URL. This is done in a very simplified way, so that even unexperienced users can follow. In particular, the user is told how to find the second- and top-level domain of a URL. In all succeeding levels the user is introduced to various URL spoofing techniques of a phisher. The learning content of each level can be consulted in Section subsection 8.5.

    b) **Exercise to Information Material** After every introductory material in each level an exercise section is followed. For the "access and analyze URL part", for example, the user is forwarded to a website. There he has to apply all important steps he has learnt in the introductory part. After successful completion of the tasks the user is linked back to the app. For the "find second- and top-level domain" information material the user gets a couple of valid URLs of which he has to identify the second- and top-level domains. All subsequent level exercises are structured as follows: the user is presented a URL. He has to decide whether the presented URL is a phish or a valid URL. If the URL is a phish, and the user has correctly identified the phish, the user has to show the second- and top-level domain. Only if the user correctly identifies the second- and top-level domain he receives the points for this URL, otherwise the answer to this URL is considered wrong, because we assume that the user has just guessed in this case.

    c) **Repeat 2.a and 2.b With Increasing Difficulty** There is an increase of difficulty in each level. That is to say, in each level it gets more difficult to distinguish phishing URLs from valid ones, cf. Section subsection 8.5.

The next section deals with the concrete rules of the game.

8.2 Gamification

As we pointed out we decided on designing the app as game. This is mainly because we think that this makes it more interesting for the users and raises the possiblity that we reach more users. In most modern games we see the following elements which we all implemented:

Lives An often used game element are lives. In general a inherent property of a game is the possibility of loosing the game. If you are not able to loose a game you will get no positive feedback from winning the game. On the other hand in most games loosing is related to a big failure. Therefore you don't want your player to loose the whole game when he makes one little mistake. Therefore most games have some kind of "you have N tries" element. Normally this element is called "lives" and often represented in heart-shaped indicators. We also introduced such an element. The details of loosing lives will be layed out in subsection 8.3.

Levels Also most games have some kind of level system. This has multiple purposes. First it is important for the player to get a feeling for the process he makes in the game. It also provides the user with fixed points in the game where he can restart or pause and play on later. To us it gives the ability to structure the game in a repeating cycle that the user learns. This way if the user plays multiple levels in a row he can skip the repeat parts easily but if he has paused he can read it. The details of the leveling Strategy can be found in Section subsection 8.4

Leaderboards Finally often games have a kind of leaderboard. This means a area where you can compare your progress within the game with others of the game. For many people this is a major motivation point. These people want to be better then others. To motivate these people we introduce two leaderboards:

Total points First there is a leaderboard that shows how many points you gained while playing the level. The details of how the points are calculated are shown in subsection 8.4.

Detected phishing URLs As the points are a relatively opaque number we also introduced another leaderboard. This shows the user that detected most phishes in the app.

Achievements There is another type of player. This player wants to find everything in a game and is willing to invest time in a level just to finish it perfectly or to find every hidden secret. To address this type of player modern games often something called "achivements". Achievements are special parts of a game that you can unlock if you for example find a special object or play a given level very good. We implemented mainly achivements for finding 5,10,25,50,100 and 500 phishing URLs.

8.3 Game Rules

The educational part of the app which is followed by the awareness part is divided into several levels. In each level the user is provided with specific informational material. After the information material is consulted by the user, he has to finish the according exercise. The first and second information materials (introduction 2 and level 1) and exercises that the user receives differ from the ones of the other levels. Here, the users obtain basic knowledge in order to bring them to the same knowledge level for the actual game.

Basic Knowledge The first information material and task of the user deals with accessing the address bar of a webbrowser and viewing its URL completetely. To prove that the user has understood how to access the address bar and view the URL he has to do the following: When the user is forwarded to the website to solve the task he has to scroll up to the top of the website to make the generally hidden address bar visible. Afterwards, he has to provide us the information we request about the URL in the address bar. This will show that he has in fact viewed the whole URL. After successful completion the user is linked back to the app and level 1 is started. From this level on, the user has three lives upon start of each level. In level 1 he has to identify the “Who-Section” (second- and top-level domain) of a URL. He has to tap the according part of the displayed URL. In this level wrong answers result in losing points and losing a live. In order not to frustrate the user he cannot get less than 0 points. When the user has no more lives left he has to restart the level. With every correct answer the user gains points.

Start of Actual Game In level 2 we start introducing URL spoofing techniques and the user has to decide whether a given URL is a phishing URL or a valid one. Here also, the user can lose and win points as well as lose lives. Here again, if the user has no more lives left he has to restart the level. Figure 8 illustrates the game flow and consequences of wrong and correct answers from level 2 and upwards. If the user has correctly decided that a phishing URL is a phish, he has

to show us the “Who-Section” to prove that he has understood the concept. In all other cases the user is directly shown the result of his answer. In summary, the user looses points for any wrong answer, but he does not lose a life for every wrong answer. We have decided that rejecting valid URLs is not as severe as accepting phishing URLs. For this reason the punishment for accepting a phishing URL is more severe than the punishment for rejecting a valid URL. All in all, the user loses points and a live in the following cases: the user has falsely accepted a phishing URL or the user has correctly rejected a phishing URL, but could not show us the “Who-Section”. In all other cases the user cannot lose lives, but only points.

The following section deals with our leveling strategy.

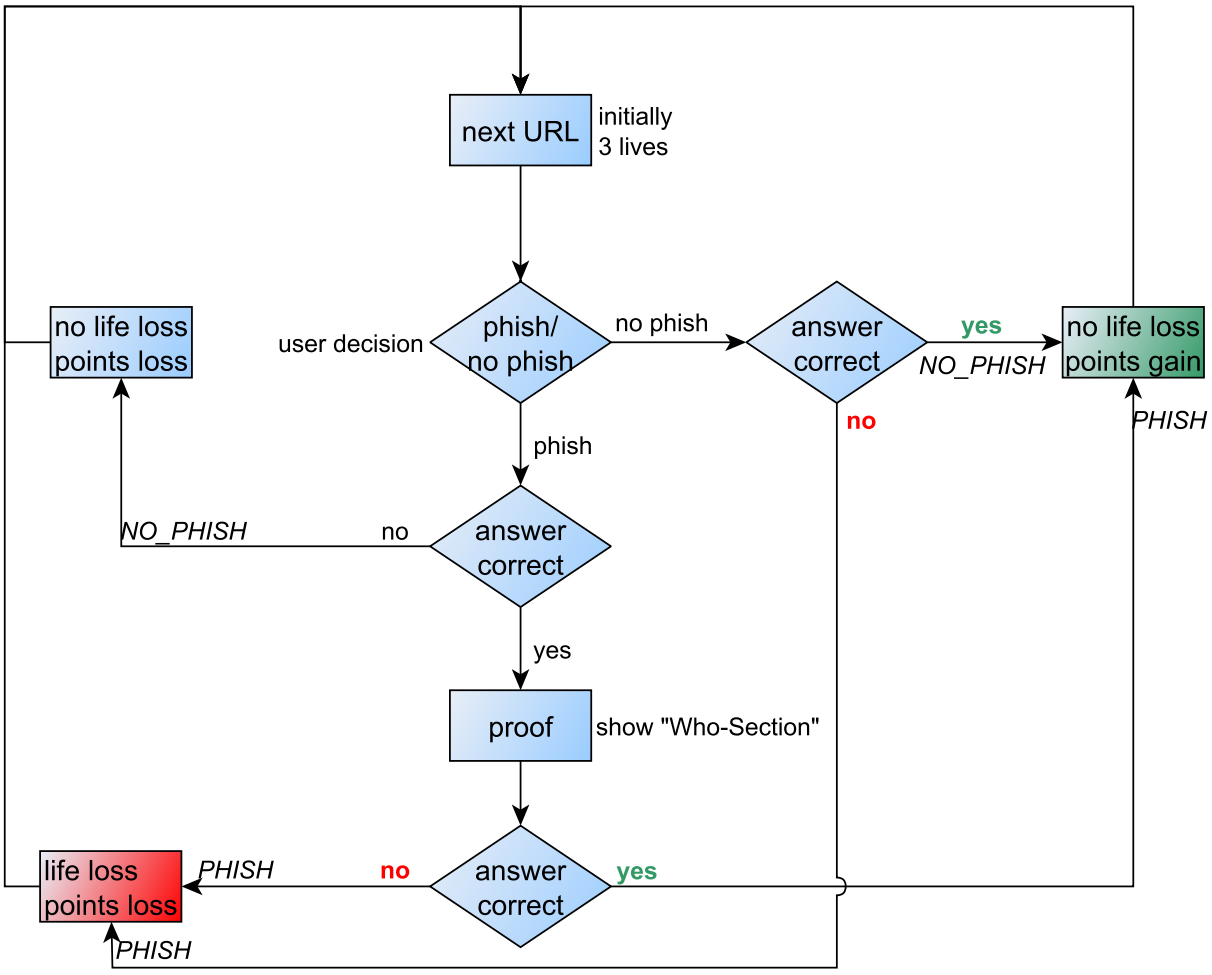


Figure 8: Losing points and lives in the game

8.4 Leveling Strategy

During the app development we have tried out several leveling strategies. This section is intended to introduce the leveling strategies we have considered for the app.

Leveling Based on Achieved Points Our very first leveling strategy was based on the achieved points per level. Each level the user had to achieve at least 100 points to pass the current level and unlock the next one. This approach had a major drawback. The fact that achieving a minimum of points to pass the level resulted in very similar points for everybody finishing a level. That is to say, everybody who has finished level x, has approximately the same points, which in turn would have meant that the comparison between single users would not be meaningful as it would only differ very slightly.

Additionally, with this strategy, users might replay early levels which are easier and gain the same amount of points as users playing later levels. This might result in users playing early levels repeatedly get more points than users playing later and difficult levels.

Leveling Based on Detected Phishes The previously described leveling strategy had the deficit of comparability among the users. However, we consider comparability very important since it serves as an incentive for the user to play better or play on. For this reason we overthought our strategy and decided that passing a level should not depend on the points a user receives. It rather should depend on the number of phishes the user was able to detect during a level. That is to say, among the shown URLs in every level there is a certain amount of phishes the user has to detect in order to pass the level. With this approach however, there is still the possibility for a user to repeat early, and thus easy, levels and possibly gain more points than users playing later, and thus more difficult, levels. To prohibit this, in increasing levels the users gains and loses increasing points accordingly. The points per correct answer increase such that it does not pay of to play lower levels. The points for each answer p in each level n is mudified by the formular:

$$p * 1.5^n$$

In this way, a user repeating early levels is not able to catch up other users of higher levels. This strategy solved the problems of our first strategy, however it also brought a new one. The strategy of passing the level when a certain amount of phishes are detected has the following flaw: always rejecting a URL will eventually result in passing the level (if the user also correctly identifies the “Who-Section” when required). The user will not gain a lot of points with this strategy, however he will eventually win, which is suboptimal for a game.

Leveling Based on Correct Answers To solve the problem of our second leveling approach we have extended the leveling passing to correct answers. Instead of detecting a certain amount of phishes per level, the user has to give correct answers to a predefined amount of phishing URLs as well as a predefined amount of valid URLs in order to pass the level. Only and only if the user has answered the predefined number of valid and phishing URLs the level is completed. To additionally incentivize the users we have included three lives per level. The lives are supposed to prevent a user playing eternally, without ever passing the current level. When the user loses all of his lives, cf. Figure Figure 8, this is an indication that he did not understand what the level is about. Consequently, he has to restart the level by being forwarded to the introductory part of the current level. The points are assigned exactly as before. This is our final leveling strategy for the app.

8.5 Teaching Goals Per Level

This section summarizes the learning objectives of each level. Note that we generally do not use technical terms like URL, domain, subdomain, protocol or the like. Figure Figure 10 illustrates and exemplifies the level flow of our app.

Introduction 1 This part is the awareness part described in Section subsection 8.1. Here, the user learns how easy e-mail spoofing is. Additionally, the user is informed about the simplicity of setting up fake websites and that he should not trust the texts of the links he is clicking on.

Introduction 2 In this part the user is explained how he can access the URL of a web browser and how exactly he has to look at the whole URL. In particular, the user is told that he has to scroll up the whole website to make the generally hidden address bar re-appear. Then he has to tap the text field of the address bar and scroll to the start of the URL. At the end of the exercise for this the user is told that he always has to analyze the URL like this, because all other displayed URLs or links might be fake too.

Level 1 The actual game starts with level 1, where the user learns about the structure of a URL. First of all, the user gets an overview of the single components of a URL. To make the comprehension of these components easier to understand we used an analogy which is summarized in Figure Figure 9 with an example URL. We told the user that he has to imagine that the website he is visiting is his dialog partner. The user is told that the section between “http(s)://” and

the third slash "/", i. e. the hostname, reveals information about his dialog partner. In particular, we explain that he has to read this part from right to left. The top-level and second-level domain is introduced as "Who-Section" (company + location of company), from which the user knows who he is actually talking to. All succeeding parts in this area are to be considered as "departments" of the company of ther user's dialog partner. The protocol part is introduced as "Security Level" of the dialog with the partner and the path part of a URL, i. e. the part after the third slash "/", is introduced as the topic of the conversation with the dialog partner. When marking parts of a URL we consistently used the according colour of Figure Figure 9. The main objective of the level 1 exercise is to be able to identify the second- and top-level domain of a URL.

Level 2 With level two we start introducing the spoofing tricks of a phisher. We considered the subdomain attack, cf. Section subsubsection 7.4.1, as a good starting point to introduce the phisher as the user has just learnt about the importance of the "Who-Section" (top-level and second-level domain) in level 1.

Level 3 In level 3 the user is first told what an IP address is. To facilitate the comprehensibility, we used the analogy of house addresses. The user is explained that like addressing our houses with street names and numbers, computers in the Internet are addressed by so called IP addresses. The IP address itself is defined as a 4-place sequence of numbers, separated by dots. Finally, the user is warned against URLs with IP addresses in the host part.

Level 4 In this level we deal with nonsense in the second-level domain, cf. Section subsubsection 7.4.1.

Level 5 In this level we deal with second-level domain names which sound trustworthy, but are in fact unrelated to the company name, cf. Section subsubsection 7.4.1.

Level 6 Here misleading and deceiving names in the second-level domain of a URL are covered. This includes typos, scrambled letters or other similar and deceptive names in the second-level domain, cf. Section subsubsection 7.4.1.

Level 7 In this level we focus on homographic attacks, where the user is able to visually distinguish a fake second-level domain from the original one, cf. Section subsubsection 7.4.1.

Level 8 In this level the user is introduced to an attack where the brand name of the visited website or even the whole legitimate URL is placed in the path of a fake URL, cf. Section subsubsection 7.4.1.

Level 9 Here we introduce the difference between the usage of http:// and https://. In particular, the user is told that the usage of https:// means that his conversation with the website is encrypted and that the dialog partner indicated in the "Who-Section" is authenticated. As an analogy we say that the https:// represents a higher security level. This means, the conversation cannot be eavesdroppbed by a third party and the dialog partner indictated in the "Who-Section" has proved his identity to a trusted third party. With http:// this security level is not established.

Level 10 This level does not include an exercise. It mainly serves as a section with some important additional input for the user. Specifically, we tell the user two things: First, we explain to him that he might encounter URLs which actually look very phishy. In such a case, we suggest him to directly contact the company and ask for the authenticity of the specific website. Furthermore, we introduce extended validation certificates. We provide the user with a link to further information to this subject.

8.6 Use of Learning Principles and Game Techniques

Our app is a learning game which purposes to introduce information on the topic of phishing and how to detect it. With the app we want to improve understanding for this topic and help users be less vulnerable for falling for such attacks in future. This section deals with the principles of learning and game techniques which are reflected in our app design. In fact, the laws of learning and game techniques have a strong connection which is the reason why games work for learning purposes [51].

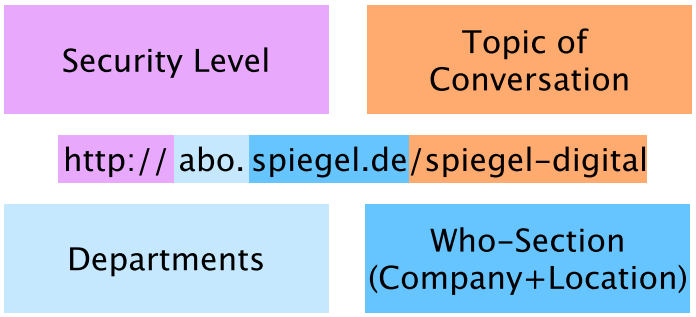


Figure 9: URL components that are communicated to the user

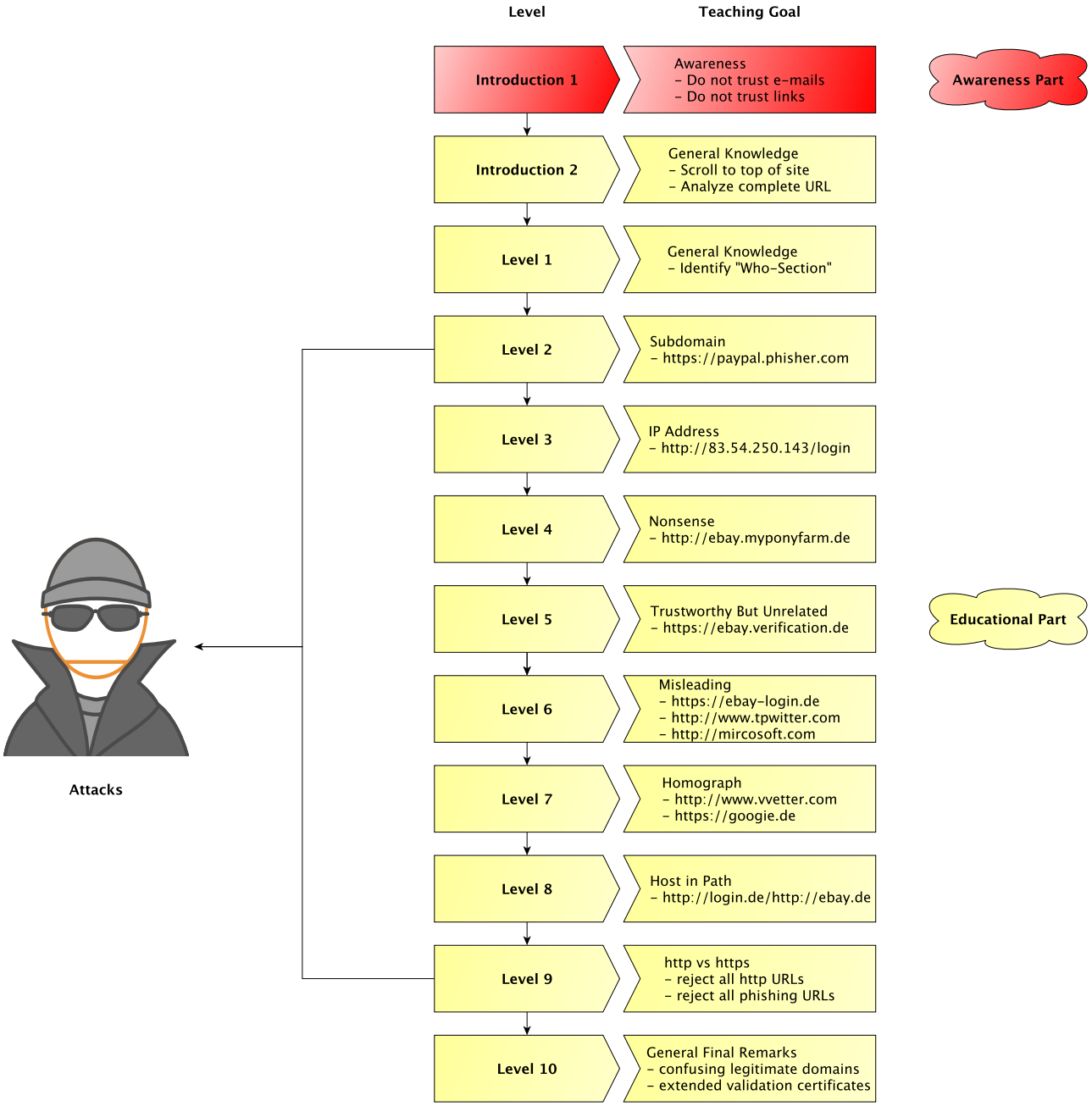


Figure 10: Teaching goals of the app

8.6.1 Principles of Learning

Edward Thorndike introduced the first three principles of learning: readiness, exercise and effect [77, 51, 32]. Later the principles of learning were further extended by: primacy, intensity and recency [51, 32]. These principles outline how people learn and which conditions improve their process of learning. In the following we will briefly introduce the meaning of these principles [51] and explain how they are reflected in our app.

Readiness The principle of readiness claims that physical, mental as well as emotional preparedness is an important prerequisite for a better learning performance. It also states that motivation is crucial for effective learning. First of all, students must want to learn something, otherwise any additional motivational efforts will be of no use. In order to make students want to learn something it is relevant for them to see a clear reason for learning, i.e. the perceived value of the material is ultimately related to their motivation. Finally, the principle of readiness says that best learning performances are achieved in combination with good physical health. The physical and health conditions of our app users are beyond our control. For this reason this is an aspect which cannot be reflected in our app. The app is targeted at users who are willing to learn something about phishing. Consequently, there is already some kind of motivation in our app users. In order to increase this motivation we present clear reasons why the user should continue to play our app. This is happening in the awareness part, where the user is told what exactly phishing is, how easy it is to phish users, spoof e-mail senders and content, spoof links as well as create exact copies of legitimate websites, cf. Section subsection 8.1.

Exercise The use of exercise is composed of two important parts: First, training and repetition help increase learning. Second, feedback is crucial for good learning performance. For best learning results, these two parts must be applied together. In a nutshell, the learning connection is strengthened by practice, and weakend by disuse [32]. After finishing the awareness part, we start with the user education and provide exercises for all of our learning goals (except for the last level), cf. Section subsection 8.5. The learning content is also permanently repeated. For example, in the introduction 2, cf. Section subsection 8.5 the user learns to scroll up to make the address bar re-appear and analyze the URL by right and left scrolling it. The scrolling of the URL is present in levels 2-9. Also, the user has to identify the Who-Section in level 1. In addition, the user has to show the Who-Section every time he has detected a phishing URL correctly. Finally, every introduced attack of each level n will appear in level n+1 at least once. That is to say, as soon as the user gets to know a new attack, he will keep seeing this attack in the succeeding levels. Our app also provides direct feedback to the users' actions. In case of correct answers, the user is rewarded with gained points, with a smiley and a small text that he has done well. When the user has made a mistake he is punished with losing points, possible life loss and a sad smiley. Also, told that the answer was wrong, why it was wrong and additionally he gets a reminder text on the applied URL spoofing attack he was not able to recognize. To sum it up, we let our app users practice what we taught them and make use of repetitions in combination with direct feedback.

Effect A student who associates his learning with positive feelings will learn more and better than another student who connects his learning with negative feelings. For example, a student who is unsuccessful with initial learning material will associate his experience with unpleasantness, frustration, anger and/or confusion, while a student with early success will have strong positive feelings and thus will be more motivated to have more success in future. Therefore, enabling particularly early success and maintaining student motivation with positive feedback and comments is crucial. In our app early success is easy to achieve, since we start with easy tasks and obvious attacks which get increasingly difficult in higher levels. When the user has given a correct answer he is rewarded with a big smiley face as well as points. Also, the user is shown a medal every time he finishes a level. These aspects of the app are intended to increase the users' positive feelings and keep him motivated to go on. However, some improvement of positive comments might be worth considering. Currently, the positive texts for a correctly answered text, for finishing a level and icons do not differ. It might be more engaging if such texts and icons differ from time to time in order to increase the positive emotions of the user. For example, texts telling the user that he has done well might slightly vary (for instance, according to the degree of difficulty of the achieved task). Also, the screen of finishing a level could vary. Here again the degree of difficulty might be considered. According to the level finished, the obtained award could get bigger, the text of the level finished screen more flattering in order to increase the users positive experience.

Intensity This principle says that learning is better encouraged by things that are more intense. For example, people likely to learn more from an exciting and enthusiastic teacher than from a boring and monotone one or from a text book. Our app is by nature more intense than a simple text based approach. The game creates incentives and intensity. Also, the fact that we do not only tell the user that e-mail spoofing and link spoofing is easy but also make him experience it increases the intensity.

Primacy The principle of primacy means that the first thing a student learns makes the strongest impression. For this reason getting rid of bad habits, and replacing incorrect or wrong logic are difficult. This principle is coupled with time. The first things our users learn is: what is phishing as well as how easy e-mail and link spoofing is. For those who already knew these things, the awareness part will not be such a high motivating factor. Yet, we believe this part is indispensable since there are still many people outside who are not aware of the aspects mentioned above.

Recency The principle of recency states that most recently learnt things are easier to remember. This is a consequence of the reduction of the learning over time. The principle of recency is coupled with time. We are aware that our app is not a game which will be frequently used and thus its users are likely to forget the content they have learnt, for example, a week ago. In order to overcome this problem, so called reminders are included in each new level introduction. There the user has a short summary of what he has learnt so far. Also, we keep confronting the user with attacks from previous levels during the exercise rounds. This repetition is, on one hand, intended to strengthen the users knowledge and understanding, on the other hand, it is intended to create a kind of recency so the user does not forget about this kind of attack. In case the user does not detect the attack (a repeated or a new one) he will be reminded what kind of attack had been applied. Furthermore, in this level the user will be confronted with this kind of attack again, until he gives a correct answer to it.

Now that we have introduced the fundamental principles of learning and associated these with our app, we proceed with the introduction of game techniques and how they are related to the learning principles as well as to our app. As already mentioned, there are strong connections between learning principles and game techniques. Therefore, we will try not to focus on redundant aspects, but rather on additional aspects which need to be considered in game design.

8.6.2 Game Techniques

Basic game techniques are: flow, feedback, simplicity, immersion and engagement, choice and involvement, practice as well as fun [51]. As some terms already reveal, these principles are strongly connected to the basic principles of learning. In the following we will elaborate on these game techniques by stating their relation to the according learning principle, mentioning additional aspects to consider and how these are mirrored in our app.

Flow Flow is the key point of games. It is “the state in which people are so involved in an activity that nothing else seems to matter; the experience itself is so enjoyable that people will do it even at great cost, for the sheer sake of doing it” [19]. Sometimes flow is also referred to as ’engagement’ [51] and relates to a person’s overall well-being [69]. Flow relates to motivation [19, 20]. Motivation in turn is a crucial part of readiness, cf- Section subsubsection 8.6.1. In essence, there are four requirements for flow [19, 20, 66].

1. **Clear Tasks** With clear tasks the user is able to understand what he needs to do. The tasks which need to be completed by the users of our app are never complex and they are always clearly told what they need to do next.
2. **Feedback** With feedback the user should always be kept up-to-date about his progression towards the goals he is asked to achieve. He also should get immediate feedback on whether his actions are good or not. Our app covers these aspects, cf. Section subsubsection 8.6.1.
3. **Balanced, Attainable Goals** The user should be confronted with challenging tasks, but at the same time these tasks should also be achievable. Especially in the beginning our app users are confronted with very simple tasks. For some users they even might be too easy which may result in a loss of interest. However, these tasks are important basics which are necessary for successful detection of phishing attacks on the smartphone. Therefore, for future work especially the first two tasks (access address bar and analyze the complete URL) could be re-designed so that

they also keep users which have already knowledge in this area. Currently, the users can just skip the introductory part of this part and directly complete the task. Besides, as the users' skills will naturally improve, their tasks get more difficult and challenging with increasing levels, but will remain achievable.

4. **Concentration** The user should not be distracted with, for example, complex interfaces. He should rather be able to fully concentrate on the game. Our app has a very simple user interface with the most necessary elements. There are no special effects, advertisement or other elements which might distract the user from playing the game with full concentration. The only intrusive and interruptive elements are our introductory sections. However, these are inevitable for the communication of the learning content.

Feedback Feedback is important which is also reflected by the fact that it is a crucial part of the learning principle 'exercise', cf. Section subsubsection 8.6.1, as well as a requirement for flow. Stated simply, feedback is how a user perceives progress [19, 20]. For the completion of even simple tasks feedback is indispensable. Feedback can be in form of a scoring system, comparative statistics or failure outcomes and provides the user information about his progression and performance. Games make use of a so called feedback loop [26]:

1. **Measure Behavior** Our app assesses whether the answer of the user to a given task is correct.
2. **Relay Measurement to User** The user is told whether his answer is correct or not.
3. **Realize Some Sort of Outcome** The outcome of the users' actions and answers are accordingly defined, cf. Section subsection 8.3. For example, the user loses a life in case he did not detect a phishing URL.
4. **Provide Opportunities for Alternate Action** The user has the chance to do better in the next tasks.

Simplicity The real world is a complex construct. However, games should simplify the real world so that there only remain rules and goals. In this way the players can fully concentrate on their tasks and how they can achieve them [20]. Hence, simplicity helps users to achieve flow and thus increased motivation. This, in turn, leads to improved learning, cf. Section subsubsection 8.6.1. Simplicity involves, for example, the user interface, the game goals, feedback loops, rules and instructions. The structure of our app is kept simple and consistent. Therefore, it should be easy to understand. Our user interface is kept to the necessary minimum and the goal of the game is clear: detect phishing URLs.

Immersion and Engagement Immersion involves a passive activity. The term is used, for example, to describe a person who shows strong interest for a story [46]. In contrast to immersion, engagement involves active actions, such as trying to solve a problem or puzzle. Games commonly use both, immersion and engagement. To achieve immersion game designers make use of stories, visual and audio techniques, attractive graphics or animations [66]. Simultaneously, the user is engaged with choices, problems, or puzzles which have to be solved. The combination of immersion and engagement has the potential of creating an intense game experience [51]. These two aspects of game techniques are strongly linked to the learning principle of intensity. By challenging the user with various tasks to solve we meet the requirement for achieving engagement. However, immersion is an aspect we have not considered yet in the scope of this thesis. In order to achieve an intense game experience, this aspect might be worth considering for future work.

Choice and Involvement Games consist of choices and involvement. There is a link between choice and positive feelings (cf. principle of effect in Section subsubsection 8.6.1, i.e. choice is important for a person's overall well-being [69, 67]. However, the downside of choices is the so called paradox of choice which states that choice is beneficial, but too many choices can cause more bad than good [67]. The problem is, when the users are confronted with too many choices they get overwhelmed, since the decision thus the task to solve becomes too complex. We believe that our app does not face the problem of this paradox since the decisions the user has to take are limited to the questions: is the following URL a phish, and show us the Who-Section. Still, the user has to make decisions and is consequently involved in the game.

Practice This technique is directly related to the learning principle of exercise, cf. Section subsubsection 8.6.1. Users practice and repeat several steps of games extensively so that they eventually gain mastery and the difficulty of their challenges can increaseč̃itemurphy2011games,schell2008art. Our app offers practices as well as repetition, cf. Section subsubsection 8.6.1.

Fun Fun is an important aspect of game design and yet the definition of it is not clearcut in literature [51, 66, 38]. Based on several definitions found in literature Curtiss Murphy introduced the following definition of fun: *"Fun is the positive feelings that occur before, during, and after a compelling flow experience"* [51]. Positive feelings include, but are not limited to, engagement, enjoyment, pleasure, entertainment, satisfaction, control and triumph. Fun is related to the learning principle of effect and its positive feelings. How we achieve the principle of effect and positive feelings in our app is described in Section subsubsection 8.6.1. Yet, fun is something which emerges from several game techniques, such as, flow, immersion and engagement, practice to achieve mastery, and choices, which all lead to positive emotions. Fun is an aspect of our app which could be considered more deeply in future work. Especially, the areas of creating positive feelings and including immersion in order to make the users' game experience more intense and fun are aspects which might be looked at.

9 Development Process

This chapter deals with the development process of our app. We do not provide in-depth insight to our source code. Instead we give a brief overview of our approach for the development of a user friendly and understandable app.

9.1 Mock Up

After we have decided about the work flow and structure of our app we built a mock up in order to get a more concrete idea of what needs to be implemented and to reveal flaws in our thought process. Also, we showed it to a couple of friends and relatives so we could expose aspects we have not yet thought about. All in all, the work flow and structure of the mock up was quite understandable. However, the first texts explaining how to access the address bar and about the structure of a URL seemed to be incomprehensible. As a consequence, we adjusted these texts in the app (only thos of the first three levels) and showed them to other friends and relatives who seemed to understand the descriptions. Based on these initial texts we wrote all remaining texts without including it into the app yet. The next section deals with the elaboration of these texts.

9.2 Pilot Study of App Texts

The app texts were written down in a Google Docs document. After finishing the texts for each step of the app flow our supervisor, a professor of pedagogy at TU Darmstadt as well as another schoolteacher reviewed our texts and gave their feedback to it. As we achieved the version with which we were satisfied we applied a small user study on the created texts. For time reasons we decided to go for the low cost method of guerilla user testing [28, 71]. This approach enables to quickly assess the effectivity of a design, in our case our app texts. Guerilla user tests are rather loosely structured and do not include participant recruitment. The testers are rather approached, in our case, we approached relatives and friends. The outcome of such studies are rather qualitative, i.e. extensive and detailed insights is achieved. A downside of guerilla testing is that the approached participants might not belong to the defined target group with respect to their expertise or skills. Since we knew our participants we are confident that they matched target audience. In detail, our approach for the guerilla user test was as follows:

1. **Prepare Texts** Our aim for this user test was to imitate the use of a smartphone as best as possible. For this reason the app texts in the Google document were formatted into short lines, so that the text appearance resembled that of a smartphone screen. Furthermore, we printed out the texts and cut the sheets into small rectangles.

2. **Think Aloud** We asked the participants to think aloud during the test. We told them that there are no stupid questions or comments and that they help most with just saying what goes through their mind. We made notes of their remarks.

3. **User Test with In-Between Exercises** The actual user test mainly consisted of reading our app texts and thinking aloud about these. We included a little simulation of our exercise parts in order to validate whether the users comprehended the texts or not. For example, for each introduced attack we included a small list of URLs on which the users had to decide whether they were phishing URLs or not.

4. **Final Comments** After going through the texts the users were asked to give general feedback about their impression of the texts. We further asked them about some aspects we were not quite sure about at the beginning. For example, we asked them whether the usage of the terms link or web address confused them.

Our guerilla user tests showed that our texts are understandable. According to our participants the main downside of the texts was their length. Yet, this can be neglected since the users had to read our complete texts (instead of for example just playing 1-2 levels at once). Furthermore, they remarked that the introduction on how to access the whole address bar and analyze the complete URL is unnecessary. For some users this might apply. However, it is possible that there are users who do not know this. For those, who already know how to access the address bar and analyze the complete URL we added a button which directly links to the exercise. In case the user had overestimated himself, he will be forwarded back to the app, where the introductory text can be consulted. Finally, the reminder texts received some criticism for their frequent re-appearance at the beginning of each level. This can also be neglected since we assume that our app users will not constantly play this game. Also, when playing the app this screen can easily be skipped as exhibits a recognition value achieved by the title “reminder”. Still, we decided for a minor reorganization of the reminder view. Before the user tests the reminders mainly referred to the URL structuring they have learnt so far. We thought it is also important to remind the users of possible attacks. Therefore, the reminder concerning the URL structure was kept to a minimum with the aid of a graphic. Additionally, for each attack in previous levels one sentence and one example was added.

So far we dealt with the texts of the app. The following section elaborates on how our app generates URLs on which the users have to decide whether they are phishing URLs or not.

9.3 Implementation and testing

keine implementationsdetails. Das einzige ist url generation. dazu siehe Appendix B

10 Evaluation

VLL FORMS IN APPENDIX? As a final step the Anti-Phishing Education we have designed and implemented needs to be evaluated which is the goal of this chapter. The app will be evaluated with the aid of a user study. After introducing our study design, we will state our hypothesis and explain how we are going to measure our statements in order to prove that they are true or false. Finally, we will analyze our results and state our conclusion.

10.1 Study Design

For time reasons and lack of participants we decided to run a "Before and After App" Study with the same groups of people. Specifically, our user study is structured as follows:

1. **General Before-Survey** At the beginning the participants have to fill out a general survey, where they have to judge their own knowledge on the topic of Internet security in general. For instance, they are asked whether it is easy for them to distinguish legitimate e-mails and websites from fake ones.

2. **Website-Survery Before** In this part of the user study the participants gets a list of screenshots of websites. The screenshots had been taken with the standard browser of an Android tablet. In total, the user is shown 16 screenshots, with 8 phishing and 8 valid URLs. The user has to decide whether he would enter confidential data on the shown website. Additionally, he has to encircle the part of the screenshot which was the primary reason for his decision. Then, the user has to indicate how sure he was about his answers on a Likert scale. Finally, the user is asked whether he knows the vendor of the website and whether he has a account there.

3. **Play App** After the "Website-Survey Before" the users get the smartphones in order to play the app. To save time, we skipped the introduction 2 part ("access address bar") for the user study. The user has half an hour to play the app. After half an hour they are asked to put the smartphones aside. Then, we collect the smartphones and note the reached points in each level.

4. **Website-Survery After** After playing the app, the participants get a second website-survey. In this, all examples of the previous survey are included. Moreover, it contains 8 further website screenshots of which 4 have phishing and the remaining 4 have valid URLs.

5. **General After-Survey** Finally, the participants are asked to fill out a form with questions to their demographics. This form does also contain questions related to the SUS and some other questions regarding their impression of the app.

10.2 Hypotheses

In order to evaluate the effectiveness and usability of our app we have formulated the following hypotheses for the user study:

1. **Hypothesis 1 - Mistakes** After playing the app, the users make significantly less mistakes in detecting phishing websites compared to before playing the app.

2. **Hypothesis 2 - URL Based Decision** After playing the app, the users base their primary decision on whether a website is a phishing website or not significantly more often based on the URL compared to before playing the app.

3. **Hypothesis 3 - URL Comprehension** After playing the app the user understands the importance of the second- and top-level domain of a URL as the only criteria to detect phishing websites.

4. **Hypothesis 4 - Good Usability** The app is easy to understand and to use.

10.3 Measurement

In the following we will elaborate on how we are going to measure the statements of our hypothesis and show that they are true or false.

1. **Hypothesis 1 - Mistakes** Correct answers in "Website-Survery After" >> correct answers in "Website-Survery Before"

2. **Hypothesis 2 - URL Based Decision** Number of URL markings in "Website-Survery After" >> number of URL markings in "Website-Survery Before"

3. **Hypothesis 3 - URL Comprehension** Number of marked second- and/or top-level domains of URLs in "Website-Survery After" >> number of marked second- and/or top-level domains of URLs in "Website-Survery Before"

4. **Hypothesis 4 - Good Usability** System Usability Scale (SUS) > 68

10.4 Results and Analysis

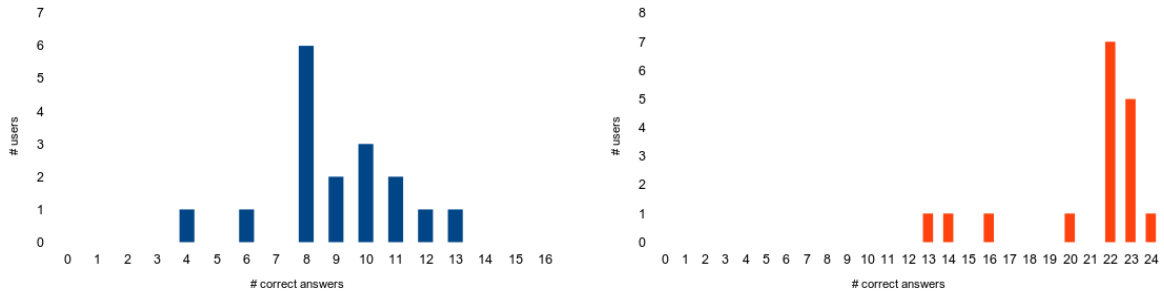
10.5 Analysis of our hypotheses

Hypothesis 1 Figure 11 shows the reslts of our study according to hypothesis 1. One can clearly see that the majority of the users identified more URLS correctly after using the app than before. While most participants correctly identified 8 out of 16, i.e. 50%, websites before they played the app, the majority gave correct answers to 22 out of 24 websites afterwards, i.e. 91.67%. One could argue that this increase is based on the fact that the examples are mainly the same. Figure 11(c) however shows that the user also got most of the new URLs right. Therefore we assume that we can furthermore ignore this learning effect.

Hypothesis 2 Figure 12 shows

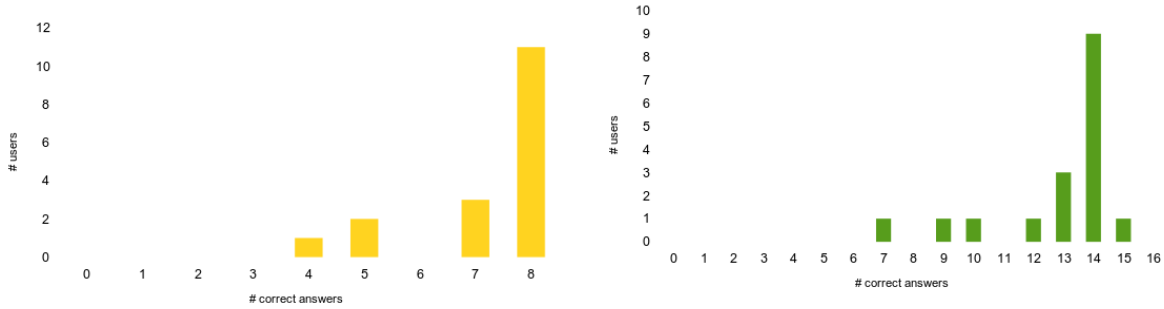
Hypothesis 3

Hypothesis 4



(a) Before

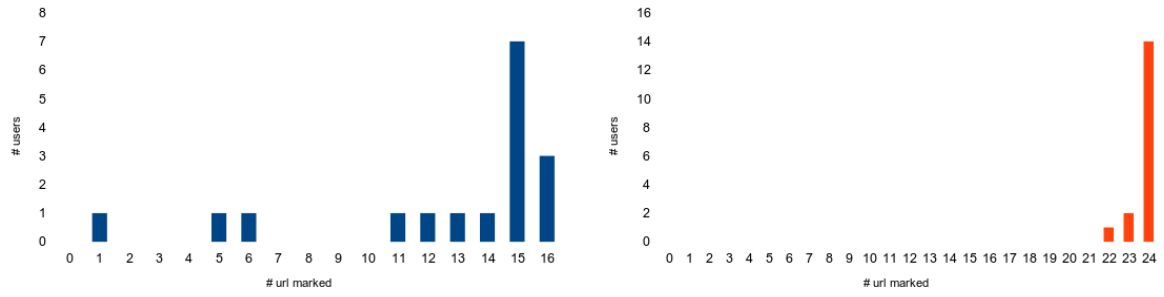
(b) After (all URLs)



(c) After (New URLs)

(d) After (Repeated URLs)

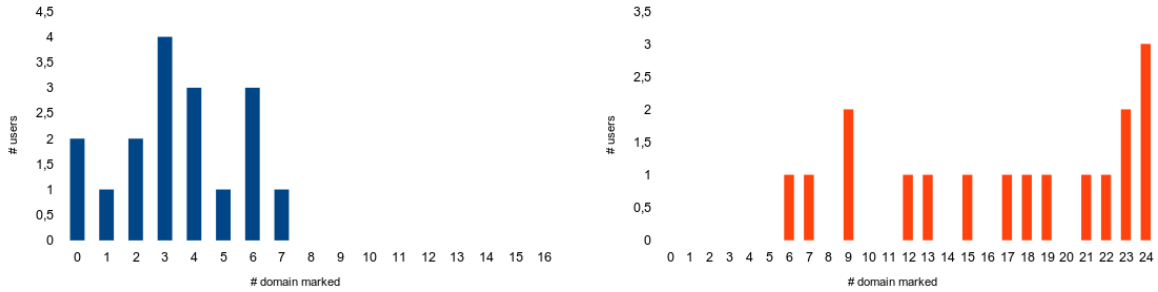
Figure 11: Correct Answers



(a) Before

(b) After

Figure 12: URL marked



(a) Before

(b) After

Figure 13: Domain marked

10.5.1 Further exploration

Some of the results can not be proven statistically. Mainly because of the low sample count. Therefore we will only exploratorily analyze these results.

text

10.6 Discussion

10.7 Conclusion

11 Conclusion

This chapter provides a short summary of what we achieved in the scope of this thesis and presents an outlook on future work.

11.1 Conclusion

The objectives of this thesis. ..

11.2 Findings

11.3 Recommendations

11.4 Future Work

This section deals with a prospect on future work for our Anti-Phishing Education App. In particular, we present ideas that might be beneficial and which we were not able to realize due to time and resource limitations.

A Mail template

```
1 <html>
2   <head>
3     <title>Anti Phishing Education</title>
4   </head>
5   <body>
```

```
6       <p>Dies ist eine automatisch generierte E-Mail im Rahmen einer Anti-Phishing
          Education App. Falls diese nicht angefordert wurde, bitte ignorieren.</p>
7       <p>Ansonsten geht es hier weiter:</p>
8       <p>Wie du im Absender siehst, hast du dir gerade selbst eine E-Mail mit gefä
          lschtem Absender geschickt. Hier ist außerdem dein Freitext:</p>
9       <p>{$usermessage}</p>
10      <p>Für einen Angreifer ist es ebenso einfach automatisierte E-Mails mit gefä
          lschtem Absender und Inhalt zu verschicken. Meist enthalten diese einen Link zu
           einer Webseite, genau wie diese E-Mail.</p>
11      <p>Um mit der App fortzufahren, klicke auf den folgenden Link.</p>
12      <p><a href="http://pages.no-phish.de/maillink.php">http://www.google.com</a></p>
13      <p>Viele Grüße,</p>
14      <p>Dein NoPhish Team</p>
15    </body>
16  </html>
```

B URL Generation

While playing the app the user is presented with URLs that he has to categorize as phish or valid. While reviewing the previous works and games in this area we found that many of them use a fixed set of examples. On some games this set is very small and therefore you are always confronted with the same URLs. As we layed out in Section subsection 7.3 we want to teach the user how to detect phishing URLs in general. To accomplish this goal we think that it is essential that the user sees as much different URLs as possible so he can build his own mental model. Therefore we decided on generating URLs rather than composing a fixed list. We will lay out the general process here and cover interesting parts of it in the following sections.

B.1 Example URLs

To present attacked URLs to the user we found int most realistic to take valid URLs and apply attacks on them. Therefore we needed a set of valid URLs. To build this set we used Alexa**??** to find the top 100 domains for german users. We then went to each of these sites and by navigating tried to find 6 URLs for each domain. We tried to find some short and some long URLs.

generate attacks for level When starting a new level we generate a list of Attacks that we want to show the user.

select valid URL When we want to show a new URL to the user we first randomly select a valid URL from the before mentioned set.

apply generator Then we apply a generator to the URL that does not invalidate the URL but modifies it.

apply attack After that we select a random attack from the previously build list and apply it to the URL.

repeat In some situations we need to try again.

B.2 generate attacks for level

Was zur historie? The types of URLs the user is presented is dependent on the level. Each level introduces on or more attacks. Which attack is introduced in which level is layed out in sectionsubsection 8.5. In general the URLs of each level *n* are distributed as follows:

The repeats are always one attack from each previous level. The rest of the repeats is filled up randomly.

There are two main exception to these rules:

Total number of URLs	u	$6+2*n$	starting with 6 URLs each level has 2 more URLS.
Number of Phishes	p	$u/2$	Half of the URLs are phishes.
Number of repeats	r	$\lfloor p/2 \rfloor$	Half of the phishes are repeats.

Table 2: distribution of URLs per level.

Level 1 In Level 1 the game is modified in the form that the user is only presented with valid URLs and has to select the domain. To prevent boring the user in this level we only present 5 URLs. None of them is a phish.

Level 1+2 The first level that contain repeats is level 3 because level 2 is the first real game level.

The generated list of attacks also contains a special attack that does no real attack. This is to simplify the URL generation. When we generated the list of attacks we save it for later reference.

B.3 Apply Generator

We were unsure if we still have enough valid URLs so we prepared a way to automatically modify the URLs in such a way that they could still be valid URLs. Some Ideas where to add subdomains or path strings to the URL. Query or fragments are also possible. We later found out that it is currently not needed to implement generators because there are a lot of URLs in our set. If however we will some time in the future find out that these URLs are not enough we have this scheme in place.

B.4 Apply Attack

After we generated a valid URL we chose a random attack from the previously build set of attacks and apply it to the URL. With this we also store which attack we currently applied. This is important when the user is failing this round. In this situation we will simply readd this attack to the set of attacks.

B.5 Repeat

There are combinations of base-URL and attack where the attack doe's not alter the URL. Therefore it would be impossible for the user to detect the Attack and he will be confused and might stop using the app. In this situation we repeat the whole URL generation process until we find a matching URL.

References

[1] A. Alnajim and M. Munro. An anti-phishing approach that uses training intervention for phishing websites detection. In *Information Technology: New Generations, 2009. ITNG '09. Sixth International Conference on*, pages 405–410, 2009.

[2] A. M. Alnajim. *Fighting internet fraud: anti-phishing effectiveness for phishing websites detection*. PhD thesis, Durham University, 2009.

[3] C. Amrutkar, P. Traynor, and P. Oorschot. Measuring ssl indicators on mobile browsers: Extended life, or end of the road? In D. Gollmann and F. Freiling, editors, *Information Security*, volume 7483 of *Lecture Notes in Computer Science*, pages 86–103. Springer Berlin Heidelberg, 2012.

[4] Android. Android development - dashboards. `http://developer.android.com/about/dashboards/index.html`, 2013. Accessed: 2013-01-08.

[5] N. Arachchilage and M. Cole. Design a mobile game for home computer users to prevent from phishing attacks. In *Information Society (i-Society), 2011 International Conference on*, pages 485–489, 2011.

[6] N. A. G. Arachchilage, S. Love, and M. Scott. Designing a mobile game to teach conceptual knowledge of avoiding phishing attacksĂİ. *International Journal for e-Learning Security*, 2(2):127–132, 2012.

[7] T. Bakhshi, M. Papadaki, and S. Furnell. Social engineering: assessing vulnerabilities in practice. *Information management & computer security*, 17(1):53–63, 2009.

[8] I. Bank. The phishing game. http://www.icicibank.com/online-safe-banking/Phishing-Game.html. Accessed: 2013-01-17.

[9] A. Bergholz, J. De Beer, S. Glahn, M.-F. Moens, G. Paaß, and S. Strobel. New filtering approaches for phishing email. *Journal of computer security*, 18(1):7–35, 2010.

[10] M. Boodaei. Mobile users three times more vulnerable to phishing attacks. http://www.trusteer.com/blog/mobile-users-three-times-more-vulnerable-to-phishing-attacks, 2011. Accessed: 2013-12-26.

[11] Brightcove. Step-by-step guide to publishing in the android market on windows. http://support.brightcove.com/en/app-cloud/docs/step-step-guide-publishing-android-market-windows. Accessed: 2013-01-08.

[12] Brightcove. Step-by-step guide to publishing in the apple app store using a mac. http://support.brightcove.com/en/app-cloud/docs/step-step-guide-publishing-apple-app-store-using-mac. Accessed: 2013-01-08.

[13] I. W. Business. Ranking: Die 100 gröSSten online-shops in deutschland 2011. http://www.internetworld.de/Nachrichten/E-Commerce/Zahlen-Studien/Ranking-Die-100-groessten-Online-Shops-in-Deutschland-2011-Zalando-macht-zehn-Plaetze-gut-70245.html, 2011. Accessed: 2013-01-24.

[14] M. Chandrasekaran, K. Narayanan, and S. Upadhyaya. Phishing email detection based on structural properties. In *NYS Cyber Security Conference*, pages 1–7, 2006.

[15] K.-T. Chen, J.-Y. Chen, C.-R. Huang, and C.-S. Chen. Fighting phishing with discriminative keypoint features. *Internet Computing, IEEE*, 13(3):56–63, 2009.

[16] T.-C. Chen, S. Dick, and J. Miller. Detecting visually similar web pages: Application to phishing detection. *ACM Trans. Internet Technol.*, 10(2):5:1–5:38, June 2010.

[17] S. Chiasson, M. Modi, and R. Biddle. Auction hero: The design of a game to learn and teach about computer security. In *World Conference on E-Learning in Corporate, Government, Healthcare, and Higher Education*, volume 2011, pages 2201–2206, 2011.

[18] comScore Data Mine. Smartphones reach majority in all eu5 countries. http://www.comscoredatamine.com/2013/03/smartphones-reach-majority-in-all-eu5-countries/, 2013. Accessed: 2013-01-24.

[19] M. Csikszentmihalyi. Flow: The psychology of optimal performance, 1990.

[20] M. Csikszentmihalyi. *Finding flow: The psychology of engagement with everyday life*. Basic Books, 1997.

[21] T. Denning, A. Lerner, A. Shostack, and T. Kohno. Control-alt-hack: The design and evaluation of a card game for computer security awareness and education. In *Proceedings of the 2013 ACM SIGSAC Conference on Computer & Communications Security*, CCS '13, pages 915–928, New York, NY, USA, 2013. ACM.

[22] eBay. GefÃd'lschte e-mails erkennen und melden. http://pages.ebay.de/help/account/reporting-spoof.html. Accessed: 2013-01-11.

[23] I. Fette, N. Sadeh, and A. Tomasic. Learning to detect phishing emails. In *Proceedings of the 16th International Conference on World Wide Web*, WWW '07, pages 649–656, New York, NY, USA, 2007. ACM.

[24] D. D. I. für Vertrauen und Sicherheit im Internet and S. I. N. und Sörgel.München; Heidelberg. *DIVSI-Milieu-Studie zu Vertrauen und Sicherheit im Internet: eine Grundlagenstudie*. Deutsches Institut für Vertrauen und Sicherheit im Internet (DIVSI), 2012.

[25] E. Gabrilovich and A. Gontmakher. The homograph attack. *Commun. ACM*, 45(2):128–, Feb. 2002.

[26] T. Goetz. Harnessing the power of feedback loops. *Wired Magazine*, 19(07), 2011.

[27] D. Goodin. From phishing to whaling. `http://www.theregister.co.uk/2008/04/16/whaling_expedition_continues/`, 2008. Accessed: 2014-01-19.

[28] GOV.UK. Guerilla testing. `https://www.gov.uk/service-manual/user-centered-design/user-research/guerilla-testing.html`, 2013. Accessed: 2013-01-24.

[29] A.-P. W. Group and C. CUPS. Phishing education landing page project. *Anti-Phishing Working Group*, 2009.

[30] A.-P. W. Group et al. Apwg global phishing survey. *Anti-Phishing Working Group*, 2013.

[31] A.-P. W. Group et al. Phishing activity trends report. *Anti-Phishing Working Group*, 2013.

[32] A. I. Handbook. Us dept of transportation. *Federal Aviation Administration*, 2008.

[33] J. Hong. The state of phishing attacks. *Commun. ACM*, 55(1):74–81, Jan. 2012.

[34] IDC. Press release. `http://www.idc.com/getdoc.jsp?containerId=prUS24442013`, 2013. Accessed: 2013-01-24.

[35] M. Jakobsson and S. Myers. *Phishing and countermeasures: understanding the increasing problem of electronic identity theft*. Wiley. com, 2006.

[36] K. Jansson and R. von Solms. Simulating malicious emails to educate end users on-demand. In *Web Society (SWS), 2011 3rd Symposium on*, pages 74–80, 2011.

[37] K. Jansson and R. von Solms. Simulating malicious emails to educate end users on-demand. In *Web Society (SWS), 2011 3rd Symposium on*, pages 74–80, 2011.

[38] R. Koster. *Theory of fun for game design*. O'Reilly Media, Inc., 2010.

[39] P. Kumaraguru. *PhishGuru: a system for educating users about semantic attacks*. ProQuest, 2009.

[40] K. Lab. The evolution of phishing attacks: 2011-2013. *Kaspersky Lab*, 2013.

[41] E. Larkin. Spot the tiny phishing trick. `http://www.pcworld.com/article/161232/tinyphish.html`, 2009. Accessed: 2013-12-29.

[42] W. Liu, X. Deng, G. Huang, and A. Fu. An antiphishing strategy based on visual similarity assessment. *Internet Computing, IEEE*, 10(2):58–65, 2006.

[43] J. Ma, L. K. Saul, S. Savage, and G. M. Voelker. Beyond blacklists: Learning to detect malicious web sites from suspicious urls. In *Proceedings of the 15th ACM SIGKDD International Conference on Knowledge Discovery and Data Mining*, KDD '09, pages 1245–1254, New York, NY, USA, 2009. ACM.

[44] S. Marchal, J. François, R. State, and T. Engel. Proactive discovery of phishing related domain names. In D. Balzarotti, S. J. Stolfo, and M. Cova, editors, *Research in Attacks, Intrusions, and Defenses*, volume 7462 of *Lecture Notes in Computer Science*, pages 190–209. Springer Berlin Heidelberg, 2012.

[45] McAfee. The economic impact of cybercrime and cyber espionage. *Center for Strategic and International Studies*, 2013.

[46] A. McMahan. Immersion, engagement and presence. *The video game theory reader*, pages 67–86, 2003.

[47] Microsoft. How to recognize phishing email messages, links, or phone calls. http://www.microsoft.com/security/online-privacy/phishing-symptoms.aspx. Accessed: 2013-01-11.

[48] Microsoft. Identify fraudulent e-mail and phishing schemes. http://office.microsoft.com/en-001/outlook-help/identify-fraudulent-e-mail-and-phishing-schemes-HA001140002.aspx. Accessed: 2013-01-11.

[49] T. Moore and R. Clayton. Examining the impact of website take-down on phishing. In *Proceedings of the Anti-phishing Working Groups 2Nd Annual eCrime Researchers Summit*, eCrime '07, pages 1–13, New York, NY, USA, 2007. ACM.

[50] T. Moore and R. Clayton. How hard can it be to measure phishing? *Mapping and Measuring Cybercrime*, 2010.

[51] C. Murphy. Why games work and the science of learning. In *Interservice, Interagency Training, Simulations, and Education Conference*, 2011.

[52] A. Obied and R. Alhajj. Fraudulent and malicious sites on the web. *Applied Intelligence*, 30(2):112–120, 2009.

[53] C. K. Olivo, A. O. Santin, and L. S. Oliveira. Obtaining the threat model for e-mail phishing. *Applied Soft Computing*, 2011.

[54] OnGuarOnline.gov. Invasion of the wireless hackers. http://www.onguardonline.gov/media/game-0006-invasion-wireless-hackers. Accessed: 2013-01-17.

[55] OnGuarOnline.gov. Mission laptop security. http://www.onguardonline.gov/media/game-0008-mission-laptop-security. Accessed: 2013-01-17.

[56] OnGuarOnline.gov. Phishing scams (game). http://www.onguardonline.gov/media/game-0011-phishing-scams. Accessed: 2013-01-11.

[57] PayPal. Was ist phishing? https://www.paypal.com/de/webapps/mpp/phishing. Accessed: 2013-01-11.

[58] Phishing.org. Phishing techniques. http://www.phishing.org/phishing-techniques/. Accessed: 2013-01-19.

[59] PhishTank. Phishtank. http://www.phishtank.com/, 2013. Accessed: 2013-12-29.

[60] P. Prakash, M. Kumar, R. Kompella, and M. Gupta. Phishnet: Predictive blacklisting to detect phishing attacks. In *INFOCOM, 2010 Proceedings IEEE*, pages 1–5, 2010.

[61] S. Purkait. Phishing counter measures and their effectiveness–literature review. *Information Management & Computer Security*, 20(5):382–420, 2012.

[62] Z. Ramzan. *Phishing Attacks and Countermeasures*. Springer Berlin Heidelberg, 2010.

[63] RSA and ECM. Phishing kits - the same wolf, just a different sheep's clothing. *Fraud report*, 2013.

[64] N. M. Sadeh. Why phish should not be treated as spam. http://www.drdobbs.com/security/why-phish-should-not-be-treated-as-spam/240001777, 2012. Accessed: 2013-01-19.

[65] G. C. Safe et al. Phishing: How many take the bait? http://www.getcybersafe.gc.ca/cnt/rsrcs/nfgrphcs/nfgrphcs-2012-10-11-eng.aspx, 2012. Accessed: 2013-12-29.

[66] J. Schell. *The Art of Game Design: A book of lenses*. Taylor & Francis US, 2008.

[67] B. Schwartz. *The paradox of choice*. HarperCollins, 2009.

[68] R. secure. Phishing for disaster: the cost of corporate ignorance. *Whitepaper about the effects of corporate ignorance of phishing*, 2010.

[69] M. E. Seligman. *Flourish: A visionary new understanding of happiness and well-being*. Simon and Schuster, 2012.

[70] S. Sheng, B. Magnien, P. Kumaraguru, A. Acquisti, L. F. Cranor, J. Hong, and E. Nunge. Anti-phishing phil: The design and evaluation of a game that teaches people not to fall for phish. In *Proceedings of the 3rd Symposium on Usable Privacy and Security*, SOUPS '07, pages 88–99, New York, NY, USA, 2007. ACM.

[71] D. P. Simon. The art of guerilla usability testing. `http://www.uxbooth.com/articles/the-art-of-guerilla-usability-testing/`, 2013. Accessed: 2013-01-24.

[72] SonicWALL. Sonicwall phishing iq test. `http://www.sonicwall.com/furl/phishing/`. Accessed: 2013-01-11.

[73] SPAMfighter. Becoming more difficult to detect phishing email attack, says security experts. `http://www.spamfighter.com/News-18495-Becoming-More-Difficult-to-Detect-Phishing-Email-Attack-says-Security-Experts.htm`, 2013. Accessed: 2013-01-11.

[74] Symantec. Race to stay safe. `https://www.staysecureonline.com/staying-safe-online/`. Accessed: 2013-01-11.

[75] T. A. R. Team et al. Spear-phishing email: Most favored apt attack bait. `http://www.trendmicro.com/cloud-content/us/pdfs/security-intelligence/white-papers/wp-spear-phishing-email-most-favored-apt-attack-bait.pdf`, 2012. Accessed: 2013-12-29.

[76] W. S. Technologies. Anti-phishing phyllis. `http://www.wombatsecurity.com/antiphishingphyllis`. Accessed: 2013-01-11.

[77] E. L. Thorndike. *The fundamentals of learning*. Teachers College Bureau of Publications, 1932.

[78] H. Zhang, G. Liu, T. W. S. Chow, and W. Liu. Textual and visual content-based anti-phishing: A bayesian approach. *Neural Networks, IEEE Transactions on*, 22(10):1532–1546, 2011.

[79] J. Zhang, P. A. Porras, and J. Ullrich. Highly predictive blacklisting. In *USENIX Security Symposium*, pages 107–122, 2008.

[80] W. zu Wem Firmenverzeichnis. Top 100 banken in deutschland. `http://www.wer-zu-wem.de/ranking/banken/`, 2011. Accessed: 2013-01-24.