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Society-Oriented Scientific and Engineering Discourse through Pop-Up Education

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Abstract

Limited knowledge of crucial and societally important computer science (CS) information can be a grave disadvantage. The absence of appropriate CS knowledge might lead to feelings of exclusion and increased vulnerability to cybercrime, especially in the working world. Consequently, educating employees and society members about the most fundamental CS topics is paramount to ensure a long-term inclusive culture in the digital era. Hence, this work aims to implement and evaluate initiatives that educate and engage a wider audience. Specifically, it seeks to foster interest in CS topics, particularly among those who may not actively pursue such subjects through traditional means, such as books. To achieve this, this work employs pop-up education, which borrows from the concept of pop-up stores. Major corporations like Microsoft and Conrad offer STEM education pop-ups, also known as roadshows, in various public venues. However, the emphasis seems to be on showcasing their products or recruiting new staff, instead of prioritising knowledge transfer. Also at the workplace, educational pop-ups are performed; however, mainly on healthcare topics. Moreover, educational pop-ups are often for special audiences such as STEM students or special employee groups, but not for general public. Even though educational pop-up initiatives are performed in public spaces and workplaces, only limited academic research is conducted on the topic.
Hence, it is uncertain whether the pop-up concept can be successfully applied to CS education for a broader society. Therefore, this work examines whether the pop-up concept can be successfully applied towards CS education regarding experience, acceptance, and knowledge transfer in free time and working time settings. Furthermore, an online training version of the developed CS pop-up serves as comparison for assessing the effectiveness of the pop-up concept. Thereby, participants take also part in the online training in their free time or working time.

This work is based on Warnaby's and Shi's conceptual pop-up framework for planning and implementing pop-up activities and is divided into two studies. To determine in which CS topics and application fields society is interested in and thus which topic and application field the CS pop-up should cover, requirements elicitation (study A) was performed. Study A was conducted as an online survey using a mixed method triangulation design. Thereby, different groups of society based on participants' gender, background in STEM, and generation were considered, aiming to enable the design of CS pop-ups which appeal to society. The qualitative data was analysed by a qualitative content analysis according to Kuckartz, while the quantitative data was evaluated by means of descriptive statistics. Information security / hacking as CS topic and society / social aspects as CS application field, were identified as the most suitable CS topic and application field, as they have the greatest intercept of interest among all groups. Other CS topics and application fields of society's interest include autonomous driving, artificial intelligence / machine learning, medicine / healthcare, and transport / logistics.
Based on the insights of study A and considering Warnaby's and Shi's pop-up activity framework, a CS pop-up initiative covering the topic information security and social engineering was developed. The CS pop-up, transferring knowledge through comics, was performed in public spaces and workplaces. Analogously to the CS pop-up, an online training, in which participants take part in their free time or working time, was con-

ducted. The CS pop-up along with the online training was performed as a quantitative study using a between-subject design combined with a within-subject design (study B). Thereby, participants' experience was measured through the short version of the user experience questionnaire (UEQ-S), acceptance through a custom questionnaire based on the technology acceptance model (TAM), and knowledge transfer (pre- and post-intervention) through custom knowledge questionnaires based on Bloom's taxonomy. Multiple linear and multilevel regression models were used for data analysis. Pop-up and online training participants achieved a positive experience and acceptance score in free time as well as working time settings. However, experience was significantly slightly higher in the free time condition. Females experienced the pop-up and online training significantly slightly higher and would also accept the educational initiative significantly slightly more than males. However, pop-up participants achieved a significantly slightly lower acceptance score than online training participants. Nevertheless, pop-ups can still be considered as a successful measure, as the difference is only small and pop-up participants achieved a significantly higher knowledge transfer. Educational CS pop-ups are suitable for all generations, as there are no significant differences among generation regarding experience, acceptance, and knowledge transfer. Furthermore, pop-ups have certain advantages over online trainings. A wider society can be reached through pop-ups, as people incidentally pass by and participate which is not the case in online trainings. Moreover, indications are found that more elderly people can be reached through pop-ups than online trainings.

This work shows that the pop-up method can be successfully applied towards CS education regarding experience, acceptance, and knowledge transfer in free time as well as working time settings. Moreover, educational CS pop-ups are suitable to a wide society with diverse demographic backgrounds. Additionally, certain society groups can be reached more compared to online trainings. Also, companies can benefit from CS pop-ups.

Keywords

Computer science and STEM education, computer science and STEM in society, computer literacy, pop-up education, educational roadshow, information security, social engineering, information security pop-up, information security roadshow

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1. Introduction

Nowadays, technology surrounds and influences us almost everywhere we go. Whether we use Google Maps to find our meeting place, ask Alexa to play our favourite songs, buy online, pay lend money back by PayPal, or watch the latest movie at the cinema, computer science (CS) and its applications are ubiquitous in our daily lives. Also, most workplaces involve a substantial amount of computer technology use. Furthermore, during times of health crises, such as the COVID-19 pandemic, the use of computer applications has increased significantly due to remote working and limited non-digital leisure activities.
CS is affecting everybody in our society from children (e.g. digital interactive toys) to the elderly (e.g. elder care robots). Additionally, CS is a rapidly changing and versatile field. Therefore, possessing adequate knowledge of CS is crucial for individuals as members of today's society and employees. Otherwise, individuals are at increased risk of falling victim to cybercrime or experiencing exclusion. Moreover, individuals may be afraid and feel threatened of emerging technologies such as that artificial intelligence (AI) will replace humanity, which is often shown in movies. Furthermore, lacking proficiency in CS may lead to employment challenges due to widespread use of CS applications in the workplace. Moreover, companies encounter challenges when their employees lack adequate CS proficiency. Consequently, productivity decreases and businesses become vulnerable to cyber security threats.

Hence, limited knowledge of societal and workplace important CS concepts can be a significant disadvantage in both personal and professional lives. Therefore, it is crucial to educate society and employees on the key CS topics to ensure an inclusive long-term digital society. Opportunities to increase CS knowledge for personal and professional development are manifold. In addition to numerous specialist CS books primarily used in professional environments, there are also CS books written for the general public. Books such as *Wie Maschinen lernen: Künstliche Intelligenz verständlich erklärt* [1], *Das Geheimnis des kürzesten Weges: Ein mathematisches Abenteuer* [2], and *Informatik Macchiato* [3] aim to convey CS knowledge in an easily comprehensible manner for non-CS professionals and explain to society inter alia, how AI and navigation systems work. Thereby, they use methods such as explaining complex CS topics embedded in a story, relate to daily life situations, and comics.
Also, many CS related podcasts are available with the public service broadcaster BBC offering numerous options like *Tech Tent*, *Digital Planet*, and *The Digital Human* [4]. One episode of *The Digital Human* explores whether moving our lives online creates a misleading sense of normality [5], for instance. The German public broadcaster Bayerischer Rundfunk (BR) also provides a CS podcast called *Das Computermagazin* [6].
Similarly, videos can effectively transmit CS knowledge. The YouTube channel *Com-*

puterphile [7], affiliated with the University of Nottingham, provides videos on a range of CS subjects, from IT security to computer graphics. However, these videos may be difficult to comprehend without a solid foundation in mathematics, whether basic or advanced. Despite this, alternative videos with simpler explanations, such as a *TedTalk* on the fundamental principles of quantum computing [8], are available.
Moreover, individuals may attend CS classes and workshops for further learning. Massive open online course (MOOC) platforms like edX provide free online classes, such as *CS for All: Introduction to Computer Science and Python Programming* [9]. However, to obtain a verified certification for these courses, a fee is required. Additionally, these classes can be time consuming. For shorter learning opportunities, programming workshops such as *CoderDojo Würzburg* [10] are also available for adolescents.
Often, employees either voluntarily attend or are required to participate in workplace training regarding CS. Nevertheless, such training sessions tend to be limited to fundamental or specialised software applications, unless the staff is engaged in a STEM (science, technology, engineering, mathematics) related field. Furthermore, CS education in the workplace often takes place through handing documents to employees or sending emails (e.g. about new software or phishing emails). However, in many cases, these documents are not perused or are left unattended in overcrowded inboxes.

Overall, these educational initiatives require active engagement which implies an already existing interest in CS or it is mandatory in people's general education or at their workplace. In order to reach a wider society – especially people who would not occupy themselves with CS actively – the pop-up concept will be applied in this work.
The pop-up concept is most well-known from pop-up stores which appear ("pop-up") suddenly and remain temporarily before moving towards a new location. Thereby, companies often sell limited editions of their products or host events such as concerts. Pop-ups can be used for multiple reasons e.g. to increase sales or visibility of a brand, to test new products and selling methods on the market, and to create a bond to customers [11, 12]. Due to their temporary and eventful nature as well as often artistic design, pop-ups create curiosity as well as excitement and thereby attract people [13]. Hass' and Schmidt's work explores the factors that contribute to the success of pop-up initiatives in Germany. Therein, they analysed three companies, including Würzburg based clothing manufacturer s.Oliver, and their pop-up initiatives which were highly successful in Germany [11]. Also, in the UK, pop-up stores flourish as the work of Jones et al. shows [12, 13]. Moreover, small businesses such as libraries can also apply the pop-up concept successfully [14]. Even pop-up villages are perceived as beneficial by attendees [15].
Also, education makes use of the pop-up concept and aims to convey knowledge innovatively. For instance, the company Solve gave students the opportunity to test their job interview skills on multiple US campuses [16, 17]. The best participants were invited for actual internship interviews. *The Bumble Hive* pop-up, organised by the social networking platform Bumble, provides a platform for female professionals to network [17, 18]. Furthermore, universities use pop-ups for practising retail skills [17, 19] and offer pop-up classes, which are brief extracurricular workshops [20], covering new themes or events that are not typically part of the general curriculum [21, 22]. Such pedagogical initiatives have the potential to inspire individuals, raise interest, and even promote greater inclusion of underrepresented groups, as a study on robotics workshops for pupils showed [23, 24]. A related term for pop-up activities are roadshows. The Cambridge Dictionary

defines pop-ups as "used to describe something that appears suddenly, and usually exists for a limited time" [25]. As example the Cambridge Dictionary gives a pop-up restaurant, whereas it defines roadshows as "a series of events in different places at which a company gives information to possible customers, investors, etc." [26] and gives an investor roadshow as example. Even though the Cambridge Dictionary has different definitions of pop-ups and roadshows, there is a great overlap as roadshows also mostly exist for a limited time and mobile pop-ups can also take place in different locations as well as provide information to customers. Basically, mobile pop-ups can be referred to as roadshows and the terms can be used interchangeably in this case. Often, the terms are also combined and an event is then referred to as pop-up roadshow or called pop-up tour such as the automotive manufacturer Jaguar's pop-up activities [27]. If a pop-up, however, is just in one certain place (e.g. a pop-up restaurant) and is not mobile, it is usually not referred to as a roadshow. In this work, however, mobile education pop-ups are applied and therefore the term roadshow could be used interchangeably. Often, STEM roadshows are performed by companies for creating a bond to customers or to draw attention to their products such as Microsoft's [28] and Conrad's [29] education roadshows for schools and universities. Also, schools can book a STE(A)M truck which offers hands-on experience and STEM education for school students [30]. However, all these education pop-ups, roadshows, or workshops discussed so far, are all designed for special audiences such as students and CS professionals, but not for a broader society.
Also in companies, pop-up education can be applied for educating employees. However, the term roadshow is more commonly used in this context. In 2019, researchers conducted the *Healthy Hub Roadshow* in England, which provided general health checks and HIV testing for employees at their workplace [31]. The participating companies regarded the roadshow as "useful, informative and appropriate" [31]. Most of the companies involved aimed to provide further health activities for their employees; however, not on HIV [31]. Another roadshow, which provided education on smoking, alcohol, and diets at the workplace, was conducted in various post offices in England in 1985 [32]. The results of this study show that the interactive part of the roadshow on a computer was the most favoured one [32]. Moreover, the number of employees seeking assistance with their drinking issues increased after the roadshow [32]. Another roadshow called "Models of Care" aiming to educate nurses and to promote innovative nursing care organisation and provision was performed in 2005 in Australia [33].

As previously highlighted, numerous initiatives exist to educate individuals on CS related topics. These initiatives include books, scientific television programmes, YouTube videos, podcasts, online classes, CS classes in schools, programming workshops, and workplace training. However, many initiatives are superficial or overly specific. Moreover, some of these CS initiatives, for example, certain videos, are not presented appealingly to the public. In addition, activities like programming workshops or STE(A)M trucks may be costly or time consuming. Furthermore, several initiatives are intended for specific groups such as school students and CS professionals; however, are not addressed to a wider public. Moreover, individuals who utilise such initiatives typically possess a pre-existing interest in CS topics or it is compulsory for them in their overall education or at their workplace. Thus, other people of society and employees who do not get a sufficient CS education for their job are rarely reached. Also, variations of pop-up education and roadshows are applied at public spaces as well as workplaces. However, educational pop-ups or roadshows at workplaces tend to focus more on healthcare topics and less on CS topics. Additionally, they are generally not extensively investigated. According to Warnaby and Shi (2018), only little academic research regarding pop-up activities has been undertaken so far, which is mainly from the point of view of pop-up operators or are guides for performing pop-ups [34, p. 2, 33]. Frequently, pop-ups or roadshows are just used for collecting research data to answer other research questions which are not related to pop-up activities or roadshows at all [33, 35, 36]. Pop-up education or education roadshows are frequently conducted for educational purposes, although without any evaluation or academic research involved. The amount of academic research implemented in pop-up activities has not seen a substantial increase from 2019 to present (2024). This can be attributed, on the one hand, to the impact of the COVID-19 pandemic and related social distancing and lockdown measures, which made research on pop-up activities unfeasible during this period. On the other hand, it can also be traced back to the aspect that pop-up activities are basically more performed than academic research is conducted in. Therefore, it is uncertain whether the pop-up concept can be successfully applied to CS education in society and the workplace, especially regarding experience, acceptance, and knowledge transfer. As a result, this work aims to shed light on this aspect.

To further investigate whether the pop-up concept can be successfully applied to CS education in society and the workplace, a CS pop-up initiative will be developed based on Warnaby's and Shi's pop-up initiative framework [34, pp. 43–82]. Moreover, an online training version of the CS pop-up initiative will be used as a point of comparison. The CS pop-up initiative can be thought of as a mobile exhibition stand with educational materials and a poster. The CS pop-ups initiatives can be placed outside as well as in buildings. Figure 1.1 shows an illustration of a CS pop-up initiative. Thereby, the black stick figure represents the pop-up operator and the blue stick figures people passing by or participating in the pop-up initiative.

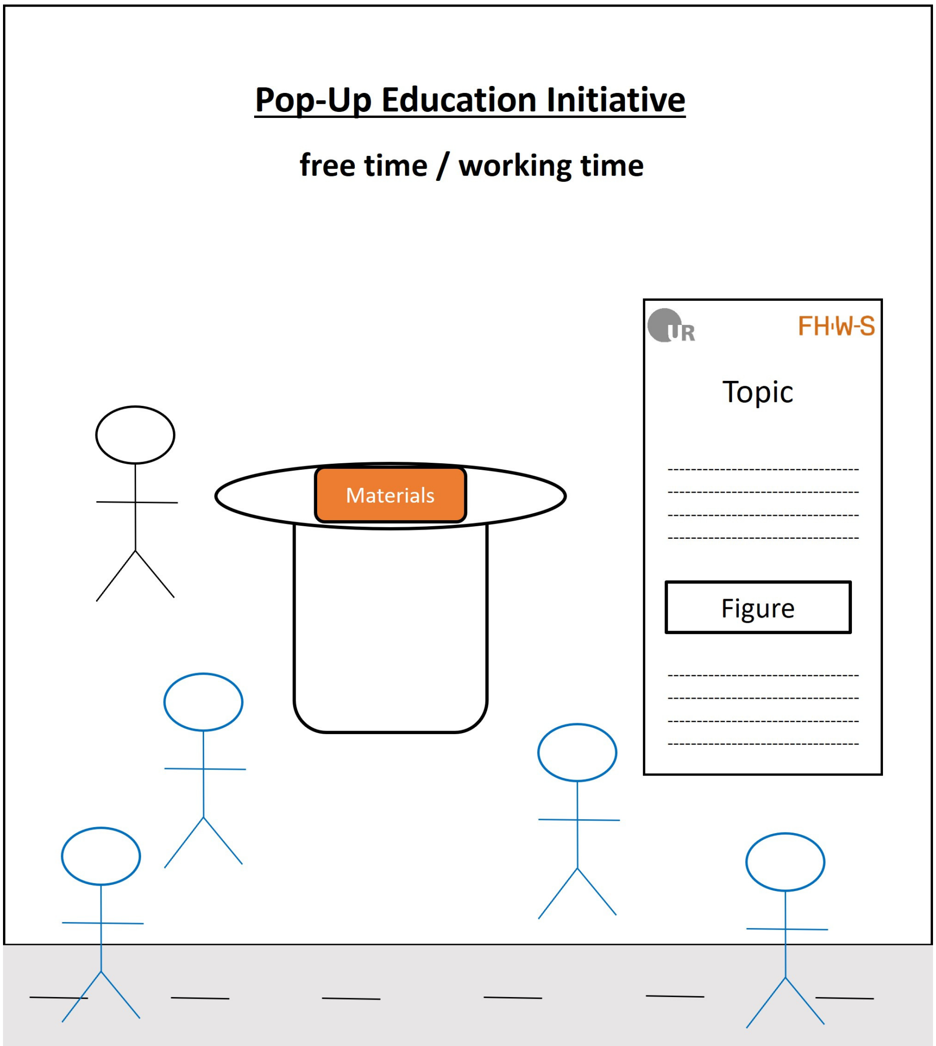

Figure 1.1.: CS pop-up initiative illustration

Warnaby and Shi present a "conceptual framework" regarding the process of "planning and implementing" a pop-up initiative over four stages, illustrated in black in Figure 1.2 [34, pp. 43–82]. The first stage, strategic objectives, deals with the objectives that a pop-up initiative should accomplish. The pre pop-up stage involves the design of a pop-up initiative, including inter alia timing, location, and atmosphere. The actual pop-up initiative is then performed in the pop-up experience stage. Finally, the post pop-up stage deals with the evaluation of the pop-up initiative. The four stages can be interpreted from both the brand and customer perspective. Thereby, the brand perspective represents the view of the researcher in this work, while the customer perspective represents the view of the people who take part in the CS pop-up initiative. The four stages of Warnaby's and Shi's framework and its corresponding application in this work will be discussed in more detail in Chapter 2 and 3.

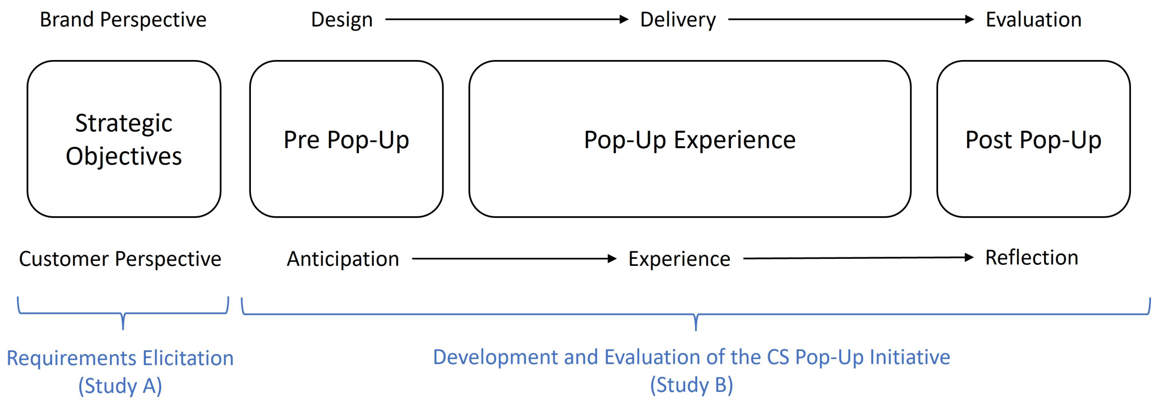

Figure 1.2.: Conceptual pop-up framework according to Warnaby and Shi [34, p. 44]

According to Warnaby's and Shi's framework, this work is divided into two phases: requirements elicitation as well as development and evaluation of the CS pop-up education initiative. The requirements elicitation phase aligns with Warnaby's and Shi's strategic objectives stage, while the development and evaluation phase aligns with their pre pop-up, pop-up experience, and post pop-up stages, as shown in Figure 1.2 in blue. The first phase of this work consists of study A and the second phase of study B. In the first phase, data was collected in order to determine in which CS topics and application fields society is interested in as well as would like to learn about and thus, which topic and application field the CS pop-ups should cover. Thereby, the aim of the first phase is to enable the design of CS pop-ups which appeal to society. Study A was conducted as a mixed method triangulation study and considered different groups of society based on participants' gender, background in STEM, and their generation. Thereby, investigating which society groups should be especially considered in the design of CS pop-up initiatives, reflects RQ A1; while determining CS topics and application fields which are of interest to society reflect RQ A2 and RQ A3, respectively (refer to Chapter 2 and Section 2.1 therein).
Based on the gained knowledge of study A, a CS pop-up initiative (study B) was developed and performed in the second phase as quantitative study utilising a between-subject design combined with a within-subject design. The CS pop-up initiative was performed in public spaces (participants' free time) and in workplaces (participants' working time). Moreover, an online training version of the CS pop-up initiative was performed. Therein, participants also partake during their free time or working time. In all conditions, experience is measured through the short version of the user experience questionnaire (UEQ-S) [37], acceptance through a custom questionnaire based on the technology acceptance model (TAM) [38], and knowledge transfer through a custom pre- and post-questionnaire based on Bloom's taxonomy [39]. All questionnaires and their related background will be described in more detail in Chapter 3. Moreover, RQ B1 reflects how the pop-up initiative was experienced by society based on the UEQ-S, RQ B2 whether the pop-up initiate would be accepted by society based on the TAM, and RQ B3 to which degree CS knowledge could be conveyed through the pop-up initiative based on Bloom's taxonomy (see Chapter 3 and Section 3.1.3 therein).

Due to the limited research situation on pop-up activities [34, p. 2, 33], it remains uncertain whether the pop-up concept can be successfully applied towards CS education in free time and working time settings, especially regarding experience, acceptance, and knowledge transfer, as outlined before. As a result, this work aims to answer the general research question outlined below. Thereby, study A and its research questions (briefly described above, additionally see Chapter 2) aid in providing a design guideline for creating and implementing CS pop-ups which appeal to society. Furthermore, study B and its research questions (briefly described above, additionally see Chapter 3) serve in investigating how CS pop-ups are perceived with respect to experience, acceptance, and knowledge transfer and thereby enable to answer the general research question:

General RQ: Can the pop-up concept be applied successfully towards CS education in *free time* as well as *working time* settings regarding: **a) experience**, **b) acceptance** and **c) knowledge transfer**?

2. Study A – Requirements Elicitation

In this chapter, study A, which belongs to the requirement elicitation phase, will be introduced and discussed. The requirements elicitation phase and therefore study A, is analogous to Warnaby's and Shi's strategic objective phase of their conceptual framework of "planning and implementing" pop-up initiatives (refer to Chapter 1 and Figure 1.2 therein) [34]. Study A lies the foundations of the CS pop-up initiative's design and thereby enables to examine the general research question.

2.1. Introduction Study A

Warnaby and Shi describe inter alia flexibility as one of the main aspects of pop-up initiatives [34, p. 14]. One part of flexibility is strategic flexibility, which discusses the possible aims of applying pop-up initiatives. Thereby, pop-ups can have multiple aims which can vary greatly among different pop-up initiatives. "To test a market, location or a product line" and "to educate the public" belong to some of the possible aims stated by Warnaby and Shi regarding strategic flexibility [34, p. 17]. These two aims also correspond to the aims of the CS pop-up initiatives in this work. Thereby, the aim of this work is to educate the public and employees about society related CS topics as well as to test a market: whether the pop-up concept can be applied successfully towards CS education in public spaces and at workplaces (refer to the general RQ in Chapter 1). In the strategic objectives stage of Warnaby's and Shi's framework, they classify pop-ups' objectives from the brand (pop-up operator) perspective into the following categories: increasing brand awareness, influencing brand association, promoting seasonal / limited collection products, engaging customers, gathering customer insight, testing market concepts, and facilitating strategic growth [34, p. 49]. As Warnaby and Shi describe their framework with a strong focus on pop-up retailing, not all objectives and parts of their framework suit to this work entirely. Still, increasing brand awareness corresponds to increasing awareness and knowledge about society related CS topics, influencing brand associations corresponds with the objective of influencing the CS pop-up initiative participants' association with CS positively, engaging customers corresponds to participants being occupied with CS, and gathering customer insight as well as testing market concepts corresponds with answering the general research question (refer to Chapter 1).

However, Warnaby's and Shi's framework focuses mainly on the brand (pop-up operator) perspective. Thereby, the customer perspective and the customers' actual objectives of using the pop-ups are neglected. Warnaby and Shi still discuss inter alia social interaction and more appealingly sale prices as possible customers' objectives in participating in pop-up initiatives [34, p. 46]. Nevertheless, what customers actually expect or would wish for in specific pop-ups is not considered. Transferred to this work, this would mean that it is unknown about which CS topics participants would like to be educated and thereby, which topics the CS pop-up initiative should cover. Also, Warnaby's and Shi's framework for planning and implementing pop-up initiatives does not offer guidance how this could be achieved or a general guide how pop-ups can be designed by considering customers' actual objectives and wishes. Therefore, requirements elicitation is applied in study A of this work, in order to enable the design of CS pop-up initiatives which appeal to society and thereby enables to examine the general research question.

In software development, requirements engineering is the process of identifying, specifying, analysing, and validating requirements for a new software product [40, p. 434]. The first step in requirements engineering, identifying requirements, is also referred to as requirements elicitation, which is applied in this work. One approach of eliciting requirements for a new product is to retrieve information from stakeholders [41, p. 77]. For a new software, stakeholders can be inter alia end users of the planned software, software developers, clients, and the operators of the software [41, p. 77]. In this work, the stakeholders of the CS pop-up initiative are the researcher of this work / CS pop-up operator and the end users who will participate in the CS pop-up initiative. The requirements of the researcher of this work / pop-up operator (from product development perspective) is to offer a realisable and manageable CS pop-up initiative in terms of inter alia transport, timing, and expenses as well as that the initiative is appealingly to participants. On the other hand, the requirements of potential CS pop-up participants cannot be determined that easily. Therefore, study A focuses on determining the requirements of potential CS pop-up initiative participants, who are the end users of the CS pop-up product. Hence, the insights of the requirements elicitation will enable to design the CS pop-up initiative appealingly to society.

As society is diverse and thereby also the requirements of the CS pop-up participants, the results of the requirements elicitation will be considered regarding participants' gender (levels: female, male), background in STEM (levels: no STEM, STEM), and generation (levels: Baby Boomers, Generation X, Millennials, Generation Z). Special groups based on generation (refer to Section 2.2.1), gender, or background in STEM and how they interact or differ from other groups are frequently researched in social computer science, human-computer interaction, and media research [23, 24, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52]. Hence, these groups were also chosen in this work as they are essential parts in human-computer interaction studies. Some participant groups might have a less positive attitude towards CS, which can imply less interest in CS as well as that they might make use of the CS pop-up initiative less frequently compared to their counterparts who have a more positive attitude towards CS. As the CS pop-up initiative targets the whole society, especially those who would not occupy themselves actively with CS (refer to Chapter 1), the elicited requirements of the groups who have a lower attitude towards CS will be especially considered in the design of the CS pop-up initiative. According to the related work introduced in this paragraph, females and people without a background in STEM, have usually a lower attitude towards CS / STEM than their counterparts. Also, young women are more prone for mental health issues regarding media usage than young men [44]. However, among generations the related work is ambiguous regarding the attitude towards CS. Moreover, related work mainly investigated one or two generations but not all generations together. Furthermore, they focused on other research areas regarding generation such as media, gaming, or reintegration in the workplace [49, 50, 51, 52]. Thus, it remains uncertain which generation should be especially considered in the design of the CS pop-up initiative. Also, people's attitude towards CS / STEM based on their gender and background in STEM was not researched in general but in special situations such as with respect to school or university STEM classes [23, 24, 42, 43, 44, 47, 48]. Therefore, related work merely provides insight into special society groups but not into overall society. Hence, all groups based on participants' gender, background in STEM, and especially generation will be examined with respect to their attitude towards CS in this work, to determine the groups which should be especially considered in the design of the CS pop-up initiative.

CS topics and technologies which are in the focus of society change over time. The Gartner [1] Hype Cycle on emerging technologies provides information about new technologies and their potential development in the future for each year [53]. In business, the Gartner Hype Cycle is often used for evaluating investments and risks [53]. Also, IEEE [2] Trends gives predictions which CS technologies will be more accepted and used in close future [54, 55]. Moreover, Google Trends can also give insight into which CS topics are currently of interest by providing which terms are searched for more frequently than others [56].
However, the Gartner Hype Cycle and IEEE Trends describe CS topics and applications more from a business or engineering perspective than from society's perspective. Also, Google Trends only states how often a term was searched for, which does not necessarily correspond to society's interest as also topics which are not that frequently searched for could also be highly interesting to them. Thus, the Gartner Hype Cycle, IEEE Trends, and Google Trends do not provide exactly in which CS topics and applications society is actually interested in, but just show which CS topics are hyped or are current trends. Furthermore, they also do not provide insight into people's interest based on their gender, background in STEM, as well as generation and whether there are differences. Hence, to identify which CS topics are suitable for appealingly CS pop-up initiatives, study A will examine in which CS topics society is interested in. Thereby, it will also be investigated which CS topics intersect most among society grouped by their gender, background in STEM, and generation. As the Gartner Hype Cycle and IEEE Trends provide an orientation of possible interesting CS topics for society, they were also considered in the requirements elicitation process (refer to Section 2.2.3).

Robots can be classified by application fields as industrial robots and service robots [57, p. 3]. Industrial robots can be used in logistics and manufacturing, while service robots can be applied for medical, home, educational or defence purposes [57, p. 3]. A study on using robots for motivating female school students for CS, also undertook requirements elicitation in order to design appealingly robot workshops for female school students [23, 24]. Thereby, the researchers also considered robots' application fields in the requirements elicitation process.

[1] Consulting and technological research company
[2] Institute of Electrical and Electronics Engineers - professional association

However, there is no official classification of CS by application fields. Hence, there is also very limited knowledge which application fields related to CS appeal to society. Therefore, to identify which application fields can be considered in the design of appealingly CS pop-up initiatives, study A will examine in which CS application fields society is interested in. Thereby, it will also be examined which application fields intersect most among society grouped by their gender, background in STEM, and generation.

Rupp and die SOPHISTen offer a guideline for choosing adequate methods for eliciting requirements [41, pp. 89 – 121]. They define three different types of knowledge which can be determined from stakeholders: unconscious knowledge, conscious knowledge, and subconscious knowledge [41, p. 96]. Based on the Kano model [58], Rupp and die SOPHISTen recommend different requirements elicitation methods. The Kano model defines product features into three categories: basic needs, performance needs, and excitement needs. Basic needs are product features which are taken for granted by customers [41, p. 94]. Thereby, basic needs correspond to subconscious knowledge. Performance needs are consciously expected features and correspond to conscious knowledge [41, p. 94]. Excitement needs are product features which are unknown to customers and they first discover it as a pleasant surprise while using the product [41, p. 94]. Thereby, excitement needs correspond to unconscious knowledge [41, p. 121]. The first step of Rupp's and die SOPHISTen's guideline is to preselect a group of elicitation techniques based on the Kano model. For eliciting basic needs (subconscious knowledge) they recommend observation and artefact methods, for performance needs (conscious knowledge) questioning methods, and for excitement needs (unconscious knowledge) creativity methods [41, p. 121]. Frequently, for developing a new software product, requirements from all three knowledge levels are gathered. As eliciting requirements for developing a CS pop-up initiative is a smaller scope than for a whole software system and also the stakeholders of the CS pop-up initiative have a greater variety, merely eliciting performance needs (conscious knowledge) is adequate for this work. Therefore, questioning methods are recommended in this case. In the next step, the three to four most important influence factors against project reality are identified from a requirements elicitation methods matrix [41, p. 120]. In this case, the four most important influence factors are: manifold opinions, development for the entire market, high geographical distribution of stakeholders, and high number of stakeholders. For each influence factor and method, Rupp and die SOPHISTen provide a recommendation were "–" means not recommended, "0" no influence and therefore applicable, "+" recommended and "++" highly recommended. In this case, as questioning methods are recommended in order to elicit performance needs (conscious knowledge), the matrix offers questionnaires and interviews as possible methods. With respect to the four identified most important influence factors, the matrix rates questionnaires with a total of three "++" and one "+", while interviews are rated with four "0". As the questionnaire has most pluses, the guideline recommends using this method. Therefore, a questionnaire was chosen to elicit requirements for the development of the CS pop-up initiative.
According to Rupp and die SOPHISTen, a questionnaire in requirements elicitation should contain open as well as closed questions to identify stakeholders' knowledge [41, p. 106]. Therefore, the requirements elicitation was performed as a mixed method triangulation study consisting of a questionnaire with open and closed questions. Due to the high number of stakeholders (participants) and the ongoing COVID-19 pandemic restrictions,

the questionnaire was performed as an online survey.

The introduced background of pop-ups, different society groups, attitude towards CS as well was CS topics and application fields, give rise to the following research questions, which will be examined by means of requirements elicitation in study A:

RQ A1: How is societies' current attitude towards CS and which participant groups based on their gender, background in STEM, and generation should be especially considered in the design of the CS pop-up initiative?

RQ A2: In which CS topics is society interested and which topics intersect most among society, grouped by their gender, background in STEM, and generation?

RQ A3: In which CS application fields is society interested and which application fields intersect most among society, grouped by their gender, background in STEM, and generation?

2.2. Methods Study A

In the following, the experimental design, approach, used data sources, and data collection of the requirements elicitation (study A) will be described.

2.2.1. Experimental Design

This study was performed as a mixed method triangulation study consisting of an online survey using open as well as closed response formats. The participants responses will be presented in general as well as grouped based on their gender (levels: female, male), their background in STEM (levels: no STEM, STEM), and their generation (levels: Baby Boomers, Generation X, Millennials, Generation Z). When born between 1946 - 1964 (56 to 74 years old at the time the study was performed), one belongs to the Baby Boomer generation [59]. To Generation X belong people born between 1965 - 1980 (40 to 55 years old), while people born between 1981 - 1996 (24 to 39 years old) belong to the Millennials and people born between 1997 - 2012 (8 to 23 years old) to Generation Z [59].

2.2.2. Participants

All in all, 72 participants completed the online survey which was advertised on social media for non-computer scientist. Before they took part in the survey, participants were informed that their data will be evaluated in order to design new education initiatives. Participation took part on a voluntary basis without receiving any financial compensation.

The participants (37 females and 35 males) were between 16 and 73 years old ($M = 39.85$, $SD = 17.7$) and 28 of them had a background in STEM.

The female participants were between 19 and 65 years old ($M = 34.95$, $SD = 13.26$) and 13 of them had a background in STEM. On the other hand, the male participants were between 16 and 73 years old ($M = 45.03$, $SD = 19.38$) and 15 of them had a background in STEM.
Grouped by their STEM background, the 44 participants (24 female, 20 male) who had no background in STEM were between 16 and 73 years old ($M = 41.93$, $SD = 18.26$). On the other hand, the 28 participants (13 female, 15 male) who had a background in STEM were between 19 and 70 years old ($M = 36.57$, $SD = 15.03$).
Grouped by their generation (refer to Section 2.2.1), the Baby Boomers (4 female, 14 male), were between 56 and 73 years old ($M = 64.89$, $SD = 5.00$) and 4 of them had a background in STEM. In Generation X (10 female, 7 male), participants were between 40 and 55 years old ($M = 44.53$, $SD = 4.91$) and 8 had a background in STEM. The Millennials (13 female, 8 male) were between 24 and 39 years old ($M = 28.71$, $SD = 3.80$) and 7 of them had a background in STEM. In Generation Z (10 female, 6 male), participants were between 16 and 23 years old ($M = 21.31$, $SD = 1.96$) and 9 had a background in STEM.

2.2.3. Apparatus

To shed light on the research questions of the requirements elicitation (see Section 2.1) and to enable to design the CS pop-up initiative appealingly, an online survey containing open and closed response formats was applied. For analysing the quantitative data, the statistical computing software environment R was used [60] and the data was examined by applying descriptive statistics. The qualitative data, on the other hand, was analysed by a qualitative content analysis according to Kuckartz [61, 62]. Thereby, a deductive-inductive coding approach was applied. As deductive categories were attitude towards CS, CS topics, and CS application fields defined which comply with the research questions A1, A2, and A3 (see Section 2.1). Thereby, the category attitude is further defined into the subcategories: association, benefits, drawbacks, and information sources. Further subcategories emerged during the inductive approach of the content analysis. An overview of the deductive codes as well as the coding book of the content analysis can be found in Appendix A.2. As software, MAXQDA 2020 was used for analysing the qualitative data [62, 63]. The whole qualitative material was coded once by the researcher of this work to build the inductive subcodes and the complete codebook with all deductive and inductive codes. Afterwards, the whole material was coded again from the beginning by the researcher with respect to the established codebook. Additionally, a second person coded 50 percent of the material independently. Thereby, an intercoder reliability of $\kappa = 0.90$ (code occurs in the document, due to survey and high number of codes [64]) according to Rädiker and Kuckartz was achieved [64]. Not assigned codes were considered as matches [64]. The agreement between the coders is greater than 0.81 and thus almost perfect according to Landis and Koch [65, 66]. The qualitative data was coded question by question. Thereby, participants' responses can belong to multiple categories. All responses can be coded with all categories if applicable. Just the subcodes of participants' first association with CS (question 1) and information sources (question 16) were only applied for question 1 or 16, respectively. The results of the content analysis were quantified and will be reported in general as well as grouped by gender, background in STEM, and generation. The quantified results represent how many participants gave statements regarding the assigned codes. As an almost perfect agreement between the coders was achieved according to the guideline of Landis and Koch [65, 66], the coding of the two coders were not merged. For quantifying the results, the coding of the researcher of this work was used.

All quantitative and qualitative questions of the online survey can be seen in Table A.1 and A.2 in Appendix A.1, respectively. The column named category lists the research question category (attitude representing RQ A1, topics RQ A2, fields RQ A3) for which each survey question was designed. The deductive as well as inductive subcategories are displayed in Figure A.1 and in the codebook in Appendix A.2, respectively. The column labelled No. in Table A.1 and A.2 provides the number of each question and thereby states in which order the questions were displayed to participants in the online survey. All questions were defined as mandatory to fill in, in the online survey tool LimeSurvey [67] which was used in this study. All quantitative questions used a 10-point rating scale (1 meaning not at all and 10 very). An exception thereby is question 18, which uses yes and no as answer options as it asks if participants are familiar with a list of CS topics. Only question 19 (see Table A.1) offered besides the 10-point rating scale also an option to specify "no answer" as some people might not know some CS topics and thereby cannot specify properly how interested they are in a topic they do not know.

In the following, the survey questions will be discussed briefly regarding the research questions they were designed for. The quantitative attitude towards CS questions (question 9 to 15) give an insight into society's current attitude towards CS (refer to RQ A1 in Section 2.1) and which demographic groups score lower on the attitude scales and thereby should be especially considered in the design of CS pop-up initiatives. The qualitative questions 1, 4 to 8, and 16 provide further understanding how CS is perceived by society regarding their first association with CS, benefits and drawbacks of using CS as well as how they inform themselves about ongoing CS topics in society. Thereby, the questions 1 to 8 as well as 17 and 20 give also insight into which CS topics and application fields society can relate to in their life or are interested in (refer to RQ A2 and RQ A3 in Section 2.1). Especially, the quantitative questions 18 and 19 give an understanding of which CS topics are known to society and how interested they are in these topics. Thereby, a list of the following terms was used which were taken from the Gartner Hype Cycles of emerging technologies 2016 to 2020 [53, 68, 69, 70, 71, 72] as well as IEEE Trends 2019 and 2020 [54, 55]: artificial intelligence / machine learning, robotics, information security / hacking, autonomous driving, virtual / augmented / mixed reality, brain-computer interfaces, internet of things / smart home and cities, blockchain / cryptocurrencies, quantum computing, 4D printing, cyborgs (microchip implants, prostheses), drones, remote communication, and social media. Moreover, CS topics were also elicited in form of qualitative questions. The Gartner Hype Cycles 2016 to 2020 as well as IEEE Trends provided a good orientation for offering participants a list of CS topics, with the task to quantitatively rate how interested they are in these topics. Nevertheless, as the Gartner Hype Cycles as well as IEEE Trends do not describe society's actual interest in CS topics as discussed before (see Section 2.1), also qualitative questions were applied. The ranking of the CS topic list took part after the qualitative questions in the online survey in order to not influence participants' responses regarding the qualitative questions. Since there is no official classification of CS by application fields (refer to Section 2.1), CS application fields were merely elicited through qualitative questions as there was no literature basis to build on for quantitative questions.

2.2.4. Procedure

The online survey was repeatedly advertised on social media for non-computer scientists between November 2020 and January 2021 (during a COVID-19 pandemic lockdown in Germany). During this time, each participant could fill in the survey by means of their own device. The advertisements (see Figure C.1 in Appendix C) as well as the online survey were in German. As computer scientists do not belong to the main target group of the CS pop-up initiatives, the online survey was advertised for non-computer scientists. Before participants took part in the survey, they electronically signed an informed consent including voluntariness and data privacy. Moreover, they were informed that their data will be evaluated in order to design new education initiatives. Participants took between 5 and 80 minutes ($M = 22.80$, $SD = 15.59$) to fill in the survey.

2.3. Results and Analysis Study A

In the following, the results of the online survey will be presented grouped by the corresponding research questions. First of all, the results of each corresponding research question will be presented in general and then grouped by participants' gender, background in STEM, and generation. Therein, the quantitative results will be reported first, followed by the qualitative results. Only the responses of the participants who completed the survey ($N = 72$) were used for data analysis. Responses from people who started and then cancelled before the survey ended were not considered. According to the survey system, one participant needed over one day to complete the survey. The time of this participant was identified as an outlier and was not considered in the statistics of the time participants took to fill in the survey (reported in Section 2.2.4).

2.3.1. Attitude towards Computer Science (RQ A1)

Figure 2.1 shows the descriptive statistics of the quantitative attitude towards CS questions for each item (refer to Table A.1 in Appendix A.1) in general. Thereby, the results show participants' self-assessed attitude towards CS on a 10-point rating scale (1 meaning not at all and 10 very). The quantitative attitude towards CS scale consists of 7 items

(Cronbach's $\alpha = .88$). The attitude towards CS scale value ($M = 5.94$, $SD = 1.86$) was calculated for each participant by adding all associated question items divided by the number of question items. As not only the overall attitude towards CS value is of interest, but also the rating of each single item, the descriptive statistics of each attitude towards CS item will be illustrated in Figures.

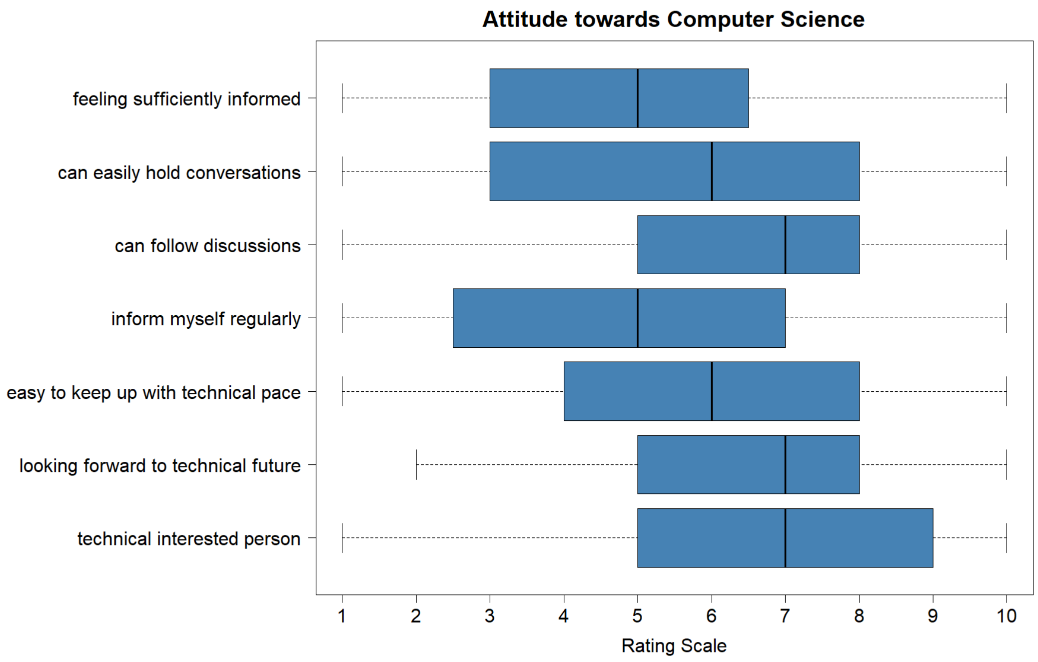

Figure 2.1.: Boxplot: Attitude towards computer science in general – quantitative questions The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

Taking a look at the data grouped by participants' gender, females ($M = 5.40$, $SD = 1.67$) score lower on the attitude towards CS scale than their male counterparts ($M = 6.52$, $SD = 1.90$). As seen in Figure 2.2, females usually score lower in all items. Especially, between the items "can follow discussions", "inform myself regularly", and "technical interested person" are greater differences between females and males. However, the distribution of the item "feeling sufficiently informed" is similar.

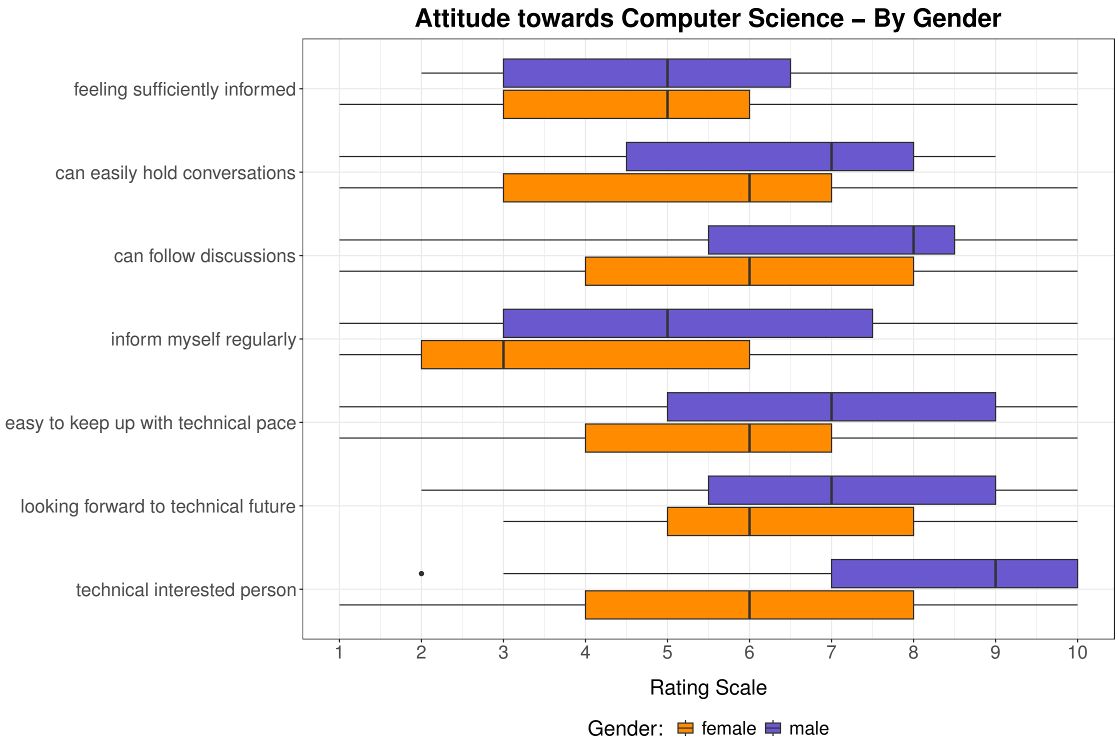

Figure 2.2.: Boxplot: Attitude towards computer science by gender – quantitative questions The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

Furthermore, participants who do not have a background in STEM ($M = 5.65$, $SD = 1.94$) score lower on the attitude towards CS scale compared to participants who have a background in STEM ($M = 6.41$, $SD = 1.64$). Particularly, participants who do not have a background in STEM score lower regarding the items "can follow discussions", "easy to keep up with technical pace", and "technical interested person", as seen in Figure 2.3.

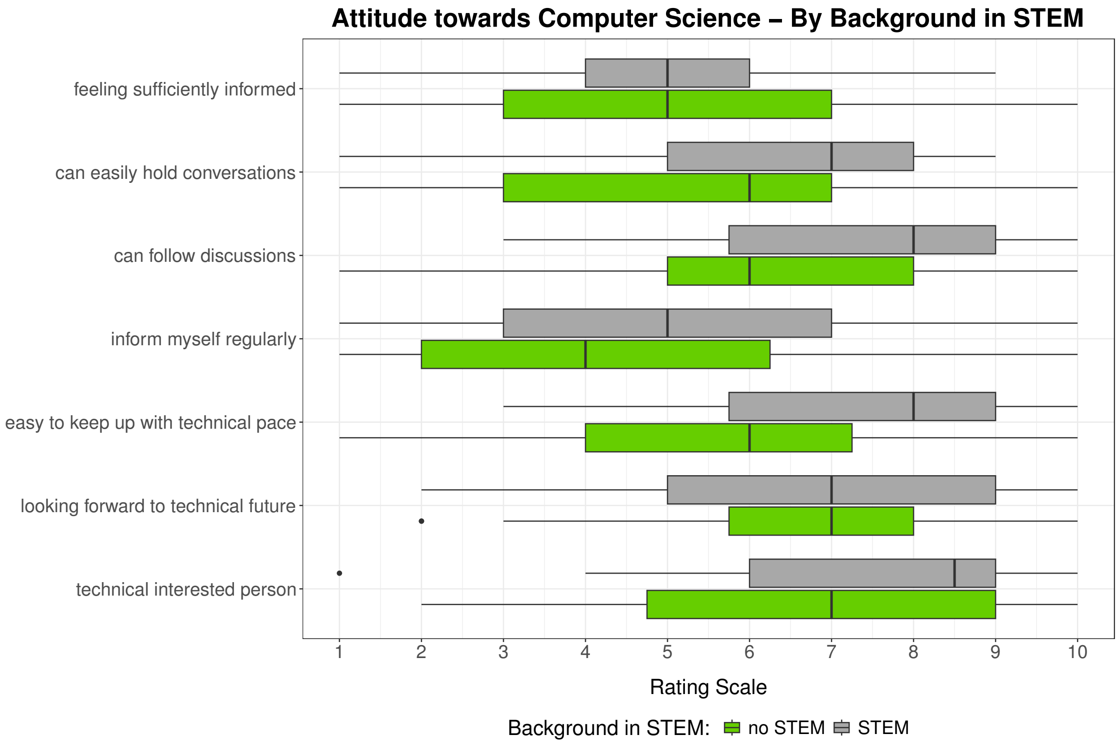

Figure 2.3.: Boxplot: Attitude towards computer science by background in STEM – quantitative questions The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

Interestingly, the youngest generation, Generation Z ($M = 5.48$, $SD = 1.49$), scores lowest on the attitude towards CS scale, followed by the second oldest generation, Generation X ($M = 5.71$, $SD = 2.11$). The oldest generation, the Baby Boomers ($M = 6.21$, $SD = 2.17$), score second highest while the second youngest generation, the Millennials ($M = 6.27$, $SD = 1.63$), score highest. The youngest generation, Generation Z, scores highest in keeping up with technical pace and looking forward to a technical future. However, Generation Z and the Millennials score lowest on informing myself regularly. Interestingly, the oldest generation, the Baby Boomers, score highest in following discussions, while the second oldest generation, Generation X, scores lowest, as seen in Figure 2.4.

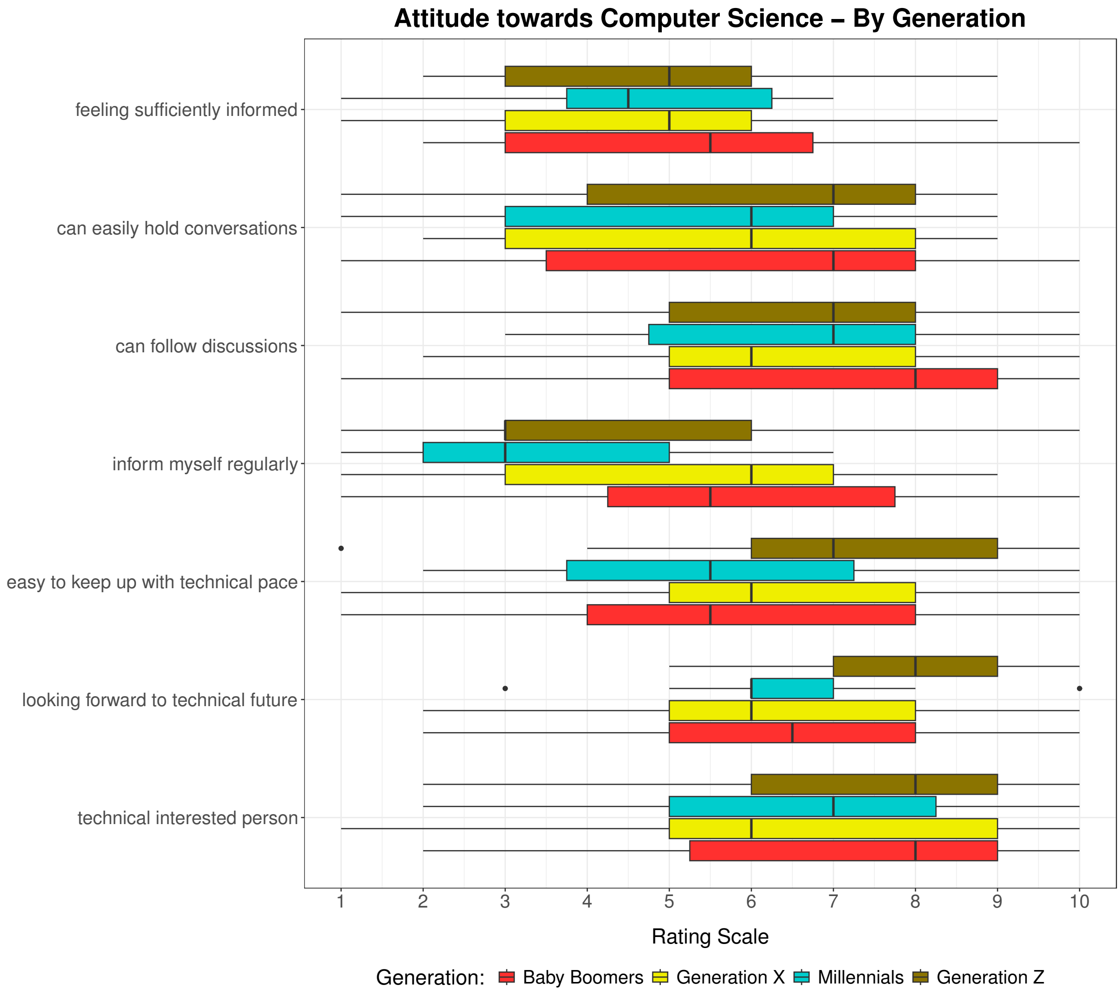

Figure 2.4.: Boxplot: Attitude towards computer science by generation – quantitative questions The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

In the following, the results of the qualitative questions regarding society's attitude towards CS will be outlined in general as well as based on their gender, background in STEM, and generation. Thereby, the numbers in Table 2.1 to 2.4 indicate by how many participants terms were stated which belong to this category (coding frequency). For examples of the specific terms which were stated for each category, refer to the codebook (see Table A.3 in Appendix A.2).
Table 2.1 shows participants' first association when they think of CS (question 1, refer to Table A.2 in Appendix A.1). If participants stated a CS topic as first association, it was coded as topic and is not included in Table 2.1. Most people associated CS with computer / maths / programming, followed by data / information. Stereotypes e.g. nerds, people they know (e.g. friends or family members who are computer scientists), that CS simplifies work and life, that CS is complex / confusing / stressful, that it is part of their

education, and that CS is progress and future-proof were associated at first only infrequently. Thereby, more females associated CS with computer / maths / programming than males, while more males associated CS with data / information than females.

Table 2.1.: First association of computer science – qualitative question

Group	Computer / Maths / Programming	Data / Information	Stereotype	People They Know	In Their Education
In General	46	10	7	4	2
Female	27	1	4	2	1
Male	19	9	3	2	1
No STEM	28	6	3	4	0
STEM	18	4	4	0	2
Baby Boomers	8	5	1	1	0
Generation X	10	3	2	0	0
Millennials	16	2	0	3	0
Generation Z	12	0	4	0	2

The most often stated benefit participants see in using CS is more efficiency, followed by progress / future-proof, and social benefits, as seen in Table 2.2. Participants associated more efficiency / simplifies work and life inter alia with time saving, faster processes, and minimising mistakes. Progress / future-proof was associated with economic growth, constant innovations and progress itself, for instance. Social benefits were associated for example with staying in touch with others remotely, less working load on people, and less dangerous work.

Table 2.2.: Benefits of computer science – qualitative questions

Group	More Efficiency / Simplifies Work and Life	Progress / Future-Proof	Social Benefits
In General	59	21	15
Female	32	9	8
Male	27	12	7
No STEM	33	14	10
STEM	26	7	5
Baby Boomers	12	5	7
Generation X	15	5	3
Millennials	16	6	4
Generation Z	16	5	1

The most stated drawbacks of CS are social issues, followed by data privacy / security issues, and dependency / loss of control, as seen in Table 2.3. Complex / fast moving and job issues were also stated as well as that participants do not see any drawbacks. More people without a background in STEM stated social issues and that CS is complex / fast moving as drawbacks compared to people with a background in STEM. Dependency / loss of control as well as more complex / fast moving were stated by more females than males. On the other hand, that they do not see any drawbacks were stated by more males than females. Participants associated social issues inter alia with escaping in virtual worlds, loneliness, and that humanity and feelings get lost. Data privacy / security issues was associated for example with viruses, surveillance, and exploitation through criminals. Dependency / loss of control was associated with handing over responsibility and that there is no access to data during blackouts, for instance. Complex / fast moving was associated inter alia with confusion, stress, and that more knowledge is needed to use computers. Job issues were mainly associated with unemployment, fewer jobs, and loss of jobs.

Table 2.3.: Drawbacks of computer science – qualitative questions

Group	Social Issues	Data Privacy / Security Issues	Dependency / Loss of Control	Complex / Fast moving	Job Issues	No Drawbacks
In General	62	37	25	18	15	8
Female	34	16	16	15	8	1
Male	28	21	9	3	7	7
No STEM	41	22	15	15	8	4
STEM	21	15	10	3	7	4
Baby Boomers	15	10	4	3	7	1
Generation X	13	9	7	7	1	3
Millennials	20	10	7	5	3	1
Generation Z	14	8	7	3	4	3

For informing oneself regarding current CS topics, internet and social media are most stated, as seen in Table 2.4. Interestingly, newspapers and magazines are stated second most. Other ways of informing oneself stated by participants are: news, through family / friends / colleagues, TV, employer / university, technical literature, radio, and that they do not inform themselves at all (none). Participants without a background in STEM seem to inform themselves more through other people (family, friends, and colleagues) than participants with a background in STEM. Interestingly, technical literature was stated by more participants without a background in STEM than with a background in STEM. Furthermore, all generations inform themselves through internet and social media most. All generations also use newspapers and magazines to inform themselves, except the youngest generation (Generation Z).

Table 2.4.: Information sources – qualitative question

Group	Internet / Social Media	News-papers / Magazines	News	Family / Friends / Col-leagues	TV	Technical Literature	Employer / University	Radio	None
In General	49	18	12	12	10	8	7	4	3
Female	26	6	9	8	7	4	6	3	0
Male	23	12	3	4	3	4	1	1	3
No STEM	30	11	5	9	7	6	3	2	3
STEM	19	7	7	3	3	2	4	2	0
Baby Boomers	10	8	1	2	4	3	2	1	1
Generation X	10	6	3	2	2	2	4	1	2
Millennials	17	4	4	5	3	3	0	1	0
Generation Z	12	0	4	3	1	0	1	1	0

2.3.2. CS Topics (RQ A2)

In order to determine in which CS topics society is interested in, a list of CS topics (refer to Section 2.2.3) was given to the participants with the task to rate, on a 10-point rating scale (1 meaning not at all and 10 very), how interested they are in these topics. Before participants could specify how interested they are, the same list of topics was shown to them and they were asked if they are familiar with the terms (refer to question 18 in Table A.1 in Appendix A.1). All terms were known by all participants, except 4D printing was not known by 51, brain-computer interfaces by 42, quantum computing by 36, chatbots by 25, cyborgs by 16, internet of things / smart home / cities by 15, blockchain by 12, virtual / augmented / mixed reality by 9, remote communication by 5, autonomous driving by 2, drones by 2, and robotics by 1 participant. Therefore, the task to rate their interest regarding the list of CS topics, offered besides the 10-point rating scale also an option to specify "no answer" as some people might have difficulties to specify properly how interested they are in a topic they do not know. Thus, 2 participants did not rate social media, autonomous driving, drones and information security / hacking, 6 remote communication and internet of things / smart homes / cities, 7 virtual reality, 9 cyborgs and blockchain, 3 robotics, 17 brain-computer interfaces and chatbots, 21 4D printing, and 19 quantum computing.

Figure 2.5 shows participants' rating on how interested they are in the listed CS topics (refer to question 19 in Table A.1 in Appendix A.1). Considering the medians, the CS topics can be grouped and ranked regarding participants' interest. Participants are most interested in social media (rank 1, $Mdn = 6.5$), followed by artificial intelligence / machine learning, autonomous driving, information security / hacking, and remote communication which are ranked second highest ($Mdn = 6.0$). Rank 3 is shared by internet of things / smart home / cities, virtual / augmented / mixed reality, cyborgs, robotics, and drones ($Mdn = 5.0$). Brain-computer interfaces, 4D printing, and chatbots share rank 4 ($Mdn = 4.0$). Participants are least interested in quantum computing as well as blockchain (rank 5, $Mdn = 3.0$).

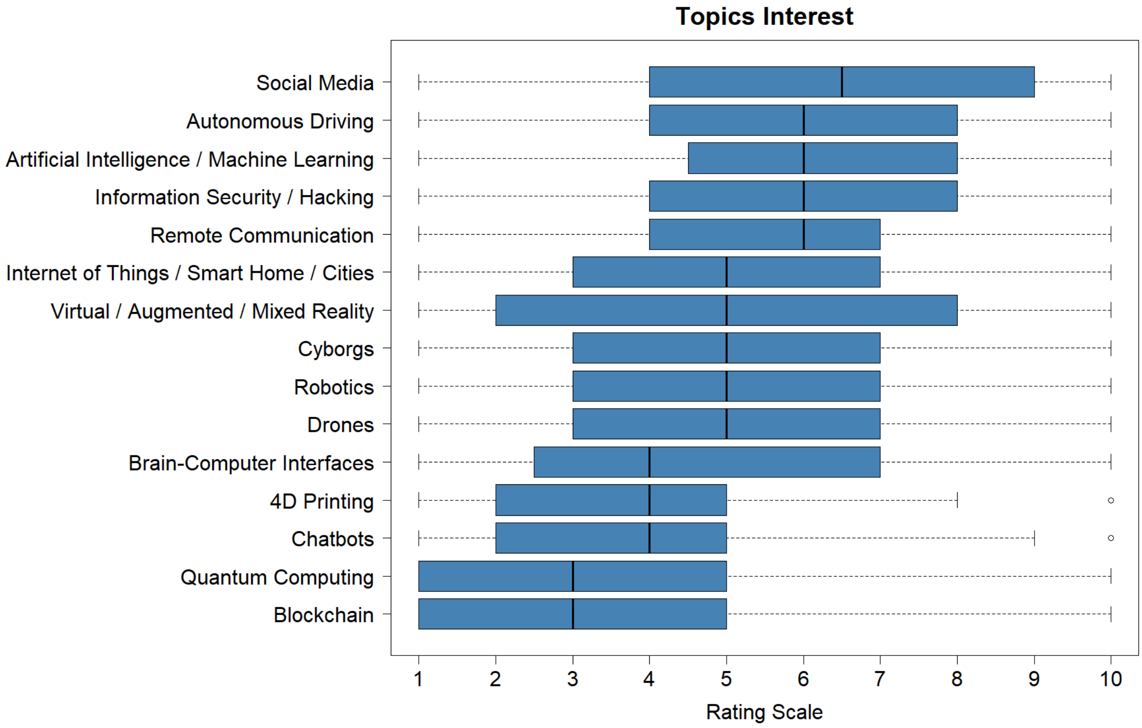

Figure 2.5.: Boxplot: Topics interest in general – quantitative questions The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

Looking at participants' CS topics interest based on their gender (refer to Figure 2.6), a new ranking for females as well as males can be established. The female participants are most interested in social media (rank 1, $Mdn = 7.0$), followed by information security / hacking (rank 2, $Mdn = 6.5$). Autonomous driving, artificial intelligence / machine learning, and remote communication share rank 3 ($Mdn = 6.0$). Rank 4 is shared by internet of things / smart home / cities, virtual / augmented / mixed reality, and cyborgs ($Mdn = 5.0$). Followed by drones (rank 5, $Mdn = 4.5$) as well as robotics, brain-computer interfaces, 4D printing, and chatbots (rank 6, $Mdn = 4.0$). Quantum computing (rank 7, $Mdn = 3.0$) and blockchain (rank 8, $Mdn = 2.0$) are ranked as the least interesting topics. On the other hand, the male participants are most interested in artificial intelligence / machine learning as well as internet of things / smart home / cities (rank 1, $Mdn = 7.0$), followed by autonomous driving, information security / hacking, cyborgs, and drones (rank 2, $Mdn = 6.0$). On rank 3 is remote communication ($Mdn = 5.5$) and on rank 4, social media and robotics ($Mdn = 5.0$). Virtual / augmented / mixed reality is on rank 5 ($Mdn = 4.5$) and brain-computer interfaces, 4D printing as well as quantum computing share rank 6 ($Mdn = 4.0$). As least interesting were chatbots and blockchain rated (rank 7, $Mdn = 3.0$).

Greater differences (median difference of more than 2) between females' and males' interest are regarding social media in which females are more interested in than males as well as internet of things / smart home / cities and drones in which males are more interested in. Considering ranks 1 to 3, information security / hacking, autonomous driving, artificial intelligence / machine learning, and remote communication intersect with females' as well as males' interest.

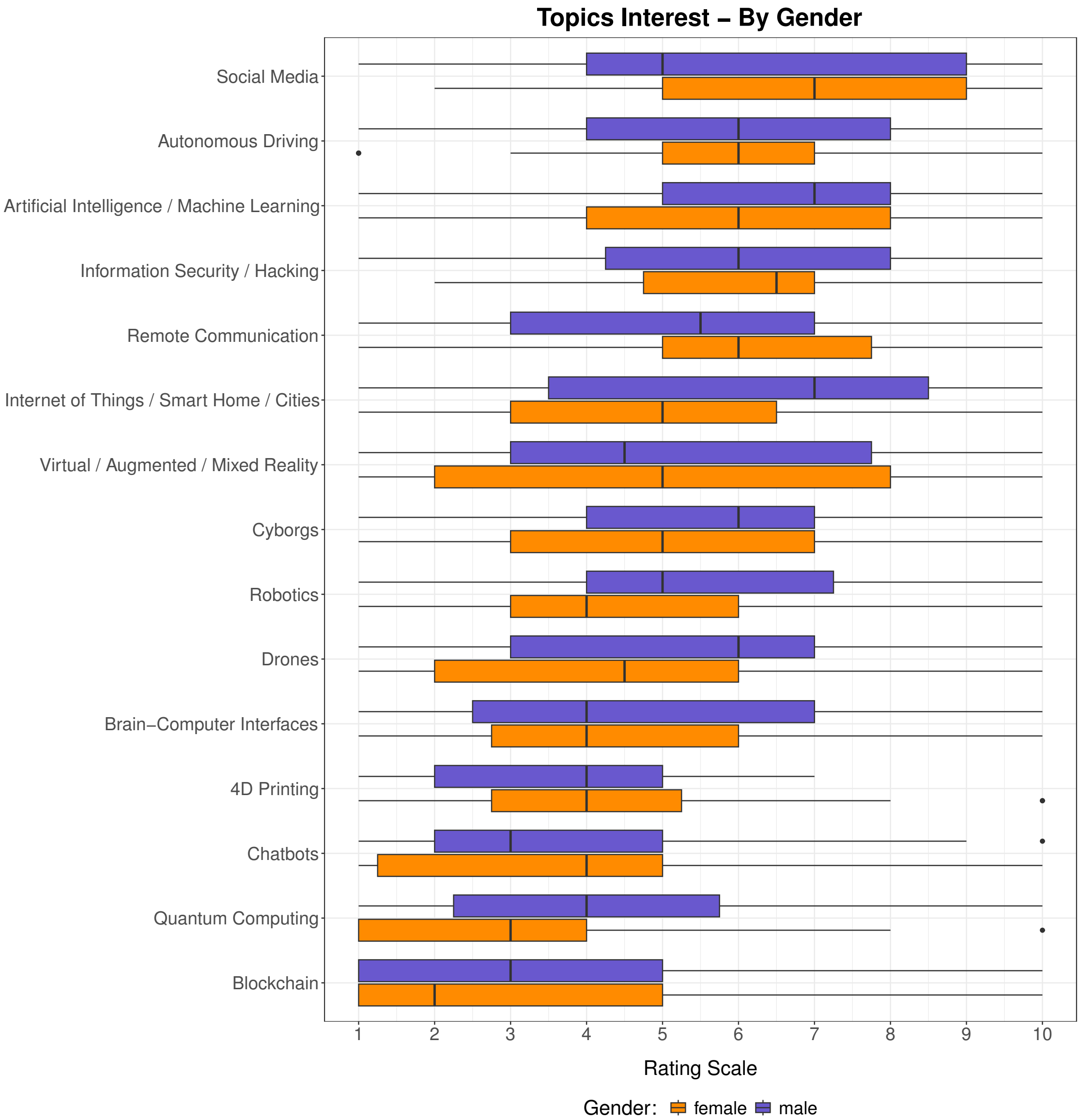

Figure 2.6.: Boxplot: Topics interest by gender – quantitative questions The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

Ranking the data regarding participants' background in STEM (refer to Figure 2.7), participants who do not have a background in STEM are most interested in social media, autonomous driving, and information security / hacking (rank 1, $Mdn = 6.0$), followed by artificial intelligence / machine learning (rank 2, $Mdn = 5.5$). Rank 3 is shared by remote communication, internet of things / smart home / cities, and cyborgs ($Mdn = 5.0$). On rank 4 is robotics ($Mdn = 4.5$), followed by virtual / augmented / mixed reality, drones, brain-computer interfaces, 4D printing, and chatbots on rank 5 ($Mdn = 4.0$). Quantum computing and blockchain were rated as least interesting (rank 6, $Mdn = 3.0$).

On the other hand, participants who have a background in STEM are most interested in social media, artificial intelligence / machine learning, and information security / hacking (rank 1, $Mdn = 7.0$), followed by autonomous driving, remote communication, virtual / augmented / mixed reality, and cyborgs (rank 2, $Mdn = 6.0$). Rank 3 is shared by internet of things / smart home / cities, robotics, and drones ($Mdn = 5.0$). Brain-computer interfaces is rated on rank 4 ($Mdn = 4.5$), quantum computing on rank 5 ($Mdn = 4.0$), and 4D printing on rank 6 ($Mdn = 3.5$). As least interesting were chatbots and blockchain rated (rank 7, $Mdn = 3.0$).

Greater differences between participants' interest without a background in STEM and with a background in STEM are regarding artificial intelligence / machine learning and virtual / augmented / mixed reality in which participants with a background in STEM are more interested in than participants without a background in STEM. Considering ranks 1 to 3, social media, information security / hacking, autonomous driving, artificial intelligence / machine learning, remote communication, and internet of things / smart home / cities intersect in participants' interest whether they have a background in STEM or not.

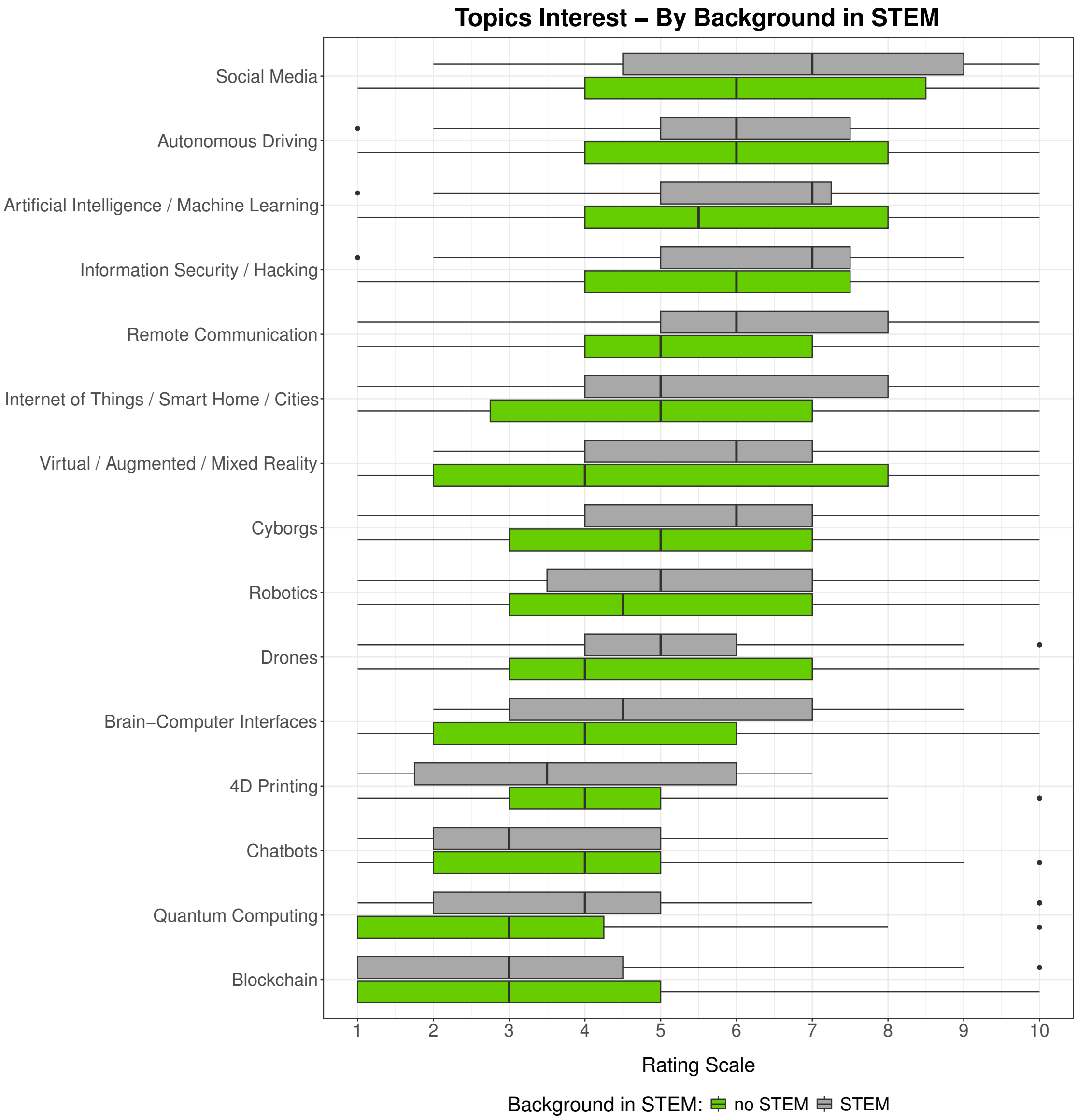

Figure 2.7.: Boxplot: Topics interest by background in STEM – quantitative questions
The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

Looking at participants' CS topics interest based on their generation (see Figure 2.8), the oldest generation, the Baby Boomers, are most interested in autonomous driving (rank 1, $Mdn = 7.5$), followed by remote communication (rank 2, $Mdn = 7.0$), information security / hacking, internet of things / smart homes / cities, and cyborgs (rank 3, $Mdn = 6.0$). Drones are on rank 4 ($Mdn = 5.5$), followed by social media, and artificial intelligence / machine learning on rank 5 ($Mdn = 5.0$). Rank 6 is shared by robotics and brain-computer interfaces ($Mdn = 4.5$), followed by 4D printing and quantum computing (rank

7, $Mdn = 4.0$). As least interesting were virtual / augmented / mixed reality, chatbots, and blockchain rated (rank 8, $Mdn = 3.0$).
The second oldest generation, Generation X, is most interested in information security / hacking (rank 1, $Mdn = 6.0$), followed by social media, autonomous driving, artificial intelligence / machine learning, remote communication, internet of things / smart home / cities, and chatbots (rank 2, $Mdn = 5.0$). Rank 3 is shared by virtual / augmented / mixed reality, cyborgs, robotics, and drones ($Mdn = 4.0$). On rank 4 is brain-computer interfaces ($Mdn = 3.0$), followed by 4D printing (rank 5, $Mdn = 2.5$). The least interesting topics were quantum computing and blockchain (rank 6, $Mdn = 2.0$).
The second youngest generation, the Millennials, is most interested in social media (rank 1, $Mdn = 8.0$), followed by artificial intelligence / machine learning (rank 2, $Mdn = 7.0$), and information security / hacking (rank 3, $Mdn = 6.5$). Rank 4 is shared by autonomous driving and virtual / augmented / mixed reality ($Mdn = 6.0$). On rank 5 are remote communication, cyborgs, robotics, and drones ($Mdn = 5.0$). 4D printing is on rank 6 ($Mdn = 4.5$), followed by internet of things / smart home / cities, and brain-computer interfaces (rank 7, $Mdn = 4.0$). Rank 8 is shared by chatbots and quantum computing ($Mdn = 3.0$), while blockchain is rated as the least interesting topic (rank 9, $Mdn = 2.0$).
The youngest generation, Generation Z, is most interested in social media, autonomous driving, and artificial intelligence / machine learning (rank 1, $Mdn = 7.0$), followed by virtual / augmented / mixed reality (rank 2, $Mdn = 6.5$). Rank 3 is shared by information security / hacking, remote communication, cyborgs, robotics, and drones ($Mdn = 6.0$). On rank 4 is internet of things / smart home / cities ($Mdn = 5.0$), followed by brain-computer interfaces, 4D printing, chatbots, and blockchain (rank 5, $Mdn = 4.0$). As the least interesting topic was quantum computing rated (rank 6, $Mdn = 3.5$).
With respect to all topics, there are greater differences among the generations; except for information security / hacking which is distributed the most similar of all topics among the generations (refer to Figure 2.8). Considering ranks 1 to 3, information security / hacking is the only intersection point among all generations. Considering ranks 1 to 4, information security / hacking and autonomous driving intersect among all generations.

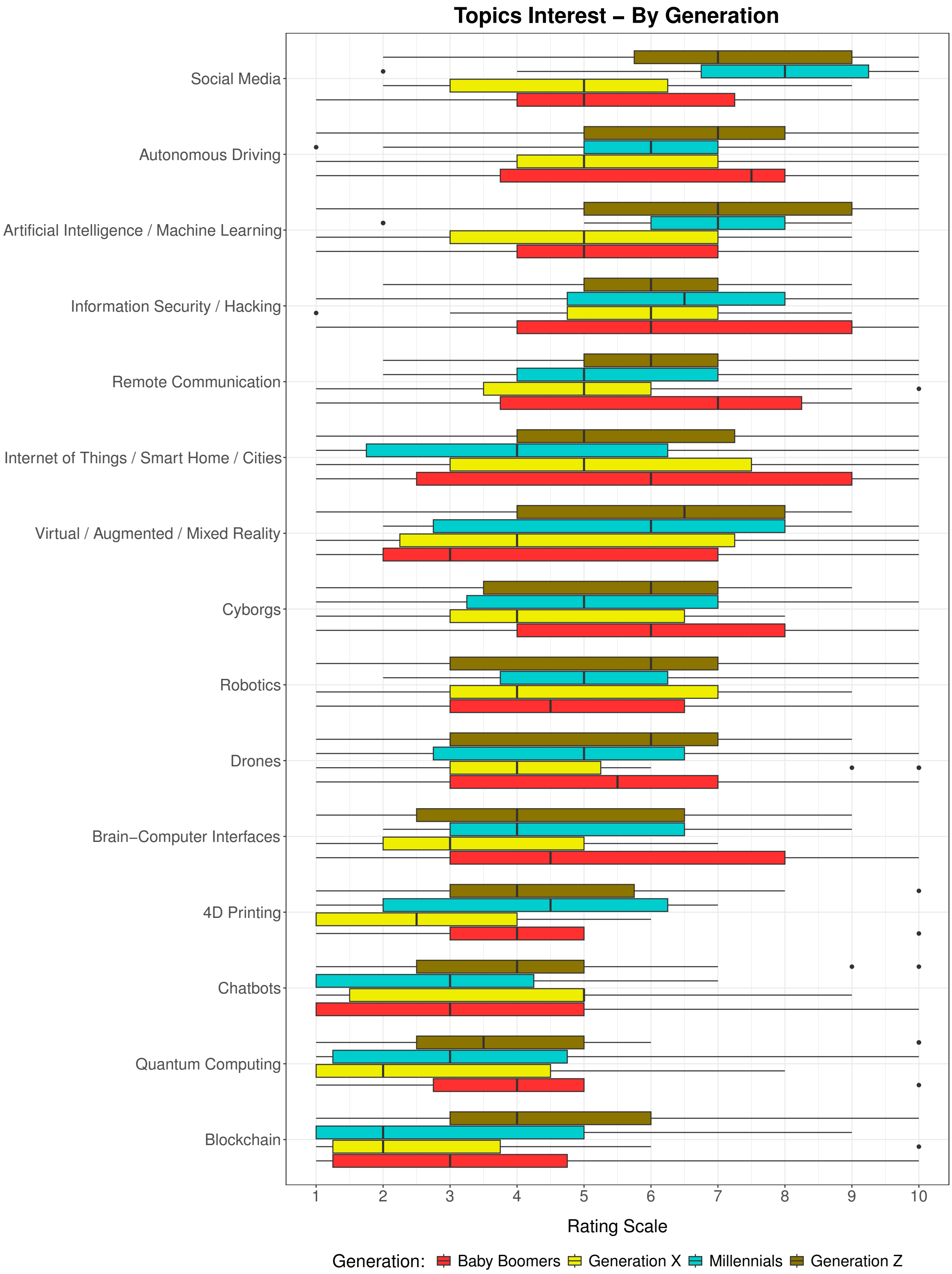

Figure 2.8.: Boxplot: Topics interest by generation – quantitative questions The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

Table 2.5 gives an overview of the first three ranks regarding the rated CS topics interest by groups. Thereby, artificial intelligence / machine learning is abbreviated as AI / ML, internet of things as IoT, virtual reality as VR, and augmented reality as AR. Information security / hacking is on rank 1 to 3 among all groups. Also, social media and AI / ML are among all groups except for the Baby Boomers. Likewise, autonomous driving and remote communication are among all groups except for the Millennials.

Table 2.5.: Topics interest by groups, ranks 1 to 3 – quantitative questions

Group	**Rank 1**	**Rank 2**	**Rank 3**
In General	social media	information security / hacking, autonomous driving, AI / ML, remote communication	IoT / smart home / cities, VR / AR / mixed reality, cyborgs, robotics, drones
Female	social media	information security / hacking	autonomous driving, AI / ML, remote communication
Male	AI / ML, IoT / smart home / cities	information security / hacking, autonomous driving, cyborgs, drones	remote communication
No STEM	social media, information security / hacking, autonomous driving	AI / ML	remote communication, IoT / smart home / cities, cyborgs
STEM	social media, AI / ML, information security / hacking	autonomous driving, remote communication, VR / AR / mixed reality, cyborgs	IoT / smart home / cities, robotics, drones
Baby Boomers	autonomous driving	remote communication	information security / hacking, IoT / smart homes / cities, cyborgs
Generation X	information security / hacking	social media, autonomous driving, AI / ML, remote communication, IoT / smart home / cities, chatbots	VR / AR / mixed reality, cyborgs, robotics, drones
Millennials	social media	AI / ML	information security / hacking
Generation Z	social media, autonomous driving, AI / ML	VR / AR / mixed reality	information security / hacking, remote communication, cyborgs, robotics, drones

Table 2.6 shows the results of the qualitative questions (1 – 8, 17 and 20, refer to Table A.2 in Appendix A.1), which and how often CS topics and technologies were mentioned by participants. Thereby, the numbers in Table 2.6 represent by how many participants the CS topics were mentioned. If one participant mentioned a CS topic multiple times, the

CS topic was coded each time but the topic was just counted once for each participant after the coding process. Based on how often a topic was stated, a ranking with the five most stated topics was applied in general as well as based on participants' gender, background in STEM, and generation. Thereby, rank 1 represents the topic which was stated most, while rank 5 represents the fifth most stated. Thus, the more often a certain topic is stated by different participants, it is implied that people are also more interested in it. If multiple topics were stated equally often, the topics were assigned the same rank and the ranking process continued normally (e.g. multiple topics on rank 1, then next rank will be 2). Furthermore, the topics software and hardware (stated by 59 participants) as well as internet (stated by 25 participants) were excluded from the ranking process, as these terms are too broad and ubiquitous. Moreover, it would be hard to offer appealingly pop-up initiatives regarding these topics, as education in these areas would either be too superficial or technical. Nevertheless, as hardware and software as well as internet are present in nearly all CS applications, these topics can be well combined with other topics and should be included in the design of the CS pop-up initiatives. Examples of exact participants' statements for all CS topics can be seen in the codebook (refer to Appendix A.2).

The topic which was mentioned by most participants and thereby implies greatest interest is information security / hacking (rank 1), as Table 2.6 shows. Information security / hacking is not only the most mentioned topic in general but also for every group except for females, Generation X, and the Millennials who mentioned it second most. Autonomous driving and remote communication were mentioned second most in general and thereby share rank 2, followed by artificial intelligence / machine learning (rank 3), maths / statistics / data analysis (rank 4), and robotics (rank 5). Internet of things / smart home / cities, automation, media, and cyborgs were less stated in general. Also, drones were stated by 6 participants, 3D / 4D printing by 5, blockchain and cryptocurrencies by 3, virtual / augmented / mixed reality by 3, cloud by 2, brain-computer interfaces by 2, quantum computing by 1, and chatbots by 1 participant as topics. As none of these topics are under the five most stated, they were not included in Table 2.6. Moreover, as these topics were not stated by many participants, the results of these topics will not be reported based on participants' gender, background in STEM, and generation, but merely in general.
Looking at the ranking regarding participants' gender, females mentioned remote communication (rank 1) most, followed by information security / hacking and autonomous driving (rank 2), which are closely followed by artificial intelligence (rank 3). The male participants, on the other hand, mentioned information security / hacking most (rank 1). However, artificial intelligence / machine learning is rated on rank 2 and autonomous driving on rank 3. Information security / hacking, autonomous driving, and artificial intelligence / machine learning overlap and belong to the three most stated topics of females as well as males.
Regarding participants' background in STEM, participants who do not have a background in STEM mentioned information security / hacking most, autonomous driving second most, and artificial intelligence third most. While participants who have a background in STEM mentioned information security / hacking most, remote communication second most, and maths / statistics / data analysis third most. Also, information security / hacking overlaps regarding the first three ranks between participants with and without a back-

Table 2.6.: CS topics and technologies from qualitative questions with ranking

Group	Information Security / Hacking	Autonomous Driving	Remote Communication	Artificial Intelligence / Machine Learning	Maths / Statistics / Data Analysis	Robotics	Internet of Things / Smart Home / Cities	Automation	Media	Cyborgs
In General	40	30	30	29	26	23	17	17	9	7
Female	16	16	20	14	12	12	9	6	5	3
Male	24	14	10	15	14	11	8	11	4	4
No STEM	23	20	17	18	14	15	8	11	6	4
STEM	17	10	13	11	12	8	9	6	3	3
Baby Boomers	12	7	7	8	7	5	4	6	2	2
Generation X	9	7	11	3	5	5	5	3	2	3
Millennials	11	10	6	12	9	8	6	5	3	1
Generation Z	8	6	6	6	5	5	2	3	2	1
		Legend:	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5			

ground in STEM.
The oldest generation, the Baby Boomers, mentioned information security / hacking most, artificial intelligence / machine learning second most, and remote communication, autonomous driving as well as maths / statistics / data analysis third most. Generation X stated remote communications most, information security / hacking second most, and autonomous driving third most. The Millennials mentioned artificial intelligence / machine learning most, information security / hacking second most, and autonomous driving third most. The youngest generation, Generation Z, stated information security / hacking most, autonomous driving, remote communication, artificial intelligence / machine learning second most, and maths / statistics / data analysis as well as robotics third most. Among all generations, information security / hacking and autonomous driving overlap. Interestingly, all generations, except Generation X mentioned artificial intelligence / machine learning most or second most. Also, all generations except the Millennials stated remote communication most, second or third most.

2.3.3. Application Fields (RQ A3)

Likewise to the ranking of the qualitative CS topics, also a ranking of the five most stated application fields was established. The application field which was most stated by participants in general, is society / social aspects (rank 1), as Table 2.7 shows. Interestingly, all groups mentioned society / social aspects as application field most. Examples of the stated terms for the category society / social aspects are media and its impact on society, opinion research, and the elderly.
Medicine / healthcare was stated second most in general (rank 2) as well as by all groups. Stated terms of the medicine / healthcare category are inter alia medical technology, artificial limbs, and hospital. While all groups correspond with society / social aspects on rank 1 and medicine / healthcare on rank 2, rank 3 to 5 differ among the groups.
Transport / logistics was mentioned third most in general (rank 3) and also by females, males, participants without a background in STEM, and the Millennials. Still, transport / logistics is under the second to fifth most stated application fields in all groups, as seen in Table 2.7. Stated terms which belong to the transport / logistics category are inter alia hyperloop, mobility, and autonomous driving cars.
As fourth most (rank 4) was industry stated in general. Only for females, Generation X, and the Millennials, could be no rank assigned regarding industry. Stated terms of the industry category are inter alia industry 4.0, production, and the term industry itself.
Rank 5 is shared by daily life and science / engineering and therefore were stated fifth most in general. Examples of the stated terms for the category science / engineering are research, chemistry, and mechanical engineering. Likewise, stated examples for the category daily life are household and daily life itself. No rank could be assigned for participants with a background in STEM regarding daily life. The same applies for participants without a background in STEM regarding science / engineering.

Also, administration was stated by 19 participants, economics by 19, finance by 11, entertainment / leisure by 10, gaming by 6, aerospace by 5, military by 5, and arts by 1 participant as application fields. As none of these topics are under the five most stated,

Table 2.7.: Application fields from qualitative questions with ranking

Group	Society / Social Aspects	Medicine / Healthcare	Transport / Logistics	Industry	Daily Life	Science / Engineering	Education	Environ-ment
In General	66	55	46	37	35	35	32	23
Female	35	29	23	18	19	19	22	12
Male	31	26	23	19	16	16	10	11
No STEM	42	34	33	22	23	21	22	10
STEM	24	21	13	15	12	14	10	13
Baby Boomers	16	15	10	13	8	6	6	5
Generation X	14	11	9	6	10	8	7	7
Millennials	20	18	16	10	11	13	10	5
Generation Z	16	11	11	8	6	8	9	6
	Legend:	Rank 1	Rank 2	Rank 3	Rank 4	Rank 5		

they were not included in Table 2.7. As these application fields were not stated by many participants, the results of these application fields will not be reported based on participants' gender, background in STEM, and generation, but merely in general. Examples of exact participants' statements for all application fields can be seen in the codebook (refer to Table A.3 in Appendix A.2).

2.3.4. Summary

Summarising, females score lower on the attitude towards CS scale than males. Also, participants without a background in STEM score lower than participants with a background in STEM. Furthermore, the youngest generation, Generation Z, scores lowest on the attitude towards CS scale, while the second oldest generation, Generation X, scores second lowest. The oldest generation, the Baby Boomers, score second highest and the Millennials highest. Participants' first association regarding CS was mostly with respect to computer / maths / programming and data / information. Most participants stated more efficiency / simplifies work and life, followed by progress / future-proof, and social benefits as advantages of CS. As drawbacks of CS were mostly social issues, followed by data privacy / security issues as well as dependency / loss of control stated. Participants use the internet and social media most for informing themselves about ongoing CS topics. Newspapers and magazines are second most used, followed by news and through family / friends / colleagues for informing oneself.
With respect to the quantitative rating of the CS topics, participants rated in general social media as most interesting to them, followed by autonomous driving, artificial intelligence / machine learning, information security / hacking, and remote communication. Considering the ratings regarding participants' gender, background in STEM, and generation the greatest overlap of interest in the rating is with respect to information security / hacking, while the second most overlap is regarding autonomous driving, artificial intelligence / machine learning, and remote communication. Also, information security / hacking was stated most by participants regarding the qualitative questions, while autonomous driving and remote communication were stated second most, and artificial intelligence / machine learning third most. Thereby, information security / hacking overlaps most among the different groups.
As application field was society / social aspects stated most (also by all groups), medicine / healthcare second most (also by all groups), and transport / logistics third most. However, regarding transport / logistics the group ratings differ with respect to background in STEM and generation.

2.4. Discussion Study A

In this study, requirements elicitation was performed in order to design CS pop-up initiatives appealingly to society and develop a guideline for CS pop-up initiatives' design. Thereby, the requirements elicitation phase is analogous to Warnaby's and Shi's strategic objective phase of their conceptual framework of planning and implementing pop-up activities (see Chapter 1 and Figure 1.2) [34]. However, as already discussed in Section 2.1, the framework focuses mainly on the brand (pop-up operator) perspective, while the customers' (pop-up participants') perspective is neglected. In order to gain insight into CS topics and application fields society is interested in and would like to learn about, a mixed method triangulation study consisting of an online survey using open as well as closed response formats was performed. Therein, participants' attitude towards CS, CS topics and application fields were captured as part of the requirements elicitation process in order to design appealingly CS pop-up initiatives. As CS pop-up initiatives target the whole society and especially those who have a lower attitude towards CS, the results are also considered based on participants' gender (levels: female, male), background in STEM (levels: no STEM, STEM), and generation (levels: Baby Boomers, Generation X, Millennials, Generation Z).

Considering **RQ A1**, participants exhibited a medium attitude towards CS in general. According to Streiner, the attitude towards CS scale can be considered as reliable as Cronbach's alpha is higher than 0.8 [73]. First associations with respect to CS were mostly regarding computer / maths / programming and data / information. As benefits of CS were mostly more efficiency / simplifies work and life, followed by progress / future-proof, and social benefits stated. Social issues, followed by data privacy / security issues and dependency / loss of control were mostly stated as drawbacks of CS. For informing oneself about ongoing CS topics, the internet and social media are mostly used. Newspapers and magazines are second most used, followed by news and through family / friends / colleagues. More people without a background in STEM stated social issues and that CS is complex / fast moving as drawbacks compared to people with a background in STEM. Also, dependency / loss of control as well as more complex / fast moving were stated by more females than males.
Especially females score lower on the attitude towards CS scale than males. Particularly regarding being able to follow discussions and informing oneself regularly, women asses themselves lower than men. Furthermore, females seem to consider themselves as less technical interested persons compared to males. This corresponds to typical stereotypes and the issues of too few women in STEM areas [42, 43]. Moreover, this goes hand in hand with the results of a study which observed that female CS major students had lower CS confidence than male non-CS major students [74]. Hence, many educational initiatives, such as robot workshops, are performed for motivating young women for computer science and research gender differences therein [23, 24]. Interestingly, one workshop seemed to have a higher motivational impact on female than male students [23, 24]. Furthermore, adolescent girls seem to have more mental health issues regarding social media usage than boys at the same age [44], which corresponds with the lower attitude towards CS score in this work. However, the issue of few women in STEM mostly seems to be a problem of developed countries as Guzdial states [75]. The following numbers of female computer science students and graduates in Asian and European countries supports this. In Malaysia, 52% of computer science undergraduate students are female (2009) [75]. Likewise, 49% of all computer science graduates in India were female (2016) [76], opposed to 19% female computer science students in the UK (2022) [77] and 25% female computer science students in Germany (2017) [78]. Hence, in other countries the attitude towards CS can be different with respect to gender. In Asian countries, computer

science is considered rather more female than male, whereas it is the opposite in western countries [75]. Nevertheless, the number of women starting computer science degrees is increasing gradually in Germany [78]. Also, the interest and attitude towards CS can change over time. Therefore, it is recommended not to take the attitude towards CS regarding gender as predictable beforehand based on stereotypes or related work, as the attitude towards CS can differ in various circumstances for example in different countries. As females show a lower attitude towards CS in this work, their responses will be especially considered with respect to choosing a CS topic and application field for designing pop-up initiatives.
Also, participants without a background in STEM score lower on the attitude towards CS scale than participants with a background in STEM. Particularly with respect to being able to follow discussions, keeping up with technical pace, and being a technical interested person, participants without a background in STEM score lower. Related work shows that students' interest in STEM can increase through STEM learning initiatives [23, 24, 46, 47, 48]. This implies that STEM interest and thereby also the attitude towards CS can be positively influenced by educational initiatives, which is beneficial for this work. However, all initiatives were aimed at and performed in K-12 education and not for broader society. Interestingly, STEM students performed better in blended learning classes than non-STEM students; however, the STEM students did not perceive the classes as positively as non-STEM students [45]. Hence, people without a background in STEM can also perceive technology-related learning activities more positively than people with a background in STEM. This does not necessarily correspond with the lower attitude towards CS scale of this work. Still, as participants without a background in STEM score lower on the attitude towards CS scale, their responses will be especially considered in the design of CS pop-up initiatives.
Surprisingly, the youngest generation, Generation Z, scores lowest on the attitude towards CS scale, while the second youngest generation, the Millennials, score highest. Generation X (second oldest) score second lowest and the oldest generation, the Baby Boomers, score second highest. Greater differences are among being able to follow discussions, inform oneself regularly, keeping up with technical pace, and looking forward to a technical future. Generation Z seems to keep up best with technical pace and is looking forward to a technical future most. Meanwhile, they inform themselves the least about on ongoing CS topics along with the Millennials. The lower attitude towards CS scale of Generation Z might be traced back to, that they are very interested in using technology but not highly interested in its development or technical discussions. However, these are just assumptions. The Baby Boomers score highest in following discussions, while Generation X scores lowest. Based on stereotypes of elderly people, it could have been assumed that they score lowest on the attitude towards CS scale as they are considered least technology savvy. In contrast, Generation Z and Generation X score lower than the Baby Boomers. As related work does not provide insight into generations' attitude towards CS, no comparison can be undertaken [49, 50, 51, 52].
All in all, responses of females, participants without a background in STEM as well as Generation Z and Generation X, should be especially considered in the design of CS pop-up initiatives, as they score lowest on the attitude towards CS scale (**RQ A1**).

In general, participants are most interested in social media (rank 1); followed by artificial intelligence, autonomous driving, information security / hacking, remote communica-

tion (rank 2) as well as internet of things / smart home / cities, VR / AR / mixed reality, cyborgs, robotics, and drones (rank 3) regarding the quantitative ratings (**RQ A2**). However, considering gender, background in STEM and generation, the interests differ and can be narrowed down to the following topics: information security / hacking, artificial intelligence / machine learning, social media, autonomous driving, and remote communication. Among all groups, only information security / hacking intersects with respect to the first three ranks. Social media, artificial intelligence / machine learning, autonomous driving, and remote communication intersect second most among all groups, also regarding rank 1 to 3. It could be observed that women are more into social media than men, whereas men are more into internet of things / smart home / cities than women. Otherwise, there are no greater differences between females and males regarding rank 1 to 3. Also, regarding participants' background in STEM there are no greater differences. People with a background in STEM though, seem to be more into robotics, drones, cyborgs, and virtual reality / augmented reality / mixed reality than people without a background in STEM. The older two generations are less interested in artificial intelligence and social media compared to the two younger generations.
Taking a look at the qualitative results, participants are in general most interested in information security / hacking (rank 1), autonomous driving and remote communication (rank 2) as well as artificial intelligence / machine learning (rank 3). Among all groups, only information security / hacking intersects with respect to the first three ranks as in the quantitative ranking. The qualitative results go hand in hand with the quantitative results. Combining the quantitative and qualitative results, information security / hacking is the most suitable CS topic for all, followed by autonomous driving, artificial intelligence / machine learning, remote communication, and social media. Females, people without a background in STEM, Generation Z, and Generation X should be especially considered in the design of the CS pop-up initiatives, as the attitude towards CS results show. Hence, information security / hacking is the ideal topic as it intersects among all groups. Nevertheless, the other topics are also highly suitable. Also, software and hardware as well as internet were frequently stated. However, these topics were excluded from the qualitative ranking as they are too broad. Still, hardware and software as well as internet can be well combined with information security / hacking as many cyber attacks occur on the internet. But these two topics can also be well combined with autonomous driving, artificial intelligence / machine learning, remote communication, and social media.
The interest in artificial intelligence / machine learning and autonomous driving is not only present within the quantitative and qualitative ranking, but also emerges in IEEE trends 2019 and 2020 as well as the Gardener hype cycles from 2016 to 2020 [54, 55, 53, 68, 69, 70, 71, 72]. Especially artificial intelligence / machine learning is strongly represented in IEEE trends and the Gardener hype cycles. Also, virtual reality / augmented reality / mixed reality and internet of things / smart homes / cities are present in IEEE trends and the Gardener hype cycles as well as in the quantitative ranking, but not highly in the qualitative ranking. However, brain-computer interfaces, quantum computing, blockchain, and 4D printing are also present in IEEE trends as well as the Gardener hype cycles, but are not of great interest to society according to participants' quantitative and qualitative rankings. This could be, as the topics usually do not have greater intersections with daily life. Information security / hacking is only slightly present within IEEE trends and the Gardener hype cycles. But information security / hacking is the CS topic which is highest ranked in the qualitative ranking. Moreover, it is the topic which intersects most

among all groups, also regarding the quantitative ranking. Comparing information security, autonomous driving, and artificial intelligence on Google trends [56], artificial intelligence has been noticeably more searched on Google than information security and autonomous driving in the last five years [79]. Nevertheless, information security was higher ranked in this study. Hence, IEEE trends, Google trends, and the Gardener hype cycles serve well as orientation but do not give insights into society's actual interest in CS topics. In addition, they do not provide insight into different groups of society based on gender, background in STEM, and generation. Also, they mostly focus on a strong business or technical expert perspective. Thus, it is important to perform requirements elicitation.
In summary, the following topics intersect most among all groups and should be considered in the development of CS pop-up initiatives: information security / hacking, social media, autonomous driving, artificial intelligence / machine learning, and remote communication (**RQ A2**). As information security / hacking intersects most among all groups and is of high interest, a CS pop-up covering information security / hacking will be developed and examined in study B (refer to Chapter 3). Furthermore, information security / hacking can also be well combined with social media.

With respect to **RQ A3**, society / social aspects (rank 1), medicine / healthcare (rank 2), and transport / logistics (rank 3) are the application fields in which participants are most interested. Also regarding all groups, society / social aspects was stated most and medicine / healthcare second most. The rank of transport / logistics differs among the groups. Still, it is under the five most stated in all groups. Industry, daily life, and science / engineering belong to the five most stated application fields in general as well; although there is not a great intersection among the groups, especially compared to the other application fields.
Unfortunately, no official classification of CS application fields exists, which could serve as orientation for requirements elicitation. However, a classification scheme of robots by application field exists [57, p. 3]. This scheme was also used in a study which performed requirements elicitation for developing robot workshops for female students [23, 24]. However, this scheme only offers a list of six different application fields. The following application fields participants stated, correspond with the classification of robots [57, p. 3]: medicine / healthcare, industry, logistics / transport, daily life, military, and education. The most stated application field society / social aspects is not in the classification scheme. Daily life, education, and military were stated by participants, but not so frequently, especially military.
Summarising, participants were most interested in society / social aspects, medicine / healthcare, and transport / logistics. Thereby, society / social aspects is of greatest interest and intersects the most among all groups. It is followed by medicine / healthcare which is of second greatest interest and intersects second most (**RQ A3**). Hence, these application fields should be considered in the development of CS pop-up initiatives. Moreover, society / social aspects as well as medicine / healthcare can be well combined with information security / hacking, artificial intelligence / machine learning, autonomous driving, remote communication, and social media. Transport / logistics can be well combined with artificial intelligence / machine learning and autonomous driving.

Cultural influences might impact the results of the study. Germany scores very high on

the uncertainty avoidance dimension of the Hofstede model [80, 81]. The cultural dimensions model was developed by Geert Hofstede. It describes cultural characteristics and behaviour of different countries on six dimensions. The uncertainty avoidance dimension describes how nations deal with the unknown and its corresponding anxiety. According to the Hofstede model, Germans score very high and cannot deal with uncertainty very well. Therefore, Germans try to avoid uncertainty by planning and minimising risks. The German word "Angst" which means fear, has even been included into the English language. The Cambridge Dictionary defines angst as "strong worry and unhappiness, especially about personal problems" [82]. Often it is also referred to as German angst which is also used to describe a stereotype of Germans. The cultural aspects of German angst and the high score of uncertainty avoidance could have influenced the ratings and interest of CS topics, as also information security / hacking is highly ranked and was the most often stated category in the qualitative part of the study. Therefore, other countries might not necessarily be interested in the same CS topics and application fields as Germans. Also, the attitude towards CS regarding gender as well as generation might be different in other countries, as discussed above. Therefore, if it is planned to perform CS pop-up initiatives in other countries, extra requirements elicitation should be performed in the country of interest.
As the study was performed during the COVID-19 pandemic, this could have influenced participants' interest and statements. Especially society / social aspects and medicine / healthcare were mentioned frequently and are on rank 1 and 2 regarding the application fields ranking. Also, during the COVID-19 pandemic these fields were important topics in daily life and on media, even more than before. Therefore, this could have influenced the ratings and interest. But these application fields could also be of general interest beside the pandemic. Hence, future requirements elicitation studies for further pop-ups will shed light on the question whether the pandemic could have influenced the ratings and interests at that time. However, the rankings of the CS topics seem not to, but still could, be influenced by the COVID-19 pandemic, as remote communication was not ranked the highest. Even internet of things / smart home / cites was less ranked and stated as remote communication, even though the interest in these topics could raise during a pandemic as people stay more at home than usual and could improve their homes with smart assistants. Also, topics which are reported on media more frequently or are currently hyped can influence general interest.
Furthermore, interest in topics and application fields can change over time as the Gardener Hype Cycles [53, 68, 69, 70, 71, 72] as well as IEEE Trends 2019 and 2020 [54, 55] show. What might be of interest today, might not be of interest in some years or even less time. Hence, requirements elicitation should be regularly conducted in order to identify society's current CS interests and to maintain appealingly and educational CS pop-up initiatives. As the effort of conducting a mixed method triangulation study is very high and as the quantitative and qualitative results in this study coincide, it could also be considered to perform future requirements elicitation merely as a quantitative study in order to save time and expenses.

All in all, information security / hacking, social media, autonomous driving, artificial intelligence / machine learning, and remote communication can be considered as suitable topics for CS pop-up initiatives. Moreover, society / social aspects, medicine / healthcare, and transport / logistics can be considered as suitable application fields. Information security / hacking and society / social aspects are the most suitable topic and application field as they intersect most among all groups and are highly ranked. Social engineering (hacking by means of psychological concepts) combines both and affects social, private as well as working life. Concluding, a CS pop-up initiative covering information security and social engineering will be developed. In study B (see Chapter 3), the pop-up will be performed and examined in public spaces as well as at workplaces. Furthermore, an online training version of the information security and social engineering pop-up serves as comparison to examine the general research question.

3. Study B – Development and Evaluation of the CS Pop-Up Initiative

Chapter 1 gave a general introduction to this work, including background information on pop-up activities and the current research situation. Furthermore, it provided a brief overview of study A and B. The results of study A show that the CS topic information security / hacking and the application field society / social aspects have the greatest overlap among all participants considering participants' gender, background in STEM, and generation (refer to Chapter 2). Therefore, based on the insights of the requirements elicitation (study A), a CS pop-up initiative covering information security and social engineering as topic was developed. This chapter will give an introduction to information security as well as social engineering and will discuss study B along with the developed pop-up initiative. Study B is analogous to the combination of Warnaby's and Shi's pre pop-up, pop-up experience, and post pop-up stages (refer to Chapter 1 and Figure 1.2 therein). Moreover, this chapter will introduce and discuss related background regarding pop-up activities with respect to Warnaby's and Shi's framework in more detail (see Chapter 1).

3.1. Introduction Study B

Pop-ups can be classified by two factors: location and function [34, p. 25]. Regarding location, Warnaby and Shi [34, p. 25] refer that Beekman and de Boer distinguish pop-ups in nomadic pop-ups, which move from one venue to another e.g. Conrad STEM education pop-up truck [29], and pop-ups which occupy unused already existent locations and settle there for a certain time [83]. In addition, Surchi groups especially fashion pop-ups with respect to location in guerrilla pop-ups, nomad pop-ups, temporary outdoor sites, and temporary online sites [84, 34, p. 26]. Figuratively for all pop-ups, not only in the context of fashion, guerilla pop-ups can be seen as pop-ups which are performed in spaces with limited relation to the pop-up's topic e.g. fashion pop-ups in areas society would not relate to fashion [84, 34, p. 26]. Nomad pop-ups are usually designed transport friendly e.g. in a truck, as they move to different locations. While temporary outdoor sites are performed outside instead of inside, temporary online sites are purely online.
Pomodoro classifies the function of pop-ups into concept brand pop-ups, community pop-ups, test pop-ups, and sustainable test pop-ups [85, 34, p. 27]. The function of

concept brand pop-ups is enhancing brand awareness as well as establishing and communicating brand identity. To strengthen rapport between the brand and the customers, community pop-ups can be performed. Often events such as concerts are hosted in community pop-ups. In order to test novel ideas or product assortments, test pop-ups are applied. Sustainable test pop-ups are test pop-ups with a focus on environmentally friendly trends and pop-up designs. However, also other functions of pop-ups without retailing focus are feasible, such as educating society, as also stated by Warnaby and Shi [85, 34, p. 17].
A selection of realised pop-ups along with their classification by location and function will be outlined in the following.

Boxpark, a pop-up shopping mall in London Shoreditch (partially seen in Figure 3.1), started in 2011 as the "world's first pop-up dining and shopping destination" [86]. The pop-up shopping mall, built out of shipping containers, offers different kind of street food, pop-up stores, and also hosts events like parties or public screening of football matches. While the pop-up mall became permanent due to its success, the pop-up stores and events in *Boxpark* change on a regular basis. *Boxpark* expanded and can be found across four London boroughs and in the cities of Liverpool, Bristol, and Birmingham. As *Boxpark* rents empty shipping containers as spaces for pop-ups, it cannot be classified easily with respect to Surchi and Pomodoro, as each individual pop-up in *Boxpark* can have personal needs and objectives. Also, neither is *Boxpark* a nomadic pop-up nor does it use already unused spaces, as the shopping mall was especially built for the pop-up mall purpose. This shows that pop-ups can be versatile and therefore difficult to classify. Giving it a try, neglecting but still considering the classifications, *Boxpark* in general can be classified as permanent inside space with chancing pop-ups, as community pop-up, and test pop-up.

Figure 3.1.: *Boxpark* – pop-up shopping mall in London Shoreditch (author's own photograph in March 2024)

Similar to *Boxpark*, also *BRYCKE* offers pop-up spaces for rent in central Stuttgart. *BRYCKE* is a coworking space providing a platform and community for visions, innovative products and connects people [87]. It is a project of the business development department of the city of Stuttgart. Figure 3.2 shows an advertisement poster of *BRYCKE* for pop-up spaces in Stuttgart. Likewise to *Boxpark*, *BRYCKE* is a greater pop-up space and can be classified accordingly to *Boxpark*.

Figure 3.2.: Advertisement for *BRYCKE* pop-up space in Stuttgart (author's own photograph in October 2022)

Figure 3.3 shows the *Dilly Dally pop-up store XL* in Regensburg. The pop-up store - which sells limited fashion, jewellery, and arts from designers across Europe [88] - was located in the Degginger pop-up space called *Pop-Up Raum*. Degginer is a cultural centre which offers spaces and a platform for creativity, culture, and innovation in Regensburg [89]. Different rooms can be rented e.g. a room with a stage and also a pop-up space. The Kreativbehörde (creativity board) of the city of Regensburg is responsible for the pop-up space and rents the room to interested parties for a certain time. The Degginger *Pop-Up Raum* can be analogously classified as *Boxpark* and *BRYCKE*. The *Dilly Dally pop-up store XL* itself, can be considered as test pop-up store to see if their products sell well.

Figure 3.3.: *Dilly Dally pop-up store XL* in the Degginer *Pop-Up Raum* in Regensburg (author's own photograph in December 2023)

During the COVID-19 pandemic, many rapid antigen test locations emerged. Some of them were also pop-ups, such as a *rapid antigen test pop-up bus* at Würzburg Hubland-platz (see Figure 3.4). The *rapid antigen test pop-up bu*s can be classified as nomadic pop-up, if it moved. After the COVID-19 pandemic was declared over, there was no need for rapid antigen tests any longer. This demonstrates and underlines the temporary characteristics and advantages of pop-ups. During the pandemic, it could be considered as a retail and healthcare pop-up.

Figure 3.4.: COVID-19 *rapid antigen test pop-up bus* in Würzburg (author's own photograph in April 2022)

A nomadic pop-up of the automobile manufacturer *Tesla*, which took place at Neupfarrplatz in Regensburg, can be seen in Figure 3.5. As society would not expect a car exhibition in the middle of the city centre, *Tesla's pop-up* can be considered as a guerilla pop-up. Furthermore, it can be classified as a concept brand pop-up, as the company aims to enhance brand awareness through the pop-up.

Figure 3.5.: *Tesla pop-up stand* in Regensburg (author's own photograph in July 2023)

Manifold pop-ups have a strong focus on retail, as seen in the presented pop-ups above and as related work shows (see Chapter 1). However, there are also pop-ups or pop-up spaces which pursue educating society. Examples thereof are *Manchester's inflatable museum* [90, 34, p. 19] and the *Münsterbauhütte m25* [91] in Ulm. While *Manchester's inflatable museum* is a nomadic pop-up which exhibits museum objects, *m25* is a permanent indoor space of the city of Ulm. The *m25* has a constant exhibition on the building of Ulm Minster and a changing pop-up exhibition on various educational topics. One *m25* pop-up exhibition, conducted by local researchers, educated on sustainability, health, mobility, and internet of things [92]. Another pop-up museum is *Kaufhausgeschichten* by the Museum der Alltagskultur of the Landesmuseum Württemberg, which attracted over 800 visitors [93]. The pop-up museum was conducted in an old former corner shop, showing how corner shops looked in the past along with sold products of this time. *The Westgate Oxford pop-up* is an archaeological pop-up museum, exhibiting artefacts from archaeological sites in vacant spaces. The author claims that the pop-up was very successful [94]. However, besides capturing general pop-up museum participants' statements, no scientific research was undertaken. Instead, the work focuses on reporting how the pop-up museum was planned and conducted. Furthermore, the author reports that a survey could have measured experience and educational achievements [94]; however, no survey was undertaken. Other forms of pop-up museums are such which take place in actual museums. Tissenbaum's and Puntambekar's *pop-up science program*, which took place in a museum, is intended for children. Therein, children build a composter by themselves and the support of their parents [95]. However, the focus of this research does not lie on pop-up museums but rather focuses on the interaction of children and their parents in educational settings. Moreover, the *pop-up science program* is intended for a certain tar-

get group and not for a broader society.
More well-known pop-up museums are *Body Worlds* (Körperwelten in German) and *immersive Van Gogh exhibit*. *Body Worlds* is a nomadic pop-up which takes place in vacant spaces aiming to educate society about the human body and its operating principles as well as to foster health prevention [96]. Different plastinated human bodies are exhibited at *Body Worlds*. Over 55 million people visited *Body Worlds* since 1995 across the globe [96]. The number of visitors and the duration of 29 years demonstrate *Body Worlds*' success. Also, visitor surveys were conducted in various countries and cities during *Body Worlds* stays. The results inter alia show that 68% will take more care of their physical health and 25% plan to do more sports [96, 97]. However, there are also manifold ethical concerns especially regarding the origin and handling of the exhibited dead bodies [98]. Nevertheless, 90% of surveyed visitors stated that they experienced *Body Worlds* exhibits as very good or good [97]. Still, people who visit *Body Worlds* most likely have an already existing interested in the topic and less ethical concerns. Also, people who reject *Body Worlds* will not visit the exhibition and thus are not included in the sample population.
A less controversial pop-up museum is the *Van Gogh immersive exhibit*, which present the Dutch artist's paintings in an immersive experience, using inter alia 360-degree projections and virtual reality [99]. Likewise, it is also a nomadic pop-up which uses vacant spaces. Over 3.2 million tickets have been sold and it was apparently one of the most successfully sold attractions on the online platform Ticketmaster [99].
None to very limited as in the case of *the Westgate Oxford pop-up museum*, or highly specific research as in the case of *Body Worlds* and the *pop-up science program*, has been undertaken regarding pop-up museums. Furthermore, the number of pop-up museum visitors or sold tickets seem to be the main point for claiming a pop-up as successful. However, there is not a certain threshold of visitors to claim pop-ups as successful. From a few hundred to a few million visitors, claiming pop-ups as successful seems to underlie subjective assessments. This goes hand in hand with Warnaby's and Shi's statement that educational pop-ups are frequently performed but very limited academic research is undertaken [34, p. 2, 33], as also discussed in Chapter 1. Moreover, experience, acceptance, and knowledge transfer have not been investigated at all to only a small extend (*Body Worlds*) regarding pop-up museums or educational pop-ups in general.

In this work, a nomadic pop-up, which can be placed indoors as well as outdoors, was developed and applied. A nomadic pop-up design was chosen to cover multiple different places in order to reach wider society. Warnaby and Shi also recommend nomadic pop-ups to obtain the broadest target group [34, p. 25]. Furthermore, CS pop-up initiatives in general as well as the developed information security and social engineering pop-up can also be classified as concept brand pop-up, community pop-up, and test pop-up. The objective of educational CS pop-ups is to enhance awareness (concept brand pop-up) and rapport to (community pop-up) CS topics as well as information security and social engineering, respectively. Furthermore, the information security and social engineering pop-up serves as a test pop-up, to examine whether the pop-up concept can be applied successfully towards CS education (refer to the general RQ in Chapter 1). Importantly, the CS pop-up initiative's function can also be classified as educating society. CS pop-up initiatives can be conducted outsides like the *Telsa pop-up* (see Figure 3.5), inside special pop-up spaces like *Boxpark*, *BRYCKE* and *Degginger Pop-Up Raum* (refer to Figures 3.1 to 3.3), or buildings not related to pop-ups at all.

3.1.1. Information Security and Social Engineering

An overall introduction to information security and social engineering will be given in the following. Moreover, the corresponding topics covered in the developed pop-up education initiative will be explained.
In their book *Principles of Information Security*, Whitman and Mattord define information security as "the protection of information and its critical elements, including the systems and hardware that use, store, and transmit the information" [100, p. 8]. As Whitman's and Mattord's definition shows, information security does not only deal with computer and technology security but also with data security (also non-digital data) and even with physical security (e.g. information loss through fire). The most important information security objectives are to always maintain confidentially, integrity, and availably of data and services (the so-called C.I.A triad) [100, p. 8]. Thereby, data should be treated confidentially and should only be accessible by authorised users. Moreover, data should be accurate and changes traceable (integrity) as well as always available.

While hacking is often associated with gaining unauthorised access to computers and digital data by means of computer technology [101], social engineering is referred to as the "science of human hacking" [102]. In his book *Practical Social Engineering - A Primer for the Ethical Hacker*, Gray defines social engineering as "any attack that leverages human psychology to influence a target, making them either perform an action or provide some information" [103, p. 3]. Hence, social engineering is hacking with the objective to get unauthorised access to data or infrastructure (digital or non-digital) by applying psychological concepts. While technical hacking mostly uses methods from computer science, such as "system administration, programming, and database administration", social engineering uses mostly psychological concepts [103, p. 8]. Often, social engineering and technical hacking are combined. Psychological concepts which are applied in social engineering are: influence (affect someone's behaviour in a positive or negative way to achieve a special reaction), manipulation (like influence but abusive), and rapport (building trust) [103, p. 8 – 9]. Furthermore, Cialdini's six principles of persuasion [104] are also frequently used in social engineering attacks: authority, likeability, urgency and scarcity, commitment and consistency, social proof, and reciprocity [103, p. 9 – 11]. Often, social engineers masquerade themselves as a person of authority e.g. assistant of the CEO or the police, as people are more likely to carry out a special activity "when someone in a position of authority tells them to do so, or when they are led to believe (truthfully or with false pretense) that an authority figure is also doing that action" [103, p. 9]. Moreover, people desire to help other people they like [103, p. 9]. Therefore, social engineers try to appear likeable by e.g. giving compliments and then exploiting the victims' helpfulness. Another approach of manipulating victims is to create urgency and scarcity "to scare victims into acting before they've had time to think things through" [103, p. 10]. This can be done for example by threatening to expose or delete sensitive data if a required action is not carried out by the victim in a certain time. As people mostly do not enjoy change, "social engineers either remain consistent or break consistency to influence targets" [103, p. 10]. Furthermore, social engineers might claim that they are committed to the same goal as the victim. Often, people behave and make decisions based on other people's behaviour or what is considered as acceptable by society

(social proof) [103, p. 10]. Social engineers might use social proof for example by telling the victim that other successful people also do the task the social engineer wants the victim to do. People attempt to help people who helped them (reciprocity) [103, p. 10]. Therefore, social engineers willingly will help their victim and thereby create a situation so that the victim owes them a favour. After helping their victim, they will ask for help to achieve their social hacking objective. Other tactics social engineers apply is to use sympathy and empathy in their favour, inter alia for establishing rapport [103, p. 11]. Examples thereof are: social engineers telling the victim that they feel sorry for him or her in a special situation (sympathy) or to relate to a similar situation which apparently happened to the social engineer and how the social engineer felt in it (empathy) [103, p. 12].
Social engineering can be highly effective as it is genuinely difficult to recognise [101, 103, p. xix] and there is too less awareness about it in general public [101].

Over 90% of all cyber attacks start with social engineering [105]. Hence, social engineering is an ideal topic for educating society as almost everybody is at risk and affected by it. A general introduction to social engineering including the six principles of Cialdini are covered in the pop-up initiative. Also, phishing, vishing, and open source intelligence (OSINT), the most frequent social engineering methods used, are explained in the pop-up initiative. These three methods will be described in the following.
Phishing is the most commonly used social engineering method in the digital world [106, p. 137, 103, p. 5]. In this method, scam emails with the objective to influence or force victims into disclosing information, opening files, or clicking on links are sent. If successful, sensitive data such as passwords are spied out or malicious software will get installed on victims' computers for further attacks and exploitation [106, p. 137, 103, p. 5]. As phishing emails are getting more professional, it is becoming increasingly more difficult to distinguish phishing emails from real messages [106, p. 137].
Vishing is similar to phishing, however, is performed via phone [103, p. 6]. The objective of vishing is to gain sensitive information or remote access to computers [106, p. 145-146]. However, vishing can also be used to announce a future phishing email. So, the email will appear more trustworthy [106, p. 145]. Vishing callers pretend false identities such as authorities, the police, the CEO of a company, or the target's boss. Also, performing a survey, being a customer or vendor is often claimed. Phone numbers are usually spoofed or forged, including emergency telephone numbers such as 110, 112, and 911 [106, p. 145-146, 103, p. 6].
Information collected from publicly available resources, also referred to as open source intelligence (OSINT), is data found in e.g. newspapers, social media, search engines, and job advertisements [103, p. 4]. Hackers use this information to enhance and prepare their social engineering attacks. By means of OSINT, attacks like phishing and vishing can be personalised, which makes them more successful and more difficult to recognise. Phishing using OSINT is called spear phishing [103, p. 5]. Normal phishing emails are usually not intended to a certain target, but are sent to thousands of email addresses, while spear phishing attacks intend a specific target person or company. Social engineers use OSINT to disguise and to improve the success rate of their attacks. In contrast to social engineering attacks, collecting OSINT is legal.

3.1.2. Edutainment in Information Security and Social Engineering

As already discussed in Chapter 1, manifold opportunities to increase CS knowledge for personal and professional development exist, also regarding information security and social engineering. The book *Meine digitale Sicherheit Tipps und Tricks für Dummies* [106] is written to educate general computer users about digital security. The authors' aim is to prevent society from falling victim to cybercrime through conveying knowledge and practical tips on information security and social engineering. The book covers inter alia how to detect and prevent phishing and vishing, practical tips for social media profiles, and securing devices. The book is written in an easily comprehensible manner for non-CS professionals. However, as with all books, an already existing interest in the topic is needed.
Even though books can be interestingly and comprehensibly written, learning through books can still be a demanding and serious task. Already in 1897, American philosopher and educator John Dewey thought that educational processes should not be tiresome and uncomfortable [107, 108]. To create an interesting and enjoyable learning environment, edutainment can be applied [109]. Edutainment is a portmanteau word combining education and entertainment [110, 111, p. 16]. It aims to educate and convey knowledge in an entertaining way [109]. Thereby, people learn in a simpler way and enjoy learning [110]. Research shows that edutainment enables people to achieve better learning outcomes and that they are willing to learn more [109, 112, 113]. For edutainment purposes, videos, games, interactive websites, virtual and augmented reality applications, and comics are often used. However, edutainment is not limited to these. The following paragraphs will discuss edutainment applications with respect to information security and social engineering.

In a study on information security awareness trainings, an approach using edutainment compared to a traditional e-learning training based on textual information was investigated. The edutainment approach uses a 360-degree VR video in which participants were part of a hacking group. Different social engineering attacks and the social engineering life cycle were explained to participants in the video. The same information, however, in textual form, was provided to the e-learning group. The results of the study show that participants in the edutainment group achieved a higher information security awareness score compared to their counterparts without edutainment approach [112].

There a manifold games available aiming to convey knowledge on information security. One example thereof is Novalab's *Cybersecurity Lab* in which the player tries to defend a company from cyber attacks by completing different tasks [114]. The tasks include the guessing passwords challenges, social engineering challenges including identifying phishing and vishing, and coding challenges. The coding challenges are not related to information security though, but contain the task to move a robot to a certain position by using the visual programming language Scratch. The game is aimed for school students in grades 6 to 12 and takes approximately 75 minutes to complete. Visuals and texts without sounds are used in the game.
Another game called *Cyber Awareness Challenge*, provided from the United States De-

fense Information Systems Agency, offers manifold different missions [115]. Each mission is designed as a comic video with different characters and a narrator, who asks quiz questions. After successful completion of a mission, players earn a badge. The game's content focuses on educating government employees on information security and social engineering.
Also, a game focusing on employee education is PwC's *Game of Threats* [116]. Two teams play against each other to protect their company from cyber threats. Software as well as playing cards are used in the game. After completion, players get a summary of their performance and how they can translate their experience to protect their company in reality.
The company Trend Micro developed a game called *Targeted Attacks*, in which the player identifies as the chief information officer of a company called The Fugle [117]. The game is an interactive film with actors in which players have to make decisions which affect the narrative and its outcome. Multiple decision options are given after each film sequence. Highly technical decisions with a strong business focus and a limited financial budget must be made. Information on information security and social engineering is not provided during the game, prior knowledge is needed. At the end of the game, the player's decisions are discussed.
Interactive e-learning courses on information security are provided among others by the E-SEC E-Learning company [118]. Their course is designed like a 3D animation game, accompanying an employee on her way to work as well as her time in the office while facing and solving different information security and social engineering incidents. The game uses quizzes and decision-making approaches.
Im Netz des Social Engineers is a game developed by G DATA. It is a point-and-click adventure which features a detective who has to solve a cyber incident and find a lost employee who fell victim to social engineering [119]. Through clicking on objects, parts of the story are getting told and explanations of information security and social engineering concepts are provided. As additional gameplay, story sequences have to be arranged in chronological order.
The Texas A&M University's *Keep Tradition Secure* is an interactive game in which the player has to chase a hacker called Bad_Bull across campus [120]. At each station a multiple-choice question related to campus information security is asked. After answering correctly, a riddle with multiple-choice answer options is presented to find the new place on campus the hacker fled to. This procedure is repeated until the final station is reached and the hacker caught. As the game was designed especially for the Texas A&M University, knowledge of their campus and information technology infrastructure is needed to play the game.
All games introduced so far were designed for school or university students or the workplace. Nevertheless, there are also games without a strong focus on these groups. *Anti-phishing Phil* is a game, teaching players to recognise malicious URLs and to distinguish them from safe ones [113]. The main character of the comic style game is Phil, a young fish who likes to grow up by eating worms. Each worm in the game is associated with either a safe or a malicious URL, which can be seen when Phil approaches a worm. Players' task is to help Phil eating only good worms (safe URLs) and rejecting bad worms (malicious URLs). After each round, players get their statistics and results which URLs are truly safe or malicious. The URLs in the game represent actual safe or malicious URLs. Before each round, information how to detect malicious URLs is provided through comics. The results of a performed study show that participants who played the *Anti-phishing*

Phil game were more capable of identifying malicious URLs than participants who took part in conventional trainings [113].
Defend the Crown is a game set in the medieval era, developed by the United States Cybersecurity and Infrastructure Security Agency, aiming to educate players on cybersecurity [121]. Players have to manage resources and knights to defend a castle from cyber ninjas. The game is available on the Google Play store. Through all the gameplay though, the actual educational part is hard to recognise.

Besides virtual reality 360-degree videos and games, also comics are used to convey information security and social engineering knowledge. Kumaraguru et al. performed several studies on the use of comics to educate employees about phishing [122, 123, 124, 125, 126, 127, 128]. In one study, participants had the task to interact with an email program of a fictitious company as its employee, answering emails and interacting with the emails as they usually would do. If they clicked on a link in a phishing email, they were either provided with a notice, a text and graphics, or with a comic which explained why this is a phishing email and how they can protect themselves from phishing in the future. The results show that participants who saw the comics performed better in recognising phishing emails than the other two groups [122]. In a subsequent study, an improved version of the explaining phishing comic was designed. There were two characters in the former version: the hacker and the victim. In the new version, the character PhishGuru (looking like an Indian guru) was added, who explains how you can protect yourself from phishing. The results indicate that participants to whom the comic was immediately shown after they fell victim to phishing, were better in identifying phishing than those who got the comic emailed to after they clicked on a phishing link [123]. In another subsequent study, the PhishGuru character was exchanged with a fish as character which is still called PhishGuru. This time, the study was performed in an actual company in which employees received test spear phishing emails. An additional comic covering spear phishing was developed, which is nearly identical to the phishing comic. Employees who saw the general phishing comic performed equally well in detecting spear phishing emails as employees who received the spear phishing comic [124]. Another comic, based on the general phishing comic, was designed in later work. The new comic contains the same information; however, uses a slightly different design. Instead of a phishing email pretending to be from amazon, it is pretending to be from a bank in the new comic. Usually a 404 not found page is displayed when visiting a phishing site which had been taken down. In order to educate people who would have fallen for phishing, they are redirected to a webpage informing them that they visited a taken down malicious site. Moreover, information how they can protect themselves is provided by using parts of the new comic [125]. The new comic was adjusted slightly in design without changing content and was used in a further study. Participants stated that they consider teaching severe topics such as phishing through comics as a great idea [126].
Not only small comic strips, but also entire comic books exist which explain CS topics. Examples thereof are *How the Internet Really Works: An Illustrated Guide to Protocols, Privacy, Censorship, and Governance* [129] and *Informatik Macchiato* [3], which both use a mixture of comics and written text. Additionally, *The Imitation Game: Alan Turing Decoded* [130] narrates Alan Turing's biography and also explains fundamentals of theoretical CS e.g. how Turing machines work, solely through comics.

All of the above edutainment concepts share a common characteristic: they tell a story. Companies which investigated along with researchers how learning processes can be best documented, so that the entire company can use them, found out that stories are the most suitable form to achieve this [131, p. 11]. Storytelling is a widely used approach in edutainment as stories make important information easier to understand, support long term learning as well as thinking, and encourage intellectual participation [131, p. 11]. Also, manifold scientific research shows that people learn more efficiently and easily when storytelling is applied [112, 113, 122, 132, 133]. Moreover, storytelling can also motivate female students as underrepresented groups to pursue CS classes [132]. Due to its success, storytelling should be integrated into CS pop-ups, as also done in the CS pop-up initiative developed in this work.

3.1.3. CS Pop-Up Stages

The three stages pre pop-up, pop-up experience, and post pop-up of Warnaby's and Shi's framework, belong to the second phase (study B) in this work: development and evaluation of the CS pop-up initiative (refer to Chapter 1 and Figure 1.2 therein). In the following, these stages will be discussed in more detail along with the developed information security and social engineering pop-up initiative.

Pre Pop-Up Stage

Warnaby and Shi describe the pre pop-up stage of their framework as a stage which covers overall strategic decisions before a pop-up event takes place [34, p. 44]. In other words, the pre pop-up stage deals with the planning of how to conduct a pop-up initiative. Thereby, the planning and overall strategic decisions include "timing, location, store atmospherics, operating practicalities, and marketing communications" which will be discussed in more detail in the following, also regarding the developed information security and social engineering pop-up initiative [34, p. 44].

One of pop-up initiatives' main features is that they are temporary. Therefore, *timing* is an important factor to consider in the planning of a pop-up. Thereby, pop-ups can also take part or can even be paired with "other important social or cultural events" e.g. Christmas, in order to increase visibility or to offer seasonal products [134, 34, p. 55]. According to Warnaby's and Shi's literature research, pop-ups can have a total duration from one weekend until to a year (average duration approximately a month) [34, p. 55 – 56]. Often, when pop-ups were successful from the point of view of the operators, they become permanent stores. One example of this is *Boxpark* in London Shoreditch (see Section 3.1 and Figure 3.1), which started as pop-up shopping mall and then became permanent after a while [86]. Warnaby and Shi argue that the concept of this mall does not entirely correspond to the original concept of "the world's first pop-up shopping mall" [34, p. 56]. Moreover, they state that if a pop-up takes place for a too lengthy period, people might start questioning if the pop-up is still one. This could have negative effects

as people feel no need to go there [135, 34, p. 56] and thereby the pop-up becomes ubiquitous like a regular store. Therefore, according to Warnaby and Shi, the vendors in the *Boxpark* shopping mall change frequently, so they maintain the temporary nature of the pop-up and also create excitement [34, p. 56]. Furthermore, this motivates customers to visit the mall frequently, so they can see what has changed and is new [34, p. 56].
According to Warnaby and Shi, the *location* of the pop-up is the most important aspect for pop-up operators when planning a pop-up [34, p. 56]. Most of the pop-up operators of the researched pop-ups stated that finding a suitable location is particularly difficult even though they made use of companies which act as broker for renting stores and other sites [34, p. 56] such as Appear Here [136], We Are PopUp [137], or Go-PopUp [138]. Still, it can be particularity difficult to find and book an appropriate place were also the main target group can be reached [34, p. 57]. Moreover, having a pop-up in a central, highly frequented shopping area is very attractive, as it supports to achieve greater awareness and other goals [139, 34, p. 56]. Therefore, it can be hard to get a location for a pop-up in these areas, especially in big cities. As pop-ups are highly flexible, they are often undertaken as travelling pop-ups in order to reach a broader target group in different locations e.g. in different cities. Thereby, they aim to raise awareness about their pop-up or brand [34, p. 56]. These pop-ups are referred to as nomadic pop-ups [140] and face additional aspects in planning such as transporting and moving the pop-up as well as finding new suitable locations [34, p. 56].
Furthermore, Warnaby and Shi state that an experience-oriented and participating pop-up setting / *store atmosphere* can be a very important factor for a pop-up's success [34, p. 57]. Therefore, pop-ups should include visitors / customers actively in the pop-up experience and engage them with materials in order to encourage communication and experience with the pop-up / brand [139, 34, p. 57]. Thereby, extraordinary and unexpected interactions which are different to the normal interaction with a topic / brand can foster the pop-up experience [139, 141, 34, p. 57]. An example thereof, for a retailing pop-up store, is to show with an actual production line how the sold products are produced as undertaken by some companies [34, p. 57]. Thereby, the pop-up operators aimed for an experience including various human senses in order to increase immersion with the pop-up / brand. Also, a fitting, artistic, or extraordinary design of the pop-up space can contribute to the pop-up being perceived positively and thereby increases word-of-mouth advertisement [141, 34, p. 57].
Operating practicalities deal with the planning of trading mechanics, stock management, and staffing [34, p. 59]. As trading mechanics and stock management only apply for pop-ups which actual sell products, only the aspect of staffing will be discussed in the following. Staffing was also identified as a crucial factor in the planning of pop-ups by start-ups as well as large companies [34, p. 59]. Large companies frequently engage specialised companies which plan and conduct the pop-up event with them. While start-ups often have financial and personnel issues, they often plan and conduct the pop-up just by themselves or with the help of family and friends [34, p. 59].
In order to draw attention to planned or ongoing pop-ups and to increase the number of pop-up participants / customers, *marketing communications* is essential. Thereby, social media plays a central role in advertising the pop-up and generating excitement about it [142]. However, also word-of-mouth advertising is a strong aspect in promotion [140] and pop-up operators also still use other channels besides social media such as newspapers [34, p. 60]. Also, some pop-up operators invite bloggers and influencers to their pop-ups

in order to get advertised. Usually, a combination of different communication channels is used such as "public relations, direct marketing, print advertising, online initiatives and sponsorships" [34, p. 61].

All aspects described above were considered in the design and planning of the information security and social engineering pop-up initiative. The pop-up was conducted from May to July in 2023. As people tend to be more enterprising in summer months than in autumn or winter months, the German summer season was chosen as timing to conduct the pop-up initiative to attract and reach a wider society. This allows pop-ups not only to be placed insides but also outsides. Hence, the pop-up can be classified as nomadic pop-up with inside and outside venues (see Section 3.1). The literature shows that it is highly difficult to find pop-up places [34, p. 56], as outlined above. Also, in this work it was genuinely difficult to find participating locations, as permission are needed to perform a pop-up in public and private places. In the planning phase, requests to perform the pop-up initiative were sent to companies as well as public and private places. All in all, the pop-up was conducted at nine different locations, seven inside and two outside. The pop-ups were conducted at a German high school, two universities, a town hall, a youth club, a Pentecost market, a club house of a choral society which sells food and drinks, a public social event serving coffee and cake at a humanitarian aid organisation, and a chemical company. The pop-up lasted one day for around six hours at each participating location. Multiple days in a row at one location would have been possible but were not practical in order to reach a wider target group. At four locations the pop-up was combined with other events: Pentecost market, public event of choral society at their club house, public social event serving coffee and cake at a humanitarian aid organisation, and at the chemical company it was paired with their annual health fair for employees.
To create a suitable atmosphere for the pop-up initiative and to attract people, the following motto was chosen: wolf in sheep's clothing. The idea of the motto origins from the cover of Gray's *Practical Social Engineering - A Primer for the Ethical Hacker* book which shows a flock of sheep and a wolf in sheep's clothing [103]. A roll-up display banner saying "information security and social engineering - wolf in sheep's clothing - how to protect yourself and your data" was designed to demonstrate the pop-up's purpose, create atmosphere, and to draw attention to the pop-up (see Figure 3.6(a)). Also, a photo of a wolf in sheep's clothing and a young woman in front of binary code is displayed on the banner as eye-catchers. Moreover, a cuddly toy representing a wolf in sheep's clothing from the manufacturer Nici [143] serves as a mascot to increase the pop-up's atmosphere and to attract people's attention (refer to Figure 3.6(b)). As interacting with a topic in an unexpected way can foster the pop-up experience, edutainment (see Section 3.1.2) was planned to integrate in the CS pop-up initiative. The virtual reality information security training described in Section 3.1.2 has a great amount of edutainment. Also, not many people have virtual reality headsets at home, so it is still something special to them. Furthermore, virtual reality headsets could draw attention to pop-ups. However, drawbacks of using virtual or augmented reality applications are the need of expensive equipment, limited number of people using it simultaneously, and motion sickness. Moreover, there is an increased risk of injuries for participants as well as their surrounding area as people do not see the real world. This implies a greater number of pop-up supervisors to take care of the participants; this was financially not feasible for the CS pop-up though. Moreover, virtual reality headsets cannot be used in online trainings, as most

people do not have it at home. Hence, virtual reality is hard to realise in this study, as the online training group is essential to test the pop-up concept for CS education. Also, auditory content can be hard to understand in lively environments in which pop-ups are placed. The latter also applies for videos and games using auditory content. However, also other technical equipment such as tablets can draw attention to pop-ups. All accessible games introduced in Section 3.1.2 were evaluated and analysed for using in the CS pop-up. However, all games are either too lengthy or too specific for a certain use case such as the Texas A&M University's game for their own university. Furthermore, some games are too specific for a certain target group e.g. *Targeted Attacks* for chief information officers, *Cybersecurity Lab* for school students, or the *Cyber Awareness Challenge* for government employees. Also, some games are focusing more on entertainment while neglecting the educational aspect e.g. *Defend the Crown.* Many of the games introduced in Section 3.1.2 use comic elements. Moreover, multiple scientific studies demonstrated that Kumaraguru's et al.'s anti-phishing comic trainings were highly successful and enjoyable [122, 123, 124, 125, 126, 127, 128]. Hence, comics were chosen to convey knowledge in the CS pop-up initiative and the online training. Furthermore, comics do not need to use auditory content, which is beneficial in lively environments in which pop-ups are located. Also, comics can be used in the online training group without facing any hardware issues. As Kumaraguru's et al.'s comics were highly successful, they served as orientation for the comics especially developed and designed for the pop-up initiative [124]. Four comics were designed encompassing information on social engineering from the books *Practical Social Engineering - A Primer for the Ethical Hacker* [103] and *Meine digitale Sicherheit Tipps und Tricks für Dummies* [106]. The first comic covers an explanation of social engineering including Cialdini's six principles of persuasion (refer to Section 3.1.1), which are widely used in social engineering attacks. The remaining comics address phishing, vishing, and OSINT. Kumaraguru's et al.'s comics only cover phishing. Each pop-up initiative comic consists of four characters, each having a specific function: wolf in sheep's clothing, a white sheep, the hacker, and a victim. The wolf in sheep's clothing explains the corresponding social engineering tactic, while the white sheep gives practical tips how one can protect himself or herself against the specific attack. The speech bubbles of the wolf in sheep's clothing and the white sheep are emphasised in orange. In the actual comic strip, the hacker tries to get advantage of the potential victim using the corresponding social engineering tactic. Only in the first comic, in which the hacker explains Cialdini's six principles of persuasion, a victim character is not included. Analogously to Kumaraguru's et al.'s comics, a hacker and a victim are characters in the developed comics. The fish from PhishGuru comics can be compared to the white sheep considering its function in the comics. The additional character wolf in sheep's clothing was chosen to explain the social engineering tactic in general, as a similar character in the PhishGuru comics and therefore a general explanation of phishing is missing. Furthermore, the character wolf in sheep's clothing and the white sheep fit well into the pop-up initiative's motto and foster atmosphere. The developed comics for the pop-up initiative can be seen in Appendix B.1 and B.2 in German and English, respectively. All images used for designing the comics are released under the creative commons license and were taken from Pixabay [144] and Canva [145]. The comics are displayed on tablets at the pop-up initiative, creating digital engagement.

(a) Roll-up display banner (b) Mascot – wolf in sheep's clothing

Figure 3.6.: Themed eye-catchers

As the pop-up is nomadic, it has to be easily transportable. Hence, a foldable high table was used to provide space for two tablets, the wolf in sheep's clothing mascot, and give-aways, as seen in Figure 3.7. The tablets are placed in mounts and secured to the table with an anti-theft system. Also, the roll-up display banner can be folded and comfortably transported in a carrier bag. The pop-up initiative was staffed with two people. A second person was needed to help transporting the pop-up equipment and acquiring participants on-site.

Figure 3.7.: Photo of conducted CS pop-up

To create awareness of the pop-up and to increase the number of possible participants, a newspaper article about the pop-up originally included information on dates and locations where the pop-ups will take place. However, the newspaper article was published too late, so the information on further pop-ups were removed and could not be used as marketing communications and for drawing attention to the ongoing pop-ups. Nevertheless, a participating university announced the pop-up initiative to all students and employees via email multiple times. Additionally, they displayed an announcing slide of the pop-up on information screens in their buildings multiple days before the pop-up took place and at the day it was conducted, as seen in Figure 3.8. The chemical company also informed and encouraged their employees via email to participate in the pop-up.

Figure 3.8.: Announcement of CS pop-up initiative on an information monitor at a participating university

Pop-Up Experience Stage

The pop-up experience stage of Warnaby's and Shi's framework, is the stage in which the pop-up is actually conducted and where the main interaction with pop-up participants / customers takes place [34, p. 63]. While conducting the pop-up, the aspects of "social environment, digital engagement, store atmospherics, product assortment, and promotion" should be considered which will be discussed in more detail in the following, also with respect to the developed information security and social engineering pop-up initiative [34, p. 63]. Store atmospherics is an important factor to consider for pop-up stores which actually sell products. However, for the information security and social engineering pop-up initiative, store atmospherics is negligible and therefore will not be discussed in the following.

Regarding *social environment*, Warnaby and Shi state that the pop-up literature highlights the importance of "customer-brand interactions" in order to broaden and evolve the "brand and its values" [139, 34, p. 63]. Furthermore, it is crucial to build a pop-up experience in which pop-up participants are able to interact in a social and interactive way [139, 34, p. 63]. A higher degree of interactivity can lead to greater enjoyment and a more positive image of the pop-up [146, 34, p. 36]. Therefore, pop-ups should not merely provide products or experiences; however, pop-ups should provide a setting and tools with which pop-up participants can achieve and design their own customised experience [147, 148, 34, p. 64]. Also, values cannot be merely communicated but are developed together by pop-up participants while actively interacting and participating [149, 34, p. 64]. Thereby, pop-up participants are more likely to be emotionally engaged as they produce the experience along with the pop-up operator [147, 34, p. 64]. An example of pop-up participants co-creating their own experience is Porterlight's bicycles pop-up in which customers could build their own custom bicycle by means of a digital

tool [150, 34, p. 64]. Also, being involved in creating the experience can possibly please pop-up participants' "hedonistic and utilitarian values" [151, 34, p. 64].
An example of *digital engagement* during pop-up initiatives is the above mentioned digital bicycle builder. Such interactive technology-based tools are important instruments in engaging pop-up participants and including them in creating the pop-up experience [34, p. 65]. Additionally, digital interactive tools enable pop-up participants to post and share stories on social media and thereby promote the pop-up [152, 34, p. 65]. Furthermore, other research detected that using new technologies correlates positively with customers' / participants' satisfaction, loyalty, and behavioural intentions [153, 34, p. 65]. Also, using technologies can enhance customers' / participants' experience by offering information and entertainment [154, 34, p. 65].
Especially for pop-up stores which sell products, the aspect of *product assortment* is an essential part. Thereby, companies often sell new, limited or special product editions and hand out giveaways [34, p. 66 – 67]. However, also for pop-ups which do not sell products, product assortment is still important, especially handing out giveaways. Giveaways act as a reminder of the experience even after it is finished. Moreover, giveaways can bring the experience into daily life and enlarge the experience after the pop-up event [155, 34, p. 67]. Furthermore, products or giveaways especially designed for the pop-up event can create a feeling of "novelty, exclusivity and community" [135, 34, p. 67].
Handing out giveaways can also be considered as part of *promotion* [34, p. 67]. Moreover, social media plays a crucial role in promoting pop-ups, as it is a mighty tool to build relationships instantaneously and efficiently [156, 34, p. 67]. Thereby, social media can support to administrate and increase pop-up participants' experience and engagement [157, 34, p. 67]. Advertisement for the pop-up or posts of people who already participated at the pop-up can be easily reposted and shared via social media, which supports to manage the pop-up on a daily basis [34, p. 68].

A social environment is given by the pop-up operator in the information security and social engineering pop-up. The pop-up operator gives a brief instruction to participants how to interact with the pop-up, tablets, and the comics. Furthermore, the giveaways (discussed in more detail in the next paragraph) are briefly explained and handed out to the participants after participation. During interacting with the comics and tablets, participants could interact with the pop-up operator if they had questions. Being directly involved in the pop-up experience can please participants' hedonistic values, as outlined above. This goes hand in hand with the measurement of user experience by means of the UEQ-S questionnaire (refer to Section 3.2.3), as it also measures hedonic quality. Through the tablets a digital interaction is provided to participants, which can foster their pop-up experience and satisfaction. Moreover, tablets were included as the results of a roadshow study show that an interactive part on a computer was the most favoured one [32] as earlier described in Chapter 1. By the use of edutainment through comics, participants are entertained and offered information on information security and social engineering. A participant being engaged in the digital interaction can be seen in Figure 3.9.

Figure 3.9.: Photo of participant taking part in the pop-up

All in all, the information security and social engineering pop-up offers four different giveaways which can be seen in Figure 3.10. A sticker saying think before you click with a hacker seen on it was especially designed for the pop-up initiative (see Figure 3.10(a)). The sticker can be placed beside or stuck on a computer device to be reminded of being careful whether to click on certain links. A brochure on using the internet securely of the German Federal Office for Information Security (BSI) [158] was provided as giveaway for participants (see Figure 3.10(c)). Furthermore, a password card [159], developed by Deutschland sicher im Netz (DsiN), for creating secure passwords were given to participants. DsiN is a non-profit organisation which offers advice on information technology security to users and companies [160]. The organisation is sponsored by Germany's Federal Ministry of the Interior and Community. The password card's front side shows a grid with letters, numbers, and special characters. The grid is surrounded by a coordinate system of the complete alphabet and the numbers 1 to 12, as seen in Figure 3.10(d). By choosing an entry and end point as well as a path between the points, which includes at least 8 fields, a secure password can be created. To reconstruct the password by means of the card, the points and path must be remembered. On the back side additional information regarding the password card is provided (see Figure 3.10(e)). Also, gummy candy (refer to Figure 3.10(b)) was handed out. On the one hand, the giveaways act as motivation for people to participate in the CS pop-up and also as a reward for doing so. On the other hand, the giveaways remind participants of the pop-up and foster people's engagement with information security and social engineering beyond the pop-up participation. Hence, participants can create secure passwords by means of the password card, read further information in the brochure, and are reminded to be careful through the sticker.

(a) Sticker – think before you click! (b) Gummy candy (c) BSI brochure – using the internet safely

(d) Password card – front side (e) Password card – back side

Figure 3.10.: Giveaways

Post Pop-Up Stage

Warnaby's and Shi's post pop-up stage deals with the aspects pop-up operators have to take care of after the pop-up took place. This involves: "packing up and moving on, measuring and evaluating success, and maintaining momentum" [34, p. 69]. As packing up and moving on as well as maintaining momentum is negligible for pop-ups which do not sell actual products, merely the aspect of measuring and evaluating success will be discussed in the following, also with respect to the developed information security and social engineering pop-up initiative.

For *measuring and evaluating success* of pop-ups, various measures can be applied which depend on the pop-ups' initial objectives (refer to Section 2.1) [34, p. 70]. Possible approaches for measuring the success of pop-ups which sell products are return on investment, company's website traffic, and how many people visited the pop-up. For pop-ups which aim to test new markets, gathering customer insight, and engaging customers, success can be measured and evaluated through surveys or interviews during the pop-up initiative.
As the aim of the information security pop-up initiative is to answer the general research question (refer to Chapter 1) which correspond to testing new markets, gathering customer insight, and engaging customers, a survey was chosen for measuring and evaluating the success of the pop-up initiative. The survey, which participants filled in during taking part in the social engineering pop-up initiative, consist of three different parts. One part consists of the short version of the user experience questionnaire (UEQ-S) [37] which measures participants' experience and thereby corresponds to *a)* in the general research question (refer to Chapter 1). Another part measures participants' acceptance based on the technology acceptance model (TAM) [38] which corresponds to *b)* in the general research question. Additionally, one part measures participants' knowledge transfer based on Bloom's taxonomy [39] which corresponds to *c)* in the general research question. The used questionnaires as well as the terms experience, acceptance, and knowledge transfer will be discussed in more detail in Section 3.2.3. As the pop-up initiative should appeal to whole society, also participants' gender, background in STEM, and generation will be considered as in study A (refer to Chapter 2). In order to aid to evaluate the information security and social engineering pop-up initiative as well as to examine the general research question (refer to Chapter 1), the following research questions were established for study B:

RQ B1: How did society (in free time and working time settings) experience the pop-up initiative and the online training as operationalised by the UEQ-S?

RQ B2: Would society (in free time and working time settings) accept the pop-up initiative and the online training for educating themselves based on the TAM?

RQ B3: To which degree could CS knowledge be conveyed to society (in free time and working time settings) through the pop-up initiative and the online training regarding Bloom's taxonomy?

3.2. Methods Study B

In the following, the experimental design, approach, used data sources, and data collection of the information security and social engineering pop-up initiative as well as online training will be described.

3.2.1. Experimental Design

This study used a between-subject design combined with a within-subject design. There were two independent variables: temporal participation in the educational initiative (with two levels: free time, working time) and the type of educational initiative (with two levels: online training, pop-up). The dependent variables are: experience, acceptance, and knowledge transfer. Experience is defined through the short version of the user experience questionnaire (UEQ-S), acceptance through a custom questionnaire based on the technology acceptance model (TAM), and knowledge transfer through a pre- and post-quiz based on Bloom's taxonomy. Furthermore, participants' generation, gender, and background in STEM were captured as in study A (see Section 2.2.1).

3.2.2. Participants

A total of 295 participants took part in the study. Thereby, 163 participated in the pop-up initiative (57 in their free time and 106 during their working time), while 132 participated in the online training (93 in their free time and 39 during their working time). Participants (132 female, 152 male, 6 identified as other, and 5 did not specify their gender) were aged 12 to 83 (M = 37.06, SD = 16.92). Moreover, 142 (46 female, 93 male, 1 who identified as other, and 2 who did not specify their gender) of all participants had a background in STEM. Overall, 44 participants belong to the Baby Boomers, 64 to Generation X, 112 to the Millennials, and 75 to Generation Z.
Before participants took part in the study, they were informed in written form that their data will be analysed in order to evaluate new education initiatives. Participation took part on a voluntary basis without receiving any financial compensation.

In the online training, 44 females, 47 males, and 2 who did not specify their gender participated in their free time. The participants were between 14 and 78 years old (M = 36.7, SD = 15.72) and 52 of them had a background in STEM. Furthermore, 11 participants belong to the Baby Boomers, 17 to Generation X, 53 to the Millennials, and 12 to Generation Z.
On the other hand, 18 females, 19 males, one who identified as other, and one who did not specify his or her gender participated in the online training during their working time. The participants were between 20 and 63 years old (M = 39.08, SD = 12.11) and 21 of them had a background in STEM. Moreover, 5 participants belong to the Baby Boomers, 11 to Generation X, 21 to the Millennials, and 2 to Generation Z.
In the pop-up initiative, 19 females, 35 males, and 3 who identified as other took part in their free time. The participants were between 12 and 83 years old (M = 44.53, SD = 21.53) and 15 of them had a background in STEM. Furthermore, 17 belong to the Baby Boomers, 10 to Generation X, 13 to the Millennials, and 17 to Generation Z.
On the other hand, 51 females, 51 males, 2 who identified as other, and 2 who did not specify their gender took part in the pop-up initiative during their working time. The participants were between 15 and 69 years old (M = 32.62, SD = 15.28) and 54 of them had a background in STEM. Moreover, 11 belong to the Baby Boomers, 26 to Generation X, 25 to the Millennials, and 44 to Generation Z.

3.2.3. Apparatus

In order to evaluate the pop-up initiative as well as to answer the general research question and the research questions of study B, participants filled in quantitative questionnaires. As already outlined at the end of Section 3.1.3, the study's questionnaires consists of three parts measuring experience, acceptance, and knowledge transfer. Experience is measured through the short version of the user experience questionnaire (UEQ-S), acceptance through a custom questionnaire based on the technology acceptance model (TAM), and knowledge transfer through a custom pre- and post-knowledge questionnaire based on Bloom's taxonomy. The UEQ-S and the acceptance questionnaire use a 7-point rating scale, scaled from -3 to 3, where -3 means strongly disagree and 3 fully agree. In the knowledge questionnaires, points are assigned for correct answers. A minimum of 0.0 and a maximum of 7.5 points can be achieved in each knowledge quiz. The three terms experience, acceptance, and knowledge transfer as well as their corresponding questionnaires and models they are based on, will be discussed in the following. Finally, in the last paragraph of each following subsection, the specifications of this work's questionnaires will be described.

Short Version of the User Experience Questionnaire (UEQ-S)

The International Organization for Standardization (ISO) defines user experience (UX) as a "person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service" [161]. Even though there seem to be different definitions of UX among UX experts [162], a study on describing the term UX shows that most UX experts correspond with the ISO definition [163].
A standardised measurement for UX, is the user experience questionnaire (UEQ) which consist of 26 items and 5 scales [164, 165, 166]. However, the UEQ is not applicable in all cases due to its length. Therefore, a short version of the UEQ, called UEQ-S, was developed [37]. The short version is recommended to apply when using the full UEQ would decrease the number of participants who are willing to fill in the questionnaire drastically [37]. Another reason for applying the short version is to decrease the length of a questionnaire when also other data besides UX is captured and multiple different questionnaires are applied [37]. As also acceptance and knowledge transfer are captured in this work, applying the full UEQ would make the survey too lengthy and participants might cancel the survey before finishing it. Therefore, the UEQ-S was used in this work. The UEQ and the UEQ-S as well as all needed information to apply the questionnaires are available complimentary on the questionnaires' website [165] and in the handbook [166].
The UEQ-S consists of eight items and measures UX on two scales: pragmatic and hedonic quality. Thereby, pragmatic quality represents aspects which "relate to the tasks or goals the user aims to reach when using the product" [37]. Hedonic quality represents aspects which "do not relate to tasks and goals, but describe aspects related to pleasure or fun while using the product" [37]. Each scale consists of four items. Furthermore, the mean value over all eight items represents the "overall UX value" [37]. The UEQ-S uses a 7-point rating scale. Each of the eight items has a negative term on the left side and a positive term on the right side of the rating scale. Thereby, the items "are scaled from -3

(fully agree with negative term) to 3 (fully agree with positive term)" [37]. The UEQ-S can be seen in Appendix B.3. The first four items belong to the pragmatic quality scale and the last four items to the hedonic quality scale. The German version of the UEQ-S was applied in this work. However, the German word "behindernd" was adjusted to "hinderlich", "unterstützend" to "hilfreich", and "übersichtlich" to "verständlich" as these words fitted better to measuring UX in the pop-up initiative and the online training. The adjusted words are synonyms and if they would be translated from German to English they would be the same words as in the English version of the UEQ-S.

Acceptance Questionnaire Based on the Technology Acceptance Model (TAM)

The American Psychological Association (APA) defines acceptance as "a favorable attitude toward an idea, situation, person, or group" [167]. Acceptance of information systems is frequently described through the technology acceptance model (TAM) which was developed by Davis in 1985 [38]. The model is based on Fishbein's and Ajzen's Theory of Reasoned Action [168, 169, 38, p. 15].
TAM models a social system and aims to map users' acceptance regarding a new technology [170, p. 235]. Acceptance is defined as the actual use of the technology (actual system use) in TAM. The actual system use in turn is determined through the behavioural intention to use the system, as seen in Figure 3.11. Furthermore, the behavioural intention to use the system is influenced by the perceived usefulness and the attitude toward using the system. The attitude toward using the system is influenced by the perceived usefulness and perceived ease of use. Perceived usefulness in turn is influenced by the perceived ease of use and external variables, whereas perceived ease of use is only influenced by external variables. The external variables were not specified in the original version of the TAM but later operationalised in an expansion of the model called TAM 2 [170, p. 237 – 238]. According to Davis, users are more willing to use the system the greater the perceived usefulness and perceived ease of use is [171, 170, p. 237]. Thereby, Davis defines perceived usefulness as "the degree to which an individual believes that using a particular system would enhance his or her job performance" [38, p. 26] and perceived ease of use as "the degree to which an individual believes that using a particular system would be free of physical and mental effort" [38, p. 26].

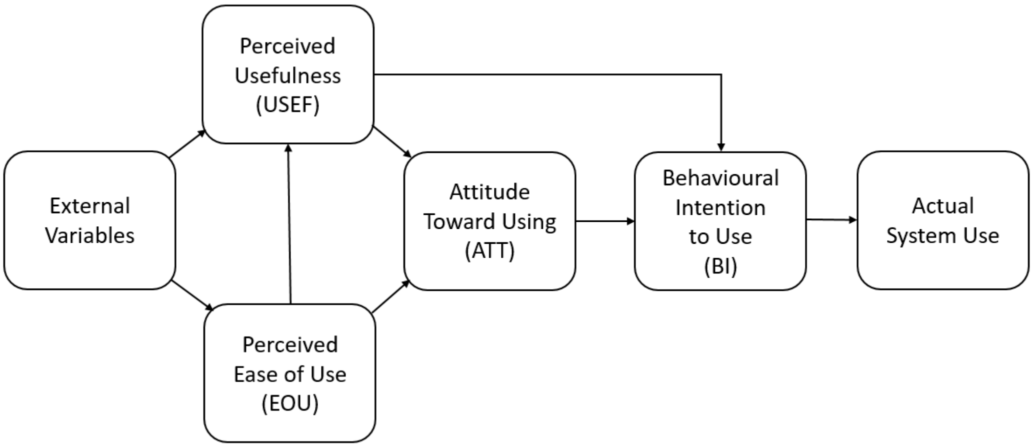

Figure 3.11.: TAM model according to Davis [38]

TAM is empirically well confirmed [170, p. 235], widely used, and expanded as the literature reviews of Venkatesh et al. [172] and Marangunić et al. [173] demonstrate. However, TAM is also criticised that the chosen influence factors are not sufficient for mapping the complexity of acceptance [170, p. 237]. Therefore, TAM was expanded to TAM 2, TAM 3, and the Unified Theory of Acceptance and Use of Technology (UTAUT). In TAM 2, the external variables (refer to Figure 3.11) were operationalised with five factors [170, p. 237 – 238]. In TAM 3, the focus from general acceptance moves to how acceptance can be achieved; therefore, six additional factors were included into TAM 2 [170, p. 238 – 239]. UTAUT redefines perceived usefulness to performance expectancy, perceived ease of use to effort expectancy and adds social influence as well as facilitating conditions as factors [174]. As TAM 2, TAM 3, and UTAUT consider additional influence factors of acceptance, the models become more complex. Thereby, the expanded models exceed the demand of describing and measuring acceptance for the CS pop-up initiative. Furthermore, a more complex model needs more scales and items, implying a longer questionnaire, which might overload participants (refer to UEQ-S above). Hence, the original version of TAM build the basis for measuring the CS pop-up initiative and online training participants' acceptance.

Based on TAM, a custom acceptance questionnaire, which can be seen in Appendix B.4, was developed. The custom questionnaire measures acceptance on four scales: perceived ease of use, perceived usefulness, attitude toward using, and behavioural intention to use. The scales are defined as follows:

Perceived Usefulness (USEF) The degree to which a person believes that CS knowledge (information security knowledge) conveyed through pop-up education / online trainings in their working time / free time is enhancing their CS knowledge (information security knowledge).

Perceived Ease of Use (EOU) The degree to which a person believes that CS knowledge (information security knowledge) conveyed through pop-up education / online trainings in their working time / free time is free of effort.

Attitude Toward Using (ATT) Positive or negative attitudes toward using pop-up education / online trainings for learning about CS in their working time / free time.

Behavioural Intention to Use (BI) The intention to actually use pop-up education / online trainings for learning about CS in their working time / free time again.

Each scale consists of three items. A 7-point rating scale is used for participants to specify how strongly they agree with the items. Thereby, the items are also scaled from -3 to 3, where -3 means fully disagree and 3 fully agree. This scaling was chosen according to the scaling of the UEQ-S (see section above), to keep the scales between the questionnaires in this study equal. Moreover, the mean value over all scales represents the overall acceptance value. These categories with related definitions were also applied in the Almere Model, which evaluates elderly people's acceptance of social robots [174]. Moreover, the custom TAM questionnaires the Almere Model [174] as well as Shroff et al. [175] and Abu-Dalbouh [176] used in their studies, served as orientation for the custom TAM questionnaire in this work.

Knowledge Transfer Questionnaires Based on Bloom's Taxonomy

According to Liyanage et al., most computer science literature explains knowledge by differentiating "among data, information, and knowledge" [177]. Thereby, Davenport's and Prusak's definition is inter alia described [177, 178, 179, p. 2 – 6]. Data are raw values consisting of numbers and letters which are received from different sources. Information is built through processing raw data in order to create context and assign meaning to the data. Finally, knowledge is interpreted information applied for making decisions or solving problems.
Knowledge transfer is defined as a process were knowledge "is transferred from a source to a user" [178]. In this process, the existing knowledge at the source is coded by a cognitive system, e.g. an author codes this knowledge in form of a textbook, and thereby transfers the knowledge into an object (refer to Figure 3.12). This object is then interpreted by another cognitive system, e.g. a textbook reader, and the knowledge reaches the user. However, this process of transferring knowledge can fail in the codification or interpretation part as both parts are usually carried out by different cognitive systems [178]. Hence, the targeted knowledge cannot be transferred as planned then.

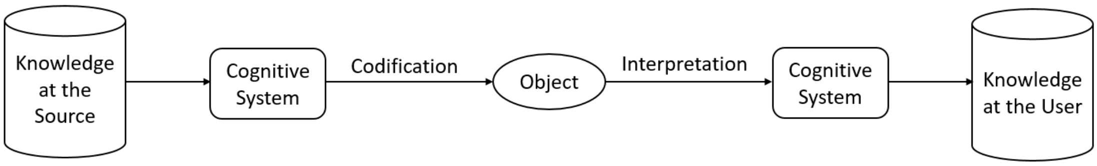

Figure 3.12.: Illustration of knowledge transfer according to Garavelli et al. [178]

In this work, knowledge transfer is measured by a pre- and post-knowledge questionnaire based on Bloom's taxonomy, before and after taking part in the CS pop-up initiative or online training, respectively. Bloom's taxonomy is a scheme for classifying "educational objectives" [39, p. 1]. It was developed by Bloom et al. in 1956 [39]. The taxonomy aims to provide a common ground for educators and researchers to define the knowledge their students should learn (e.g. in a university class) and also be capable of after the learning experience [39, p. 1]. Furthermore, the taxonomy can also be used to design course materials and to measure to which degree the learning objectives were reached. Bloom's taxonomy is divided into six categories: remember, understand, apply, analyse, evaluate, and create [180]. The definition of each category and examples of words which can be used to describe and measure the specific category of learning objectives are illustrated in Figure 3.13. The categories or levels of the learning objectives are ordered hierarchically "from simple to complex and from concrete to abstract" [181]. This means that in order to proceed from one simpler (e.g. remember) to the next more complex (e.g. understand) level, the previous simpler level (e.g. remember) needs to be mastered [181].

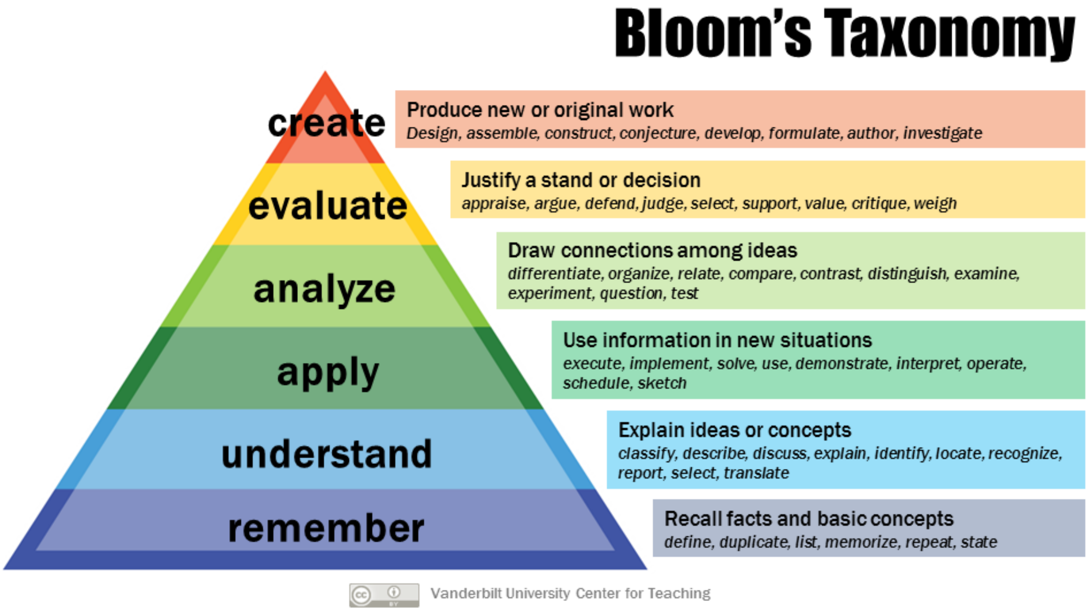

Figure 3.13.: Blooms' taxonomy [180]

Since its development, Bloom's taxonomy has been often applied by educators [180] to write learning objectives for course syllabi or to create assignments and learning resources, for instance. Also, researchers apply Bloom's taxonomy such as Selby who examined the relationship among computational thinking, programming pedagogy, and Bloom's taxonomy; thereby, she developed a computational thinking taxonomy [182]. Moreover, Bloom's taxonomy is also often used to evaluate classes and students' exam performance as Pikhart and Klimova did in their blended learning intercultural business communication class [183] as well as Wei Li et al. in their medical classes [184].
In 2002, Bloom's taxonomy was revised by Krathwohl who is also a co-author of the original taxonomy [181]. Krathwohl added an additional dimension called "the knowledge dimension" which is divided into four categories: factual knowledge, conceptual knowledge, procedural knowledge, and metacognitive knowledge [181]. Along with the original Bloom's taxonomy, which Krathwohl defines as "the cognitive process dimension",

the new knowledge dimension forms a matrix [181]. As the additional dimensions would make the measurement of knowledge transfer too complex and the questionnaire too lengthy (refer to UEQ-S and TAM above), the original version of Bloom's taxonomy was applied in this work.
Based on Bloom's taxonomy, a custom pre- and post-knowledge questionnaire, which can be seen in Appendix B.5, was developed for the CS pop-up initiative and the online training. The custom questionnaires measures participants' knowledge on the first three scales of Bloom's taxonomy: remember, understand, and apply. Each scale consists of three items. Four possible answer options are provided per question for the remember and understand scale, while the apply scale has two possible answer options. Only one option per question is true. The multiple-choice questions were designed based on Carneson et al.'s and University College Dublin's guidelines [185, 186]. For each right answer given, one point is assigned, except on the apply scale 0.5 points are given, as there are two answer options. Wrong answers are assigned with zero points for the corresponding question. A minimum of 0.0 and a total of 7.5 points can be achieved per knowledge questionnaire. The mean value over all scales represents the overall knowledge value per questionnaire. The order of the questions was not randomised in the pre- and post-questionnaire, to maintain the order of Bloom's taxonomy in which all previous stages have to be mastered to proceed to the next stage.

3.2.4. Procedure

The information security and social engineering pop-up was conducted from May to July in 2023 at nine different locations. The following locations gave permissions to perform the pop-up on their premises: a German high school, two universities, a town hall, a youth club, a Pentecost market, a club house of a choral society which sells food and drinks, a public social event serving coffee and cake at a humanitarian aid organisation, and a chemical company. The pop-up lasted one day for around six hours at each location. Participants came to the pop-up on their own accord or after being approached by the pop-up operator. Each participant was given a brief introduction of the pop-up's purpose to educate about information security through comics on the tablets. Furthermore, they were informed that they will take part in a study including filling in questionnaires. Also, the giveaways were introduced to them before they started learning on information security and social engineering at the tablets. First of all, participants filled in the pre-knowledge questionnaire. Afterwards, the learning through the four comics started. The comics are followed by the UEQ-S, the custom TAM questionnaire, the post-knowledge questionnaire, and a brief demographics questionnaire including how they found out about the pop-up or online training, respectively. After successful participation, participants could choose which giveaways they would like to take. They could take all four if they liked.
The online training took place from July to September in 2023. The link to the online training was sent along with a description to a company and two universities which were willing to forward the online training to their employees and students, encouraging them to participate. Moreover, the online training was advertised on social media (LinkedIn, Facebook, Instagram, see Figure C.2 in Appendix C). The order of the questionnaires and

comics in the online training is exactly as in the pop-up.
The online survey tool LimeSurvey was used in the pop-up as well as in the online training to display the questionnaires and comics. Before participants took part, they electronically signed an informed consent including voluntariness and data privacy. Furthermore, they were informed that their data will be analysed in order to evaluate new education initiatives. In the online training it is not apparent if participants take part in their free time or working time. Also, locations can be working places and places where people are in their free time simultaneously e.g. a university, a town hall, or a youth club. Therefore, participants were asked after the UEQ-S if they participate in their free time or working time, to assign them to the specific groups.
On average, participants took 14.78 minutes (SD = 5.75) to take part in the CS pop-up initiative in their free time and 12.61 minutes (SD = 4.40) in their working time. In the online training, participants needed 16.92 minutes (SD = 9.98) to complete it in their free time and 13.78 minutes (SD = 6.48) in their working time. All time specifications include taking part in the CS pop-up initiative or online training and filling in the questionnaires, respectively.

3.3. Results and Analysis Study B

In the following, the study's results will be presented grouped by the corresponding research questions. Just complete datasets were used for data analysis. Responses from people who started and then cancelled before the questionnaire ended were not considered. Seven datasets were excluded from the complete analysis: one participant always selected the first answer option, three datasets were conspicuous and it seemed participants misunderstood the questions in the post-knowledge questionnaire, and three participants completed the study in an unrealistic amount of time (5 minutes or less). A total of N = 295 complete datasets were analysed. No missing data is present within the datasets. Multiple linear and multilevel regressions have manifold advantages over analyses of variance (ANOVAs), particularly greater statistical power, as outlined by Hilbert et al. [187]. Therefore, multiple linear and multilevel regression models were chosen for analysing the data. The assumptions of normality and independence of residuals, homoscedasticity, multicollinearity, and outliers and influential cases were checked for all multiple regression models. Regarding the multilevel regression models, normality of residuals, homoscedasticity, and outliers were checked on both levels. The significance level was set to $p < .05$ in all models. No alpha adjustment was applied as suggested by Sinclair et al. in order to not miss out on possibly valuable insights [188].

Table 3.1 shows how participants found out about the pop-up initiative or the online training, respectively. Answer options are: incidental, work, through other people (family / friends / colleagues), and media. One or more answer options could be ticked by participants. In general, people became aware of the online training through family / friends / colleagues the most, followed by work. Regarding the pop-up, most people became aware of it incidentally, followed by work as second most, and through family / friends / colleagues third most.

Most participants came to know about the online training through family / friends / colleagues in their free time, followed by work. In their working time, most participants found out about the online training through work and second most through family / friends / colleagues. Very few or even not at all, came participants to know about the online training incidentally or through media. With respect to the pop-up, most participants incidentally found out about the pop-up in their free time followed by family / friends / colleagues. Very few came to know about the pop-up through work or media in their free time. In their working time, participants found out about the pop-up through work the most and second most incidentally. Also, almost no one found out through family / friends / colleagues and media about the pop-up in their working time.
While nearly nobody found out about the online training incidentally, most pop-up participants did so. No greater differences can be seen between free time and working time regarding finding out about the online training incidentally. This also applies to finding out about the pop-up incidentally. Regarding coming to know through work, more people in the online training found out about it in their free time compared to pop-up participants in their free time. While in the online training people nearly equally found out about it through work in their free time and working time, in the pop-up a greater difference can be detected between finding out in participants' free time and working time. Most participants became aware of the online training in their free time through family / friends / colleague, whereas substantially less participants in the pop-up became aware of it in their free time. Across all conditions, just one or even no one stated to have found out about the online training or pop-up through media, respectively.

Table 3.1.: Frequencies how participants found out about the online training / pop-up

	online training		pop-up	
	free time	working time	free time	working time
incidental	0	2	32	40
work	21	20	3	67
family / friends / colleagues	74	16	23	3
media	0	1	1	0

3.3.1. User Experience (RQ B1)

The general overall UEQ-S score lies in the upper part of the rating scale (M = 1.56, SD = 1.07, Cronbach's α = 0.89). Also, participants' overall UEQ-S score of the online training free time (M = 1.77, SD = 0.93), online training working time (M = 1.40, SD = 1.26), pop-up free time (M = 1.64, SD = 1.05), and pop-up working time condition (M = 1.39, SD = 1.11) are located in the upper part (above zero). As seen in Figure 3.14, participants who take part in their free time score slightly higher in the online training and in the pop-up, compared to their counterparts who participated in their working time. Comparing experience across the online training and the pop-up regarding free time, it seems to be similarly distributed. The same applies to working time. A minority of participants scored in the lower part of the rating scale (below zero), as seen in Figure 3.14.

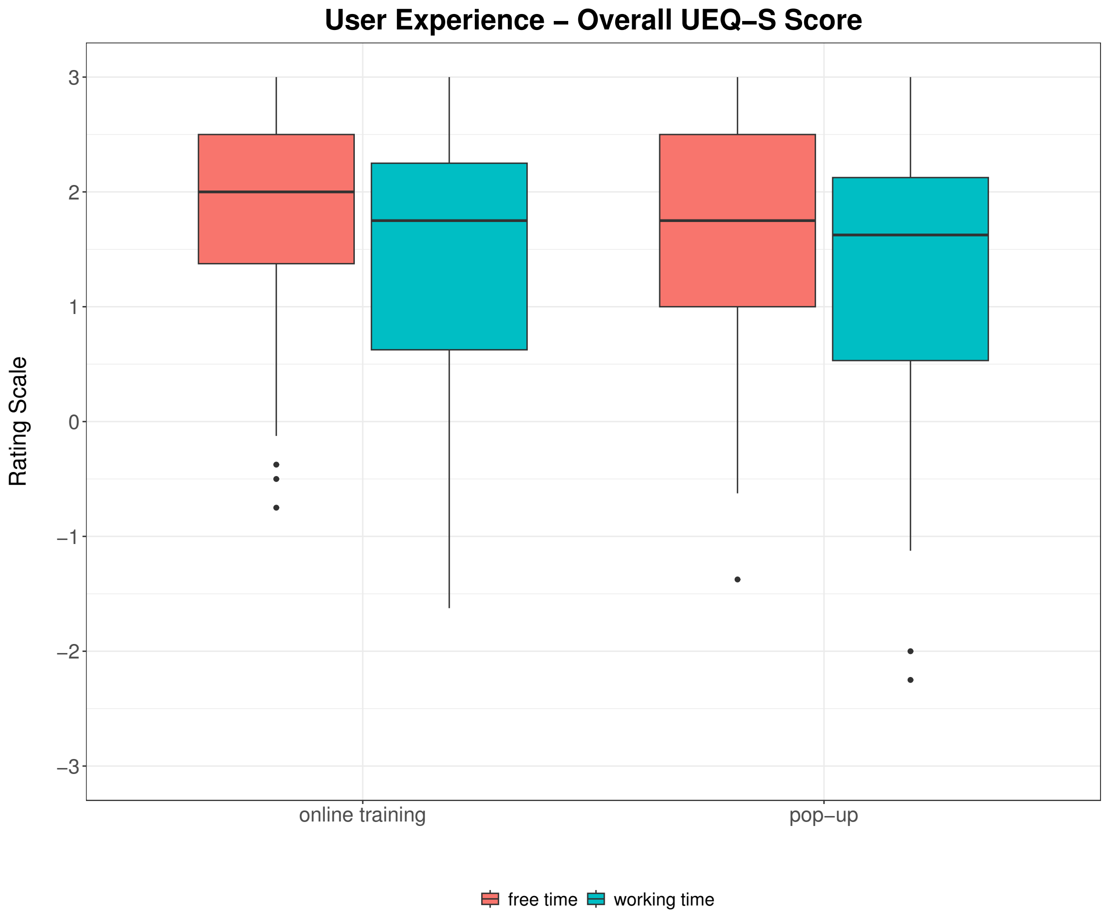

Figure 3.14.: Boxplot: Overall UEQ-S score The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

Figure 3.15 shows the UEQ-S subscales: pragmatic quality (in general: $M = 1.72$, $SD = 1.13$, Cronbach's $\alpha = .82$) and hedonic quality (in general: $M = 1.40$, $SD = 1.20$, Cronbach's $\alpha = .86$). Analogously to the overall UEQ-S score, also the subscale scores are located in the upper part. Regarding pragmatic quality, the online training group scores higher in their free time ($M = 1.99$, $SD = 0.99$) and working time ($M = 1.66$, $SD = 1.32$), compared to the pop-up group (free time: $M = 1.67$, $SD = 1.11$, working time: $M = 1.52$, $SD = 1.16$). While hedonic quality is similarly distributed in the online training free time ($M = 1.55$, $SD = 1.15$) and pop-up free time condition ($M = 1.61$, $SD = 1.15$), the working condition shows some differences. The pop-up participants experience a higher hedonic quality in their working time ($M = 1.26$, $SD = 1.18$) than their online training ($M = 1.14$, $SD = 1.38$) counterparts, as seen in Figure 3.15.

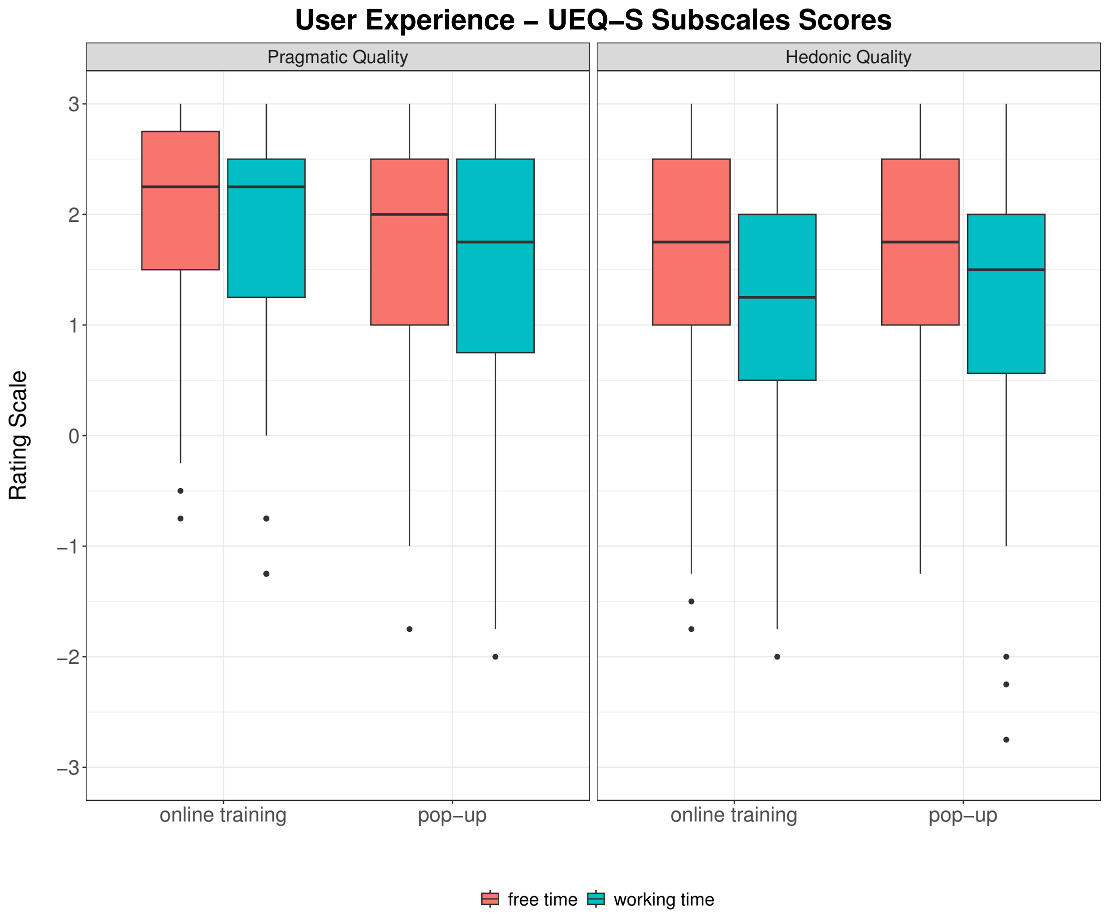

Figure 3.15.: Boxplot: UEQ-S subscales scores The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

To answer RQ B1, how society experienced the pop-up initiative and the online training in free time and working time settings, a hierarchical linear regression analysis predicting the overall UEQ-S score was calculated with the following independent variables: type of educational initiative (levels: online training, pop-up), temporal participation (levels: free time, working time), gender (levels: female, male, other, no answer), generation (levels: Baby Boomers, Generation X, Millennials, Generation Z), and background in STEM (levels: no background in STEM, background in STEM). Table 3.2 shows the results along with the variables' dummy coding of the hierarchical linear regression analysis predicting the overall UEQ-S score. Assumptions were checked for all model steps. All assumptions were met (refer to Section 3.3); except checks for normality of residuals indicated non-normality. Therefore, bootstrapping was applied for performing robust regression. The robust regression model leads to exactly the same results as the non-robust regression regarding two decimal places. Moreover, the confidence intervals of the robust and non-robust model only differ marginally, which indicates that there are no issues of non-normality [189, p. 301]. Hence, multiple linear models without bootstrapping are used for investigating user experience.

Step 1 ($BIC = 893.163$) predicts the overall UEQ-S score based on the type of educational training variable (called pop-up in the model) and the temporal participation variable (called temporal in the model). Participants who take part in one of the educational initiatives in their working time exhibit a lower experience than those who take part in their free time ($B(1) = -0.300$, $p < .05$). However, there is no significant difference in experience whether participants take part in the pop-up or in the online training. Step 1 explains 2.44% of the experience variable's variance ($F(2,292) = 3.646$, $p < .05$, $R^2 = .0244$).
In Step 2 ($BIC = 905.459$), participants' demographic variables were included as predictors: gender, background in STEM, and generation. Despite small differences, the pop-up and temporal predictor of step 1 are similar in step 2. An additional significant predictor in step 2 is gender. Men exhibit a lower experience than women ($B(3) = -0.473$, $p < .001$). Also, participants who specified their gender as other have a lower experience than women ($B(3) = -1.524$, $p < .001$). There are no significant differences regarding the other demographic predictors. Step 2 explains 11.12% of the criterion's variance ($F(9,285) = 3.964$, $p < .001$, $R^2 = .1112$). Thereby, step 2 significantly improved step 1 ($F(7,285) = 3.980$, $p < .001$, $\Delta R^2 = .0868$).
Additionally, a third step, which takes interactions between the pop-up variable and the demographic variables, the temporal variable and the demographic variables, and the pop-up and temporal variable into account, was calculated. Only the interaction between the temporal and STEM variable is significant ($B(1) = 0.818$, $SEB = 0.292$, $\beta = 0.762$ $p < .01$). Participants who take part in their working time and have a background in STEM have a higher user experience than their counterparts. Step 3, including all interactions, did not significantly improve step 2 ($F(15,270) = 1.158$, $p = .305$, $\Delta R^2 = .0538$). However, adding only the significant interaction to step 2, the model significantly improved ($F(1,284) = 7.591$, $p < .01$, $\Delta R^2 = .0232$). The results of step 3 ($BIC = 903.364$), including only the significant interaction of temporal and STEM, can be seen in Table 3.2. Even though the model of step 3 explains the most variance, step 1 would be the preferred model as it has the lowest Bayesian information criterion (BIC).

Table 3.2.: Hierarchical linear regression model: User experience (overall UEQ-S score)

	ΔR^2	R^2	B	$SE\ B$	β	t	p
Step 1		.0244					< .05
Constant			1.750	0.100	0.177	17.414	< .001
Pop-up			−0.076	0.133	−0.071	−0.571	.569
Temporal			−0.300	0.132	−0.280	−2.268	< .05
Step 2	.0868	.1112					< .001
Constant			2.069	0.244	0.474	8.476	< .001
Pop-up			0.049	0.140	0.046	0.350	.726
Temporal			−0.328	0.131	−0.305	−2.496	< .05
STEM			0.000	0.130	0.000	0.002	.999
Gender			−0.473	0.129	−0.441	−3.675	< .001
Gender other			−1.524	0.432	−1.421	−3.531	< .001
Gender no answer			−0.661	0.472	−0.616	−1.400	.163
Generation X			−0.095	0.205	−0.088	−0.462	.644
Generation Z			−0.271	0.201	−0.253	−1.348	.179
Generation Millennials			0.001	0.192	0.001	0.005	.996
Step 3	.0232	.1344					< .001
Constant			2.548	0.298	0.599	8.565	< .001
Pop-up			0.002	0.140	0.002	0.015	.988
Temporal			−1.314	0.381	−0.595	−3.451	< .001
STEM			−0.345	0.179	−0.322	−1.924	.055
Gender			−0.446	0.128	−0.416	−3.497	< .001
Gender other			−1.420	0.428	−1.323	−3.314	< .01
Gender no answer			−0.468	0.472	−0.436	−0.992	.322
Generation X			−0.038	0.203	−0.036	−0.187	.852
Generation Z			−0.269	0.199	−0.251	−1.353	.177
Generation Millennials			0.020	0.190	0.019	0.105	.916
Temporal × STEM			0.676	0.245	0.630	2.755	< .01

Note: Pop-up: online training = 0, pop-up = 1. Temporal: free time = 0, working time = 1. STEM: no background in STEM = 0, background in STEM = 1. Gender: female = 000, male = 100, other = 010, no answer = 001. Generation: Baby Boomers = 000, Generation X = 100, Generation Z = 010, Millennials = 001.

3.3.2. Acceptance (RQ B2)

The overall general TAM score (M = 1.41, SD = 1.12, Cronbach's α = 0.91) lies in the upper part of the rating scale. The same applies to the overall TAM score regarding each condition. Acceptance is almost equally distributed in both pop-up conditions (free time: M = 1.28, SD = 1.21; working time: M = 1.21, SD = 1.23), as seen in Figure 3.16. In the online training, participants who take part in their free time (M = 1.67, SD = 1.02) exhibit a higher level of acceptance than participants who take part in their working time (M = 1.53, SD = 0.77). Furthermore, the online training participants have a higher acceptance level than the pop-up participants regardless of whether they participated during their free time or working time, as Figure 3.16 demonstrates.

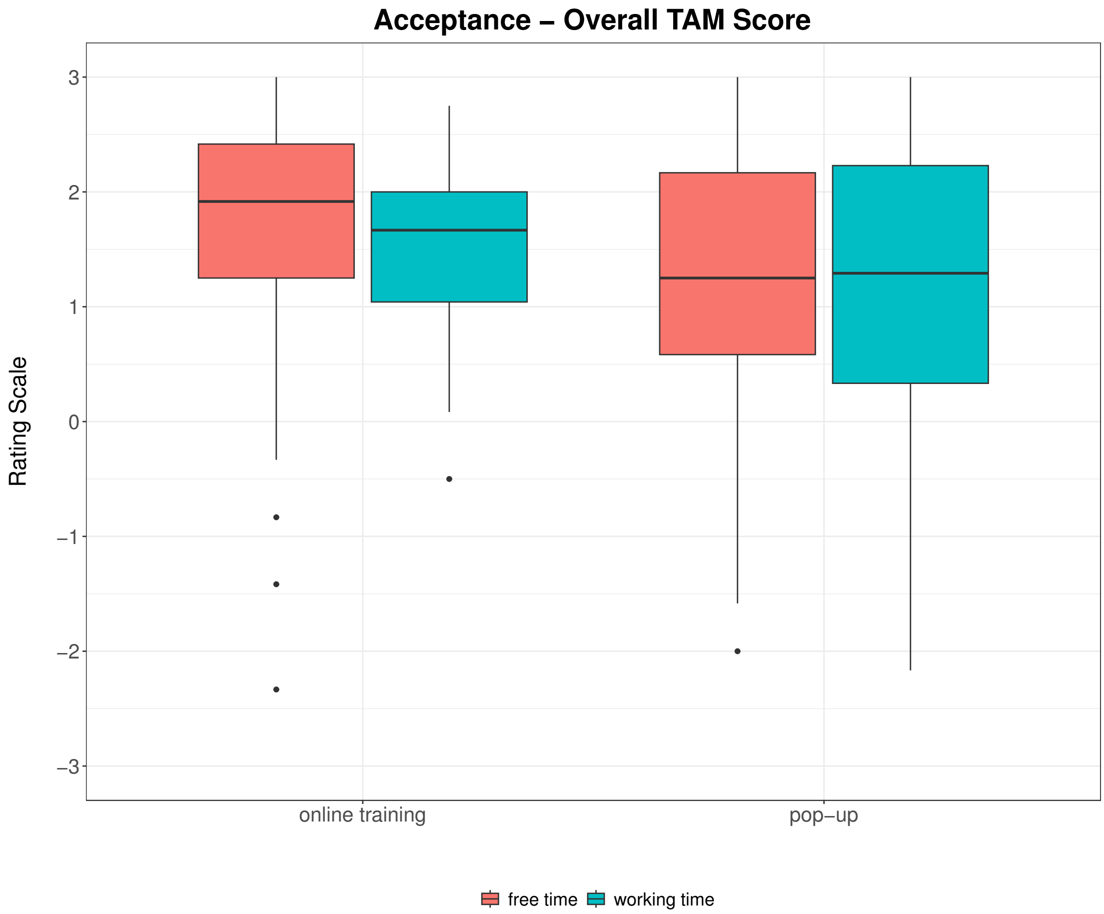

Figure 3.16.: Boxplot: Overall TAM score The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

Figure 3.17 illustrates the TAM subscales: perceived usefulness (in general: $M = 1.34$, $SD = 1.18$, Cronbach's $\alpha = .88$), perceived ease of use (in general: $M = 1.29$, $SD = 1.30$, Cronbach's $\alpha = .88$), attitude toward using (in general: $M = 1.64$, $SD = 1.23$, Cronbach's $\alpha = .87$), and behavioural intention to use (in general: $M = 1.37$, $SD = 1.35$, Cronbach's $\alpha = .85$). All subscale values are located in the upper part of the rating scale with respect to all conditions. Perceived usefulness is similarly distributed in the online training; however, participants who take part in their free time ($M = 1.46$, $SD = 1.22$) score higher than participants who take part in their working time ($M = 1.26$, $SD = 1.09$). The same applies for the pop-up (free time: $M = 1.39$, $SD = 1.08$; working time: $M = 1.23$, $SD = 1.24$). Overall, there seem to be no greater differences in perceived usefulness among all conditions. Taking a look at perceived ease of use, pop-up participants (free time: $M = 1.05$, $SD = 1.46$; working time: $M = 1.11$, $SD = 1.34$) score lower than online training participants (free time: $M = 1.55$, $SD = 1.23$; working time: $M = 1.55$, $SD = 0.93$) in all conditions. Also, participants who take part in the pop-up (free time: $M = 1.37$, $SD = 1.47$;

working time: M = 1.42, SD = 1.34) score lower on the attitude toward using scale in all conditions than participants who take part in the online training (free time: M = 1.99, SD = 0.95; working time: M = 1.81, SD = 0.91). Furthermore, pop-up participants (free time: M = 1.32, SD = 1.33; working time: M = 1.07, SD = 1.44) also score lower in all conditions compared to online training participants (free time: M = 1.68, SD = 1.28; working time: M = 1.51, SD = 1.12) regarding behavioural intention to use. Additionally, participants exhibit a lower level of behavioural intention to use when participating in their working time compared to participating in their free time regardless of the pop-up or online training, as seen in Figure 3.17.

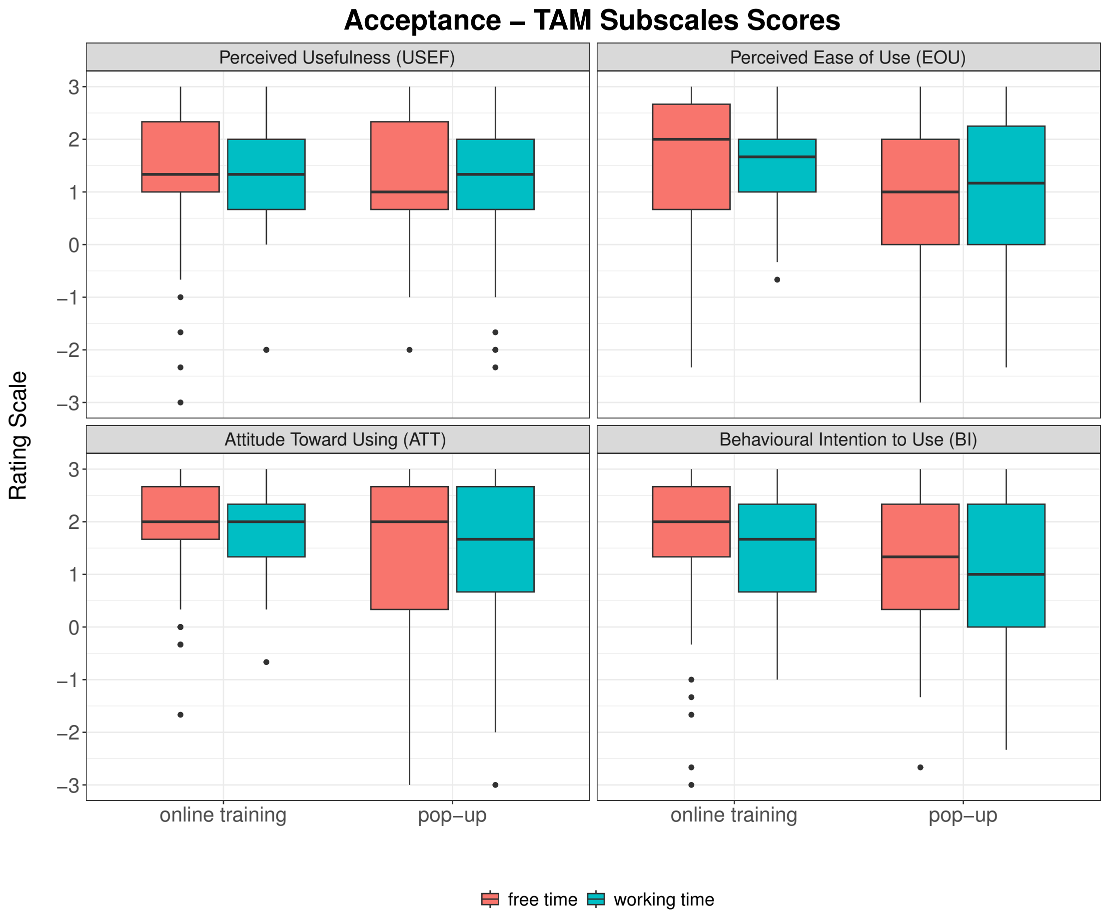

Figure 3.17.: Boxplot: TAM subscales scores The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

To examine RQ B2, if society would accept the pop-up initiative in free time and working time settings to educate themselves, a hierarchical linear regression analysis predicting the overall TAM score was calculated, analogously to UEQ-S analysis. Table 3.3 shows the results along with the variables' dummy coding of the hierarchical linear regression analysis predicting the overall TAM score. All assumptions were met in each step (refer to Section 3.3).

Pop-up participants experience a lower acceptance compared to online training participants ($B(1) = -0.361$, $p < .01$), as seen in step 1 in Table 3.3. There are no significant differences in acceptance regarding the temporal variable. Step 1 ($BIC = 917.218$) explains 3.27% of the acceptance variable's variance ($F(2,292) = 4.936$, $p < .01$, $R^2 = .0327$). Disregarding small differences, the pop-up and temporal variable remain similar in step 2 ($BIC = 939.278$) compared to step 1. Solely gender is an additional significant predictor in step 2. Men have a lower acceptance than women ($B(3) = -0.376$, $p < .01$). Also, participants who specified their gender as other have a lower acceptance than women ($B(3) = -1.073$, $p < .05$) and men. Step 2 explains 8.92% variance of the overall acceptance score ($F(9,285) = 3.101$, $p < .01$, $R^2 = .0892$). Hence, step 2 significantly improved step 1 ($F(7,285) = 2.525$, $p < .05$, $\Delta R^2 = .0565$).
In addition, a third step, which considers interactions between the pop-up variable and the demographic variables, the temporal variable and the demographic variables, and the pop-up and temporal variable, was calculated. The model did not identify any significant interactions. As step 3 did not significantly improve step 2 ($F(15,270) = 1.039$, $p = .415$, $\Delta R^2 = .0497$) and no significant interactions exist within the model, the results of step 3 are not included in Table 3.3. Although step 2 explains greater variance than step 1, step 1 would be the preferred model as it has a lower BIC.

Table 3.3.: Hierarchical linear regression model: Acceptance (overall TAM score)

	ΔR^2	R^2	B	$SE\ B$	β	t	p
Step 1		.0327					$< .01$
Constant			1.659	0.105	0.222	15.854	$< .001$
Pop-up			−0.361	0.139	−0.321	−2.601	$< .01$
Temporal			−0.101	0.138	−0.090	−0.731	.465
Step 2	.0565	.0892					$< .01$
Constant			1.960	0.258	0.394	7.583	$< .001$
Pop-up			−0.307	0.148	−0.274	−2.070	$< .05$
Temporal			−0.111	0.139	−0.099	−0.795	.427
STEM			−0.108	0.137	−0.097	−0.784	.433
Gender			−0.376	0.136	−0.335	−2.758	$< .01$
Gender other			−1.073	0.457	−0.956	−2.347	$< .05$
Gender no answer			−0.713	0.500	−0.635	−1.427	.155
Generation X			−0.108	0.217	−0.096	−0.496	.620
Generation Z			0.078	0.213	0.070	0.368	.713
Generation Millennials			0.172	0.203	0.153	0.847	.398

Note: Pop-up: online training = 0, pop-up = 1. Temporal: free time = 0, working time = 1. STEM: no background in STEM = 0, background in STEM = 1. Gender: female = 000, male = 100, other = 010, no answer = 001. Generation: Baby Boomers = 000, Generation X = 100, Generation Z = 010, Millennials = 001.

3.3.3. Knowledge Transfer (RQ B3)

Figure 3.18 shows the overall point score of the pre-knowledge questionnaire (in general: $M = 5.16$, $SD = 1.66$) and the post-knowledge questionnaire (in general: $M = 4.09$, $SD = 1.34$). In the pre-test, participants answered more questions correctly in the online training (free time: $M = 6.04$, $SD = 1.18$, working time: $M = 6.06$, $SD = 1.18$) than in the pop-up in all conditions (free time: $M = 4.04$, $SD = 1.62$, working time: $M = 4.65$, $SD = 1.62$). Also in the post-test, online training participants (free time: $M = 4.66$, $SD = 1.30$, working time: $M = 4.71$, $SD = 0.91$) answered more questions correctly than the pop-up participants (free time: $M = 3.43$, $SD = 0.98$, working time: $M = 3.73$, $SD = 1.40$). Figure 3.18 indicates that there are greater differences between the online training and pop-up, whereas between free time and working time there are only slight differences.

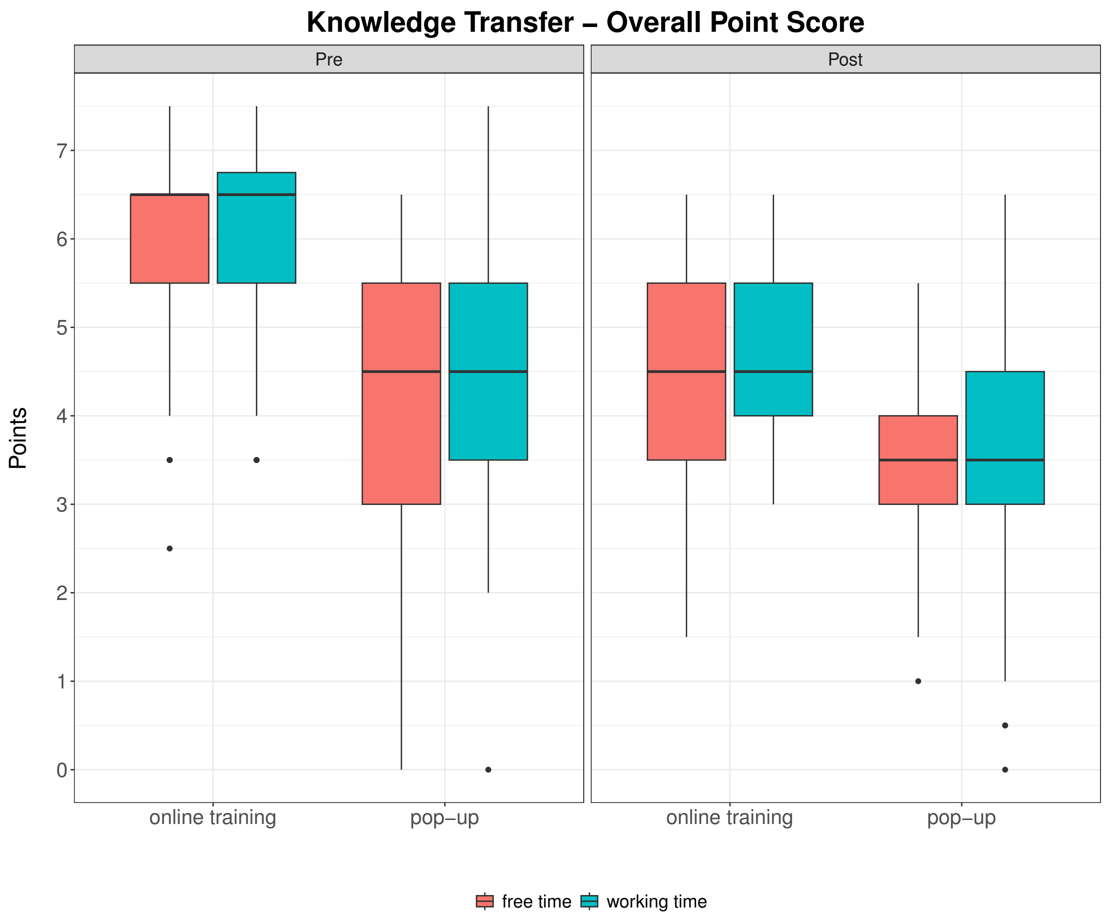

Figure 3.18.: Boxplot: Overall point score – pre and post The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

The overall point difference score (in general: $M = -1.07$, $SD = 1.46$) is visualised in Figure 3.19. Most participants scored slightly lower in the post-test than in the pre-test, in all conditions. The pop-up participants (free time: $M = -0.61$, $SD = 1.56$; working time: $M = -0.92$, $SD = 1.54$) demonstrate a larger point different score in both conditions than their online training counterparts (free time: $M = -1.39$, $SD = 1.30$; working time: $M = -1.36$, $SD = 1.24$). Hence, the pop-up participants achieved a higher knowledge transfer than online training participants. The temporal participation seems to be similarly distributed within the online training and pop-up, respectively.

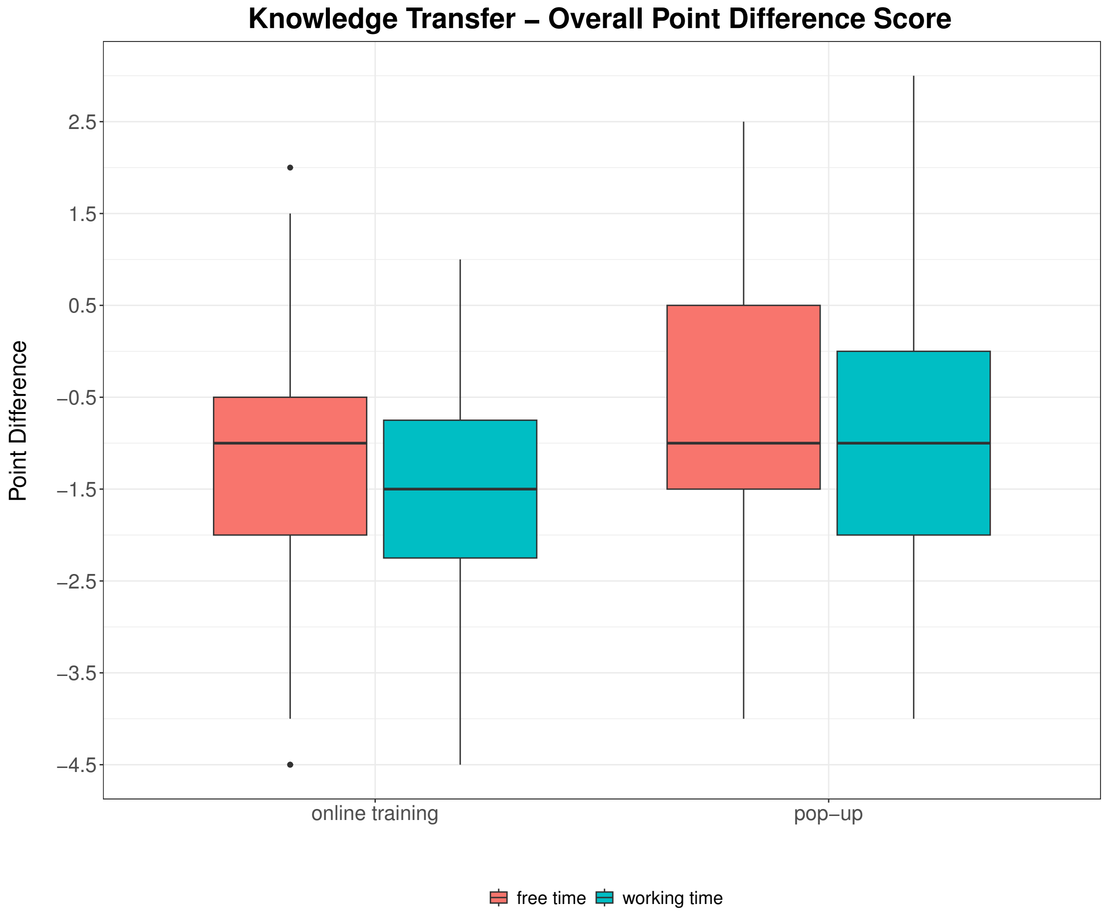

Figure 3.19.: Boxplot: Overall point difference score The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

The knowledge transfer point difference results of the subscales remember (in general: $M = -0.73$, $SD = 0.89$), understand (in general: $M = -0.16$, $SD = 1.12$), and apply (in general: $M = -0.18$, $SD = 0.40$) are presented in Figure 3.20. Greater differences between the online training and pop-up regarding all conditions, can be seen with respect to the remember subscale. The pop-up participants have a higher remember score (free time: $M = -0.33$, $SD = 0.89$; working time: $M = -0.56$, $SD = 0.87$) compared to online training participants (free time: $M = -1.00$, $SD = 0.82$; working time: $M = -1.10$, $SD = 0.79$).

This implies that participants who take part in the pop-up can remember information security and social engineering facts better than participants who take part in the online training. With respect to the understand subscale, the online training (free time: $M = -0.15$, $SD = 1.05$; working time: $M = -0.15$, $SD = 1.04$) and the pop-up (free time: $M = -0.18$, $SD = 1.26$; working time: $M = -0.15$, $SD = 1.15$) seem similarly distributed among all conditions. The same applies to the apply subscale regarding the online training (free time: $M = -0.24$, $SD = 0.37$; working time: $M = -0.10$, $SD = 0.31$) and pop-up (free time: $M = -0.10$, $SD = 0.41$; working time: $M = -0.22$, $SD = 0.44$).

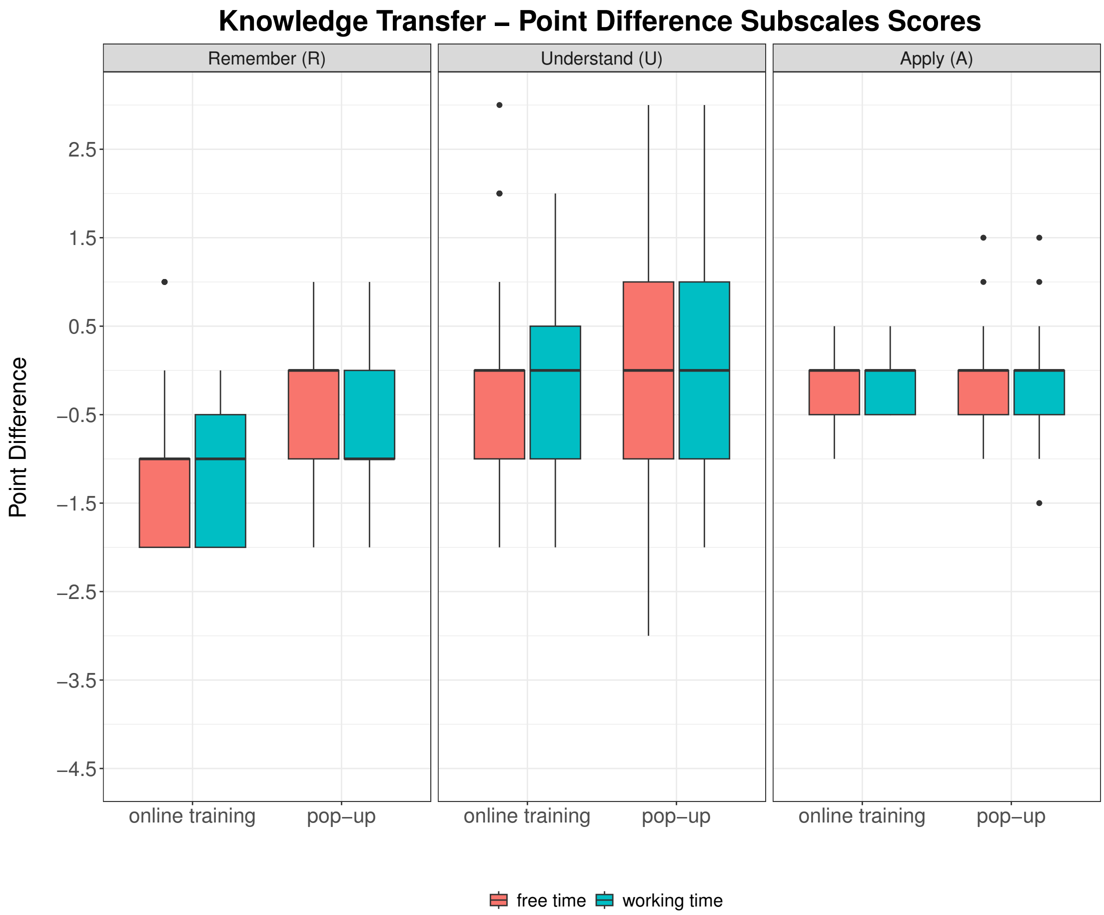

Figure 3.20.: Boxplot: Point difference subscales scores The median is represented by the line in the middle of the boxes. The middle 50% of all observations lie within the boundary of the boxes. The lower 25% of all observations lie beneath the first quartile (lower boundary of the boxes), whereas the upper 25% lie above the third quartile (upper boundary of the boxes). The whiskers (end of the lines outside the boxes) represent the minimum and maximum values, excluding extreme values, respectively. Extreme values are marked as dots.

To investigate RQ B3, to which degree knowledge can be conveyed through pop-up initiatives, a multilevel regression analysis with two levels was performed. Thereby, participants are the level 2 unit. As in the linear regression analysis of experience and acceptance, the same variables were used as predictors in this analysis. Additionally, the variable quiz was added as predictor, with 0 representing the pre-quiz and 1 the post-quiz. Also, interaction terms with the repeated measure variable quiz were added, as the interaction coefficients represent the point difference score between a category and its reference category. Random intercepts were included in the models, as prior knowledge in information security and social engineering is expected to differ among participants in the pre-quiz. Table 3.4 shows the results along with the variables' dummy coding. All assumptions were met in each step (refer to Section 3.3).

Step 1 (BIC = 2008.511) includes the variables quiz, pop-up, temporal, and the interactions between quiz and pop-up as well as quiz and temporal as predictors. Overall, participants scored lower in the post-quiz, answering roughly 1.5 questions less correctly compared to the pre-quiz ($\gamma(1) = -1.328, p < .001$). Furthermore, participants who took part in the pop-up had less prior knowledge (lower point score in the pre-quiz) than online training participants ($\gamma(1) = -1.742, p < .001$). Also, participants who participated in their working time answered almost half a question more correctly in the pre-quiz compared to participants who took part during their free time ($\gamma(1) = 0.363, p < .05$). However, the next paragraph will reveal that this is actually non-significant. Pop-up participants achieved a higher knowledge transfer (point difference) than online training participants ($\gamma(1) = 0.627, p < .001$). No significant interaction could be detected regarding knowledge transfer and the temporal predictor. While 29.63% of the variance are explained by the fixed effects of the model ($R^2{}_{Marginal}$), 59.91% of variance are explained by fixed and random effects combined ($R^2{}_{Conditional}$).
In step 2 (BIC = 2017.467) the demographic variables are added, also jointly with the interactions of the quiz variable. Besides some smaller differences, the predictors pop-up, the interactions of quiz and pop-up as well as quiz and temporal are similar to those in step 1. However, the predictor temporal becomes non-significant. This aspect was investigated further by an error bar plot, which can be seen in Figure 3.21. As the error bars do overlap, a non-significant difference is indicated. Also, in step 1 the predictor temporal was close on the boarder of being significant (p = 0.031). Furthermore, the quiz predictor also becomes non-significant. Nevertheless, there is still a significant difference between the pre- and post-quiz, as seen in Figure 3.18. However, the difference between the pre- and post-quiz is now distributed among the demographic predictors. Participants with a background in STEM had a higher prior knowledge (higher point score in the pre-quiz) than participants without a background in STEM ($\gamma(1) = 0.646, p < .001$). Also, Generation X ($\gamma(3) = 0.828, p < .001$) and the Millennials ($\gamma(3) = 0.789, p < .001$) had more prior knowledge than the Baby Boomers. No significant difference in prior knowledge is present among gender as well as between Generation Z and the Baby Boomers. Also regarding knowledge transfer (point difference), no significant differences could be identified among gender and generation. Interestingly, participants with a background in STEM experienced a lower knowledge transfer compared to participants without a background in STEM ($p < .01$). Nevertheless, the difference is not huge as participants with a background in STEM answered half a question less correctly ($\gamma(1) = -0.504$). Compared to step 1, step 2's fixed effects explain 10.22% more variance ($R^2{}_{Marginal} = .3985$). However, only 1.83% more variance is explained by fixed and random effects combined ($R^2{}_{Conditional} = .6174$). Yet, step 2 significantly improved step 1 ($\chi^2(14) = 80.365$, $p < .001$). Nevertheless, step 1 exhibits a lower BIC and thus would be the preferred model.

Table 3.4.: Hierarchical multilevel linear regression model: Knowledge transfer

	γ	SE	t	p
Step 1				
Constant	5.942	0.127	46.764	< .001
Quiz	−1.328	0.136	−9.792	< .001
Pop-up	−1.742	0.168	−10.353	< .001
Temporal	0.363	0.167	2.167	< .05
Quiz × Pop-up	0.627	0.180	3.489	< .001
Quiz × Temporal	−0.171	0.179	−0.959	.338
Step 2				
Constant	4.335	0.297	14.576	< .001
Quiz	−0.374	0.335	−1.114	.266
Pop-up	−1.279	0.171	−7.490	< .001
Temporal	0.236	0.160	1.478	.140
STEM	0.646	0.158	4.085	< .001
Gender	0.140	0.157	0.894	.372
Gender other	−0.858	0.526	−1.630	.104
Gender no answer	−0.529	0.575	−0.920	.358
Generation X	0.828	0.249	3.320	< .001
Generation Z	−0.274	0.245	−1.119	.264
Generation Millennials	0.789	0.234	3.378	< .001
Quiz × Pop-up	0.469	0.193	2.434	< .05
Quiz × Temporal	−0.122	0.180	−0.678	.498
Quiz × STEM	−0.504	0.178	−2.824	< .01
Quiz × Gender	−0.254	0.177	−1.413	.159
Quiz × Gender other	0.254	0.593	0.428	.669
Quiz × Gender no answer	0.012	0.649	0.018	.986
Quiz × Generation X	−0.091	0.281	−0.324	.746
Quiz × Generation Z	0.156	0.277	0.564	.573
Quiz × Generation Millennials	−0.108	0.263	−0.411	.681

Note: Quiz: pre-quiz = 0, post-quiz = 1. Pop-up: online training = 0, pop-up = 1. Temporal: free time = 0, working time = 1. STEM: no background in STEM = 0, background in STEM = 1. Gender: female = 000, male = 100, other = 010, no answer = 001. Generation: Baby Boomers = 000, Generation X = 100, Generation Z = 010, Millennials = 001.

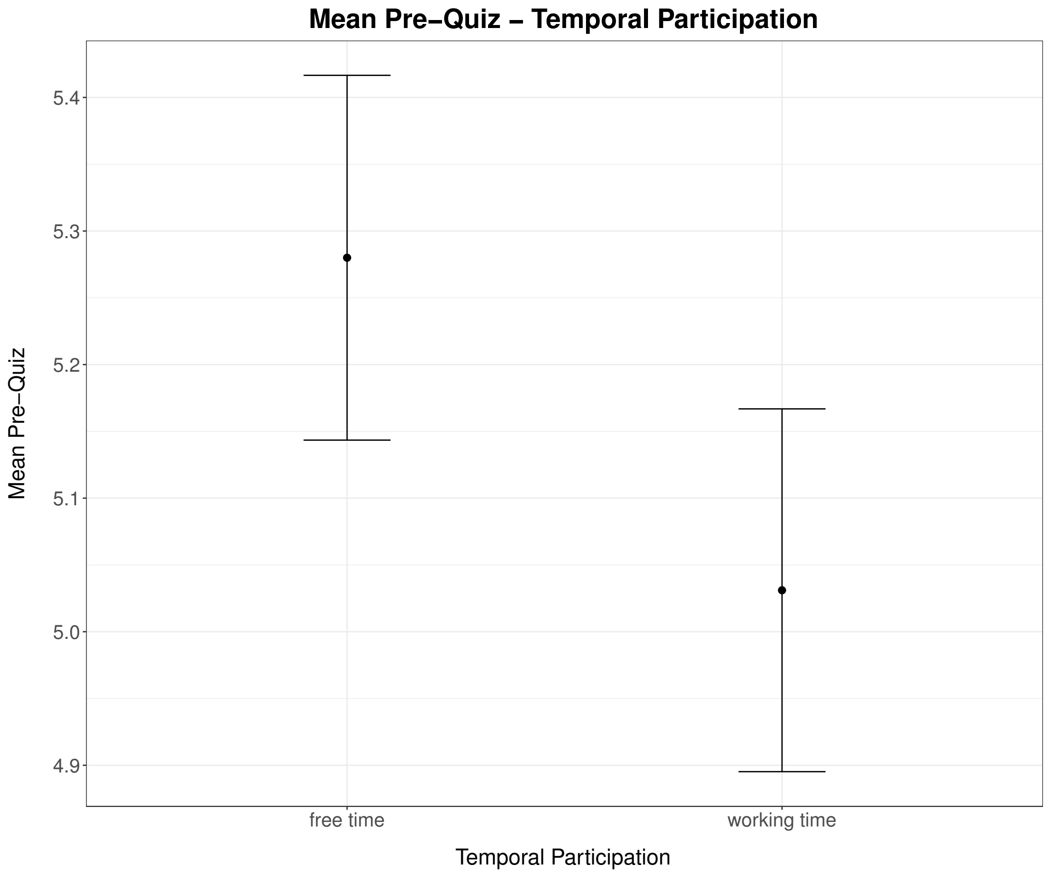

Figure 3.21.: Error bar chart: Mean ± standard error of predictor temporal

3.3.4. Summary

While most participants found out about the pop-up incidentally, nearly nobody found out about the online training this way. Most online training participants came to know to the training through family / friends / colleagues, followed by work.
In all conditions, participants achieved a positive UEQ-S score on average. There are no significant differences whether a participant takes part in the online training or pop-up regarding user experience. However, participants who take part in their free time (online training and pop-up) achieve a significantly slightly higher experience than participants who take part in their working time. Also, males and people who identify their gender as other, score significantly lower on the UEQ-S compared to females. There are no significant differences in user experience among generations. Apart from the predictors temporal and STEM, there are no significant interactions.
On average, participants achieved a positive TAM score in all conditions. However, pop-up participants experience a significant slightly lower acceptance than online training participants. There are no significant differences in acceptance whether participants take part in their free time or working time. Furthermore, males and participants who identify as other, exhibit a significantly lower acceptance compared to females. There are no significant differences in acceptance among generations. Also, no significant interactions are present within the acceptance models.

On average, descriptive statistics shows that participants achieved fewer points in the post-quiz than in the pre-quiz, in all conditions. Inferential statistics confirms this difference as significant. In the pre-quiz, pop-up participants scored significantly lower than online training participants. Furthermore, Generation X and the Millennials answered more questions correctly in the pre-quiz than the Baby Boomers. Also, participants with a background in STEM achieved a higher point score in the pre-quiz than their counterparts. Looking at the point difference score between the post- and pre-quiz, pop-up participants gain a significantly better score than online training participants, while participants with a background in STEM score significantly lower than participants without a background in STEM. There are no significant differences in the point difference score among gender and generation.

3.4. Discussion Study B

In this study, a nomadic CS pop-up initiative covering information security and social engineering was developed and conducted. The motto "wolf in sheep's clothing - how to protect yourself and your data" was chosen for the CS pop-up initiative which was developed based on the insights gained in study A (refer to Chapter 2). Moreover, Warnaby's and Shi's framework for planning and implementing pop-up activities was considered in the design of the CS pop-up initiative. Thereby, the development and evaluation of the CS pop-up initiative phase is analogous to Warnaby's and Shi's pre pop-up stage, pop-up experience stage, and post pop-up stage (see Chapter 1 and Figure 1.2) [34]. Comics were chosen to convey knowledge as they have been shown to be engaging and successful in other studies and settings (refer to Section 3.1.2). Especially the comics of Kumaraguru et al. have shown this [122, 123, 124, 125, 126, 127, 128] and thus served as orientation for the comics in this work. Across four comics, the following methods frequently used in social engineering are explained: Cialdini's six principles of persuasion, phishing, vishing, and OSINT.
To examine whether the pop-up concept can be successfully applied towards CS education in free time and working time settings, a quantitative study using a between-subject design combined with a within-subject design was performed. Thereby, an online training version using the same comics served as comparison for the pop-up initiative. The dependent variable experience was measured through the short version of the user experience questionnaire (UEQ-S), acceptance by means of a custom questionnaire based on the technology acceptance model (TAM), and knowledge transfer through a pre- and post-knowledge quiz based on Bloom's taxonomy. For data analysis, multiple linear and multilevel regression models were applied. In additional model steps, participants demographics (gender, generation, and background in STEM) were considered.

Most participants incidentally found out about the pop-up, while nearly no one found out about the online training this way. This is a huge advantage of pop-ups, as a wider society as well as people who would usually not occupy themselves with CS topics can be reached. Likely, people would rather participate in a pop-up when passing-by in-

cidentally than taking part in an online training they incidentally encounter on the internet. Furthermore, more elderly people participated in the pop-up than in the online training, indicating that more elderly people can be reached through pop-ups than online trainings. Family / friends / colleagues and work play an important part in finding out about the pop-up or online training, respectively. Even though, especially the online training was advertised on social media, nearly no one specified that they found out about it through media. Probably, participants experienced family / friends / colleagues or work as source of finding out even though the information was sent through social media or emails. Hence, the distribution of media in finding out of the educational initiatives is not a realistic depiction.
The wolfs in sheep's clothing mascot attracted plentiful attention. Many participants stated that they find the mascot remarkably cute and would like to take it home with them. The mascot notably contributed to create a fitting atmosphere at the pop-up, attract people, and a positive perception of the pop-up [141, 34, p. 57]. However, this was not further quantified. The password card was the most favourite giveaway, almost all of the 100 cards were taken by participants. The sticker and gummy candies were also favoured. The information brochure on information security seemed to be the least favourite as only few people took one. The giveaways act as a reminder of the pop-up and encourage participants to occupy themselves with information security after the pop-up participation [34, p. 66 - 67]. Considering staffing and transport [34, p. 56, 59], two operators were sufficient for supervising the pop-up and comfortably transporting it with a larger car.
Multiple newspaper and online articles about the CS pop-up initiative and this work was published, as seen in Table C.1 in Appendix C. Furthermore, the idea of conveying CS knowledge through pop-up education, especially on information security, was awarded two prizes: the Jury award of the Zukunftsforum Schweinfurt 2023 and the first prize of the phaeno science slam in September 2023 (refer to Figure C.4 and C.3 in Appendix C). The Zukunftsforum Schweinfurt was organised by the city of Schweinfurt, while the phaeno science slam was organised by the phaeno science museum in Wolfsburg. The awards emphasise pop-ups' potential of successful use and acceptance as measures for conveying CS knowledge.

Taking a look at **RQ B1**, society experienced the pop-up initiative and the online training positively. In all conditions, mean values lie in the positive part of the rating scale and the data is also mainly distributed in the positive part. The applied UEQ-S can be considered as reliable as Cronbach's alpha is higher than 0.8 [73]. The pop-up and the online training were equally positively experienced by society, as no significant difference could be found. However, during working time participation, the pop-up and the online training were slightly less positively experienced (significant) compared to free time participation, respectively. This effect could be, as information security trainings and knowledge transfer on computer science topics are more common in working than in free time settings. Thus, in free time settings, unexpected trainings and knowledge transfer could be a positive surprise and hence be experienced more positively; whereas at work additional trainings could be associated with extra work. This is also reflected in the hedonic quality subscale on which participants who took part in their free time score higher. This implies that people who take part in their free time enjoy the pop-up and online training more, respectively. Nevertheless, the pop-up and the online training were

also experienced positively in working settings and the difference between free time and working time settings is only small.
Females experience the CS pop-up and online training significantly more positively compared to males and people who identify their gender as other. However, the difference between females' and males' experience is only small. The results of study A show that females self-assess their attitude towards CS lower than men. Due to the lower self-assessed attitude, they might see more need and use to learn and improve their CS knowledge. Thus, experiencing the educational initiatives more positively. Furthermore, study A's responses of females were especially considered in the design of the educational initiatives. This could result in a slightly more positive educational initiative experience compared to men. Additionally, these results go hand in hand with the insights of a study conducting robot workshops for school students, as one workshop seemed to have a higher motivational impact on females [23, 24]. People with a background in STEM experience the pop-up and the online training significantly more positively in working settings than in free time settings or people without a background in STEM in any time setting. This could be as people with a background in STEM are used to trainings and knowledge transfer on CS topics in their working time. However, the difference is only small. The STEM variable itself is not a significant predictor in the models. Hence, there are no significant differences between people with and without a background in STEM regarding experience. However, in related work, non-STEM students perceived a blended learning class more positively than STEM students [45]. The online training and pop-up seem to be suitable for all generations with respect to experience, as there are no significant differences among generation. Hence, generations' attitude towards CS does not seem to affect the educational initiatives' experience (refer to Chapter 2), as the attitude did differ among generations regarding study A.
Besides temporal participation and STEM, no other significant interactions were present in the models. Hence, neither temporal participation nor gender, background in STEM, or generation have a depended effect on the pop-up's and the online training's experience, respectively. This implies that CS pop-ups and online trainings are suitable for all participants with various demographic backgrounds regarding experience. Furthermore, gender and generation also do not have depended effects on temporal participation. Thus, the pop-up and online training are suitable in free time and working time settings for society. Especially for people with a background in STEM, they are slightly even more suitable in working settings.

Regarding acceptance, the mean values of the overall TAM score are located in the positive part of the rating scale and the data is also mainly distributed in the positive part in all conditions. This implies that society accepts the pop-up initiative and the online training in free time and working time settings (**RQ B2**). The custom TAM questionnaire can be considered as reliable as Cronbach's alpha is higher than 0.8 [73]. Temporal participation does not seem to affect acceptance, as there is no significant difference whether participation took part in free time or working time settings. However, online training participants would accept their information security training significantly more than pop-up participants. The difference is only small though. Society might accept pop-ups slightly less compared to online trainings, as pop-ups usual serve non-educational objectives such as fashion pop-up stores. Moreover, society is less familiar and not used to educational pop-ups, while educational online trainings are ubiquitous and thus acceptance

might be more prevalent. Looking at the subscales, perceived usefulness is similarly distributed among conditions, while pop-up participants especially score lower on the perceived ease of use, attitude toward using, and behavioural intention to use scale. This implies that taking part in the pop-up is associated with more effort for participants than taking part in the online training. This in turn might influence the attitude toward using pop-ups as well as the behavioural intention to use them. The main influential factor seems to be perceived ease of use though. Going and participating at a pop-up, even when passing by incidentally, seems to be more effort than taking part in an online training. However, re-emphasising, the difference between acceptance of the online training and the pop-up are only small. Notably, there are no greater differences in perceived usefulness between the pop-up and the online training, implying that pop-ups and online trainings are perceived equally well in enhancing participants' CS knowledge.
Females accept the CS pop-up and online training significantly more compared to males and people who identify their gender as other. Nevertheless, the difference between females' and males' acceptance is only small. Similar to experience, females might accept educational initiatives more, as the might see more need and use to enhance their CS knowledge due to their lower self-assessed attitude towards CS. Also, that the responses of females in study A were especially considered in the development of the educational initiatives can play an important part. Females' greater acceptance also corresponds to the higher motivational impact on females in a study of robot workshops for school students [23, 24]. The CS online training and pop-up seem to be an acceptable measure for all generations and for people with and without a background in STEM, as there are no significant differences among generation and STEM. In related work though, non-STEM students perceived a blended learning class more positively than STEM students [45].
No significant interactions are present in the acceptance models. Thus, neither temporal participation nor gender, background in STEM, or generation have a depended effect on the pop-up's and the online training's acceptance, respectively. This indicates that CS pop-ups and online trainings are accepted equally well as appropriate measures for conveying CS knowledge by society members with diverse demographic backgrounds, respectively. The same applies to temporal participation along with the demographics variables, as no significant interactions are present. Hence, CS pop-ups and online trainings are equally well accepted in free time and working time settings by society members with various demographic backgrounds, respectively.

Regarding knowledge transfer (**RQ B3**), the mean values of the point difference score between the post- and the pre-quiz are located in the upper negative part of the rating scale in all conditions. Roughly one-half to one-and-a-half questions were less correctly answered in the post-quiz compared to the pre-quiz, indicating that the post-quiz might have been slightly too difficult. The significant difference found between the pre- and post-quiz score supports this. However, the number of questions was kept low (9 per quiz) to keep the total study length adequate. Hence, one mistake affects the overall point score in a shorter quiz more than in a longer one. In the online training conditions, the point difference score is mainly distributed in the upper negative part of the rating scale, while in the pop-up condition the score is mainly distributed in the upper negative to lower positive part. Furthermore, knowledge transfer is significantly better in the pop-up than in the online training condition. Looking at the subscales, bigger differences between the pop-up and online training condition are on the remember scale,

followed by differences on the understand scale, while the apply scale is similarly distributed. Pop-up participants can remember and understand facts better than online training participants. This might be as online trainings are more ubiquitous than pop-ups. Thus, concentration, interest, and excitement might be higher in the pop-up as it is more novel, like an event, and less common to participants than online trainings. Also, the pop-up's atmosphere, the social interaction with the pop-up operator, and giveaways might have a positive effect on memorising and understanding facts. Usually, pop-ups are conducted in more noisy environments than online trainings; however, this does not seem to affect knowledge transfer as it is higher in the pop-up condition. Pop-up participants had significantly less prior knowledge compared to online training participants, which can also affect the point difference score. Still, the difference in prior knowledge was controlled for by adding random intercepts in the multilevel models. Nevertheless, the difference in knowledge transfer is not immensely between the pop-up and online training condition. Even though the point difference score is negative, pop-ups can still be considered as appropriate measure for conveying CS knowledge, as the point difference score in the online training is also negative and knowledge transfer is significantly higher in the pop-up than in the online training condition. Knowledge transfer does not seem to be affected by temporal participation, as there is no significant difference. Hence, CS pop-ups and online trainings are suitable in free time and working time settings regarding knowledge transfer.
Interestingly, there are no significant differences in prior knowledge and in knowledge transfer among gender. This corresponds to the results of Beyer et al.'s research, which investigated gender differences among university students: While there were no significant differences between female and male students regarding CS ability, females exhibited less CS confidence [74]. This in turn corresponds to the attitude towards CS results in study A. Generation X and the Millennials have a significantly higher prior knowledge compared to the Baby Boomers. However, there are no significant differences among generations regarding knowledge transfer. This suggests that CS pop-ups and online trainings are suitable for all genders and generations. Unsurprisingly, participants with a background in STEM have a significantly higher prior knowledge than participants without a background in STEM. Nevertheless, participants with a background in STEM score slightly significantly lower on knowledge transfer than their counterparts. This might be as there is less new to learn for participants with a background in STEM or they might be too confident and hence less diligent in answering the quizzes, as they could think that they already know the facts. In contrast to this work, in which people with a background in STEM achieved a lower knowledge transfer, STEM students in related worked performed better in blended learning classes than non-STEM students [45]. Nevertheless, the differences are not huge in this work. Hence, CS pop-ups and online trainings are also suitable for people with and without a background in STEM.
Stadler et al. argue that questions in knowledge measurements are usually heterogeneous while Cronbach's alpha concentrates on homogeneity [190]. Hence, Cronbach's alpha is not a dependable measure for assessing reliability of knowledge scales [190]. Therefore, Cronbach's alpha was not reported for knowledge transfer.

After taking part in the pop-up, some participants stated that they enjoyed the comics and the possibility of learning in an entertaining way. However, this was not further quantified. One participant even asked if there are more comics available and wished to take a printed version of the comics home with her. This implies that the edutainment approach of using comics could be successfully applied to CS pop-up education. These insights go hand in hand with the results of Kumaraguru's et al.'s studies, in which participants inter alia stated that they consider teaching severe topics (such as phishing) through comics as a great idea [122, 123, 124, 125, 126, 127, 128]. Furthermore, participants who learned through comics in Kumaraguru's et al.'s study, performed better than the other groups which learned through a notice or a text along with graphics [122]. The same effect was found in a study teaching social engineering. The group which learned through an edutainment approach using a VR video, achieved a better information security awareness score than the non-edutainment group which learned through a text-based e-learning platform [112]. These studies support the use of edutainment and imply that pop-up and online training participants achieved a higher knowledge transfer than if they would have learned about information security through a non-edutainment approach. Hence, comics and other edutainments approaches should also be used in further CS pop-ups.

According to Warnaby and Shi, only little academic research has been undertaken with respect to pop-up activities [34, p. 2, 33], as already discussed in Chapter 1. This especially applies for pop-up education. Educational pop-ups are frequently performed, however, rarely researched as related work shows. Examples of performed educational pop-ups without any research involved are *Manchester's inflatable museum* [90, 34, p. 19], *m25* changing pop-up exhibitions [91, 92], *Kaufhausgeschichten pop-up museum* [93], and *the Westgate Oxford pop-up* [94] (refer to Section 3.1). Even though a scientific journal article about *the Westgate Oxford pop-up* was published, it focuses on planning and conducting the archaeological pop-up museum instead of researching pop-up participants' experience, which could have been done through a survey, but was not, as stated by the author [94]. In contrast to *the Westgate Oxford pop-up*, experience was researched and captured through the UEQ-S questionnaire in this work. As the experience mean values lie in the positive part of the rating scale in all conditions and there is no significant difference between the pop-up and the online training, educational CS pop-ups can be considered as suitable for society and as successful regarding experience.
Main factors of claiming profit-oriented educational pop-ups as successful seem to be the number of visitors or sold tickets as in the cases of *Van Gogh immersive exhibit* [99] and *Body Worlds* [96] (see Section 3.1). However, a scientific study about *Body Worlds* was performed, which showed that people think and take more care of their bodies than before visiting the pop-up exhibition [97]. Similarly, an educational effect regarding educational pop-ups is present within this work, as pop-up participants achieve a significantly higher knowledge transfer score compared to online training participants. Also, *Body Worlds* was experienced as very good or good by nearly all surveyed participants [97]. Likewise, educational CS pop-ups can be considered as suitable for society and as successful regarding experience, as the experience mean values lie in the positive part of the rating scale in all conditions and there is no significant difference between the pop-up and the online training. Even though *Body Worlds* can be perceived as ambivalent (see Section 3.1), it seems to be accepted by majority, as over 55 million people visited it [96]. Albeit pop-up participants score slightly lower on the acceptance scale than online training participants (significant), educational CS pop-ups can still be considered as suitable and successful as the difference is only small and the acceptance mean values lie in the

positive part of the rating scale in all conditions. Additionally, CS pop-ups are less ethically ambivalent than *Body Worlds* and hence might suit for an even wider society than *Body Worlds* does.
Also, other medical education pop-ups, performed at workplaces, were perceived as successful. An example thereof is the *Healthy Hub Roadshow*, which most participating companies found "useful, informative and appropriate" [31]. Furthermore, the number of employees seeking assistance with their alcohol drinking behaviour increased after a roadshow on smoking, alcohol, and diets [32]. Likewise, educational CS pop-ups can be considered as successful in free time and working time settings, as all experience and acceptance mean values lie in the positive part of the rating scale in free time and working time settings. Furthermore, there are no significant differences between free time and working time participation regarding acceptance and knowledge transfer. Only working time participants score slightly lower (significant) on the experience scale compared to free time participants. As the difference is very small, CS pop-ups are still suitable for use in working time settings, which corresponds to the results of the medical education pop-ups at workplaces [31, 32].
Large companies [11], libraries [14], entire pop-up villages [15], and educational healthcare pop-ups [31, 32, 97] can use the pop-up concept successfully regarding their use case (see Chapter 1). This work shows that also educational CS pop-ups can be successfully applied in free time and working time settings regarding experience, acceptance, and knowledge transfer.

The limited number of questions in the pre- and post-quiz, is one of this study's limitations. One mistake affects the overall point score more than if the quizzes would have more questions. However, to keep the total study length adequate, the number of questions was kept low (9 per quiz). Even though the entire questionnaire was designed to keep its length adequate, some participants became impatient during the pop-up. Additionally, some participants stated that the pop-up took too long for them, which could have influenced their answers in the questionnaires. No feedback regarding this could be obtained from the online training, as there was no possibility of oral feedback. However, if educational CS pop-ups are performed in the future without academic research involved, participation time will be reduced substantially as there is no need to fill in questionnaires. Moreover, only short-term learning can be measured through this study, as long-term learning involves follow-up questionnaires which would drastically reduce the sample size. Also, exclusively multiple-choice questions were used for measuring knowledge transfer. Hence, points could also be scored by random guesses. However, open-ended questions would have gone beyond the scope and would have extended participation time even more. Moreover, the post-quiz seemed to be slightly too difficult, as the point score decreased mostly compared to the pre-quiz.
Comics were used in the pop-up and online training as related work showed that comics are highly successful in educational settings. Moreover, comics were also used to keep research conditions equal for comparing the results between the pop-up and online training. In contrast to pop-ups, no exciting and attention attracting novel hardware or hands-on experiences can be used in online trainings. Therefore, the potential of pop-ups could not be completely used in this study.
The results of this study provide valuable insights into CS pop-up education. Nevertheless, the sample size is limited. Especially, regarding people who identify their gender

as other or who did not specify their gender. Hence, the results of these gender groups should be considered with caution. Furthermore, no alpha adjustment was undertaken as suggested by Sinclair et al. [188] and as already discussed in Section 3.3, in order to not miss out on possibly valuable insights, in return for a higher type I error probability. In addition, it was genuinely difficult to find public places and particularly companies which permit conducting CS pop-ups on their venues. Some inquired venues and companies declined or did not even respond to the researcher's request. Possible reasons thereof are: additional work, no interest in co-organising a pop-up, do not see a benefit for them, already have sufficient information security trainings in their company, and perceiving a pop-up with its corresponding operators as a thread from outside for their company.
Marketing communications of the pop-up was attempted to keep equal among the different participating places. However, some aspects were out of the researcher's control. While some participating places were highly supportive and announced the pop-up multiple times beforehand e.g. via their digital information boards and emails, other places merely allowed to place the pop-up at their site without any possibility of prior announcements. Furthermore, a newspaper article about the pop-up and its upcoming public venues was published after the pop-up conducts were already over.

Further CS pop-up initiatives will be developed and conducted in future work, investigating different CS topics, mottos, and learning materials regarding experience, acceptance, and knowledge transfer. Thereby, a pop-up covering a different CS topic and a different motto, which also uses comics to convey knowledge, will be developed. This pop-up will be compared to the current information security and social engineering pop-up, to gain further insights into CS pop-ups with different mottos and topics. Likewise, different materials will be used in further pop-ups for conveying CS knowledge. Interactive games like *Targeted Attacks* [117], *E-SEC's interactive e-learning course* [118], or the game *Im Netz des Social Engineers* [119] will be used, as related work shows that game-based learning is highly successful in cyber security learning [191]. However, an interactive game will be especially developed for the pop-up to suit whole society, as the current available games are too difficult or specific (see Section 3.1.2). Thereby, also information security and social engineering will be captured as topic and compared to the pop-up which uses comics, in order to research the effect of different learning materials in pop-ups. Moreover, insights will be gained into which CS topics, mottos, and learning materials serve best regarding experience, acceptance, and knowledge transfer. Online trainings will be undertaken analogously for comparison.
In order to gain more precision in knowledge transfer measurement, the information security and social engineering pop-up will be conducted with a pre- and post-quiz consisting of more items and open-ended questions. As the focus lies on knowledge transfer in this case, the questionnaires measuring experience and acceptance will not be part of the study, in order to keep the survey at an adequate length. This will be undertaken analogously with the new developed pop-ups using different topics, mottos, and learning materials. In addition, qualitative interviews will be undertaken to gain further insights into the benefits and drawbacks of pop-ups compared to online trainings.
Finally, achieving a higher sample size for increasing results' precision and enhancing the post-quiz questions, which seemed to be slightly too difficult, will be aimed at. Also, printed versions of used comics or other educational materials will be prepared as giveaways,

as wished by a participant.

All in all, pop-up and online training participants achieved a positive experience and acceptance score in free time as well as working time settings. However, experience was significantly slightly higher in the free time condition. Females experienced the pop-up and online training significantly slightly higher and would also accept the educational initiative significantly slightly more than males. This implies that considering especially the responses of females (of study A) in designing the educational initiative, worked well. However, pop-up participants achieved a significantly slightly lower acceptance score than online training participants. Nevertheless, pop-ups can still be considered as a successful measure, as the difference is only small and pop-up participants achieved a significantly higher knowledge transfer. Educational CS pop-ups are suitable for all generations, as there are no significant differences among generation regarding experience, acceptance, and knowledge transfer. Furthermore, pop-ups have certain advantages over online trainings. A wider society can be reached through pop-ups, as people incidentally pass by and participate which is not the case in online trainings. Furthermore, indications were found that more elderly people can be reached through pop-ups than online trainings. It can also be assumed that young children could be reached more easily through pop-ups than online trainings, as young children and the elderly seem to spend less time on the internet than other age groups.
Concluding, the pop-up method can be successfully applied towards CS education regarding experience, acceptance, and knowledge transfer in free time as well as working time settings. Moreover, educational CS pop-ups are suitable to a wide society with diverse demographic backgrounds. Additionally, certain society groups can be reached more compared to online trainings. Also, companies can benefit from CS pop-ups as additional trainings for their employees, alongside their conventional trainings.

4. Discussion

As solely limited academic research has been undertaken regarding pop-up activities [34, p. 2, 33], especially with respect to CS education, the potential use and benefits of pop-up activities in CS education had remained vaguely. Hence, this work was dedicated to developing, researching and evaluating CS pop-ups as educational measures for society and working places. Thereby, this work is based on Warnaby's and Shi's conceptual pop-up framework for planning and implementing pop-up initiatives [34] (refer to Chapter 1). The first phase (study A), utilising requirements elicitation, focused on identifying crucial factors for the development of appealingly CS pop-ups, including CS topics and application fields which are of learning interest, and society groups which should be especially considered in the development of CS pop-ups. The second phase (study B) covered the development of CS pop-up initiatives and researched its applications in free time and working time settings regarding CS pop-up participants' experience, acceptance, and knowledge transfer.
Suitable CS topics and application fields for CS pop-ups were identified by society's interest and perceived need of learning. A guideline for developing CS pop-ups, including edutainment approaches and which society groups should be especially considered, is provided. Moreover, it has been shown that CS pop-ups are perceived positively and can be successfully applied in free time and working time settings to a wide society with diverse demographic backgrounds regarding experience, acceptance, and knowledge transfer.

Even though Warnaby and Shi outline a strategic objective stage which covers the overall pop-up objective from the brand and customer perspective, usually merely the brand perspective is considered in the design of pop-ups, while the customer perspective is neglected. Frequently, educational pop-ups cover predefined topics, which pop-up operators consider as crucial for educating on; however, without previously taking potential participants objectives and considerations into account. By considering the customer perspective through performing requirements elicitation, the success of educational pop-ups can be further enhanced. Therefore, in contrast to manifold educational pop-ups e.g. STEM roadshows [28, 29], health roadshows [31, 32, 97], and pop-up museums [91, 92, 94, 90, 34, p. 19] requirements elicitation was performed in this work.
The results of performed requirements elicitation identified information security / hacking as the most suitable CS topic, as it has the greatest intercept of society's interest among all demographic groups. Furthermore, society / social aspects was shown to be the most suitable CS application field for CS pop-ups. Other suitable CS topics and application fields for CS pop-ups include autonomous driving, artificial intelligence / machine learning, medicine / healthcare and transport / logistics. The results indicate, that IEEE trends [54, 55], Google trends [56, 79], and the Gardener hype cycles [53, 68, 69,

70, 71, 72] can serve as orientation for potential CS topics for CS pop-ups. However, it is recommended to perform requirements elicitation, as IEEE trends, Google trends, and the Gardener hype cycles have a strong business or technical expert focus and do not necessarily correspond to society's interest and learning needs. Females, persons without a background in STEM as well as Generation Z and Generation X should be especially considered in the design of CS pop-up initiatives, as they exhibit a lower attitude towards CS. This corresponds to typical stereotypes and the subject of too few women in CS as addressed in gender studies [42, 43]. Furthermore, the lower attitude towards CS of females compared to males, goes hand in hand with the results of a study which observed that even female CS major students exhibited a lower CS confidence than male non-CS major students [74]. However, the matter of few women in STEM mostly seems to be an issue of western countries [75]. Also, cultural characteristics and behaviour differs among countries as the Hofstede model outlines [80]. Hence, interest in CS topics and application fields can be different in other countries compared to Germany. Due to cultural differences, it is recommended to perform requirements elicitation for the specific countries the CS pop-ups are planned to be implemented in. Moreover, requirements elicitation should be performed regularly, as technological progress is advancing and interests and needs might change.
Study A shed light on how the strategic objective stage of Warnaby's and Shi's pop-up initiative framework can be addressed from the customer perspective by means of requirements elicitation and laid foundations for the design, implementation, and evaluation process of educational CS pop-ups.

The last stage of Warnaby's and Shi's pop-up framework, the post pop-up stage, inter alia encompasses "measuring and evaluating success" [34, p. 69]. Plethora of educational pop-ups have been performed, however, without any evaluation or research involved. This applies inter alia to *Manchester's inflatable museum* [90, 34, p. 19], the city of Ulm's *m25* changing pop-up exhibitions [91, 92], and *the Westgate Oxford pop-up* [94]. The scientific article on the archaeological pop-up museum called *the Westgate Oxford pop-up*, even mentioned that participants' experience could have been measured through a survey, but it was not undertaken [94]. Instead of researching pop-up museums, the article focuses on planning and conducting the archaeological pop-up museum. If educational pop-ups are researched, they are mainly on healthcare topics such as the *Healthy Hub Roadshow* [31], a roadshow on alcohol and diet at the workplace [32], or *Body Worlds* [96, 97]. Furthermore, a main factor of claiming income-oriented educational pop-ups as successful seems to be the number of visitors or sold tickets as in the cases of *Body Worlds* [96] and *Van Gogh immersive exhibit* [99]. As mainly educational healthcare pop-ups have been researched and experience, acceptance, and knowledge transfer were neglected, it remained uncertain whether the pop-up concept can be successfully applied towards CS education in society and workplaces. Hence, study B addressed this research gap by means of a developed CS pop-up based on the insights of study A, covering information security and social engineering as topic.
In contrast to *the Westgate Oxford pop-up* [94] and other educational pop-ups, experience was measured and researched through the UEQ-S in this work. The results show that the educational information security and social engineering pop-up was experienced positively. Especially women experienced the pop-up slightly significantly higher than men. This coincides with the insights of a study on robot workshops for school students, in

which one workshop seemed to have a higher motivational impact on females [23, 24]. There were no significant differences in experience between the pop-up and the online training as well as background in STEM, and among generations. Considering **general RQ a)**, the pop-up concept can be successfully applied towards CS education in free time and working time settings regarding experience. The concept is suitable for a broad society with diverse demographic backgrounds. Women, participation in free time settings, and people with a background in STEM participating in working settings seem to profit additionally from CS pop-ups with respect to experience.
Also, acceptance, measured through a custom questionnaire based on the TAM model, was rated positively. Even though the online training achieved a significantly higher acceptance than the pop-up, pop-ups can still be considered as successful regarding acceptance, as the difference is only marginal. Women accepted the pop-up slightly significantly more than men. This goes hand in hand with the experience results and the study of robot workshops for school students, in which one workshop seemed to have a higher motivational effect on females [23, 24]. Otherwise, there were no significant differences regarding free time or working time settings as well as STEM and generation. Hence, the pop-up concept is suitable for a broad society and can be successfully applied towards CS education regarding acceptance (**general RQ b)**). Also, the concept seems to be particularly accepted by females.
Even though the post-quiz seemed to be slightly too difficult, CS pop-ups can still be considered as successful regarding knowledge transfer, as knowledge transfer was significantly higher in the pop-up condition compared to the online training condition. Interestingly, participants with a background in STEM achieved a slightly lower knowledge transfer score than participants without a background in STEM. In contrast to this work, STEM students performed better than non-STEM students in a study on blended learning classes [45]. No significant differences were found regarding knowledge transfer between free time and working time settings and STEM as well as among gender and generations. Hence, females and males performed equally well, which corresponds to the results of a study which researched gender differences among university students [74]. However, while females and males exhibited equally well CS abilities, females showed a lower CS confidence than males [74]. This in turn corresponds to the attitude towards CS results in study A of this work. Considering **general RQ c)**, the pop-up concept is suitable for a broad society and can be successfully applied towards CS education regarding knowledge transfer. Especially, participants without a background in STEM can additionally profit from CS pop-ups.
Furthermore, indications were found that elderly people can be reached more easily through CS pop-ups. For further CS pop-up initiatives, it is recommended to also use edutainment approaches for conveying knowledge, as participants stated that they enjoyed learning in an entertaining manner through the comics. This insight corresponds to the results of Kumaraguru's et al.'s studies [122, 123, 124, 125, 126, 127, 128].

Due to the limited amount of conducted research on pop-up activities [34, p. 2, 33], this work can only be compared to previous work to a limited extent, especially as experience, acceptance, and knowledge transfer had not been systematically researched with respect to pop-up activities. Nevertheless, related work of pop-up activities showed that large companies [11], libraries [14], entire pop-up villages [15], and educational healthcare pop-ups [31, 32, 97] can use the pop-up concept successfully regarding their use

case.
All in all, this work sheds light on the development and usage of pop-ups as measures for educating society and employees on societally important CS knowledge. It is shown that the pop-up method can be successfully applied towards CS education regarding experience, acceptance, and knowledge transfer in free time as well as working time settings. Furthermore, this work demonstrates that educational CS pop-ups are suitable to a wide society with diverse demographic backgrounds, especially to underrepresented groups in STEM fields such as females. Indications are found that certain society groups such as the elderly, can be reached more easily through pop-ups compared to online trainings. These findings and indications make an important contribution to clarifying and encouraging the successful application of the pop-up concept as measures in CS education for society and working places. Also, the two prizes which were awarded to this work support the successful use and acceptance of CS pop-up education. Finally, this work laid foundations for further research of the pop-up concept in CS education.

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Appendix

A. Study A – Requirements Elicitation

A.1. Online Survey

Table A.1.: Quantitative questions – study A

Category	No.	Question
attitude	9.	I feel sufficiently informed about current computer science topics in society.
attitude	10.	I can easily hold conversations related to computer science with family, friends, and colleagues (e.g. discussing about autonomous driving).
attitude	11.	If I see discussions related to computer science in media (e.g. political talk show), I can follow them.
attitude	12.	I inform myself regularly regarding current computer science topics in society.
attitude	13.	It is easy for me to keep up with the fast pace of technical development.
attitude	14.	I am looking forward to a future with new technical developments.
attitude	15.	I am a technically interested person.
topics	18.	Are you familiar with the following terms? (yes/no) List of topics: artificial intelligence / machine learning, robotics, information security / hacking, autonomous driving, virtual / augmented / mixed reality, brain-computer interfaces, internet of things / smart home and cities, blockchain / cryptocurrencies, quantum computing, 4D printing, cyborgs (microchip implants, prostheses), drones, remote communication, social media.
topics	19.	How interested are you in these topics? (Same list of topics as in the question above)

Table A.2.: Qualitative questions – study A

Category	No.	Question
attitude, topics, fields	1.	What is the first thing that comes to your mind, when you think of computer science?
topics, fields	2.	What applications or technologies are you thinking of thereby?
topics, fields	3.	In which application areas do you think computer science is most useful?
attitude, topics, fields	4.	How do you envision the future in 20 years? What technologies do you think we will use?
attitude, topics, fields	5.	What benefits do you see from using computer science?
attitude, topics, fields	6.	What are you looking forward to in the future regarding computer science and its applications?
attitude, topics, fields	7.	What drawbacks do you see from using computer science?
attitude, topics, fields	8.	What concerns do you have for a future with computer science and its applications?
attitude	16.	How do you inform yourself about current computer science topics which impact society?
topics, fields	17.	In which areas do you see a need for more computer science knowledge in society?
topics, fields	20.	In which other technologies and computer science applications are you interested in? Please give a brief explanation.

A.2. Qualitative Content Analysis

Overview of Deductive Codes

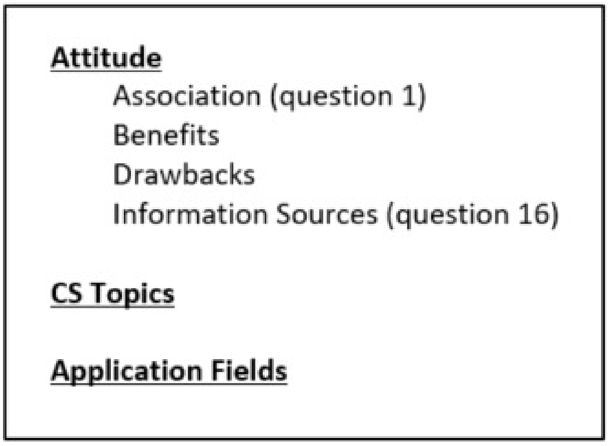


Figure A.1.: Deductive codes of the content analysis

Codebook

Table A.3.: Codebook – study A. Deductive codes are bold; all other codes are inductive.

Code	Description	Examples
Attitude		
Association	Participants' first association with computer science (question 1).	
Computer / maths / programming	This code will be assigned when participants' first association was regarding computer, maths or programming.	Numbers, maths, algorithms, computers, programming
Data / information	This code will be assigned when participants' first association was regarding data, data processing, data analysis, information, or digitalization.	Data, data storage digitalization, information, information processing

Stereotype	This code will be assigned when participants' first association were computer science stereotypes.	Nerds, people sitting in cellar, men, wearing slipover
People they know	This code will be assigned when participants' first association was with respect to a person they know.	My boss, my partner, my son's project, friends
In their education	This code will be assigned when participants' first association was with respect to their education.	Subject during studies
Benefits	Benefits of using computer science stated by participants.	
More efficiency / simplifies work and life	This code will be assigned when participants stated more efficiency or that computer science simplifies work or life.	More efficient working, time saving, faster processes, simplifies working, access form any place, minimising mistakes, programs which simplify life, fast way to get information
Progress / future-proof	This code will be assigned when participants stated progress or future-proof related terms.	Progress, future-proof, economic growth, gaining knowledge, globalization, constant innovations
Social benefits	This code will be assigned when participants stated social benefits.	Staying in touch with others remotely, multi-optional society, replaces missing labour, less working load on people, less dangerous work
Drawbacks	Drawbacks of using computer science stated by participants.	

Complex / fast moving	This code will be assigned when participants stated complexity, fast moving technical pace, or related terms.	You need to know more to use computers, everything gets faster, fast-paced, complicated, very complex, confusion, stressful, something I do not understand
Social issues	This code will be assigned when participants stated social issues.	Escaping in a virtual world, loss of reality, humanity and feelings get lost, always available, loneliness
Data privacy / security issues	This code will be assigned when participants stated data and privacy issues.	Data privacy, virus, exploitation through criminals, information security, surveillance
Dependency / loss of control	This code will be assigned when participants stated being dependent on computer science or dependency related terms.	Dependence, hand responsibility over, energy and a device is always needed, no access to data during blackouts, loss of control
Job issues	This code will be assigned when participants stated job issues.	Unemployment, loss of jobs, fewer jobs
No drawbacks	This code will be assigned when participants stated that they do not see any drawbacks in using computer science.	None
Information Sources	How / through which medium participants inform themselves about current computer science topics (question 16).	
Internet / social media	This code will be assigned when participants stated that they inform themselves through the internet in general, social media, special websites, or social media platforms.	Internet, social media, Facebook, Google, YouTube

Newspaper / magazines	This code will be assigned when participants stated that they inform themselves through newspapers, magazines, special newspapers, or websites of newspapers.	Newspapers, magazines, sueddeutsche.de, print media, Frankfurter Allgemeine Zeitung (FAZ)
News	This code will be assigned when participants stated that they inform themselves through news or special news shows.	News, Tagesschau
Family / friends / colleagues	This code will be assigned when participants stated that they inform themselves through other people they know.	Friends, colleagues, husband, boyfriend, conversations with other people
TV	This code will be assigned when participants stated that they inform themselves through television.	TV, TV programs, TV documentary
Employer / university	This code will be assigned when participants stated that they inform themselves through their employer, job, or university.	University, company, job, data protection officer, employer
Technical literature	This code will be assigned when participants stated that they inform themselves through technical literature, journals, books, or websites which just discuss technical aspects.	Technical literature, journals, books, heise.de
Radio	This code will be assigned when participants stated that they inform themselves through the radio, broadcasting or podcasts.	Radio, broadcasting, podcasts

None	This code will be assigned when participants stated that they do not inform themselves.	Not at all, nowhere
CS Topics	CS topics / technologies stated by participants.	
Software / hardware	This code will be assigned when special software, programming, programming languages, hardware, or software in general was stated by participants.	Hardware, Arduino, smartphone, tablet, software, programming, apps, excel, java, python
Information security / hacking	This code will be assigned when information security, privacy, surveillance, hacking, or related information security terms were stated by participants.	Data protection, hacking, surveillance, secure communication, risks and weaknesses of devices
Autonomous driving	This code will be assigned when autonomous driving, self-driving cars, cars, or related terms were stated by participants.	Driving, autonomous driving, self-driving cars, cars, automotive
Artificial intelligence / machine learning	This code will be assigned when artificial intelligence, machine learning, or applications which use these technologies were stated by participants.	Artificial intelligence, intelligence, AI, ML, motion-tracking, deep learning, image and face recognition, voice control
Internet	This code will be assigned when internet, www, or other related internet terms were stated by participants.	Internet, www, online marketing, Google, search engines, websites
Remote communication	This code will be assigned when communication or communication tools were stated by participants.	Communication, office communication, zoom, emails

Internet of things / smart home / smart cities	This code will be assigned when internet of things (IoT), smart home, smart cities, or products which are used in smart homes were stated by participants.	IoT, smart home, kitchen appliances, building trade, cities, communities, government, urban planning, household
Maths / statistics / data analysis	This code will be assigned when maths, statistics, data analysis, or related terms were stated by participants.	Statistics, data, calculations, data analysis, big data
Robotics	This code will be assigned when robots, robotics, or special robots were stated by participants.	Robots, robotics, nanobots, Cyberknife, da Vinci Surgical System
Automation	This code will be assigned when automation or automating was stated by participants.	Automation, automating, automatic processes
Media	This code will be assigned when media or media related terms were stated by participants.	Media and its impact on society, targeting, social media
Drones	This code will be assigned when drones was stated by participants.	Drones
Cyborgs	This code will be assigned when cyborgs, artificial limbs, or related terms were stated by participants.	cyborgs, artificial limbs
3D / 4D printing	This code will be assigned when 3D or 4D printing was stated by participants.	4D printing, 3D printing
Blockchain / cryptocurrencies	This code will be assigned when blockchain or cryptocurrencies were stated by participants.	Blockchain, digital currency

Virtual / augmented / mixed reality	This code will be assigned when virtual, augmented, or mixed reality was stated by participants.	VR, augmented reality, technology integrated in glasses
Cloud	This code will be assigned when cloud or cloud computing was stated by participants.	Clouds, cloud computing
Brain-computer interfaces	This code will be assigned when brain-computer interfaces or technologies which use it were stated by participants.	Interfaces with brain, control through thoughts
Quantum computing	This code will be assigned when quantum computing was stated by participants.	Quantum computer
Chatbots / virtual agents	This code will be assigned when chatbots or virtual agents was stated by participants.	Virtual agents
Application Fields	Application fields stated by participants.	
Medicine / healthcare	This code will be assigned when medicine, medical or healthcare terms were stated by participants.	Medicine, medical technology, artificial limbs, medical doctor, hospital
Transport / logistics	This code will be assigned when transport, logistics, self-driving cars, cars, or driving related terms were stated by participants.	Hyperloop, mobility, autonomous driving, cars, logistics, e-bike, e-mobility, automotive, parcel service
Industry	This code will be assigned when industry, production, or related terms were stated by participants.	Industry 4.0, industry, production
Society / social aspects	This code will be assigned when society or social terms (negative, positive, or neutral) were stated by participants.	Media and its impact on society, humanities, opinion research, elderly, politics, cities, communities, government

Education	This code will be assigned when educational terms were stated by participants.	Concentrated knowledge, teacher, school, courses
Daily life	This code will be assigned when daily life or household related terms were stated by participants.	Daily life, household
Science / engineering	This code will be assigned when research, science, engineering, physics, chemistry, or biology related terms were stated by participants.	Science, engineering, research, chemistry, biology, mechanical engineering, bionics
Environment	This code will be assigned when environmental terms were stated by participants.	Stopping climate change and collapse of world, green energy, renewable energy, use of energy, oil, gas
Administration	This code will be assigned when administration or related terms were stated by participants.	SAP systems, effective administration, digital accounting, planning support, public service
Economics	This code will be assigned when economics or related terms were stated by participants.	Economics, commerce, purchase behaviour, personalised advertisement
Finance	This code will be assigned when finance, banking, or money related terms were stated by participants.	Financial technology, digital currencies, banks, account balance
Entertainment / leisure	This code will be assigned when entertainment, leisure, or related terms were stated by participants.	Entertainment, leisure, more free time, fun
Gaming	This code will be assigned when gaming or video games were stated by participants.	Gaming, video games, games I can play with my friends

Aerospace	This code will be assigned when aerospace terms were stated by participants.	Aerospace, outer space
Military	This code will be assigned when military related terms were stated by participants.	Armament, Bundeswehr, war weapons
Arts	This code will be assigned when art related terms were stated by participants.	Artistic aspects

B. Study B – Development and Evaluation of the CS Pop-Up Initiative

B.1. Material – Comics German Version (Used in Study)

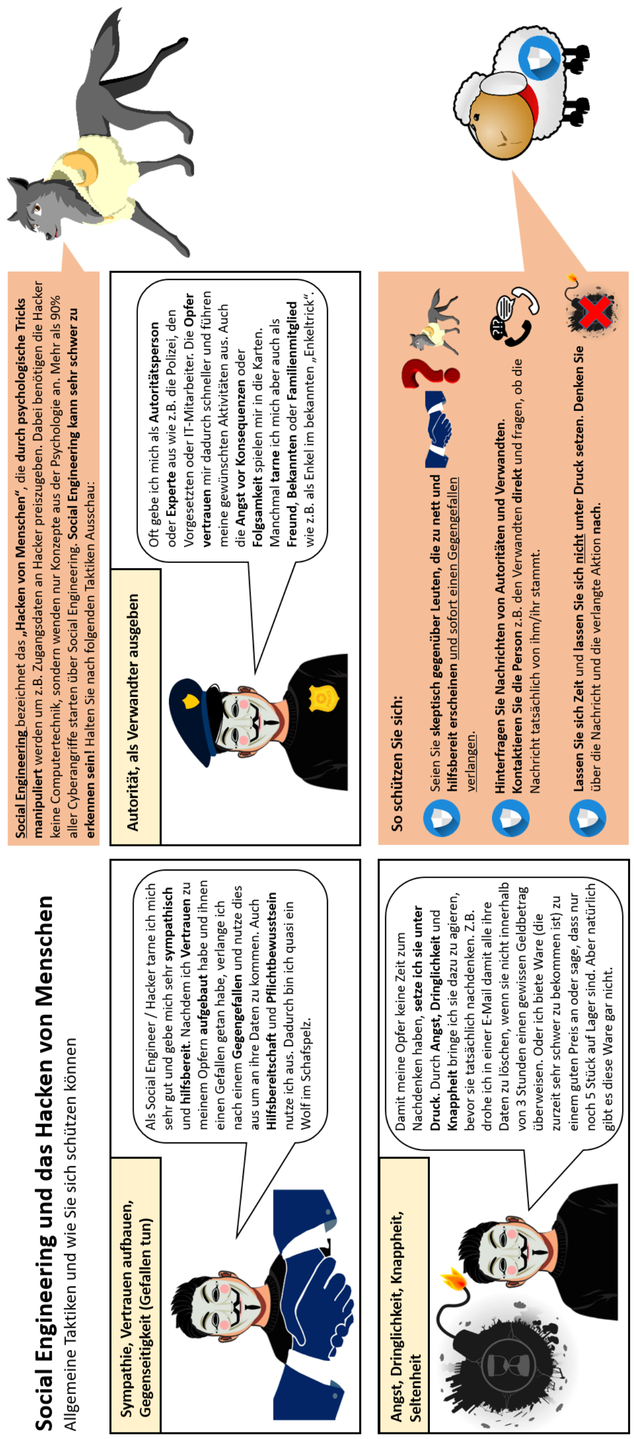


Figure B.1.: General social engineering tactics comic – German version

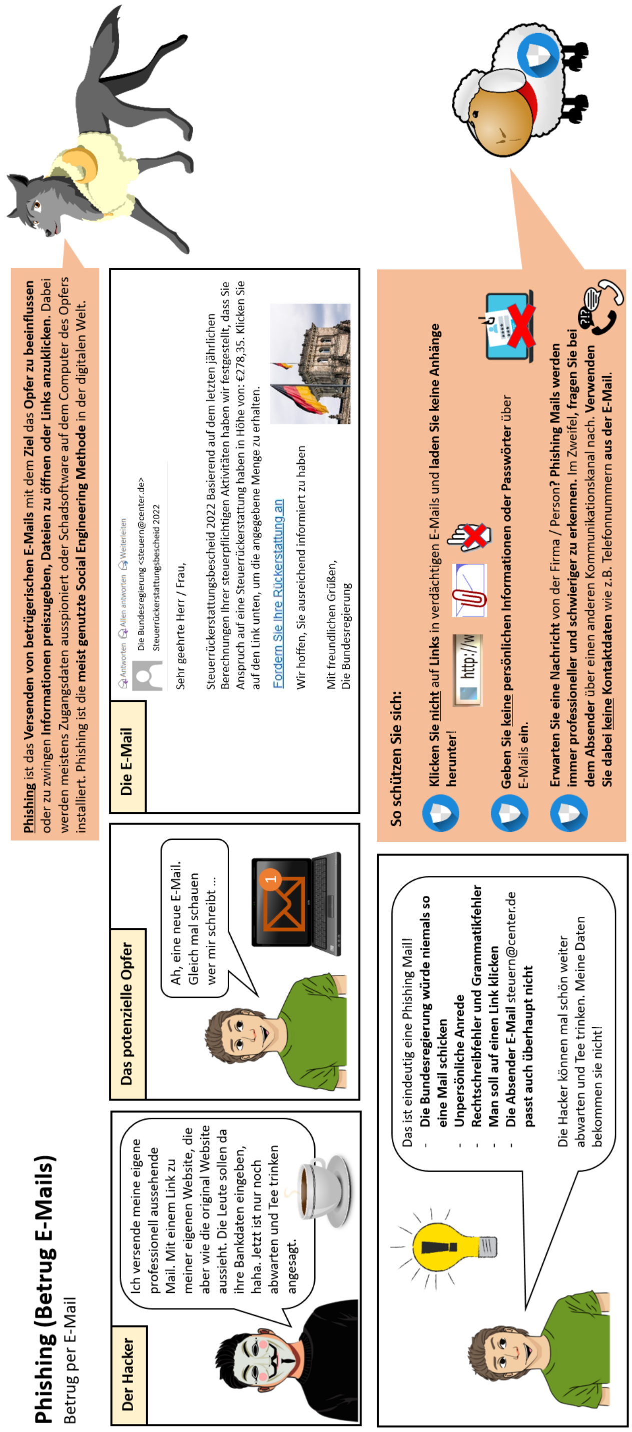


Figure B.2.: Phishing comic – German version

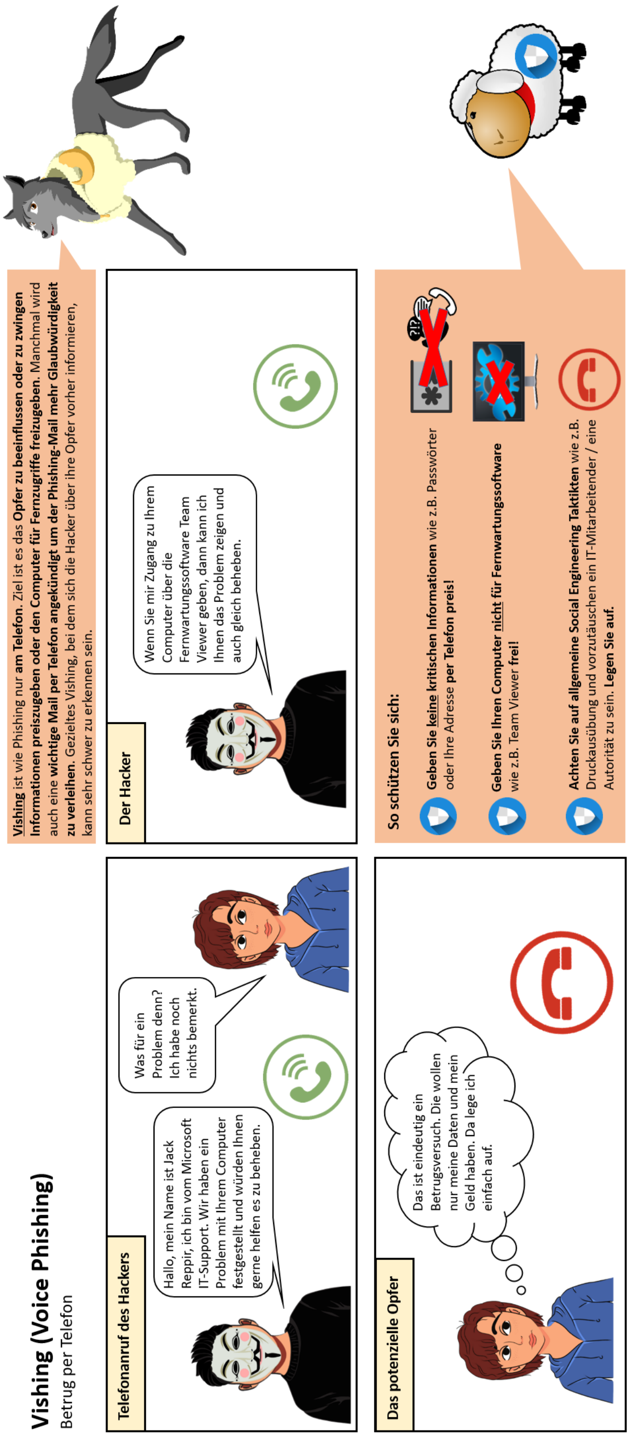


Figure B.3.: Vishing comic – German version

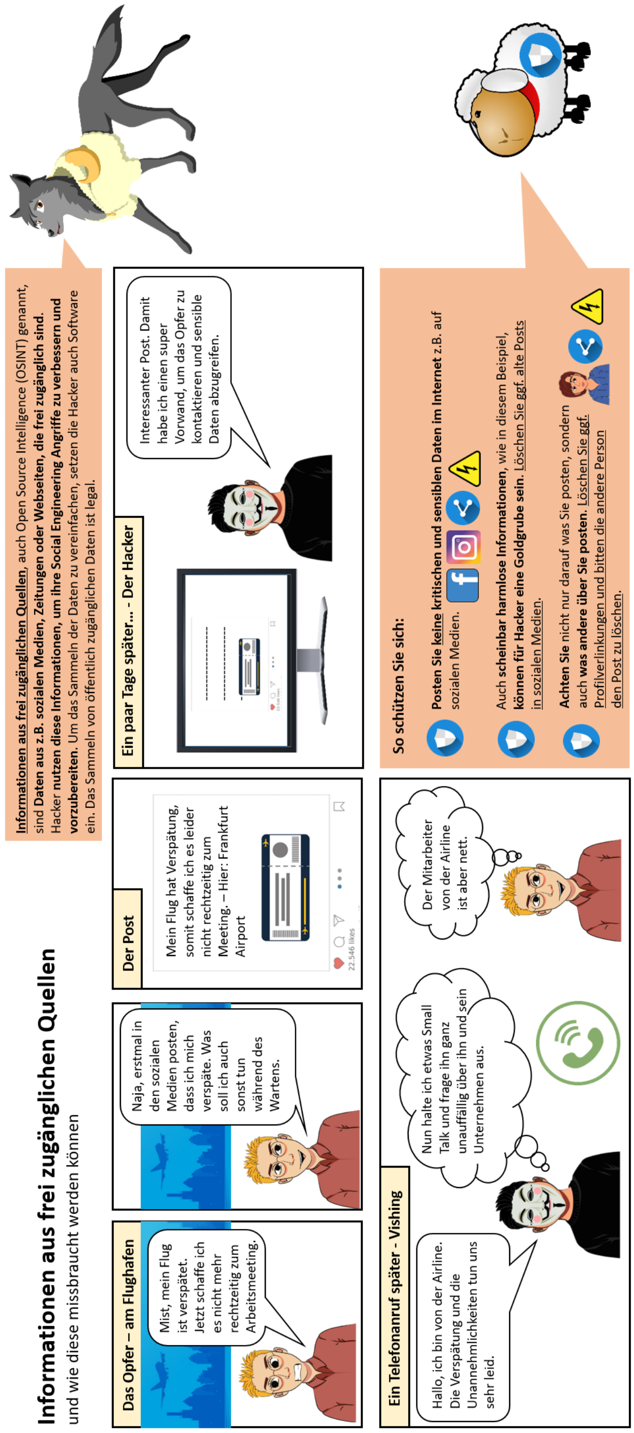


Figure B.4.: Open source intelligence comic – German version

B.2. Material – Comics English Version (Translation of German Comics)

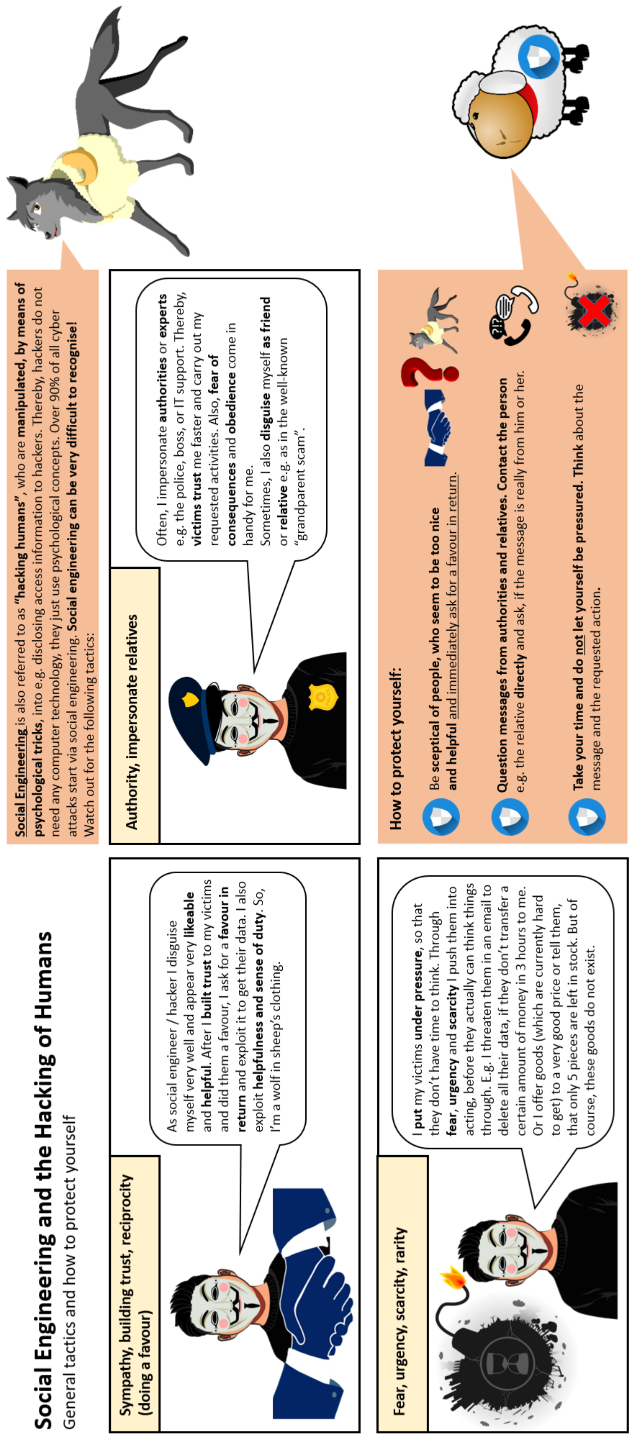


Figure B.5.: General social engineering tactics comic – translated

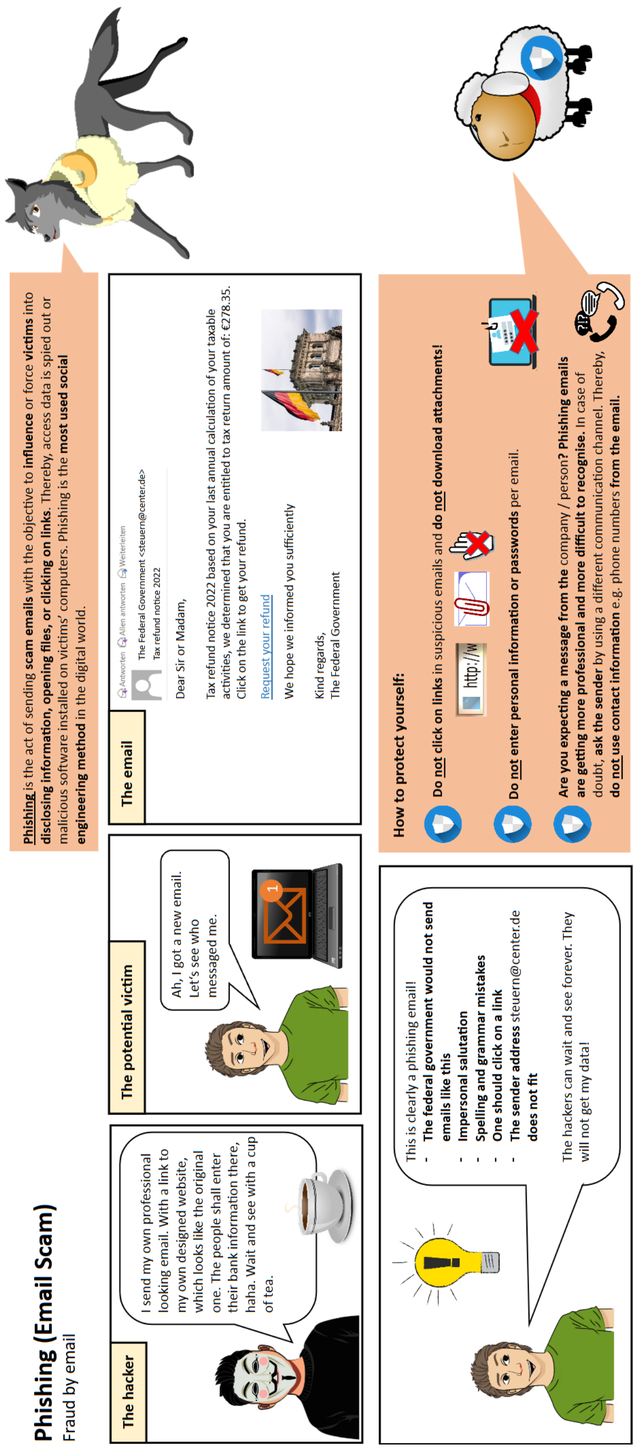


Figure B.6.: Phishing comic – translated

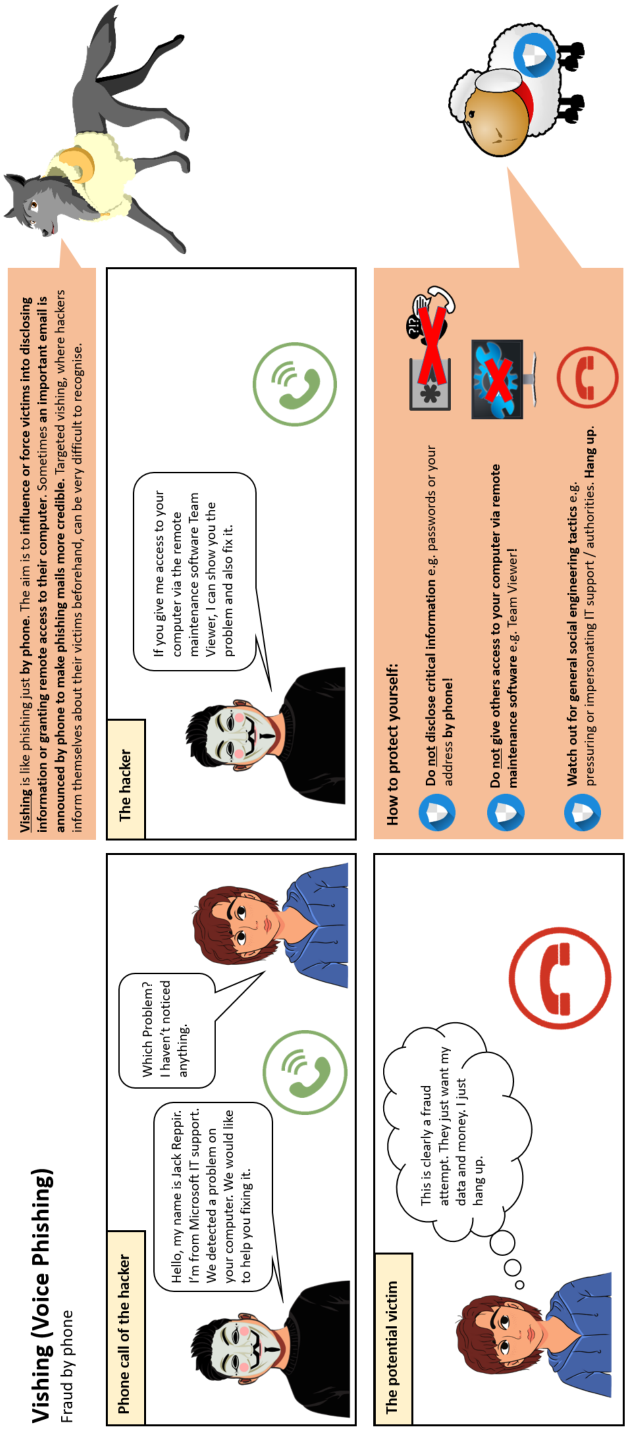


Figure B.7.: Vishing comic – translated

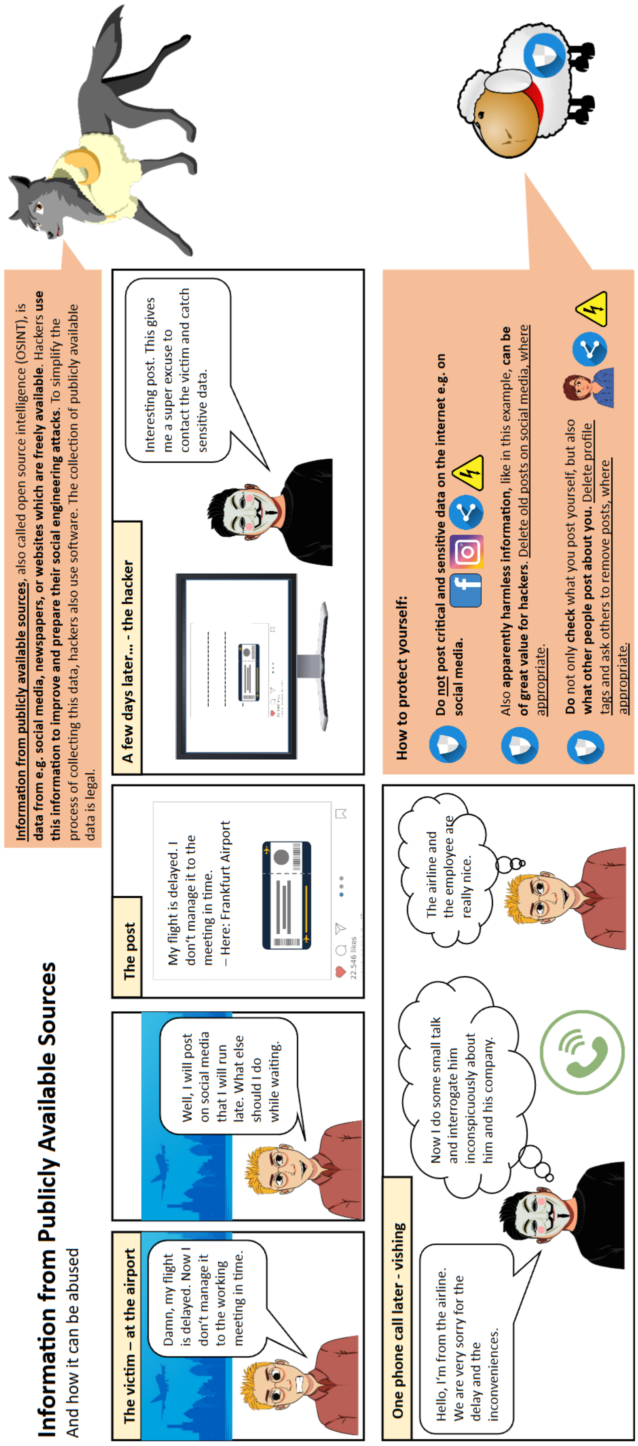


Figure B.8.: Open source intelligence comic – translated

B.3. Short Version of the User Experience Questionnaire (UEQ-S)

Table B.1.: UEQ-S (The German version as used in study B is in brackets)

obstructive (hinderlich)	o o o o o o o	supportive (hilfreich)
complicated (kompliziert)	o o o o o o o	easy (einfach)
inefficient (ineffizient)	o o o o o o o	efficient (effizient)
confusing (verwirrend)	o o o o o o o	clear (verständlich)
boring (langweilig)	o o o o o o o	exciting (spannend)
not interesting (uninteressant)	o o o o o o o	interesting (interessant)
conventional (konventionell)	o o o o o o o	inventive (originell)
usual (herkömmlich)	o o o o o o o	leading edge (neuartig)

B.4. Acceptance Questionnaire

Table B.2.: Acceptance questionnaire

Perceived Usefulness (USEF)

USEF1: I have improved my information security knowledge through the pop-up stand / online training.

USEF2: I feel more enlightened about information security after participating in the pop-up stand / online training.

USEF3: I perceive information security knowledge transfer through pop-up stands / online trainings as useful for me.

Perceived Ease of Use (EOU)

EOU1: It was easy for me to learn about information security through the pop-up stand / online training.

EOU2: I could learn about information security through the pop-up stand / online training without great effort.

EOU3: I could learn about information security through the pop-up stand / online training without spending much time.

Attitude Toward Using (ATT)

ATT1: I think pop-up stands / online trainings are a good idea for learning about computer science.

ATT2: It was fun to take part in the pop-up stand / online training.

ATT3: I think the concept of pop-ups / online trainings is useful for computer science knowledge transfer.

Behavioural Intention to Use (BI)

BI1: I would use pop-up stands / online trainings of this kind further to learn about computer science.

BI2: I would recommend the pop-up stand / online training to other people.

BI3: I would also take part in pop-up stands / online trainings in my free time / at my workplace (includes university and school) to learn about computer science.

B.5. Knowledge Transfer Questionnaires

Table B.3.: Knowledge transfer questionnaire – pre-quiz

Remember (Rpre)

Rpre1: What does the term social engineering mean? (1 point)
- educating about information security
- manipulation / hacking of computers
- optimisation of cyber security vulnerabilities
- manipulation / hacking of humans (x)

Rpre2: Which communication channel does the phishing method use? (1 point)
- email (x)
- SMS
- phone
- video call

Rpre3: Which of the following terms is NOT a general social engineering tactic? (1 point)
- trust
- authority
- urgency
- antipathy (x)

Understand (Upre)

Upre1: Which of the following statements is FALSE? (1 point)

- Social engineering is widespread.
- Social engineering requires a computer and an Internet connection. (x)
- Social engineering uses multiple communication channels.
- Collecting data from publicly available sources is a step in social engineering.

Upre2: Which of the following statements is FALSE? (1 point)

- Social engineering is clearly recognisable. (x)
- Sending spam emails is a part of social engineering.
- Social engineering is punishable.
- Social engineering uses methods from psychology.

Upre3: Which of the following statements is FALSE? (1 point)

- Before using, links should be checked in emails.
- Known senders can be trusted in emails. (x)
- Internet forms should not be used via emails.
- File extensions can provide information whether an email is hazardous.

Apply (Apre)

Apre1: An old school friend, you have not heard of in a while, messages you that he just has thought about you and sends you a link to an online greeting card. (0.5 points)

- I look at the greeting card.
- I do not look at the greeting card. (x)

Apre2: You are at the airport on your way to your well-deserved holidays. You like to share your joy with your friends through a photo of you and your flight ticket. (0.5 points)

- I post it on social media.
- I do not post it on social media. (x)

Apre3: Is the following email possibly a spam email? (0.5 points, an image is shown of a phishing email pretending to be from PayPal, according to the image on the BSI website [192])

- yes (x)
- no

Table B.4.: Knowledge transfer questionnaire – post-quiz

Remember (Rpost)

Rpost1: Which social engineering method is the most used? (1 point)

- phishing (x)
- vishing
- smishing
- OSINT

Rpost2: Which of the following terms is <u>NOT</u> a social engineering tactic? (1 point)

- fear
- reciprocity
- sympathy
- joy (x)

Rpost3: Which of the following statements is <u>FALSE</u> regarding vishing? (1 point)

- Is like phishing just via video call. (x)
- Uses general social engineering tactics.
- Has the objective to spy out information.
- You should not grant access to your computer via remote maintenance software.

Understand (Upost)

Upost1: Which of the following statements is <u>FALSE</u> regarding social engineering? (1 point)

- Phishing can be made more credible through vishing.
- A technical medium is needed for social engineering. (x)
- Phishing is like vishing just with another medium.
- Publicly available data is used to improve social engineering attacks.

Upost2: Which of the following statements is <u>FALSE</u> regarding phishing? (1 point)

- Phishing mails should tempt to click on links and attachments.
- The sender email address can be used to check if it is phishing.
- Phishing emails can also contain just text (no links and no attachments).
- To check whether the message is really from the right sender, the phone number listed in the email can be called. (x)

Upost3: Which of the following statements is FALSE regarding social media use? (1 point)

- When registering, as much data as necessary and as less as possible should be provided.
- You should regularly type in your own name in search engines.
- Posting uncritical data is unproblematic. (x)
- Other people's posts can affect my privacy.

Apply (Apost)

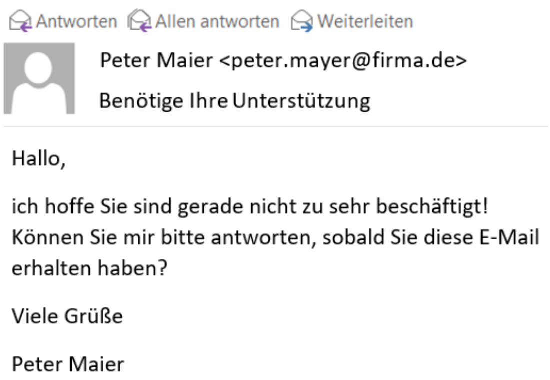
Apost1: You are very proud; you just passed your advanced training. You like to share your joy with the world through a photo of you and your certificate. (0.5 points)

- I post it on social media.
- I do not post it on social media. (x)

Apost2: You ordered a packet and expect its arrival. You receive a link via SMS for tracking your packet. (0.5 points)

- I track my packet.
- I do not track my packet. (x)

Apost3: You receive the following email from your boss Peter Maier. Is it possibly social engineering? (0.5 points, image self-designed)


Antworten Allen antworten Weiterleiten

Peter Maier <peter.mayer@firma.de>

Benötige Ihre Unterstützung

Hallo,

ich hoffe Sie sind gerade nicht zu sehr beschäftigt!
Können Sie mir bitte antworten, sobald Sie diese E-Mail erhalten haben?

Viele Grüße

Peter Maier

- yes (x)
- no

C. Newspaper Articles and Public Relations

Figure C.1.: Example of social media posts for advertising study A

Figure C.2.: Example of social media posts for advertising the online training version of study B

Table C.1.: Newspaper and online articles

Title of Article	**Type**	**Reference**
Aus den Schulen - Kaufmännische Schule Geislingen	newspaper article	[193]
Aufklärung über Datensicherheit im Germania Waldheim Kuchen	newspaper article	[194]
Phaeno Slam: Wissenschaft auf den Punkt gebracht	newspaper article	[195]
Ehemalige Abiturientin mit Dissertation zu „Datensicherheit“	online article	[196]
Lisa Keller gewinnt den phaeno Science Slam	online article	[197, 198]

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URKUNDE LISA KELLER

Erster Platz beim phaeno Science Slam am 07.09.2023.

Sehr geehrte Damen und Herren,

hiermit bestätigen wir, dass Lisa Keller von der Technische Hochschule Würzburg-Schweinfurt (THWS) / Fakultät für Informatik und Wirtschaftsinformatik und von der Universität Regensburg (UR) / Fakultät für Humanwissenschaften mit ihrem Beitrag „Pop-up Education: Social Engineering und Security Awareness - Der Wolf im Schafspelz " am 07.09.2023 den ersten Platz beim phaeno Science Slam belegt hat.

Mit freundlichen Grüßen

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10. Januar 2024

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phaeno – eine Initiative der Stadt Wolfsburg – dankt seinen Partnern: Volkswagen AG, Sparkasse Celle-Gifhorn-Wolfsburg, Nieders. Kultusministerium

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Figure C.3.: First place certificate, phaeno science slam, 7th September 2023

Figure C.4.: Jury award certificate, Zukunftsforum Schweinfurt 2023, 26th June 2023