Interaction Design and Architecture(s) Journal - IxD&A, N.29, 2016, pp. 136-158

People lining up to use a cool new gadget in the city? Surprise and variety in technology appropriation of multipurpose public displays

Leena Ventä-Olkkonen[1], Netta Iivari[1], Arto Lanamäki[1], Marko Jurmu[2], Hannu Kukka[2], Kari Kuutti[1],

[1] INTERACT Research Unit / [2] Center for Ubiquitous Computing,
Faculty of Information Technology and Electrical Engineering (ITEE),
Pentti Kaiteran katu 1, 90014 Oulu, Finland
{firstname.lastname}@oulu.fi

Abstract. People have always used tools and technologies creatively. Technology appropriation concerns on how users adopt technologies for personal purposes. In this paper, we review the appropriation literature and explicate four varieties of this concept. Then we explore these varieties in the empirical setting of a citywide network of multipurpose interactive public displays. This network was designed to support communication among a multitude of people for a variety of purposes. We show how people used this technology in ways not captured in original design. The analysis retrospectively examines cases of appropriation of different themes. We particularly concentrate on surprising "unfaithful" appropriation and discuss unanticipated users, usages, circumstances, and design for the unanticipated. Our contribution is the scrutiny of the varieties of the appropriation concept, showing these varieties in the setting of public displays in an urban space.

Keywords: appropriation, public displays, urban technologies.

1 Introduction

Appropriation research has been vibrant in fields related to information technology since 1990's. In these various fields, appropriation has different meanings but it focuses largely on how an individual adapts technologies in use. In this paper, we elaborate three different appropriation interpretations by first introducing appropriation "themes" through a literature review and then by examples of each theme.

Technology is usually designed for certain purposes, but possibilities exist for using it differently. To study the appropriation of technologies is to study use that "has changed, evolved or developed beyond the original design" [13]. In other words, appropriation places the focus on "whether people conform to or deviate from designers' perceptions of how the technology should be used" [28, pp. 6–7]. For limited-purpose artifacts such as ATM machines, studying appropriation may not lead to surprising findings. The value of appropriation research increases for artifacts that

are meant to serve multiple types of users, uses, and contexts [44]. For example, when designing open ubiquitous computing technologies for public environments, anticipating future users, usages, and circumstances is difficult or even impossible.

Our study concentrated on this type of technology development endeavor. We investigated a research project that included 18 interactive multipurpose public displays implemented around a city. After seven years of existence, we retrospectively examined the appropriation of these displays, or the lack thereof. In this paper, we concentrate on the "unanticipated" appropriation that surprised the developer-designers.

How ubiquitous computing technologies are integrated into people's everyday practices has been studied during recent years within the ubiquitous-computing community. A few public display networks have been established for enabling in-the-wild research (e.g. Lancaster eCampus, Photo Wray display, UBI Oulu, Screens in the Wild) [15, 36, 7, 31]. While "in the wild" [41] and practice-oriented [21, 26] studies have been called for to understand how ubiquitous urban technology becomes integrated into the everyday life of people, not much empirical work has been reported yet. So far, public display appropriation and practices have been studied either in relatively short-term installations [20, 7, 31] or the studies have concentrated more on non-appropriation instead of appropriation [52]. Memarovic studied emergent practices with a situated snapshot application in public display during 12 weeks of observational study at the beginning of the deployment [31]. Fortin and her colleagues studied appropriation of a media facade installation called Mégaphone during a 10-week installation [14]. Jurmu et al. took a different perspective on appropriation by studying how non-moderated community displays are tailored and adapted by a community of users [20]. Ylipulli et al. studied the appropriation process in two public infrastructures of UBI Oulu: public WiFi and a network of multipurpose public displays. Their studies concentrated on how technologies are integrated into people's daily practices. They revealed some reasons that led to non-appropriation of the displays [52]. None of these studies, however, investigated public display use practices and variety of appropriation around long lasting public display installation. Neither did any of these studies critically examine the variety of appropriation concepts in the literature. This study fills that void. In addition, this study responds to the recent call to study the unexpected in technology appropriation [49]. It shows that there is much creativity and that the element of surprise is intertwined with the design of technology. Unanticipated and surprising users, usages, and circumstances emerged in our empirical analysis.

The empirical study for this paper was conducted around 18 interactive multipurpose public displays that are part of the UBI (UrBan Interactions) Oulu research program [50]. The project is an initiative among the university, municipality, and business partners; it provides services for citizens and enhances the communication between city dwellers and the municipality. The core of the project is a network of interactive public displays, deployed at pivotal indoor (sports centers, library, educational institutions) and outdoor (pedestrian streets, market square) locations around the city [36]. The network has been in existence since 2009; it therefore offers a fertile site to study technology appropriation or the lack thereof.

2 Appropriation

While technologies are often designed for specific purposes, possibilities exist to use them otherwise. The process by which people integrate new technologies into their existing practices can be called appropriation. Appropriation can mean fitting technologies into existing practices or evolving new ones [11].

Appropriation has been studied since 1990's in technology-oriented research fields [44]. During those years, several interpretations of appropriation have emerged in the literature. Researchers have highlighted various aspects, for instance: invention of new use purposes [10, 11], improvisation [6], customization and adaptation [40], integrating into existing practice [2], and making the technology one's own [45, 46]. Common to all appropriation interpretations, however, are that 1) users are seen as active actors who adapt technologies for their own purposes, 2) the focus is on changes in technology use, which concern either integrating technology into existing practices or inventing uses that differ from common use patterns, and 3) appropriation is seen both as the process of evolving technology related practices and as the outcome of emerged uses [44]. There are, however, different approaches to appropriation in the literature and they will be discussed next.

2.1 Designers' anticipated purpose

Especially in the field of human-computer interaction, appropriation has been seen as user's ability to invent new purposes for use. The assumption is that technologies were designed for specific purposes and the question is whether users use the systems for those purposes in anticipated manners, or whether they find novel, unexpected uses [10, 11, 22]. A recent interpretation of appropriation, representing the "designer's purpose" approach, was demonstrated by Flint and Turner [13], who see appropriation as "active purposive exploitation of the affordances offered by the technology" and as a "natural consequence of this enactive use" [13, pp. 41]. These uses which differ from designers' anticipated purpose, also called as "behavioral adaptations" [34], have been studied [44, 43, 22]. In addition, unexpected users may also be surprising from the developer's perspective [41].

In organizational studies, especially in adaptive structuration theory, technology is seen to include structural features as well as the spirit, which is the intended use of the technology [9]. The spirit of technology guides the user's behavior and use patterns. The users either follow the designers' intentions and spirit, or use technology in ways inconsistent with its spirit. Poole and DeSanctis [9] call the use that is in line with the designers' intended use as *faithful* appropriation and the use that differs as *unfaithful* appropriation. Orlikowski [38] takes a more neutral viewpoint to technology structuration in the sense that she calls the faithful appropriation as *design mode* and unfaithful as the *use mode* professing also the possible benefits of the unintended appropriation [38].

Many studies on appropriation focus on repurposing technology. This view could be characterized as a "readymade" approach; it takes something as it is, but brings a new context or purpose to it.

2.2 Purpose-in-context

The previous section introduced branches of appropriation studies, which highlight the relationship between designers' intentions and actual use. Another approach to study appropriation is to focus on the *process of technology use becoming embedded within existing social practice* [11]. These studies draw from the framework of social construction of technology [44]. Appropriation includes activities that are necessary to "make technology work," such as adopting and restructuring work processes and environment [44, 2]. For example, Bødker and Christiansen studied appropriation of smartphone applications from this perspective [5].

A viewpoint to appropriation that can also be located within this approach studies it through the framework of *domestication*: how one makes technology one's own. Domestication research takes both functional and symbolic perspectives on technology. [45, 46]. Technology embedded into existing practices and routines becomes familiar and personal. Domestication research studies the process of technology becoming embedded into the local context of use, so that it becomes nearly invisible in people's daily routines [45, 46]. The core questions are: what do the technologies and services mean to people, how do people experience technology, and what roles can these technologies play in our lives [16, 17]. Three main dimensions of technology domestication are: **practical**, which highlights the construction of artifact-related practices (e.g. routines); **symbolic**, which stresses the construction of the meaning and role that the artifact has; and **cognitive**, which highlights the processes related to learning the practices and their meaning [46].

If the domestication process is successful, technology increasingly becomes an integral part of everyday life, although sometimes technologies refuse to be tamed. People confront technologies and either work out how to fit them into their everyday routines (adoption) or reject them (non-adoption) [17]. Technological artifacts are rarely domesticated fully and re- and de-domestication can occur, too [4].

2.3. Customization

An alternative approach to readymade appropriation is to study appropriation as customization: users intentionally modify technology to make it more suitable for their needs. This behavior can be anticipated and encouraged by developers and designers by making systems adaptable. [40]. Users can be classified according to their adaptation skills and willingness to do so [3, 29, 39]. As users differ in technological skills and eagerness to experiment with novel technological artifacts, they can be classified into three groups: workers, thinkers, and programmers. The last group is obviously most capable of tailoring technologies to suit their own purposes [30]. In addition, some modifications may be performed by users to systems that are not specifically designed to be modified by users. Appropriation in this sense can also emerge without the designer's special support for it [40].

2.4. Summary / Framework

On the basis of the described appropriation concepts, we formed a framework of appropriation types. Its variables are 1) whether the object is used for the designer's anticipated purpose versus for user's unanticipated purpose, 2) whether the object is used as readymade or is customized by the user, and 3) whether the object is integrated into users existing practices or whether the object stimulates a new practice. This framework will be utilized to make sense of technology appropriation in the case involved in this study.

	WHY?	HOW?	ON WHAT CONSEQUENCE?
	Designer's anticipated purpose	**User's unanticipated purpose**	**Practices with the product**
Ready-made	The user uses the product for the designer's anticipated purpose without customization.	User uses the designed product for purposes other than the designer's anticipated purpose without customization.	The product becomes part of user's existing practices
Custo-mized	User uses the product for designed purpose, but makes customizations.	User uses the product for other purposes and makes customizations.	The product stimulates a new practice

Figure 1. Summative framework of the varieties of appropriation.

3 Research methods

This section introduces the UBI Oulu case and the methods used for acquiring and analyzing the data. Overall, this study provided a retrospective reflection on the UBI Oulu research program (in a manner similar to, e.g., [8, 15, 19, and 48]), where the selection of research material was guided by our analytic interest in appropriation and specifically "unfaithful" appropriation. Such appropriation includes unanticipated users, usages, circumstances, and design for the unanticipated. The selection was data driven and based on the authors' collaborative consideration. Data concerning four specific displays was analyzed, as was some research material related to the overall UBI Oulu program.

3.1 Case UBI Oulu

The empirical study was conducted in the city of Oulu in northern Finland, where a public display network called "Open UBI Oulu" was launched in 2009. UBI Oulu is an initiative of a local university and the municipality; its purpose was to offer services to citizens and to enable ubiquitous computing studies "in the wild" of urban

environments [41]. The network consists of 18 large interactive multipurpose public displays situated around the city, either outdoors (in the streets and squares) or indoors (in the public library, sports centers, and schools) (see figures 2 and 3). The displays are similar to each other, except for the library display, which has location-specific services. They contain a variety of services, including news, weather information, art installations, games, and advertisements to serve tourists and local residents [52]. Our study, spanning 7 years as of this writing, offers a unique opportunity to examine technology appropriation or the lack thereof.

The outdoor displays and some of the indoor displays are double-sided 57-inch screens and have full HD LCD panels, touch-screen foil, control computer, local hard drive, two cameras, NCF/RFID reader, and loudspeaker. Most indoor displays are single-sided, but are otherwise similarly equipped. The displays include two display modes: interactive for services and advertising for a rotating playlist of full-screen advertisements and notifications. Touching the display surface activates the interactive mode, which consists of various non-profit services such as news, weather, bus timetables, games, and art installations [cf. 24, 36].

The display network offers a variety of means and tools for communication; most of these are provided by the municipality or advertisers to inform residents but others enable residents to communicate with the municipality [18] or among themselves [36]. Overall, communication support is significant in this infrastructure, which offers a channel for presenting visual information and has enabled commercial and informative communication for years in busy locations [50]. Studying the appropriation of these displays may reveal a variety of ways that communication has been enabled by novel technology.

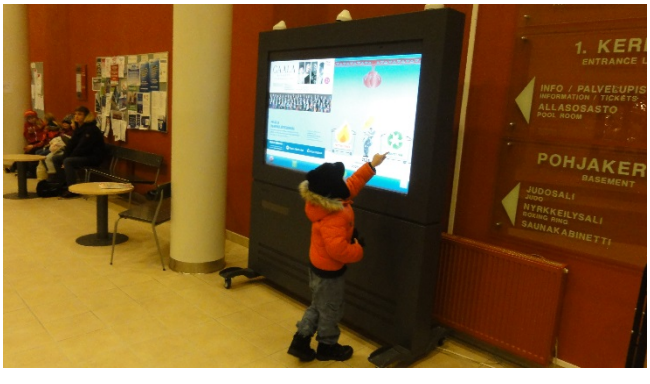

Figure 2. UBI display at swimming center entrance hall.

In addition to the 18 public displays, a lighter and mobile version of an indoor public display has been used in some on-campus studies. These displays have run either the UBI display user interface or a user interface that was customized or purpose-built for the study in question.

3.2 Displays, data collection, material and analysis

We studied different types of appropriation around the interactive public displays. The empirical material of the study comes from five main sources: I) display developers, II) display users, III) usage logs, IV) process data, and V) community display users. The process data refers to "stories about what happened and who did what when—that is, events, activities, and choices ordered over time" [27, pp. 692]—that has been gathered unsystematically from various sources during the project. Although the display network consists of 18 displays, we took a closer look at only four of them. One of these represent a high-use display within the network according to the log data (see Table 1), two of them provide novel insights into their display appropriation according to the process data. Moreover, we examined one (high-use) lightweight on-campus display. This display and study also allowed us to pinpoint a novel angle concerning the variety of forms that appropriation can take around such displays. In addition, we also examined the whole display network as an entity.

Table 1. Public displays in this study. Usage logs of the displays between 17.4 and 16.10.2015.

Display	Location	Description	Clicks/day
Swimming center	Indoors, lobby of a swimming/ sports center	1-sided display. Display at the center of the space. All-age visitors at the space throughout the year.	289
Ritaharju school, north & south side	Indoors, lobby of an elementary school in connection with a youth center	2-sided display. Especially used on school days. Mostly school pupils 7–15 years old occupied the space.	North: 33 South: 34
Rotuaari	Outdoors, center of the city, pedestrian street	2- sided displays located at pedestrian zone at the center of the city, close to shops, cafeterias, and restaurants.	East: 11 West: 1
Community display	Indoors, university, guild room	1-sided lightweight display. semi-public space, non-moderated display, customized content, especially designed for communication.	Approx. 215

I) UBI display designer/developers. The first part of the research data consists of *in-depth-interviews* with seven informants who had distinctive roles in the design and development of the display network. The interviews were semi-structured and supported with the so-called "timeline method," in which interviewees were asked to draw a timeline of the project stages, including highlights and other events from their own perspective [cf. 1]. Each interview lasted 1–2 hours. One of the participants was interviewed twice. All of the interviews were conducted by two researchers. All interview material was transcribed prior to analysis.

II) UBI display users. The second part of the data was acquired through an ethnographic field study conducted around a display located at an entrance hall of a swimming center. Data was also acquired through theme interviews around the swimming center and Ritaharju school displays (see tables 1 and 2). According to the

usage log statistics (see Table 1), the swimming center display was consistently used most frequently. This suggested a good possibility for finding recurrent use practices around it. For this reason, we decided to focus our research on this particular display. The data consists of 55 hours of *observation and field notes*, and video recordings. In addition, data includes 38 *field interviews* with 43 display users and their parents, and 3 interviews with swimming center workers who worked near the display and observed it regularly.

In addition, we wanted to examine the appropriation of public displays in a versatile and holistic manner. We therefore carried out *theme interviews*. We were able to recruit four swimming center UBI display users and five UBI display users from Ritaharju school (see table 2). The school display also represented a relatively frequently used display. The theme interviews lasted 30–60 minutes and the interview questions were inspired by domestication [46, 45] and practice theories [35]. For example, the following questions were part of the interview script: *How often do you use the display? How long do you use the display at a time? When or in what kind of situations do you usually use the display? Do you use the display alone or with someone else? What do you like and what do you dislike about the displays? Do you consider using the display as cool or embarrassing? (For parents) What meaning does the display have for you as a parent of a child?*

III) Usage logs. The third data source utilized was the displays' usage logs. The UBI display system records user information such as faces detected and number of clicks by each display. Part of the data is openly available on the Web[1]. We utilized information about the number of clicks on the screen surface of each display and the number of different application launches at the swimming center display. This quantitative data was used to support our qualitative findings.

IV) Process data. The process data included anecdotal evidence collected by the researchers during maintenance visits in the field as well as informal observations. This data enabled us to pinpoint novel findings on appropriation in public display use.

V) Community display users. This data was collected in the context of a student guild room at a university. It consisted of 20 pre-study interviews and observations. Pre-study interviews charted existing communication practices and discussed the possible role for an "interactive public display that could tie the heterogeneous communication practices together" [20]. This was followed by a 3-week experiment with a tailorable non-moderated community display; it was designed to meet the communication needs of the student community. The collected data included usage logs, related discussions at the students' IRC channel, and semi-structured interviews with guild members. This material was analyzed by the thematic analysis method, in which emerging themes of use were classified as practices (findings elaborated e.g. in [20]).

[1] http://vm0031.virtues.fi/ubistats/

Table 2. Materials, displays in focus, analysis methods, and rationale categorized by each appropriation theme.

Appropriation theme	Data source	Display in focus	Analysis	Rationale
#1 designers' purpose vs. users' actual practices	#1 Seven developer interviews	The entire display network	Coding according to pre-set goals (designers visions)	For understanding the designers original intentions and anticipations
	#3 Usage log statistics	The entire display network & Swimming center display	Comparing numbers of touches and launches of apps.	For understanding actual usage of the UBI displays and for supporting observations
	#2 User observations	Swimming center display	Observing the usage demographics and behavior	For understanding actual usage
	#2 User interviews	Swimming center display	Coding according to pre-set themes (performances/practices, dimensions, meanings)	For understanding actual usage
#2 Integrating into existing practices	#2 User observations	Swimming center display	Coding according to pre-set themes (performances/practices, dimensions, meanings)	For understanding how display usage is integrated within users practices
	#2 User interviews	Swimming center display		
	#4 Process data	Pedestrian street (Rotuaari), display	Deviations observed / reported during routine on-site visits	For understanding cases when technology was not appropriated as expected
#3 Customi-zation	#4 Process data	Ritaharju elementary school display	Deviations observed / reported during routine on-site visits	For understanding unexpected customizations
	# 5 Community display users	Guild room community display	Data driven	For understanding designing for unexpected

The above-described material (including developer interviews, user interviews and observations, process data, log data, and community display user data) was examined through the analytic lens introduced in Section 2. The analysis process was highly iterative and the analytic lens was developed along with the analysis of the empirical material. The relationships among the data sources, displays, analyses carried out, and the empirical findings on appropriation are describe in Table 2.

Overall, the empirical analysis included the following steps.

- Examining the designers' visions and anticipations of the display usage to understanding their initial goals (dataset I).
- Inquiring whether there was evidence of appropriation in the public display network (datasets II, III, IV, and V).
- Studying which approaches to appropriation (see Figure 2, themes I, II, III) could be supported by the findings.

- Focusing the analysis to unanticipated appropriation, responding to the recent call for such studies [49], resulting in the identification of unanticipated appropriation in the sense of: a) unanticipated users, b) unanticipated usages, c) unanticipated circumstances, and d) design for the unanticipated.
- Categorizing the appropriation findings into three themes: i) appropriation from the perspective of designers' intentions and users' actual practices, ii) appropriation as integrating technology into people's existing practices, and iii) appropriation as customization. We highlighted our findings on unanticipated appropriation within all these themes.

4 Findings

The first section concentrates on appropriation from the perspective of designers' intentions and users' actual practices. We present designers' original intentions and then our findings on unanticipated users and usages. We then discuss appropriation in the sense of integrating technology into people's existing practices and identify some findings on unanticipated circumstances in technology use. Finally, we approach appropriation in the sense of customization and discuss our findings concerning "design for the unanticipated," which was the subject of an experiment with one of the displays.

4.1 Theme I: Appropriation in the light of designers' purpose and users' performance

The designers' original intentions were considered in relation to users' actual performances. There was much evidence of unfaithful or unanticipated appropriation of the technology in question. These were surprising users and usages that appeared to dominate the usage logs and field study data. In first section, we concentrate on the whole display network as an entity and in the second and third sub-chapters, we focus on the swimming center display.

Designers' anticipated purpose: Focus on the whole display network. As mentioned, one of the original aims of the display project was to create a network to serve as a ubiquitous computing test bed. The main intention was to build an infrastructure to enable ubiquitous computing experiments in the wild. The developers' focus was on the technology itself and making it functional: *My view has always been that Ubi-displays are research enablers. There wasn't any one permanent vision that we do this kind of displays with these services, but the idea was that the displays are like computers with which we can do different things. (Developer #5)*

As the municipality was an important stakeholder (it provided locations and funding) [40], however, it was also crucial to find a mutual goal that would benefit the municipality and residents. The goal was to use the displays for improving

communication between residents and the city and offering various services for people in the urban context [50].

According to the users' potential information needs, various display services were designed and developed. It was expected that so-called serious services such as maps, public transportation schedules, events, and news would gain the biggest audience. Developers also expected positive reaction from the citizens: *We thought that when we put the display there, the city dwellers come self-confidently there and line up for the display and be like, "When it is my turn to use the cool new gadget?" (Developer #2)*

Unanticipated users: Focus on the display network and the swimming center display. Although the developers envisioned people lining up to the displays and their willingness to try out new technologies, people did not act like that. Usage of the displays slowly decreased after their launch [52]. Some displays, however, were popular while others were not. Certain displays gained significantly more clicks on their surface than others did (see Table 1). One of the displays was used more than the others combined [24]. This display was located at the entrance hall of the swimming center and attracted a user base who repeatedly returned and used the display regularly, thus exhibiting a high retention rate.

The designers envisioned that the displays would cater to a large and diverse user population: *"User was anybody living or visiting the city, who opportunistically come across with this kind of display and finds something interesting for him/herself." (Developer #6)* Content and services were targeted for all ages: There were games for children, media content for teenagers, and news for adults. Contrary to the original intentions, however, observations at the swimming center showed that the display users were mainly children. Table 3 shows users' (age estimated) observed behavior with the swimming center display. As seen in the table, the most frequent users seem to have been school-aged and preschool-aged children. Although children were considered as possible users in the development phase, their big role was a surprise: *The swimming hall [display have been a surprise]. I have seen crowds of children there, which use the display as game machine. We couldn't have predicted that. (Developer #6)*

Table 3. Observed number of display use sessions with each user group and session type.

User group & estimated age	Use session		Random tapping/ browsing		Watching (ads/ others using)		Playing	
	N	%	N	%	N	%	N	%
Infants 2–6 yrs	90	27,0	63	70,0	14	15,6	12	13,3
School students 7–12 yrs	142	42,6	42	29,6	19	13,4	81	57,0
Teenagers 13–17 yrs	10	3,0	6	60,0	1	10,0	3	30,0
Adults 18–70 yrs	48	14,4	9	18,8	37	77,1	2	4,2
<17 yrs users from more than one age group	18	5,4	9	50,0	1	5,6	8	44,4
Adult and a child user	23	6,9	4	17,4	3	13,0	16	69,6
Total	333	100	133	39,9	75	22,5	122	36,6

The display therefore did not support their use in the best possible way. Children, especially younger ones, had difficulties even in reaching the content, as the display was located on a pedestal. Moreover, the game menu was located at the top of the display. Children were very eager to play games on the display (see "Unanticipated usages" section). The original design did not target such a small user group. Problems in reaching the content led to various types of appropriation activities: using mittens as hand extensions, pushing chairs to use them as standing stools, and moving other furniture from the space into the front of the display to facilitate contact with it.

Unanticipated usages: Focus on the swimming center display. As described earlier, the displays were designed for many purposes, including strong support for communication. Developers anticipated that the most popular informational content would be related to maps, traffic, events, etc. After six years of deployment, however, statistics showed (see Table 4) that the most-used content type was games. Seven of the 13 most-used applications were different types of games. The popularity of a simple hangman game especially surprised the developers [cf. 36]. A surprising use of the displays was also random tapping (see Table 3), which was revealed through the user observations at the swimming center. Randomly tapping the display surface seems to have been popular among the youngest user group, partially due the reaching issues discussed above.

Table 4. The 13 most-frequently launched applications at the swimming center display between 26.2 and 31.3.2015. Games are in bold face.

Application	Total Launches	Avg/ Day
Start page	3864	117.09
Waste tower game	**1740**	**52.73**
Hangman game	**1177**	**35.67**
Martians from outer space game	**958**	**29.03**
Ubitris game	**637**	**19.30**
Wordster game	**495**	**15.00**
BelleMemory game	**416**	**12.61**
UBI Mosquitos game	**374**	**11.33**
City of Oulu	273	8.27
Hiukkavaara	267	8.09
Streetgallery	247	7.48
Whole city walks - around the world	244	7.39
Oulu university of applied sciences	238	7.21

Moreover, our empirical data shows that gaming practices around the displays was versatile. Games were used to support social communication among groups of children and for entertainment or killing time [51]. Related to gaming, another surprising indirect purpose for using the displays at the swimming center was labeled as babysitting. Parents often left their small children at the display while lining up to the cashier, parking their car, and communicating with each other, thus using the display as a babysitter [51].

4.2 Theme II: Purpose-in-context

This type of approach to appropriation emphasized the process by which technology use becomes embedded within existing social practices. Here, we were interested not the designers' intentions, but only the users' creativity. In this approach, we studied whether and how technology becomes one's own, how it is integrated into existing practices, and whether new practices evolve.

Integrating into existing practices and evolving new ones: Focus on the swimming center display. For understanding appropriation from this perspective, we utilized the concept of domestication (see Section 2.2) and looked at three dimensions: 1) artifact-related practices, 2) the meaning and role of the artifact, and 3) learning the practices.

For evolving display *practices and routines*, users had to spend time near the displays regularly. Our data concentrated on frequent visitors to the swimming center, mainly children and adolescents, who visited the swimming center on weekly or daily basis. According to our interviews, they usually had a recurring weekly practice time and spent time in the entrance hall around the UBI display before and after the training sessions. Our data shows that the interactive display became embedded into these visitor's recurrent practices at the swimming center: *"He has used the display for six times. We have had the swimming class here six times now and he has used the display during every single time". (Mother of 6-year-old).* We can say that these young people "tamed" the swimming center public display, which was once "wild." When talking about wild technology, we mean an unfamiliar or even frightening artifact separate from users' practices.

Interactive public displays might be especially wild artifacts for at least two reasons: 1) the concept is new, people do not really have anything to associate with it, and 2) they are to be used publicly in open spaces in front of everybody. For these reasons, approaching the public displays might be frightening. There is reason to believe that these factors contributed to the low usage of other UBI displays in the city center. By taming, we mean that a group of users at the swimming center became familiar with the artifact. They did not hesitate to use it when they needed it or when they felt like it. They were not afraid of embarrassment while using the artifact publicly. They used the display regularly (weekly or every time they visited), were familiar with the display's user interface and content, they knew how the display worked and had favorite games, etc. We can say that they integrated its use as a natural part of their practice of visiting the space.

At the swimming center, the display was located visibly at the center of an open space. This location is optimal from the perspective of *learning* by seeing. Groups of swimmers often gathered in front of it before their rehearsals, an observation our interviews supported. Interviews also indicated that use of the displays usually began after observing others' use. When seeing others play, users became interested and tried the display themselves. *"Others used it first and that arouse an interest and then I had to test it." (User 15 years).*

The display had different *roles* and it *meant* different things to different users and in different situations. Our data gives evidence of display practices in which the display played various roles. For example, while using the display alone, it was

treated as an entertainer, whereas while using the display with others, it was used as a supporter of social interaction. Moreover, the role of the display seems to have changed: e.g., use decreased as users got older. Adolescents seemed to prefer personal smartphones for gaming and social media when spending time alone in the space: *"When I am alone I prefer my phone but when I am with friends I prefer playing with the public display so everybody can take part." (User 19 years).*

Another role for the display came from a families' perspective when it was used as a "babysitter;" it entertained a child for a while when an adult bought tickets or chatted with some other person: *"[If the display was removed from the space] it would of course have an effect on the comfort of the children in the space. Sometimes the queues reach across the hallway, and when the adults are queueing up the children are bustling there [on the display]." (Cashier #1)* We can say that this practice emerged after the introduction of this technology. In this case, the technology therefore contributed to the emergence of new practices.

We also found evidence that emphasizes the element of surprise related to this approach to appropriation. These findings concern the perseverance of existing practices despite the installation of a display as a technological artifact. Next, we will show examples of appropriation in which people have encountered the display and integrated it into their existing practices, but with highly problematic outcomes. These occurrences emerged due to unanticipated circumstances in which the existing practices of city dwellers did not change as expected after the display was installed.

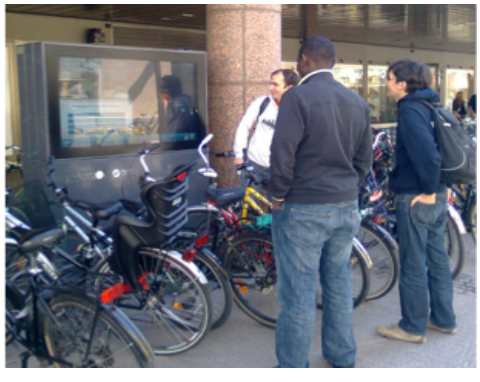

Figure 3. Example of observed emergent practices: Inhibitive practices appearing in the form of persistent bicycle parking.

Unanticipated circumstances: Focus on the Rotuaari display. These examples concern cases in which using technology did not become a practice, but the material artifact itself became integrated into existing practices. One existing practice that proved relevant from the perspective of technology appropriation was that of parking bicycles, which took place in certain locations around downtown. In summertime, certain areas of downtown feature rows of bicycles, as people bike to downtown where they continue their activities on foot. The location in this example was interesting for the city itself, as it featured parked bikes although it was not intended

as a bike-parking area and the location of parked bikes partially obstructed access to certain local businesses. When the installation of displays at selected areas was discussed with the city, this area was chosen on the premise that the display, as a visible technological artifact, would drive away the parked bikes, and thus end this unwanted practice.

After the Rotuaari display was installed, however, the bike-parking practice persisted. This meant that not only did the bikes remain within the unsolicited parking area, but also that the display itself quickly became inaccessible due to the parked bikes that consistently encircled it. As can be seen from Figure 3, three people are showing interest towards the display, but due to the parked bikes, they cannot approach it as a group. One person has inched toward the display, and is perhaps demonstrating its interactive features to the two other people. This example, as in the swimming center example, shows that social use of the display with a group of three emerges, but due to the inhibitive practice of bike parking it could not truly take place.

It is also interesting that, although signs were attached to the display stating that the parking of bikes was prohibited near it, the parking practice persisted, transforming the display into a useful bike stand, but hindering its use for other purposes.

It is as if the bike users did not see themselves as accountable to the new technological artifact. Instead, they maintained their existing (unsolicited) agency and ownership towards this particular area of downtown; they simply did not notice the interactive display as a consequence of display blindness, or they considered the display as too handy a bike stand to stop using it as such.

4.3 Customization

This type of appropriation concerns users making intentional modifications to technology to make it more suitable for their needs. The literature recommends that designers anticipate and support this type of appropriation. Next, we describe two cases in which users made modifications. The first case was not anticipated by the designers and was seen as undesirable behavior rather than appropriation. The second case presents an experiment with a community display in which customizations were expected and supported by the designers.

Unanticipated customization: Focus on the Ritaharju school display. According to the developers: "*There was positive hacking as well. Especially at the displays in the school and the swimming center where there were children." (Developer #1)*. Our first customization appropriation example concerns a display placed at a lobby area of an elementary school, where a schoolchild found a way to use the display for browsing the internet. This was not supposed to be possible with the public display and was not considered as desired behavior by the developers. Especially in the school location (but also in other public locations) controllability of the displays was important in order to avoid misuse, e.g. uploading inappropriate content or committing any sort of vandalism, which was witnessed in other locations with specific services: *As you were able to upload pictures [to a photo service in the Ubi-*

display], people of course uploaded some inappropriate content there. This led to entirely removing the application from the display system. (Developer #1)

According to a spoken report given to us by the school janitors, one of the children had started to disconnect and reconnect the UBI-display's main electrical plug during the recess periods of the school day. During the boot-up sequence caused by the power disconnection, this child observed a chance to launch a web browser instance. This child then used this additional "rogue" web browser to load certain flash-based game apps and play them during the recess break. Eventually, other children learned of this and gathered around the UBI-display to watch this one child play. This practice of manipulating the electrical plug came to our attention after it had caused a relay in the UBI-display to malfunction, prompting the janitors to contact us for maintenance. Eventually, the electric plug was covered with a metal casing, preventing the direct manipulation of the plug. After this, we no longer received reports of this kind of appropriation.

Design for unanticipated: Focus on the community display. Our final example of appropriation concerns a non-moderated community display. The community display was designed so that users could customize the content without an appointed moderator. For evaluation, the display was installed at a university student guild room, where students regularly spend time. The possibility to customize and appropriate the displays to the students' purposes was taken into account in the design phase. Several solutions for supporting display appropriation as a communication medium were implemented, including the possibility to upload pictures to the display canvas, to move and resize images through touch control, and to clear the canvas and draw on it. To better integrate with the existing practice, the community display was also associated with the guild's IRC channel.

As a result, researchers discovered many types of appropriation during the study. The display was integrated into existing community meeting and communication practices. In addition, evidence of customization appropriation was found. Users requested that a section of non-editable information be added to the display. Before the researcher reacted, users had solved the issue by "reducing the browser from the full screen state, opening additional tabs, and loading persistent materials there. Examples included the lunch menu of the week and the YouTube video service" [13, pp. 113].

5. Discussion and Conclusion

In this section, we summarize our findings, discuss their implications for research and practice. We also consider the limitations of the study, and provide interesting paths for future work.

5.1. Summary of findings

This work has shed light on the appropriation of multipurpose public displays. As the concept of appropriation is ambiguous in the literature [13], we formed a classification of appropriation and provided clarifying examples from the case of UBI Oulu public displays. In our literature review, the appropriation concepts were first divided into three categories according to their focus: 1) designers' anticipated purpose, 2) purpose-in-context, and 3) customization.

The first category highlights the difference between designers' intentions and users' actual performances. The focus is on the designer and his/her intentions and anticipations. From this viewpoint, it is necessary to understand the designers' original ideas and visions. The terminology (faithful vs. unfaithful) might suggest that appropriation that does not follow the designers' original intentions is somehow negative or unwanted, but it can also be seen as evidence of true acceptance of technology [10] and a natural consequence of enactive use [13]. Unforeseen examples can be divided into two categories: inventing new purposes for the technology and working against designer's "spirit." Examples of this sort of appropriation from our data include how parents of young children started to use the public display as a babysitter or child entertainer in difficult waiting situations, and how children started to play with the display by just tapping it randomly.

The second category concerns the integration of technology into existing social practices or the emergence of new technology-related practices. In this type of appropriation, the focus was on users and their actions. This approach expanded from technology and the use performances to wider practices and routines related to technology. We utilized the domestication concept to study this type of appropriation. The focus was also on broader issues, such as connections among practices, symbolic dimension, learning, etc. Such issues were highlighted when inquiring into frequent users' practices, interpretations, and meanings attached to public displays [cf. 51, 21].

The last category concerns users' adaptations, which may also be anticipated and enabled by designers by building tailorable systems [40]. The focus was on users' actions to make technology more suitable for their needs. To understand appropriation, it is important to study users' actions continuously, as appropriation is not something that happens just once [47]. This category differs from the previous ones in the sense that future customizations may be envisioned and supported by designers. An example related to the community of computer engineering students. During the three-week field study, the students continuously performed actions that could be classified as appropriation. For example, additional browser tabs were adapted as links for important informational content.

In this paper, we showed that appropriation happens in the sense of users using the displays for an anticipated purpose and for purposes not anticipated by designers. In addition, we showed that users used the displays as readymade technological artifacts and made their own adaptations, with or without designers' specific support. An example of an object being used in a readymade fashion for a designed purpose was that of the public displays being used for playing games in the swimming center. In this location, using the display became a practice for certain user groups. They

integrated display usage (usually gaming) into their routines and practices. They used the display for an anticipated purpose in an anticipated manner.

There were many examples of technology being used without customizations for unanticipated purpose in our data. There are examples in which the user's practical purpose was "against designer's spirit" and cases in which repurposes were more in line with the original design idea. For example, the practice of using the display for babysitting was probably not something that was anticipated, but it did not go against the original idea. Tapping randomly, uploading inappropriate content, and using the display as a bike stand, however, were not wanted practices from the designer's point of view.

5.2. Research Implications

This study explored appropriation of multipurpose interactive public display infrastructure in urban setting. In addition to empirical analysis, the study pointed out that the appropriation concept actually denotes a variety of things. The study showed that appropriation in several of the identified forms could be found in our case. This study concentrated on unanticipated appropriation, and identified unanticipated users, usages, and circumstances as well as designing for the unanticipated.

The study showed that, although display infrastructure has the potential to support communication for a variety of purposes and among a multitude of people, people appropriated only a small portion of the available functionality. Most of the appropriated functionality did not support communication, except for the community display case, in which appropriation was strongly focused on communication. Such multipurpose technology in a public urban space might enable and support communication between the municipality and residents. Previous studies also indicated that people are interested in this type of content and service [24, 25, 18, 36, 37]. In practice, however, people mostly did not appropriate the technology to meet their communication needs but instead they appropriated the technology for entertainment, time killing, socializing, and babysitting [51]. Some of those purposes nevertheless could obviously be connected with communication; socializing in a group while playing games naturally involves communication, and all the purposes involve meaning-making and signification [cf. 12]. If communication is considered as transmission of intended messages from one party to another [cf. 12], however, we must conclude that use for communication was marginal. Additionally, the user population differed from the expected demographic, as mainly children appropriated the technology and their communication needs were not studied at the beginning. Children largely did not want or could not use this technology for meeting their communication needs.

Other researchers will benefit from the discussion of the variety of forms appropriation may take. Variety and ambiguity exist in the terminology. Not all appropriation researchers mean the same thing when discussing the topic [cf. 44]. So far, the few studies that have addressed appropriation in relation to multipurpose public displays have addressed very specific forms of appropriation; they have studied it in the sense of domestication [52] or customization and adaptation [20]. We maintain that it is useful to be explicit about the differences between these

approaches. Not all research results may be comparable, even though they rely on the same terminology.

Our empirical results point out a variety of unanticipated issues that may emerge when technology is installed into a social setting (in line with [49]). Here, the technology in question was multipurpose technology and the setting was a public urban space; hence, there likely are technologies and settings with more fixed users, usages, and contextual factors. Specifically, we consider the findings useful for other researchers working with ubiquitous urban technology, but the results provide value for other settings and use cases as well. People are creative beings and technological artifacts typically have flexibility; hence, appropriation is a process that has the potential to surprise the observer, regardless of context. The integration of technology into existing social practices necessitates creativity from users and may require inventing new uses or customization of the technology to meet users' purposes better [cf. 10, 11, 40, 44].

5.3. Practical Implications

The appropriation of urban public computing technologies may have distinct features compared to other type of technologies. Our study suggests, however, that appropriation of any technologies could be supported by enabling users to make their own interpretations and customizations. When designing technologies for open use, user groups are large and diverse. Thus, it is impossible to design solutions that fit and fulfill everybody's purposes. Leaving space for individual appropriation is important. Open solutions, which enable both repurposing and customization, are valuable. As we saw in the example of the community display in which users were allowed to make their own customizations, the users found meaningful purposes for the technology and thus integrated its use into their existing communication practices. When designing for public spaces, however, technology should also serve fixed purposes, so that users can easily realize the benefits of using the services. In our case, "multipurpose" displays appeared to have no purpose for many. In this sense, the displays should be able to communicate their designed and meaningful purposes clearly to the user. In the end, repurposing and customizing technology requires preceding use practices and interest in using the technology.

The importance of existing mental models in appropriation processes has been highlighted by [44]. His studies suggest that mental models are even more important for appropriation than in learning from others. In addition, Müller pointed the importance of mental models in the adoption of public displays [32]. Our research indicated, however, that learning from others and seeing others play and use the display turned out to be a key factor for the adoption and appropriation of the displays. Most of the display users started to use the display after observing others using it. Observability of the display might even help to explain the differences in the usage rates from other similar displays around the city [cf. 33].

5.4. Limitations of the research and future work

We acknowledge that our study is asymmetric concerning the level of research evidence from each example case. While some of the examples were studied rigorously using triangulation, others were based on unsystematic observations of the developers during the research program. For example, the electrical plug practice at the school was based on second-hand observations taken from personnel working at the school, not from evidence gathered firsthand by the authors. The practice was, however, recurrent and temporally predictable (due to the regularity of the recess breaks), making it easier for the janitors to observe it within their other work and thus increasing our confidence in it. Additionally, the broken relay hardware itself was a tangible incident that strongly suggested disruptions of the UBI display power feed.

Our aim in this work was to demonstrate the many faces of the appropriation concept. We gave examples derived from a public display infrastructure research program and suggested distinctions that would be beneficial in studying the variety of technology appropriation. Future work is suggested, adopting multi-setting comparative research designs, studying longitudinal processes, and investigating different configurations of technologies, users, usages, and circumstances.

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