Challenges and Opportunities of Using Redirection of Activity for Self-Regulation Online

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ABSTRACT

This paper explores *redirection of activity* as an intervention strategy for self-regulation online. We conducted an explorative study (N = 19) of the browser extension *Aiki*, which redirects a user from a self-defined 'time-wasting' website to an online platform for learning programming (Sololearn, Codecademy, or Udemy). Based on quantitative measures alone, using Aiki decreased the participants' time spent on time-wasting websites on average, and increased programming knowledge. However, several users ended up avoiding their time-wasting websites entirely when Aiki was active, or they discontinued the use of the extension after 'the novelty wore off'. Based on these effects, we qualitatively explored the user experiences and identified four challenges and four opportunities for using redirection of activity as an intervention strategy for self-regulation of time management in a browser. Our results suggest that this intervention strategy is promising, but careful design is necessary to strike an optimal balance between independence and regulation.

CCS CONCEPTS

• **Human-centered computing** → **User interface design**; **Interactive systems and tools**.

KEYWORDS

self-regulation, user experience evaluation, procrastination, microlearning, self-control, productivity management

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1 INTRODUCTION AND BACKGROUND

This research is aimed at forwarding a research agenda of exploring how we might assist computer users spend their time in front of a computer in a way that is experienced as *meaningful*. In the context of this study, we are particularly interested in cultivating an experience of *purposefulness*, that is, which provides the person with a sense of direction in how they spend their time online [68].

An increasing amount of jobs in industrialized countries require humans to use a computer as their primary working tool [75]. In addition to raising major challenges to the reskilling and upskilling of digital competencies of the general workforce, computer-based work puts significant demand on our cognitive abilities to self-manage out attention. The internet provides resources for everything from work to personal growth and social interaction. The browser has become a portal for work as well as a primary appliance for leisure, which means that it is easy for the individual to quickly transfer in and out of interactions which are experienced as more or less purposeful.

According to a 2018 report by Pegasystems Inc. [78], desktop-based workers check their email once every six minutes throughout the day (13% of their total work time), switch between 35 job-critical applications more than 1,100 times every day, of which only 23% is spent completing actual value-generating work. In response to the experienced challenges of managing online distractions, a vast amount of applications and software designed to help us manage our own attention and productivity have sprouted. Applications which *block* access to "distractions" from work have been popular in Human-Computer Interaction (HCI) research [40, 55, 61, 63–65, 73], as have interventions that use data visualizations [18, 46, 94], self-defined time limits [56], and goal setting [47]. Although blocking interventions have generally been shown to increase productivity and focus, there are also adverse effects: Many experience increased stress when certain websites are completely blocked, because some "distracting" websites can provide much-needed breaks from work [64, 65, 72, 89]. Furthermore, people often find blocking interventions *annoying*, even if the interventions correspond with the individual's overall productivity goals [62]. Navigating this space between productivity, procrastination, purposefulness and entertainment presents a multitude of complex challenges for technology design – challenges that lie within so-called third-wave HCI [10].

Recent research has suggested *redirection of activity* (automatically redirecting a user to a website which is aligned with their goals or intentions) as a promising intervention strategy to manage and self-regulate behavior while working on a computer [39, 61]. An extension which intercepts one activity with another can be used to scaffold 'controlled procrastination': where a person uses a self-defined procrastination activity as a reward for engaging in some 'productive' activity, for instance, learning [80].

There is, however, limited research and evaluation of this strategy in practice. To this end, the current paper presents an explorative study to identify opportunities and challenges for redirection of activity as an intervention strategy for self-regulation. In the study, we explored the overall research agenda: ***how might we design digital systems that assist people spend their time online in purposeful ways?*** *Purposeful*, in this context, is understood as interactions which provde the user with *a sense of direction* of their activities, or the absence of aimlessness [68]. In this question, we recognize that taking breaks from tasks is important and useful. We want to investigate is whether people might experience a higher sense of purposefulness and a lesser sense of aimlessness (negative procrastination) if they are redirected towards a learning activity [16, 80] *before* spending time on so-called 'time-wasting' websites.

We specifically explored the following subquestions:

- **RQ1:** What are the effects of using *redirection of activity* as an intervention strategy on time spent on 'time-wasting' websites (in the browser) and on learning?
- **RQ2:** What are the opportunities and challenges of using redirection of activity as an intervention strategy?

We focus on websites that the individual user themselves has categorized as 'time-wasting'. In this study, we have used online coding tutorials as proxies for learning, but many other learning activities could be imagined. We will discuss some issues related to this, later in the paper. To investigate these questions, we used the open source browser extension *Aiki* [39]. Aiki is a concept from martial arts, which describes *blending or redirecting an attacker's energy instead of opposing or blocking it.* The Aiki browser extension redirects a user from any self-defined 'time-wasting' website or websites to another website. For example, a user may decide that every day between 9AM and 2PM, any visits to the website Reddit.com will be intercepted so that when the user attempts to visit this site, Aiki will redirect them to e.g. Sololearn.com – an online resource for learning to code – for two minutes. When the two minutes are up, the user will be free to continue to Reddit.com for a pre-defined amount of time, e.g., five minutes. When the user has spent five minutes on Reddit.com, they will again be redirected to Sololearn for two minutes, and so forth.

The novelty of our contribution consists particularly in the qualitative insights that explore why, when, and for whom a redirection of activity-intervention might work (or not work). We identify four challenges to and four opportunities for the design of such applications: *Challenges:* 'Websites are not categorically "good" or "bad"', 'Learning imposes cognitive demand (rather than a break)', 'If it works, it doesn't', and 'Not now, ask later'. *Opportunities:* 'Design for user independence', 'Redirection of activity should pose minimal cognitive requirement' , 'Consider redirection prompts', and 'Carefully consider the pervasiveness of the system'.

2 RELATED WORK

This research is situated in third-wave HCI, where we are less concerned with optimizing productivity and efficiency and are more interested in minimizing the adverse effects of distractions and procrastination, such as mental exhaustion, stress, feelings of guilt, and lack of self-efficacy [16, 25], and of maximizing human empowerment and well-being in a digital, multi-device world [10, 72].

More specifically, our work falls within the more recent strain of research in *digital behavior change* [79]: a family of approaches that aim to use technological interventions to bring about positive behavior change. Such approaches have been applied in a broad variety of domains aiming to help users to: eat more healthy [21, 76], manage chronic health conditions [36, 91], manage stress and promote mental well-being [15, 30, 48], control impulse buying [74], and engage in physical activities [20, 70].

A particular domain to which digital behavior change has been applied is *digital self-regulation*, in which researchers investigate intervention strategies for self-regulation and self-control of online behavior via, for instance: increasing awareness of 'procrastination' habits, [2, 3, 46], therapeutic inventions [90], gamification [5], alterations to the UI of specific social media sites [32, 49, 62], and even rotation between different intervention features [50, 53]. In one of the most comprehensive meta reviews on design features of existing digital self-control tools, Lyngs et al. [61] propose a map of existing tools based on their intervention strategy as the strategy relates to a dual systems model of self-regulation, where **System 1** control is driven by environmental inputs and internal states, and behaviors are more often 'automatic', and **System 2** control is driven by goals, intentions, and rules held in conscious working memory. System 2 control is, for instance, necessary when a goal requires planning or decision-making, or overcoming of habitual responses or temptations. For more on the dual systems theory, see [69]. Lyngs et al. categorize interventions into four different clusters based on their primary design features and how these relate to the dual systems theory: *blocking*, *self-tracking*, *reward/punish*, and *goal advancement*. We organize the following discussion of related tools and studies around the dominant strategy that they employ.

2.1 Blocking

One of the most popular approaches to assist a user self-regulating their online behavior is to block the user from visiting or seeing certain websites or parts of it. Lochtefeld et al. [58] reported on a study of suppressing the usage of certain apps on Android devices and found that messenger and social networking apps were the most popular applications users would block. A flurry of blocking desktop applications and browser extensions exist, from the ironically named *SelfControl* [84] and *Freedom* [28], to the more mundane *StayFocusd* [86], *WasteNoTime* [92] and *FocusMe* [26]. Clearly, such blocking applications are popular – each one of the mentioned extensions has at least 20,000 installations at the time of writing this article.

Kim and colleagues showed with *LocknType* [45] that even complete blocking is not necessary; instead even a small increase in the interaction cost of accessing an app could successfully discourage app use. Their *just-in-time* intervention, which delays the rendering

of the time-wasting website [34] gives the procrastinator sufficient time to reconsider the visiting of the time-wasting website in the bigger context of their goals.

In their work on *conservation of procrastination* [51] Kovacs et al. showed that when blocking a time-wasting website, the gained time is not automatically redirected to other unproductive activities or across devices (e.g. from mobile to desktop) – suggesting in this way that productivity behavior change systems can have a net positive effect on their users.

However, while blocking has been shown to increase productivity and focus in some situations[19, 43, 44, 66], it has also shown to increase stress and produce *annoyance* in others, where the user wants or needs a break from tasks to process difficult problems [62, 64].

2.2 Self-tracking

A series of applications and studies focus on using smartphone tracking and visualization to encourage *awareness* of how users spend their time online [6, 37, 46, 57, 95] Some studies suggest that increasing awareness of time spent on social networking sites might decrease associated stress [97]. Mobile operating system creators now often provide their own applications for tracking screen use: iOS's *Screen Time* and Android's equivalent *Digital Wellbeing* allow users to gain insight and objective measurements into their own behaviour surrounding smartphone use [42].

Some research results have shown that pop up-notifications about smart phone use had no effect on neither use of "problematic" (self-reported) websites or on smartphone use in general [59], while Lottridge suggested that the act of categorizing websites into productive and not-productive may be beneficial to help users self-regulate their time [60]. Interestingly, Kim et al. [46] found that emphasizing the time spent on *distracting activities* (negative framing) resulted in participants improving their productivity. Emphasizing time spent on *productive activities* (positive framing), on the other hand, did not.

2.3 Reward/punishment

In some approaches, the application attempts to motivate the user to stay away from distracting sites by granting virtual rewards (e.g. points, streaks, achievements, leaderboards). In *Forest* [27], for instance, the user plants a tree at the beginning of a working session; the tree will die if the user brings another application in the foreground. Variations on this theme with animals also exist (e.g. *DonutDog*).

The punishment-focused applications are quite creative. *Time-Waste Timer* [88] allows the user to pledge money which they will lose in case they spend more than one hour on Facebook per day, and the *PAVLOK Productivity* browser extension [77] uses aversion therapy in order to help users break bad habits: a bracelet delivers an electric shock when the users visit blacklisted websites. While these applications are interesting, to the best of our knowledge, their effectiveness has not been evaluated in any formal research context.

2.4 Goal advancement

The goal advancement category is not well explored in HCI, although some interventions have shown promising results, e.g., [13]. Applications in this category are often combined with some degree of blocking the distraction website (e.g. *NewsFeedEradicator*, which replaces feeds on social media websites with motivational quotes [93] and *Hypercontext*, which overlays a to do-list on the screen if the user visits a distraction website[38]), or inserting microlearning directly in social media feeds [49]. Cai et al. introduced the concept of *wait-learning*, where a digital system automatically detects when a person is waiting, and offers them a "productive opportunity" to learn language. Their users described *system-triggers* as important to help them form a habit [14].

Lyngs et al. evaluated various interventions with different users throughout the course of six weeks and discovered that both goal reminders and removing the "newsfeed" from Facebook users helped participants stay on track [62], but goal reminders were often perceived as annoying, and removing the news feed made some people fear missing out on information.

Lyngs et al. [61] suggested that goal advancement may be a promising direction of research for applications aimed at self-control by *scaffolding the transfer of System 2 goals* (conscious, capacity-limited cognitive processes driven by goals, intentions and rules) *into automatic System 1 habits* (instinctive, non-conscious behavior) [87]. Psychological research has found that individuals who are better at self-control develop habits that make their behavior less reliant on System 2-control and more subject to automatic System 1-processes [23, 24, 29]. Lyngs et al. [61] highlight *redirection of activity* as a potentially promising way to accomplish this by design.

3 METHODS

Under the overarching research agenda of *how we might design digital systems that assist people spend their time online in purposeful ways?*, we explored the following subquestions:

- **RQ1:** What are the effects of using *redirection of activity* as an intervention strategy on time spent on 'time-wasting' websites (in the browser) and on learning?
- **RQ2:** What are the opportunities and challenges of using *redirection of activity* as an intervention strategy?

In other words, we were interested in quantitatively exploring the use patterns and effects of browser redirection on procrastination/learning and qualitatively exploring the opportunities and challenges of using such an intervention.

Aiki uses the intervention strategy *redirection of activity* (as described by Lyngs et al. [61]) to attempt to transfer a System 2 goal (e.g. 'learning Python') to an automatic System 1 habit. If successful, a user would eventually form the habit of visiting a goal-advancing website as a break activity in place of aimlessly or automatically browsing 'time-wasting' websites.

3.1 System design: Aiki

Aiki[1] is a Google Chrome extension in which a user can specify 'time-wasting sites' (Fig. 1) – as many or as few as they want to, a desired learning platform (in our experiment, this setting was locked

[1]Download available on: https://aiki-extension.github.io/

to a Python learning site), and time frames for for both learning time (time spent on learning platform) and reward time (time spent on time-wasting sites) – per redirection session. We implemented (with permission from the original developers) a redesign of Aiki in the JavaScript framework Svelte, and this version included some features suggested by initial evaluation of Aiki, which indicated that the extension should be more customizable in an attempt to be as minimally intrusive as possible, and to cater to different states of focus during the day [39]:

- **Operating hours:** The user can specify which hours of day Aiki should be active or not active by default (Fig. 1).
- **Floating 'Continue'-button:** While redirected, Aiki displays a floating (i.e., it can be moved around the browser window to not block any parts of the screen) 'Continue procrastinating'-button which is greyed out as long as the user still has learning time left, and turns green as soon as the time is up as a visual indication that the user has completed their intended learning time (Fig. 2). The user can always toggle Aiki on or off in the browser toolbar menu, so the user is never blocked from entering a time-wasting website.
- **Countdown timer:** We redesigned the toolbar menu icon to include a counter showing how much time the user has left of their procrastination "allowance" (Fig. 3).
- **Redirection from other tabs:** If the user opens their time-wasting site in a different tab before the learning time is up, the new tab will display a button taking them back to the learning site (shown in Fig. 4).
- **Snooze-button:** 5 seconds before redirecting from a time-wasting site to the learning website, a 'Snooze-button' appears in the middle of the browser window, allowing the user to choose to delay redirection for one minute. This was added to prevent sudden redirections, if the user was in the middle of doing something important on their time-wasting website.

In the redesign, we aimed to preserve the main functionality of the redirection mechanics while making the state of the system more visible to the user (redirection from other tabs), providing clear guidance when the user is being redirected (snooze-button), how long they can expect the interruption to last ('Continue'-button, countdown timer), and allowing the user to customize active hours (operating hours).

3.2 Participants

Participants were recruited by convenience sampling from public social media announcements from the authors' personal profiles on Facebook, LinkedIn, and Twitter. We announced the study as an opportunity to decrease procrastination and to learn Python. We announced the study as relevant to participants who were beginners or novices in programming and Python, who were not subjected to programming learning through other sources, and who could be characterized as *knowledge workers*, using their computer as a primary work station [81]. 31 people filled out our opening survey and signed a consent form, but of these, 12 people dropped out during the study. Two of the 12 never installed Aiki for phase 1, and the remaining 10 dropped out of the study during phase 2. This is a high

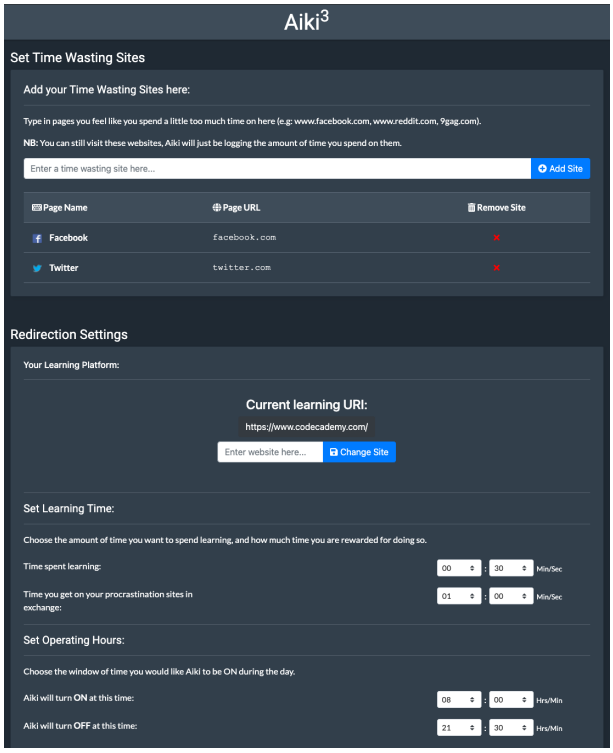

Figure 1: Settings of the Aiki extension: Desired time-wasting sites, desired learning platform, time per learning session, time per 'procrastination' session, and operating hours of the extension.

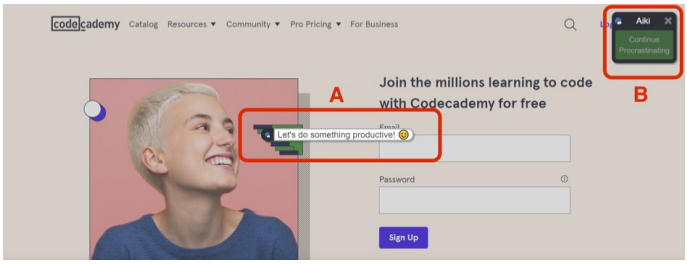

Figure 2: When Aiki redirects the user (here, to Codecademy.com), it shortly displays a reminder of why the user was sent here, in the middle of the screen (A) ("Let's do something productive!"). It also displays a "greyed out", floating button (B). When the user has spent their configured time in the learning platform, this button turns bright green and will take the user back to the (time-wasting) website they were attempting to visit.

drop-out rate, and we reflect further on this in the following section 3.2.1. An overview of the 19 participants who remained in the study are shown in Table 1. All 19 full participants completed onboarding, middle and final qualitative surveys, and eight participants further chose to participate in a follow-up interview (elaborating on the finishing survey). The finishing interviews lasted between 10 and

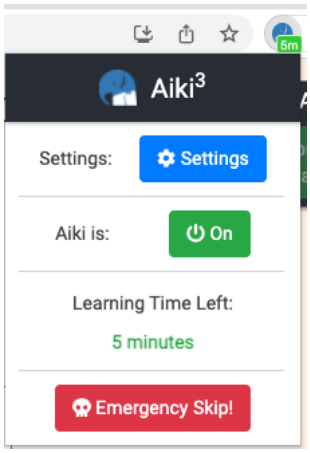

Figure 3: The toolbar menu shows the time left in either the learning platform or on the time-wasting website. It also offers an *Emergency skip*-button if the user wants to continue to their time-wasting website immediately.

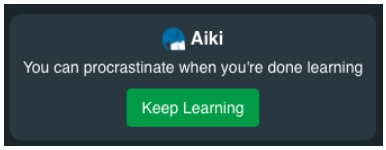

Figure 4: If the user opens a new browser tab and tries to access a time-wasting address before the learning time is up, Aiki "blocks" the address with a *Keep learning*-button, which will take the user back to the learning platform.

15 minutes, were recorded and subsequently transcribed by one of the authors. No sensitive data was collected on the participants. This research did not require official ethical approval from the laws of the country where it was conducted, but all possible measures were taken to follow official GDPR regulations and best practices for responsible research.

3.2.1 A remark on time, numbers, and knowledge. While numerous applications and intervention systems for regulating online behavior exist, and substantial research has been conducted in many of these, the biggest unknown appears to still be *reducing attrition rates*, i.e. designing systems which people continue to use after "the novelty wears off". This is not easily achieved: *"we tread a fine line: behavior change systems themselves suffer from attrition, so we may sometimes need to make tradeoffs between better retaining users and helping them regulate their behaviors"* [53].

The longitudinal study approach is threatened by attrition itself: inevitably, more participants "drop out" the longer the study lasts. In the interest of conducting a user experience evaluation which is true to the lived experience of people, and which carries greater ecological validity [4, 10], we have prioritized obtaining detailed data from fewer participants in place of statistical generalizability.

We believe it is important to report the attrition rate of the study, as well as to include the participants who *did* provide their

#	Age	Gender	Occupation	Learning platform	Facebook	Youtube	Linkedin	Instagram
1	18-25	Male	Student	Codecademy	✓			
2	25-35	Female	Researcher	Sololearn			✓	✓
3	18-25	Female	Student	Sololearn	✓			✓
4	18-25	Female	Developer	Sololearn	✓			✓
5	25-35	Male	Researcher	Codecademy		✓		
6	25-35	Female	Unemployed	Udemy	✓			✓
7	25-35	Male	Postdoc	Sololearn	✓			
8	25-35	Female	Student	Codecademy	✓	✓		
9	25-35	Male	Project manager	Codecademy	✓	✓	✓	
10	36-45	Female	Data librarian	Sololearn	✓		✓	
11	25-35	Male	3D artist	Codecademy	✓			
12	25-35	Female	Student	Sololearn	✓	✓		✓
13	36-45	Male	Postdoc researcher	Udemy	✓	✓		
14	25-35	Male	Portfolio and Pricing Analyst	Codecademy	✓	✓		
15	36-45	Female	Communications Consultant	Codecademy	✓	✓	✓	
16	25-35	Male	Researcher	Udemy	✓	✓		
17	25-35	Female	Lighting designer	Sololearn	✓	✓	✓	✓
18	25-35	Male	Cloud advisor	Udemy	✓	✓	✓	
19	36-45	Male	Software engineer	Codecademy			✓	

Table 1: Overview of study participants together with their gender, occupation, assigned learning platform, and those self-declared time-wasting sites mentioned by more than one participant

qualitative input on why they chose to deactivate Aiki or only use it for a short amount of time – i.e., participants 1, 4, 5, 8, 15, and 17 (see Fig. 6). The goal of this article is to present honest insights from a study of how this intervention strategy works or does not work in practice, and we believe that includes reporting on the participants for whom the study did not work. Perhaps these insights can be helpful to future researchers designing similar studies.

A participant number between 10 and 20 has shown to be enough for formative quantitative problem discovery [83], as well as for uncovering the most important codes from qualitative data [31, 35]. The combination of mixed methods (use patterns, questionnaires, and qualitative surveys and interviews) provided us with enough saturation to discover the salient issues that could be useful to interaction designers in developing novel systems/interactions, or in reducing attrition in existing intervention systems.

3.3 Study design

To explore the experience of browser redirection, we designed a three months-long study with three interventions in the duration. The study took place between April and July 2021 (participants did not start on the exact same day). The study overlapped with summer holiday for some participants (summer holiday often takes

place in July in the country of study), which we considered an advantage in terms of investigating *natural* use patterns, where a user would also experience weekends, exam deadlines, holidays etc. An overview of the timeline is shown in Figure 5.

Opening survey. After recruitment, participants were informed about the study and asked to sign a consent form. All participants then filled out a survey about their age, occupation, and average computer usage, both in work and leisure contexts. We also asked a few questions about their own experience of procrastinating and taking measures to limit procrastination. All survey questions are shown in Table 6, Appendix B.

Phase 1. The participants then installed a 'passive' version of Aiki, and decided which websites they would categorize as 'time-wasting websites' in the Aiki settings. During the following four weeks, Aiki logged the time, participants spent in the browser, and the time spent on their predefined time-wasting websites. We had no access to information about the participants' behavior on the websites, only the times during which either of the websites was active in the browser. We also recorded no information about any other websites accessed while Aiki was installed.

Middle survey and Python test. After four weeks having the passively logging version of Aiki installed, the participants were asked a question about whether they would prefer very short learning sessions (microlearning), or longer, more in-depth learning sessions. Based on their response to this question, the participants were assigned to one of three learning platforms, as described in the *Treatments* section. Finally, all participants were asked to complete a test of 41 questions assessing their Python knowledge. The test was modelled after questions on www.realpython.com, and included both multiple answer-questions and open answer-questions for participants to write simple segments of Python code. The test included seven sections on basic data types and variables, operators and expressions, conditional statements, strings, lists and dictionaries, while loops, and scripts and program structure. These sections were designed to match the curriculum on the three learning platforms.

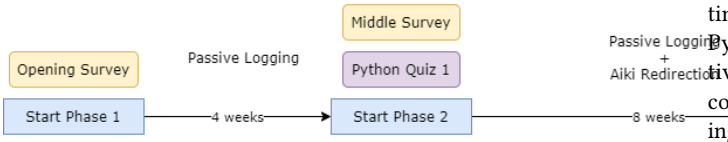

Figure 5: The study timeline. The participants completed an opening survey, and then a period of four weeks of passive logging of the time they spent on their self-proclaimed time-wasting websites (phase 1). They then completed a middle survey and a Python quiz, assessing their initial knowledge of Python. In phase two, which was eight weeks long, the participants installed Aiki and were free to use it or not use it as they pleased. Finally, they completed a closing qualitative survey, repeated the Python quiz, and those who consented participated in a follow-up interview.

Phase 2. The 'active' version of Aiki was installed for eight weeks, during which it was logging time spent in Chrome, time spent on the 'time-wasting' websites, and time spent on the learning platform, as well as telemetry data about redirects, both completed ones and skipped ones. Participants were allowed (and encouraged) to use Aiki as they pleased, including toggling it on and off if they wanted. We were interested in obtaining as natural evaluation of the extension's usefulness as possible, also if that meant less use time.

Closing survey, second Python test and interviews. At the end of phase 2, participants filled out a detailed, qualitative closing survey (questions can be found in Appendix B), a second Python test containing the same questions as the first test, and asked if they were interested in participating in an interview. Interviews were optional, considering we obtained qualitative data from the final surveys alone. The interview questions can be found in Appendix A.

3.4 Treatments: Python learning platforms

We assigned participants to one of three different learning platforms: Codecademy.com, Sololearn.com, or Udemy.com. These were selected based on several reviews of best available online sources for learning Python. Codecademy and Sololearn are similar in content and types of exercises, while Udemy offers longer, instructional videos. Users who indicated in the middle survey that they preferred longer, more in-depth learning sessions (more than 5 minutes) were assigned to Udemy, while users who indicated they preferred short microlearning sessions (less than 5 minutes) where assigned randomly to either Codecademy or Sololearn. The split between Codecademy and Sololearn was devised to control for effects of the learning platform being the main influence on the Aiki experience (as was observed in inital research on Aiki [39]). We created user profiles for the participants on the different websites and signed them up for the most popular beginner's course in Python.

3.5 Data analysis

An overview of the data we collected from the study and the analyses we performed is presented in Table 2. For the quantitative tests we used the Kolmogorov-Smirnov test (K-S) to determine normality, a t-test for dependent means to compare minutes spent on time-wasting websites from phase 1 to phase 2 and to compare the Python test scores before and after the Aiki intervention, respectively. We used the Pearson Correlation Coefficient to determine correlation between the Likert ratings of Aiki and the user's learning site. For statistical tests we adopt a confidence level of .05, which is satisfactory for our purposes [33].

We performed a thematic analysis of the qualitative data, focused on 'identifying and interpreting key, but not necessarily all, features of the data, guided by the research question' [17]. Thematic analysis was led by the first author, and all authors met for discussion and participation in the 'generating initial codes', and 'reviewing themes' steps [17]. All survey responses and interview transcripts were read several times while initial codes and following themes were generated. These are shown in Table 3.

The aim of the experiment design was to combine the methods of *uniqueness* and *dimension studies* [8] to obtain rich data for both

Data	Data type	Analysis
Demographic data, occupation, and work type	Mixedlike Aiki.	None
Total amount of **time** spent in Chrome, on participants' self-defined time wasting websites, and on the learning platforms	Quantitative	K-S (normality) & *t*-test for dependent means
Amounts of redirections by Aiki, snoozed redirections, and completed redirections	Quantitative	None
User-defined **settings** in Aiki (i.e. listed time wasting websites and active hours)	Mixed	None
Likert-scale ratings of Aiki and the learning platform	Quantitative	K-S (normality) & Pearson Correlation Coefficient
Python **test scores** before and after the intervention	Quantitative	K-S (normality) & *t*-tests for dependent means
Open-ended **survey responses** about perceived procrastination, experience of Aiki and experience of the learning platform	Qualitative	Thematic analysis
Follow-up **interviews**	Qualitative	Thematic analysis

Table 2: Overview of data collection and analyses.

Initial codes	Theme
Procrastination sites are sometimes work relevant, Requires too much brain, Extra time consumption, Bugs/missed information, Phone/different browser, Blocking instead of redirecting, About the learning platform, Procrastination	Challenges
Timing and customization, Creates awareness/reflection, Something different, but still useful/fun/engaging, About the learning platform, Deliberate choice, Ideas, Motivation	Opportunities

Table 3: An overview of codes and themes generated through thematic analysis of qualitative surveys and interviews.

quantitative and qualitative evaluation of the experience and usefulness of a redirection of activity-system. As for all data gathering methodologies, this involved both advantages and challenges - for instance prioritizing detailed, rich data in place of large participant numbers. Our main priority was to get a valuable, truthful evaluation which would be useful for the further development of systems self-regulation via redirection.

4 FINDINGS 1: USAGE PATTERNS AND LEARNING

4.1 An Overview of Usage Patterns

A timeline of when users were active is shown in Figure 6. Of the 19 participants who installed the Aiki extension for phase 2 of the study, three ended up not actively using the extension; one because they "Didn't have the time for it" (P1), one because their IT department did not allow them to install Aiki on their work computer (P15), and one because they had not been able to enter their learning website, but had not made us aware of this (P17). P1, P15, and P17 are therefore excluded from the usage and Python test graphs. We still report on their qualitative feedback, since it is relevant for future (re)designs to understand some of the reasons why some participants might choose to disengage with an extension like Aiki.

Of the 16 active users, three participants (P4, P5, and P8) had less than 14 'active' days (days were they were redirected by Aiki). The remainder of of the participants had, on average, 41 active days during the 56 day long phase 2. On average, participants experienced 32 redirections (median 28.5) or 35 (median 29.5) for the 14 participants who were active for more than 10 days.

Figure 6 shows that for the most active users, activity was spread out over the period – P9, for instance, deactivated Aiki for a period in the middle, and then used the redirections very actively towards the late part of the study. However, for most users we see patterns of very limited use, where even very few daily redirections did not convert' into time spent learning (for instance, P3, P11, and P19). We note that all participants were recruited voluntarily, based on a self-proclaimed desire to both procrastinate less and learn Python, so this non-active use was surprising to observe. We explore the reasons behind participants' use further in the qualitative results section (5).

4.1.1 Time-wasting websites. Participants entered an average of 4.9 time-wasting websites in Aiki. The 10 most commonly listed are indicated in table 1 (the 10 most commonly listed were listed by more than one participant). Facebook was the most commonly entered website, but also news websites and shopping websites were represented. The participants entered a total of 36 unique websites into the system. We discuss some of the challenges of categorizinf 'time-wasting' websites further in section 5.

4.1.2 Total time spent on time-wasting websites. Participants spent between 1 and 144 minutes on their time-wasting websites during phase 1 (without Aiki) and between 1 and 94 minutes during phase 2 (while Aiki was active) (Figure 7). A paired *t*-test for two dependent means shows that participants spent less minutes on their listed time-wasting websites in phase 2 than in phase one, $t(15) = -3.33$, $p = .005$.

4.1.3 Time spent on time-wasting websites corrected for Chrome use. As shown in Figure 8 the amount of time, participants spent in the browser also decreased from phase 1 to phase 2 (with an average of 47 minutes per day). In the final surveys and interviews, six participants mentioned directly that they had occasionally used other browsers or their phone to reach their time-wasting websites instead of Chrome. We did not see this as a necessarily undesired effect of Aiki (after all, the extension attempts to *exchange* procrastination time for learning time, rather than blocking the user), as previous research has shown that procrastination time is *not* conserved or redistributed across different devices when it is reduced on one platform, but rather remains generally constant or reduces [52]. This was confirmed by some of the participants:

> *"**Did your [...] phone procrastination increase a lot?** Um, I'm not sure. I don't think so. Maybe at times (...) But I think for the most part, I just got into learned behaviour of just not going to these websites at the time,"* (P9).

To correct for the decrease in time spent on the Chrome browser, we calculated the minutes spent on time-wasting websites *per hour spent on Chrome*. We still see an average decrease in minutes spent

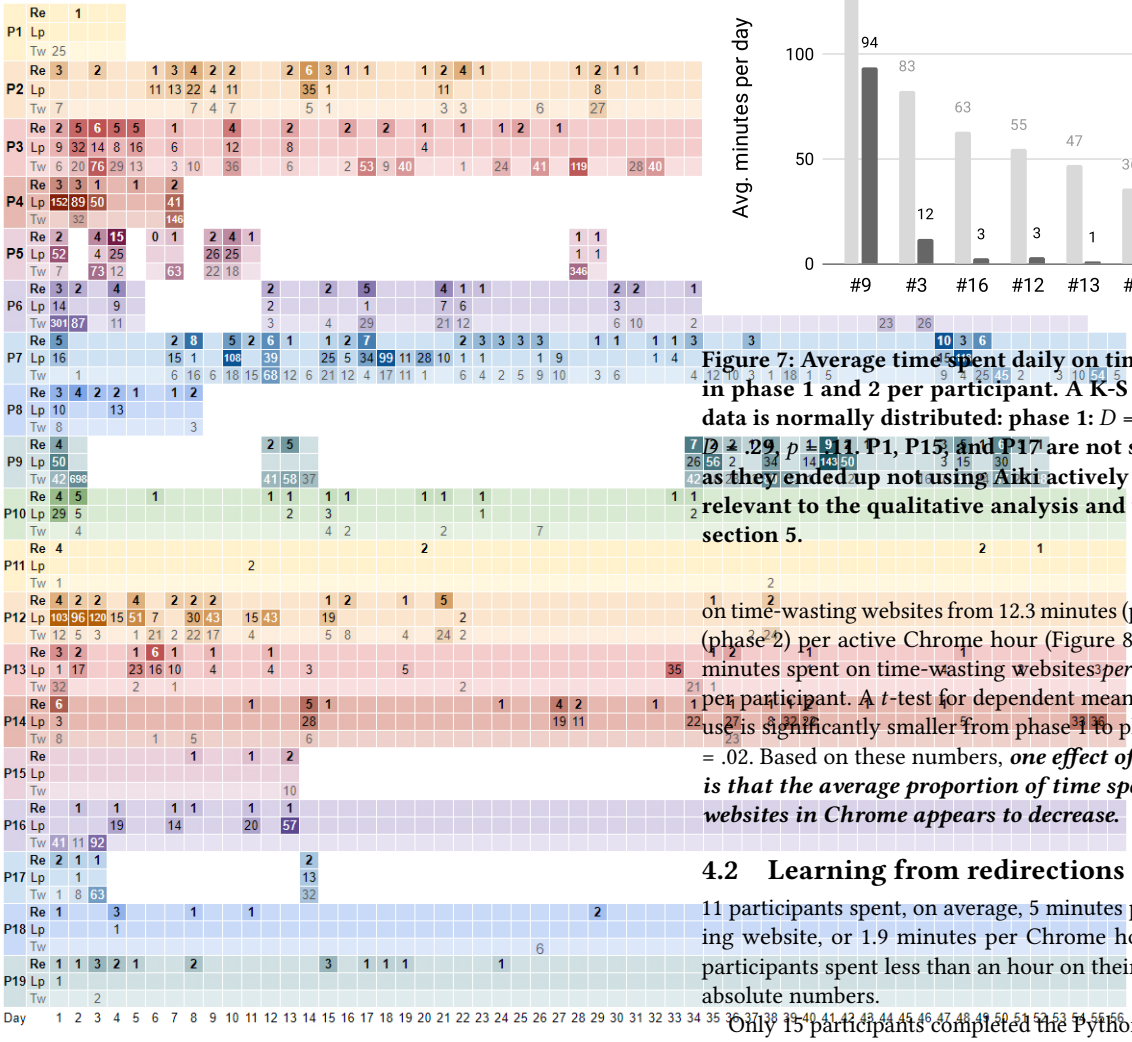

Figure 6: A timeline and heat map of use patterns. Individual days are shown as columns. Each participant is represented by three adjacent horizontal rows which are colored in if Aiki was active (installed and turned on) for the user on that day. The top row for each user shows the amount of redirections (Re) on the given day, and the middle row shows the amount of minutes spent on a participant's learning platform (Lp). The bottom row shows the amount of minutes spent on time-wasting websites (Tw) (accumulated for all entered time-wasting websites) for the given day. If the cell is colored, but no number is shown, Aiki was installed and active, but registered no redirections/learning platform minutes/minutes spent on time wasting websites (depending on the row). If a participant experienced redirections but chose to press the Skip-button (as shown in Fig. 3) (i.e., redirections did not translate into minutes spent on learning platform), that will show up as a number in the top row, but no number in the middle row (e.g., P19). If a participant chose to visit the learning site independently (i.e., without being redirected), that will show up as a given number of minutes in the middle row, but no number of redirections in the top row (e.g, P14, days 54 and 55). Finally, if a participant has spent minutes on their time-wasting websites while Aiki was not actively redirecting, e.g. outside of the hours where they asked Aiki to

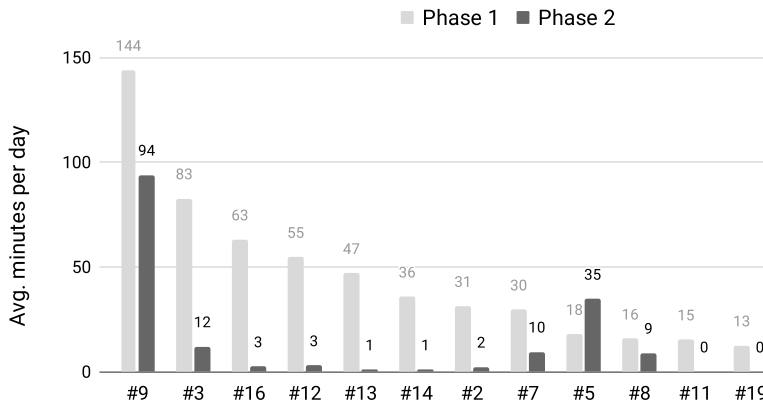

Figure 7: Average time spent daily on time-wasting websites in phase 1 and 2 per participant. A K-S test shows that the data is normally distributed: phase 1: D = .19, p = .57, phase 2: D = .29, p = .11. P1, P15, and P17 are not shown in this graph as they ended up not using Aiki actively for reasons that are relevant to the qualitative analysis and will be discussed in section 5.

on time-wasting websites from 12.3 minutes (phase 1) to 4.6 minutes (phase 2) per active Chrome hour (Figure 8). Figure 9 shows the minutes spent on time-wasting websites *per hour spent in Chrome* per participant. A t-test for dependent means shows that the time use is significantly smaller from phase 1 to phase 2, $t(15)$ = -2.49, p = .02. Based on these numbers, ***one effect of using Aiki actively is that the average proportion of time spent on time-wasting websites in Chrome appears to decrease.***

4.2 Learning from redirections

11 participants spent, on average, 5 minutes per day on their learning website, or 1.9 minutes per Chrome hour. The remaining 5 participants spent less than an hour on their learning platform in absolute numbers.

Only 15 participants completed the Python test before and after phase 2. Of the 15 participants who completed both tests, two did not increase their score at all (P11 even decreased their score by 1, from 30 to 29 correct answers). Even including these three, the average increase in score was 10.56 answers from before to after the Aiki intervention. A paired t-test shows that this difference is statistically significant at $t(14) = 5.51$, $p < .001$ (Figure 10). According to these numbers, ***active users of Aiki improved their knowledge of Python using the provided online programming learning platforms.***

4.3 Ratings and user experiences of Aiki

In the final survey, we asked participants to rate their general experience with Aiki on a scale of 0 (Not good) to 10 (Very good), as well as their experience of the learning platform they were redirected to. The ratings are shown in Figure 11.

In the final survey, seven participants described **avoiding their time-wasting websites** to circumvent the redirection, and this

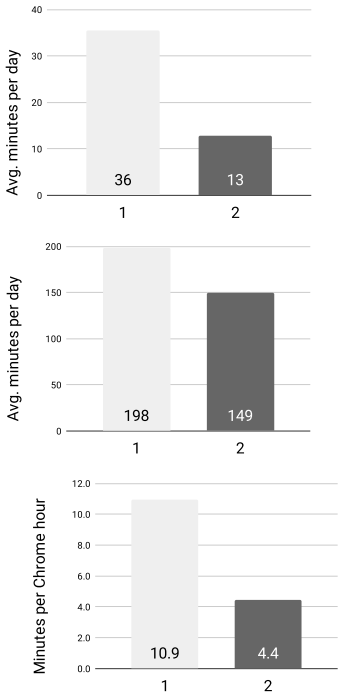

Figure 8: Comparing phase 1 and phase 2: Average procrastination in minutes per day in (left), average Chrome activity in minutes per day (middle), and average procrastination in minutes per active Chrome hour (right).

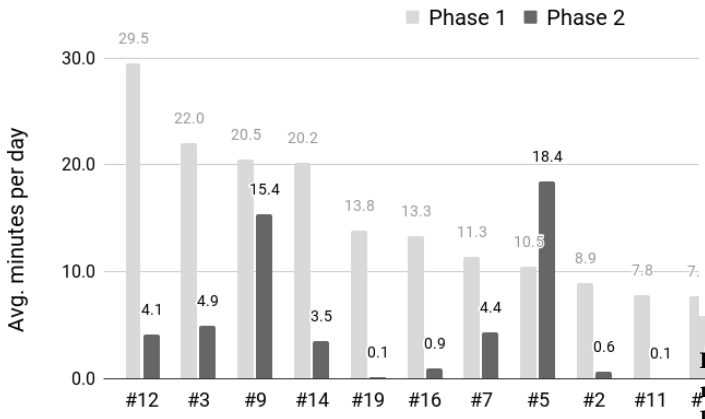

Figure 9: Minutes spent on time-wasting websites per Chrome hour per participant from phase 1 to phase 2. A K-S test shows that these data are likely to represent normal distribution: $D = .14$, $p = .86$ (phase 1), $D = .21$, $p = .41$ (phase 2). P1, P15, and P17 are not showed in this graph as they ended up not using Aiki actively for reasons that are relevant to the qualitative analysis and will be discussed in section 6.1.

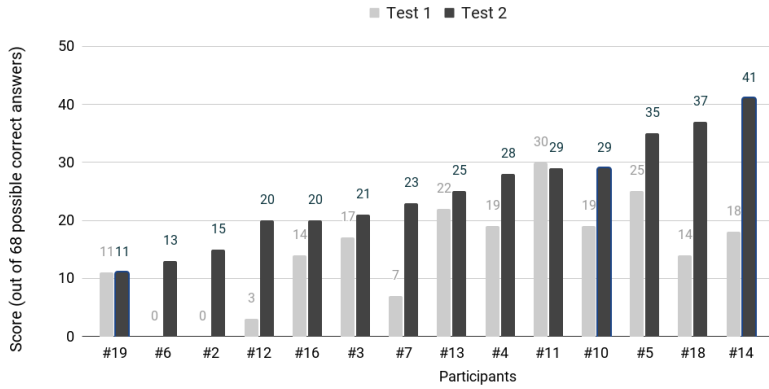

Figure 10: Results of Python test scores per participant. A K-S test indicates normal distribution: $D = .13$, $p = .94$ (before phase 2) and $D = .12$, $p = .97$ (after phase 2).

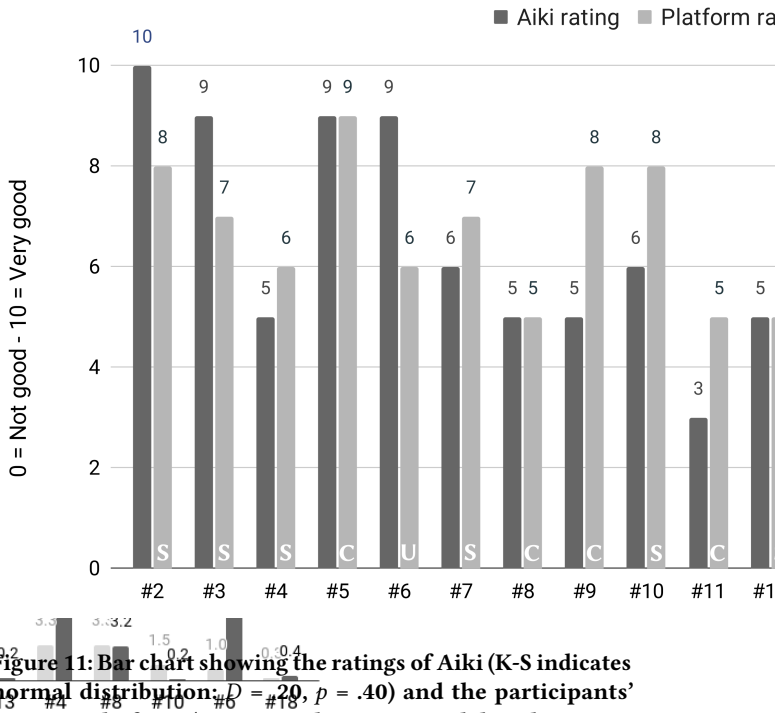

Figure 11: Bar chart showing the ratings of Aiki (K-S indicates normal distribution: $D = .20$, $p = .40$) and the participants' learning platform (K-S test indicates normal distribution: $D = .18$, $p = .48$), respectively. The assigned learning platform is indicated as S for Sololearn, C for Codecademy, and U for Udemy. The answers for the three participants (#1, #15, #17) who did not use the extension actively for phase 2 are omitted, since they have little grounds for evaluating neither the extension nor the learning platform.

means that they would not reach the learning platform either. In this case, the 'learning' element of the redirection is unsuccessful, but interestingly, the 'blocking' element of the extension was reported as positive: *"after the second or third week, I realized that I ended up not going to those sites. So I did not end up learning a lot of Python, but I for sure did not procrastinate. (...) So you guys have improved... probably my efficiency in the last few months"* (P5).

Five users described **deliberately visiting the learning platform, because they started preferring using their break time there**, e.g. *"sometimes I even did it on purpose when I felt like okay, now, I don't want to do what I'm actually doing right now anymore. So I would rather like to do something different, but still useful. And then I went on the platform. On purpose"* (P2). Four of the users who described developing a preference for spending break time on the learning platform also said that this was a feeling they had *in the beginning* of the study, and that they **discontinued the use of Aiki once the novelty wore off**: *"after a while, it wasn't really fun for me. (...) I felt like I need a break from work. And it was not a break, it was just something that was asked for..."* (P13).

5 FINDINGS 2: CHALLENGES FOR REDIRECTION OF ACTIVITY-SYSTEMS

Extending on initial research on the Aiki extension [39], this study confirmed that the approach can potentially increase purposeful or productive online behavior. Several of the quantitative effects of using Aiki showed promising results (an average decrease in time spent on self-defined time-wasting websites and increased knowledge about Python), however, the fact that several participants chose to abandon the study, turn the extension off, or avoid the redirections, indicates that redirection of activity is not an unambiguously favorable "solution" or answer to self-regulation of online behavior. Therefore, this section will present a qualitative analysis of general challenges, users experienced in using Aiki.

5.1 Websites are not categorically "good" or "bad".

Six participants described frustration that some of the websites they had listed as time-wasting websites were sometimes necessary for work or social reasons, e.g.

> *"many of the sites that I marked as procrastination sites are also some sites I use for learning material when I work"* (P11).

> *"after, like, a week or two, it started to get a bit annoying. Because sometimes I wasn't even going on to Facebook to procrastinate, I just wanted to write someone or something."* (P3).

In fact, P8 (who was a student at the time of participating in the study) turned off the extension completely after only 10 days because they had to use Facebook for communication with their thesis group. They could have removed Facebook from the list of time-wasting websites, but this was maybe not clear enough, or did not solve their issue. The reason a user visits a procrastination website at the given moment influences whether redirection is more or less welcome, and while Aiki is designed with an "Emergency skip" button (for when the user needs to promptly access a website that will cause them to be redirected but does not wish to turn Aiki off completely), only eight participants ever used this button.

This is an inherent consequence of many websites we frequently use providing content and functionality for both work and leisure, i.e., Facebook or Twitter are used for to communicate with family and friends as well as for professional contact, and YouTube is used for entertainment as well as education. Not to mention, many people are employed to primarily manage communication, marketing, and content creation via these media, and thus can not avoid them when working. Two participants also mentioned that they felt like the productivity exercise was equally illegitimate as otherwise procrastinating:

> *"in an office setting where I have to deliver, it felt like I was doing something I wasn't allowed to, even though I would have gone to an article that would have taken me five minutes to read as well. That just felt like I was cheating at work, instead of taking a break."* (P11)

One participant circumvented this by installing Aiki only on their personal computer:

> *"I've got my work computer here and then I've got my personal computer here, which I installed Aiki on. And I kind of made sure I was using that during the day if I wanted to procrastinate"* (P14).

However, as most of us work on one computer at a time, and if a user wants to reclaim control over their working habits at their primary working station, this is a sub-optimal setup.

It is possible that interruptions based on the website are not the optimal configuration for redirections, and further reflections on what constitutes *time-wasting* and *procrastination* (and when) are clearly necessary.

5.2 Learning imposes cognitive demand (rather than a break)

We found, perhaps unsurprisingly, that the website, the user is redirected to, influences the user experience significantly. We asked the participants to rate their learning platform, and the ratings of the learning platform were strongly positively correlated with their rating of Aiki at r=.77, p<.05 (Figure 11). The design and content of the website, the user is redirected to, can impose a bad user experience in and of itself:

> *"it was a bit passive. At least Udemy, because all the lessons, the lectures were just explaining the thing. (...) Probably making it more interactive, I would say, will make it a bit more engaging."* (P13).

> *"In the start I actually began using Sololearn as my new procrastination thing, I would prefer using time there. But I reached something I didn't understand and had nobody to ask, so I stopped using Aiki."* (P12).

This was also reported as a finding in the first study of Aiki [39], in which users were sent to a language learning environment. In this study, we deliberately chose three different learning websites to mitigate such effects, and we confirm with this constellation that the choice of learning platform is important for the experience of the redirection-system.

Four participants described that the requirement to do another type of productive work (i.e., learning) was interfering with their state of focus in a way that visiting one of their procrastination websites would not have been:

> *"some times the whole, do five minutes of coding that, like pulled me out of my focus at work. (...) I get tunnel vision when I work. And I it takes a long time for me to get into flow. And if I'm pulled out of that flow, I need another 30 minutes to get back into the other flow. (...) if I go to just watch a silly movie or something that doesn't take me out of my focus, it just, like shuts off my brain for a bit."* (P11)

> *"the main problem was that I would not like to spend time on Python during those moments, and I preferred to condensate Python learning in specific moments of the day (both for having more time to spend on it, and for not interrupting my work)" (P7).*

The task of learning programming may be too cognitively demanding to work as a redirection activity, at least when the user is in a state of focus. The cognitive demand may have been higher because we defined the learning platform for the participants, which may counteract the purpose of redirection as *self*-regulation:

> *"And the way [Aiki] didn't work is that... is because of the way humans are built. We want to procrastinate, no matter – this is my personal experience – procrastinating is something that this is not fully under my control (...) I just wanted to something else more pleasant, more rewarding. And just what is rewarding at the moment is independence"* (P13).

This finding is in line with research that shows that interruptions which do not occlude the primary task generally are perceived to be less mentally demanding and less annoying [1, 11, 14]. P2 described in their interview that they did not have a specific use case in mind for learning Python, they just believed it might be a useful thing to know. Several other participants also described their motivation as a more general desire to "brush up their coding skills" or "learning a new language". This led us to speculate that if the user does not have a clear goal in mind for the learning activity, the cognitive effort or *attention investment* [9] required to enter a learning session may be higher that what the user is willing to pay. According to the dual systems model, the *Goal advancement* category of interventions should work by scaffolding the transfer of System 2 goals to more automatic System 1 habits [61], however, if the system 2 goal is not clear and well-motivated, it is likely that this process will be much harder. It may, therefore, be worth prompting the user to carefully consider which goal they would like to achieve using the intervention, and what might be the best way to achieve this goal.

5.3 If it works, it doesn't

The closing survey responses revealed an interesting paradox of a system like Aiki; if Aiki is successful in limiting visits to time-wasting websites, the amount of redirections (and thus, time spent in the learning environment) will also be reduced. We decided to explore participants' motivations for participating in the study during the interviews. Three participants (P2, P9, P11) said that their main motivation was to develop better control over their procrastination habits, four said that their main motivation was to learn Python (P3, P5, P13, P14).

One participant said that their motivation was equal between stopping procrastinating and learning Python (P19). This participant also said that because their goal was to stop visiting procrastination sites entirely, the idea of being rewarded with procrastination did not work:

> *"I guess the idea of being rewarded to go to sites that I just didn't want to go to, full stop, just didn't work out. [...] there was no motivation for me to, like, if I spend some time on Python, I can waste my evening on Reddit"* (P19).

Depending on whether the motivation for using Aiki is to procrastinate less or engage in more productive behavior, different users may have different expectations of the system.

5.4 Not Now, Ask Later

Kovacs et al. [54] exposed a (for most of us, all too well-known) reluctance of people to adhere to promises they have made to themselves in the past. The article suggested that users may be overly optimistic when initially choosing their behavior change regimen, and may succumb to present-biased choices over time – a pattern which we also expected to see in this study. Therefore, Aiki is designed as relatively non-constraining: it is limited to one browser, user-defined active times, and includes a skip-button to allow the user to reach their procrastination website if they really need or want to.

Interestingly, four users described the lack of pervasiveness as *less* desirable:

> *"And in the worst cases, I would then just be like, okay, like, I can't use this right now, I'll just use my phone instead. Which I guess in future for something like this, [it] would have been nice if I had, like, more restrictions on me on different devices?"* (P9).

Other users described frequent redirections as more annoying:

> *"I got redirected all the time from Facebook so I unfortunately had to turn off the extension"* (P8).

One of the greatest challenges in designing systems for self-regulation seems to find the right timing for and balance between reminding the user of their goals while not annoying the user enough that they avoid the intervention completely, an open topic of a significant amount of earlier research, e.g. [1, 14, 49, 50, 62].

6 DISCUSSION

Initial work on the extension Aiki indicated that redirection of activity in a browser had potential to both limit procrastination and increase engagement with learning activities [39]. The study was, however, based on a small number of participants (N=10) and a short period of time (10 days). The current study extends on that initial work by a) Redesigning the system in accordance to feedback from the initial study. b) Expanding the learning platform to a different area, namely that of *programming* in place of language learning. c) Exploring opportunities and challenges of the

Challenge	Design opportunity
Websites are not categorically "good" or "bad"	Design for user independence
Learning imposes cognitive demand (rather than a break)	Redirection of activity should pose minimal cognitive requirement
If it works, it doesn't	Consider redirection prompts
Not now, ask later	Carefully consider the pervasiveness of the system

Table 4: A summary of challenges and opportunities to redirection of activity-systems identified.

redirection of activity-approach in more depth. d) Evaluating the method over time, i.e., eight weeks instead of two, and e) Adding a benchmark of time-wasting minutes by tracking four weeks of "normal" browser behavior for a point of comparison.

While it is not a goal in itself to design a system which works for everybody, we had expected participants to remain more engaged during the current study because they voluntarily and deliberately signed up. We conclude from this study, however, that the intervention strategy of redirection of activity needs careful (and further) design to work optimally. In this section, we identify four opportunities for the future design of redirection of activity-systems, which correspond to the challenges identified in the Findings sections. An overview of the challenges and opportunities is presented in Table 4.

6.1 Opportunities for Design

6.1.1 Design for user independence. Users may be motivated by the deliberate break away from something they are *supposed* to be doing, e.g.: *"I just wanted something else more pleasant, more rewarding. And just what is rewarding at the moment is independence"* (P13). Three participants mentioned that they appreciated the fact that they could control the hours during which Aiki is active and the amount of minutes and seconds each interception lasts:

> *"I would like that I could check Twitter, for example, in the morning, but then I say, okay, from nine o'clock, I don't want to check it anymore. Or I don't want to be able to check it anymore"* (P2).

> *"It's nice that you can set like, the timeframes, like how much how much time you want to do programming or whatever. And then how much procrastination time you get, I think that's nice – that I can see that for myself."* (P3).

Two participants also mentioned frustration about settings that they *would* have been able to control (times of day Aiki was active and the time-wasting websites), if they had known that these settings were available. This indicates that it is important that the user is informed about what the system actually does and what they are able to customize.

Redirection should ideally be experienced more as self-*regulation* than as self-*blocking*, as blocking is likely to lead to the user becoming annoyed with the system [62, 64]. Therefore, we encourage developers of self-regulation systems to design for the highest possible degree of *user independence* and making user control visible. This is strongly related to the discussions about a move to a *fourth-wave* of HCI where we design to strengthen human autonomy in their interactions with autonomous things [12].

6.1.2 Redirection of activity should pose minimal cognitive requirement. The learning environment (unsurprisingly) influenced the experience of redirection to a critical degree. Even though all participants said they were motivated to learn Python, many participants avoided the redirections because the learning platforms required significant cognitive effort. It is possible that users choosing their own redirected to-website would allow them to find what is maximally engaging for them on a longer term. If learning is the primary goal for the user, exercises that are integrated into the procrastination website may be more successful than a complete redirection [49]. It is also possible that the redirected to-website could rotate between different destinations; perhaps between exercises, reading, and other entertainment sources.

Another design opportunity might be to consider how to design more intentionally for the user to develop or reflect on *purposefulness* in their browser interactions – for which it should be "apparent how one's actions and short-term goals relate to one's higher-order aims, and values" [68]. Raising awareness for the user about their online behavior may lead to such reflection and potential positive effects [46, 60]. The current Aiki-interface is designed to be minimally intrusive and thus, does not provide cues about the user's goals or progress towards such goals. It is possible that asking the user to relate to and reflect on their goals more deliberately before initiating and during the use of Aiki would be beneficial, as suggested by research on the intervention strategy *Goal advancement* [13, 61].

6.1.3 Consider redirection prompts. Users are more open to redirection at some times than at others. That might mean different times of day to some, but it also may depend on the other tabs or programs open on the computer, physical location of the user, patterns of activity during a typical workday, or combinations of these or other factors. One participant described using the redirection as a *reminder* when visiting Wikipedia:

> *"sometimes I would just innocently go on one of my procrastination websites. One of them was Wikipedia. (...) And then it reminded me, oh actually yeah, I haven't done any Python today. It's not even [as] though procrastination was a huge problem. It was just a nice reminder"* (P14).

Different prompts and different contexts will likely work well for different users, as has been shown in previous research on *rotating* different interventions [53]. It might be possible to discover inspiration for the right timings and contexts of redirections by looking toward "contextually sensitive approaches" [22]. Contextually sensitive design has perhaps become particularly important since Covid 19-lockdowns have changed the expectations of many workplaces to allow and facilitate more remote work, with the consequence that much more work than previously is conducted in home environments.

It is also possible that different framings and semantics used in the UI-prompts of the redirection system may make a positive difference. In the Aiki UI, we framed the 'time-wasting' websites

as procrastination websites (negative framing), and the learning website as 'productive' (positive framing) (e.g., in the prompt "Let's do something productive", Fig. 2 or the red-colored *Emergency skip*-button with a skull, indicating this button should be avoided, Fig. 3). It would be interesting to compare potential effects of different UI-framings of these activities in future systems – particularly as positive or negative framings might relate to different primary motivations for using the system, e.g. 'avoiding procrastination' or 'learning to code'.

6.1.4 Carefully consider the pervasiveness of the system. On one hand, several participants said they wanted the redirection to work on their phone as well as in their browser. On the other hand, most participants also said they deliberately avoided the redirections for multiple reasons. Based on this, it is unclear what is the best balance of the pervasiveness of the system, but it is a design implication which is worth being extremely mindful of. Previous research has highlighted simultaneous, uncorrelated multi-device use as one of the most problematic aspects of design of Digital Self-Control tools, and suggested that education of the individual user may be a more promising way forward than more pervasive lock-out mechanisms [72]. This corresponds to findings that *blocking* approaches may lead to short-term benefits in terms of time dedicated to 'productive tasks', but may also lead to attrition and higher amounts of stress [62, 64]. One opportunity for future systems might be to let the user specify which devices (or browsers) they wish to be redirected on, and additionally to tailor the redirection to each of these devices. This would also depend on the redirected to-website, as not all websites work well on mobile platforms.

6.2 Limitations and future work

While the redirection of activity-strategy is relatively unexplored in previous research, there are some comparable elements of our results which may inform other interventions for self-regulations. One of the more important ones is the discussion of what constitutes time-wasting or purposefulness of time spent online. While social media are often used as exemplars – Meier and colleagues even coined the term 'Facebocrastination' [67] – in studies of self-regulation applications and portrayed as agreed-upon culprits of unproductive behavior, the reality is of course much more complex. Distinguishing between productive and unproductive breaks is not simple, and can likely not be reduced to specific url-addresses, but requires careful reflection from each individual user – potentially, but not necessarily, with the guidance of a digital intervention.

Much of what we know about self-regulation and procrastination is based on studies of a *student* population and focuses on academic procrastination, e.g., [7, 41, 82, 85, 96]. While student populations are often easier to study, academic procrastination is a slightly simplified version of the 'time-wasting' we wished to address in the current study. Students are in a situation where they constantly have specific goals and tasks (assignments) which must be accomplished within a specific time frame. This makes it easier to distinguish between 'tasks that contribute towards that goal' (productive) and 'tasks that do *not* contribute towards that goal' (not productive). However, by introducing a third task in the flow (in our case, the learning platform), we try to create a space where breaks can be spent on something that feels meaningful to the user, rather than aimless [68]. The goal is *not* to remove breaks or to stop aimless behavior, which we recognize are crucial for digital wellbeing. Nor is it to frame procrastination as inherently 'bad' or productivity as inherently 'good'. Currently, a lot of research on digital wellbeing is focused on breaking old habits, rather than forming new habits [71], and this is the research gap that we aim to contribute to. While Aiki does not completely 'crack the code' to promoting meangingful online behavior in its current version, we hope that there is potential for future development in our experiences and findings.

It is also worth mentioning that long-term studies of the effects of self-regulation applications are difficult to conduct, but needed. Most research in the domain is based on studies that last only a few weeks (most often between three and six), and most studies show promising results from the initial use of the interventions, while the long-term effects remain unknown. That being said, it may be unrealistic to expect digital applications to have longer-term effects than weeks or months, and one impactful interaction may have long-term cognitive impact beyond what is immediately measurable – just as one memorable discussion can impact a person's framing of a particular topic.

We believe that there is still significant work to be done to balance the appeal and effectiveness of this approach to work on a long-term basis. Our study design was exploratory and comes, of course, with some caveats, the most important of which we have listed in the following.

1. Our study is based on a relatively **small participant number** and during a **limited period of time**. In the interest of conducting a thorough user experience evaluation with the use of rich, qualitative data, we have prioritized detailed data in place of statistical generalizability. It means that we can not make statistical predictions about whether our findings generalize to other populations and contexts.

2. Even though we saw a significant decrease in average time spent on time-wasting websites from phase 1 to phase 2, **we only logged time spent on websites, that participants self-defined, and only time spent in the Chrome browser**. We therefore can not be sure that we logged 'procrastination' time completely accurately between phase 1 and phase 2. This will, however, always be one of the caveats of studies that log personal habits in an unobtrusive way. It is possible that participants procrastinated more on their phone than they otherwise would have. However, we traded this uncertainty for the risk of the extension being too invasive and too technically complex. Future studies could experiment with at least logging smartphone behavior during the deployment of Aiki to investigate whether this would change significantly, though such an investigation has not been the focus of this study. We relied on participants' self-reports in estimating their time spent on purposeful activities versus procrastination, since the primary goal was to explore a system for *self-regulation*, rather than to confirm an objective hypothesis.

3. **The timing of the study** may have influenced computer use. A recent study has indicated that data about general web navigation behaviour traces can be leveraged in order to identify patterns that can be associated with procrastination behaviour, and also that

these behaviors are highly seasonal [80]. All of our participants installed Aiki roughly around the same time of year, and we do not know whether this period correlated with exams, deadlines, holidays etc. for the participants. We chose to let the enrollment in the study be based on participants' self-evaluation of whether the timing was right for them.

4. There could be a **learning effect** from using the same Python test in the beginning as in the end of the study, i.e. participants could have been more aware of the concepts introduced in the test during their visits to the learning platforms. We did not take any measures to control for this, since the overall improvement in scores was high enough that we do not estimate such a learning effect would have a significant impact.

5. We did not have a **control group for learning**. Participants could theoretically have achieved the same amount of Python learning without the Aiki extension if we had provided them with access to the learning environment and asked them to use it as they pleased for eight weeks. Because the goal of this study was primarily investigating redirection as an intervention strategy to increase purposeful use of time, rather than teaching the participants to program, we only report this as a potential limitation to the results. We imagine an ideal version of Aiki to be fully customizable to participants, so that they can choose both their 'redirected from' and their 'redirected to' website freely, however, for the purpose of comparing outcomes, this experiment was more controlled.

Further quantitative insights about online behavior might be useful in understanding more general and longer-term patterns. In this paper, we have focused on qualitative insights to inform the best possible design of similar systems to be tested in a larger scale. The next steps for our research is to reiterate based on the opportunities identified in this paper, and to deploy Aiki publicly with the option for users to define their own websites to be redirected to. Our future work in this domain will explore how well redirection of activity works if users are allowed to define their own learning platform or redirected to-websites. We look forward to investigating which websites, users would enter, and whether this would lead to higher retention rates and increased user empowerment and satisfaction.

7 CONCLUSIONS

In this paper, we presented an explorative study of *Aiki*, a browser extension designed to use redirection of activity as an intervention strategy for self-regulation online. We found that the active use of Aiki decreased time spent on self-defined time-wasting websites, and increased knowledge of Python. However, we also saw that many users avoided their time-wasting websites completely (and thus, the learning platform), or turned the extension off after some time. We therefore identified a list of challenges and opportunities for the design of redirection of activity-systems:

Challenges: 'Websites are not categorically "good" or "bad"', 'Learning imposes cognitive demand (rather than a break)', 'If it works, it doesn't', and 'Not now, ask later'. **Opportunities:** 'Design for user independence', 'Redirection of activity should pose minimal cognitive requirement', 'Consider redirection prompts', and 'Carefully consider the pervasiveness of the system'.

The novelty of our contribution consists particularly in the qualitative insights that explore *why*, *when*, and *for whom* a redirection of activity-intervention might work (or not work). As identified by previous research (particularly Lyngs et al. [61]), this type of system appears attractive and promising but is not well explored in research. We hope that these insights will be useful to other designers of self-regulation systems.

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A INTERVIEW QUESTIONS

	Interview questions
1	What was your motivation to participate in the study?
2	What was your motivation to learn Python?
3	Why did Aiki work or why did Aiki not work for you?
4	Will you continue using Aiki? Is there something missing that would convince you to keep using it?
5	Would you describe yourself as a procrastinator? Why or why not?
6	Would you describe yourself as a person who structures their work a lot? Why or why not?
7	Do you feel like you work well under pressure, for instance as a deadline approaches? Why or why not?
8	Do you often start working on tasks at the last moment, and does that lead to problems finishing on time?

Table 5: Open-ended interview guide, intended to both evaluate the participant's experience of using Aiki, and their motivation for using a redirection tool.

B SURVEYS

Opening survey

- How often do you feel like you visit a "time-wasting" or unproductive web as though your fingers almost type the address out of habit? (Scale, 0 = N
- Do you have any websites you wish you spent more time on or visited mo sites and why you wish you spent more time there. (Open answer)
- Do you have any websites you wish you spent less time on or visited less o about which sites and why these pages take up your time. (Open answer
- Have you ever taken any measures to limit your visits to certain websi distracted you from doing your work? If so, which mea (Open answer)

Follow-up

- How often do you feel like you visit a "time-wasting" or unproductive web as though your fingers almost type the address out of habit? (Scale, 0 = N

Closing survey

- How often do you feel like you visit a "time-wasting" or unproductive web as though your fingers almost type the address out of habit? (Scale, 0 = N
- Did you learn or discover something about your procrastination behavior d Was the redirection how you expected? Did you get redirected more or l answer)
- How would you rate your general experience with Aiki? Try to think ab redirected and the coding platform you were sent to as separate things. We platform in the next questions, so focus only on the Aiki browser extensi 10 = Very good)
- Tell us more about why you chose that rating? Describe your experience you can think of. (Open answer)
- How would you rate your general experience with your coding platfo experience of being redirected and the coding platform you were sent to Not good – 10 = Very good)
- Tell us more about why you chose that rating? Describe your experience much detail as you can think of. (Open answer)

Table 6: Questions from opening, follow-up, and closing surveys.