Tool development for measuring and optimizing workplace utilization in activity-based work environments

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ABSTRACT

Activity-Based Working (ABW) is supported by work environments that combine hot-desking with a variety of workplaces, designed to support different types of activities. While the advantages of these work environments in terms of efficiency seem obvious (cost savings because less workplaces and space are needed), there is hardly any evidence for the presumed effectiveness regarding job performance, satisfaction, health, and well-being. To develop both theory and evidence-based ABW practices, the purpose of this project was to develop, test and validate a tool for measuring and optimizing workplace utilization, using work sampling and mobile technology. This new tool, 'MyPlace2Work', uses a mobile application, to be installed on any smartphone or tablet, enabling on-the-spot collection of self-report data. Participants provide data about the activities they perform, the workplaces they use and associated levels of satisfaction, several times a day during a measuring period. These data are combined with the answers to a questionnaire covering several psychological and job characteristics. The tool has been tested extensively, resulting in some improvements of the software and a protocol for the application in field studies. Preliminary results confirmed the relevance and usability of the data for further research regarding the utilisation of workplaces in ABW environments.

Keywords

Tool development, activity-based working, workplace utilization, work sampling.

1 INTRODUCTION

The fact that knowledge work in general is becoming more autonomous and interactive (Duffy & Powell, 1997), with workers switching more frequently between different activities, co-workers, tools and locations (Van Yperen, Rietzschel, & De Jonge, 2014), is reflected in contemporary work environments. Activity-Based Working (ABW) refers to the idea that people can work flexibly, using different types of workplaces, designed to support different types of activities (Veldhoen, 2008). Within an ABW environment, people do not have an assigned workplace, but they can use the available workplaces on an as-need basis instead.

The number of users exceeds the number of workplaces, because they can work time- and place-independent, using workplaces at home and at third places office as well.

The growing popularity of ABW environments among organizations is understandable, since the concept is argued to offer both efficiency and effectiveness. Efficiency gains seem obvious, because less workplaces, square meters and associated costs are needed to facilitate the workforce, compared with concepts that are based on assigned workplaces (that are under-utilized in many cases). Presumed effectiveness is merely based on the assumption that within an ABW environment, workers are able to use an appropriate workplace, one that is specifically designed for the activity at hand, at all times.

There is reason to doubt the effectiveness of ABW environments, at least as a 'one-size-fits-all' solution for all organisations and all individuals. So far, evaluative case studies and cross-case studies comparing ABW environments with other types of work environments have shown mixed and sometimes contradictory results regarding output variables like job performance, satisfaction, health and well-being (Van der Voordt, 2004; De Croon, Sluiter, Kuijer, & Frings-Dresen, 2005; Bodin Danielsson & Bodin, 2008; De Been & Beijer, 2014; Appel-Meulenbroek, Kemperman, Van Susante, & Hoendervanger, 2015). Some studies indicate that the ABW concept might not work as intended (Appel-Meulenbroek, Groenen, & Janssen, 2011; Kleijn, Appel-Meulenbroek, Kemperman, & Hendriks, 2012) and numerous examples of dissatisfaction are documented (Van der Voordt, 2004; De Been & Beijer, 2014).

Further research is needed to identify and understand the factors and mechanisms that cause (dis)satisfaction and affect job performance, health and well-being of the users of ABW environments. This might contribute to the development of a more comprehensive 'workplace theory', including physical, psychological, social and organisational aspects that may contribute to a fit between employee/organisation and work environment. For practice, further research is essential for the development of an evidence-based approach, taking into account relevant differences between individual organisations and employees.

This further research should be based on highly detailed and reliable data about the utilization of workplaces. We need to find out what *person* is using what type of *workplace*, for what type of *activity* and how this person *experiences* this specific combination of place and activity. Moreover, we need to analyse behavioural patterns (switching between different types of activities and workplaces) that occur within ABW environments. Essential aspects of these data are that they need to (1) be self-reported, to enable analyses of subjective experiences (e.g. level of concentration), (2) be recorded real-time, on-the-spot (*in situ*), in order to avoid recall bias and optimize ecological validity, and (3) include individual characteristics, to enable analyses of individual differences.

This requires for more sophisticated research methods and tools than the ones that are commonly used in this field (Davis, Leach, & Clegg, 2011), i.e. mostly questionnaires measuring user satisfaction (Vischer, 2008) and observations focusing on workplace occupancy, sometimes diaries or wireless technologies (e.g. RFID). Therefore, the purpose of this project is to develop and validate a new tool for measuring and optimizing workplace utilization, using work sampling and mobile technology.

In section 2 we introduce work sampling as a well-established research method and explain the advantages of mobile technology within this context. Section 3 contains a description of the new tool, 'MyPlace2Work', its development process and some preliminary results. In section 4 we discuss future perspectives for further research and application in practice.

2 WORK SAMPLING USING MOBILE TECHNOLOGY

Work sampling (also known as activity sampling) is an established methodological approach for analysing how people spend their working time (Robinson, 2010). Robinson (2010) summarizes the essence of this approach:

"The basic principles (...) essentially involve identifying and recording the tasks that people are performing at a number of randomly occurring sample points. *(...) Once data have been collected from a sufficiently large number of sample points, it is then possible to estimate the percentage of working time that people spend engaged in each task."*

In this project, we use a slightly broader definition, including not only tasks or activities, but also locations and satisfaction ratings. Because we include satisfaction, our approach can also be regarded as experience sampling (also known as ecological momentary assessment), a method that *"captures within-person, temporal experiences within natural settings through asking participants to provide information regarding their subjective experience on multiple occasions"* (Totterdell, 2006).

Work sampling uses self-reported, repeated measures to collect data regarding multiple moments within a certain time span (the period of data collection). In some fields of research repeated measures are used to analyse changes over this time span (i.e. progression in a learning process), but in this case they are used to analyse patterns that are assumed to be stable during the period of data collection.

A major advantage of work sampling compared to questionnaires and diaries is that it does not rely on retrospective recall of experiences, as these can be systematically biased (Shiffman, Stone, & Hufford, 2008). This is especially important since the usage of workplaces probably falls, at least partly, into a category known as unconscious automated behaviour (Aarts & Dijksterhuis, 2000). The fact that data are recorded on-the-spot, while respondents are performing their daily activities in their regular work environment, with minimal disturbance due to the research, ensures a high level of ecological validity (Wegener & Blankenship, 2007).

Traditionally, work sampling was conducted by observing people in their workplace, making it very resource-intensive. Modern work sampling techniques resolved this issue by using self-reported data instead. Another important advantage of self-reported data collection compared to observation data, is that a far more detailed analysis of activities is possible, including subjective aspects like perceptions, motives and satisfaction ratings. Also, this approach enables the recording of spatial patterns (movements between different locations), which is very difficult for an observer to do (Robinson, 2010).

Since the introduction of the electronic pager in the 1960s, many researchers have used this device for work sampling studies (e.g. Mobach, 2008). Whenever the pager gives a signal, the participant is expected to note his or her current activity on a paper checklist. Although this technique can provide reliable data, filling out the checklist may become unpractical when workers are moving around. As a consequence, this restricts the volume and detail of the collected data and it may negatively affect compliance. Practicality and quality of data – in terms of precision, accuracy and level of detail – can be improved by using a Personal Digital Assistant (PDA), as shown by Robinson (2010). Alternatively, text messages can be used to collect data via cell phones (Blok, Groenesteijn, Schelvis, & Vink, 2012).

Nowadays, the functionality of a PDA is integrated in any smartphone or tablet. The fact that these devices have become a very common tool for (knowledge) workers in many organizations creates new opportunities for work sampling research. The researcher no longer

has to provide PDA's with pre-installed software, since participants can install a mobile application themselves and/or provide data via a (mobile) website. This saves money (no need to invest in PDAs) and it is more convenient for the participants because they use their own device – one that they are familiar with already – and they don't have to carry an extra device. In comparison with text messages, the more streamlined graphical user interface of mobile applications have been found to significantly improve compliance and shorten entry times (Ainsworth, et al., 2013).

In conclusion, work sampling seems to be a promising research method for analysing the utilization of ABW environments, especially when mobile technology is used for data collection. The data are expected to be both detailed and reliable, because of the on-the-spot, self-report collection method. Moreover, the application of mobile technology will enable large-scale data collection at low costs.

3 THE DEVELOPMENT OF 'MYPLACE2WORK'

As explained in the previous sections, more sophisticated research techniques are required to expand our knowledge about workplace utilization in ABW environments. Within this context, work sampling using mobile technology seems to offer important advantages compared to commonly used methods. Therefore, the purpose of this project is to develop, test and validate a new tool for measuring and optimizing workplace utilization.

The project is a public-private partnership in which two academic institutions (Hanze University of Applied Sciences, Groningen, and University of Groningen) and a private company (Scan & CTRL, with Mobile Agency as its contractor for software engineering) are engaged. The academic institutions provide knowledge and have interest in data collection for research purposes. The private company invests in the development of the tool with the intention create a new service for its clients.

3.1 Description of the software

Participants have to fill out a questionnaire at the MyPlace2Work website before the registration process can be finished and the mobile application can be installed (this procedure excludes the possibility of partially filled out questionnaires). The current version of the questionnaire contains 61 questions and is subdivided into four sections:

1. *Individual Characteristics:* Which (psychological) characteristics are typical for how the participant feels and behaves in his/her working life?
2. *Job Characteristics:* What is the nature of the participants' job and which types of activities are important for his/her contribution to the organization?
3. *Workplace Preferences:* Which types of workplaces does the participant prefer for different types of activities?
4. *Master Data:* General information like age, gender, commuting time and employment.

The core of MyPlace2Work is a mobile application ('app') that can be installed on smartphones and tablets (Scan & CTRL, 2014). A few screenshots of the application are shown in figure 1. Different versions for iOS (Apple devices) and for Android are available. After installing the application, a participant can log in and take part in a research project. During the measuring period, he or she receives push notifications several times a day at randomized moments. After tapping on a push notification, the application presents four simple questions (one-by-one):

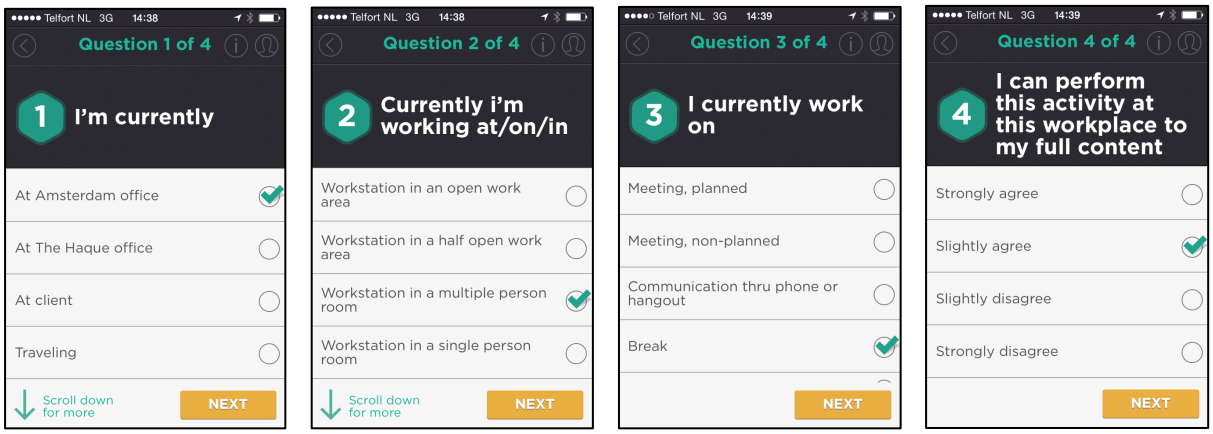


Figure 1 - Screenshots of the mobile application.

1. *I am currently at …* (choice between several locations)
2. *Currently I am working at/on/in …* (choice between several types of workplaces)
3. *I am currently working on …* (choice between several types of activities)
4. *I can perform this activity at this workplace to my full content* (four points scale: strongly agree – strongly disagree)

After answering these four questions, the data are uploaded (via a Wi-Fi or mobile internet connection) to the server that hosts the MyPlace2Work website. All answers are collected in a database, together with a user ID, measuring time (the time the push notification was send) and time of data entry. For reasons of practicality, respondents are enabled to answer the questions at a later moment on the same day. In order to keep a high standard regarding data validity (which could be undermined by recall bias as mentioned before), the software removes this opportunity at the end of every day. After the measuring period, data can be downloaded and imported in different software programs for data analysis.

After the measuring period, participants can go back to the website to obtain an automatically generated personal report. This report summarizes workplace utilization, activity patterns and satisfaction ratings. As an illustration, figure 2 shows a fragment of the personal report.

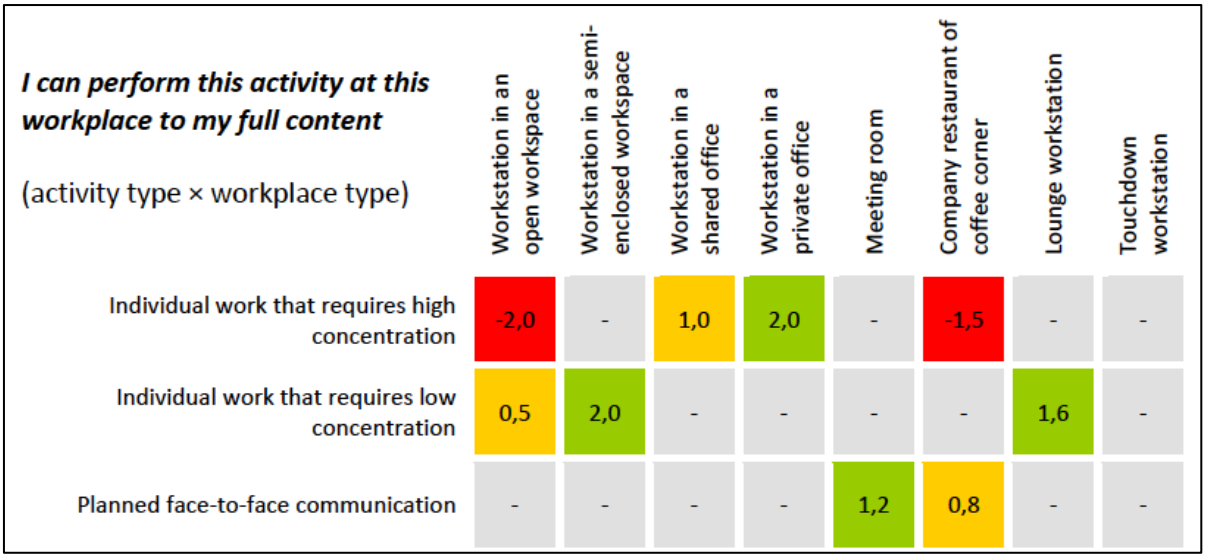


Figure 2 - Fragment of the personal report as generated by the software (the scores and associated colours represent average satisfaction ratings for a specific combinations of workplace type and activity type).

3.2 Research procedure

Although it is possible for individuals to use MyPlace2Work, in order to self-analyse their behavioural patterns[1], for research purposes we prefer collaboration with organisations that are willing to let their employees participate. The main reason is, that this enables us to observe and analyse the specific context within which data are collected: features of the physical and social work environment and of the organisation at hand. This is important with respect to the reliability and validity of the data. Especially when data from different organisations or locations are used for cross-case analysis, we have to be sure that variables like types of workplaces and types of activities have the same meaning in different contexts.

This also implies that it can be necessary to rephrase questions and adapt answer options in order to avoid misinterpretation or confusion among participants. Certain types of workplaces may for instance have different names within different organisations. Also, some types of workplaces may be non-existent in certain ABW environments.

Before the measuring period can start, it needs to be prepared in close cooperation with representatives of the organisation. Major points of attention within this process are data security, adapting questions and answer options to specific circumstances and communication with the prospective participants. A contract is signed regarding the handling, storage and anonymisation of personal data. A communication strategy is worked out for informing employees and managers about the project and its purpose – for the researcher, for the organisation and for the individual participant.

About a week before the start of the measuring period, all prospective participants receive an e-mail including a link to the MyPlace2Work website. By following this link, they will automatically join the group that was prepared to collect the data of their organisation. From this point, participants can proceed with the registration and installation process, as described in 3.1. If they need assistance, they can refer to a help page or contact the research team by e-mail. Participants are able themselves to log-out, change their password or remove their account at any time.

3.3 Data preparation and analysis

Obviously, the precision and reliability of research findings strongly depends on the number of sample points that is collected. More specifically, it is important to pay attention to the fact that more sample points are required, as smaller proportions of the total working time need to be detected. Pape (1988) developed a mathematical formula ('work sampling equation') that enables us to calculate the required number of sample points, given the smallest proportion of working time to be analysed. For instance, to precisely (precision level = ± 10%) and confidently (confidence interval level = 95%) detect an activity or workplace that accounts for 5% of total working time, 7,300 sample points are required. This formula can also be used the other way around, to calculate the level of precision and reliability, given the size of the dataset and the smallest proportion of working time within this dataset.

Before analysing the collected data, the structuring and cleaning of the dataset require special attention. Missing data are inevitable since most people are not able or willing to provide data at every requested moment during the measurement period. For overall analyses this may not be a problem while general patterns can be detected in a reliable way by analysing the data of

[1] This is possible for anyone by creating an individual account at www.myplace2work.com.

all respondents together. When focussing on individual patterns and differences however, a minimum number of reports per respondents is required and participants who have provided less reports should be removed from the analyses (McCabe, Mack, & Fleeson, 2012). Furthermore, it is important to find out whether data are missing (completely) at random or not at random, because in the latter case this can undermine the validity of results (Black, Harel, & Matthews, 2012). An example of non-random missing data could be that respondents would not report their activity while making a phone call, causing this activity to be underrepresented in the dataset.

3.4 Testing and optimizing the tool

The first phase of testing involved a group of twenty colleagues and students. They were asked to register, install the application, provide (fictitious) data for one week and give their feedback. The second phase of testing concerned a pilot field study within an engineering company. After presenting the tool to the employees, ten of them participated during a measuring period of 9 work days, providing a total of 183 measurements. Afterwards they were asked to fill out an evaluation form. During the same period, a larger field study was prepared in cooperation with a financial institution. Although this cooperation was ended and the study did not take place, the preparatory process learned some additional things about implementing the tool in a corporate organization. Finally, a first large-scale field study was conducted at a public sector institution (see section 4 for some results). Overall, these first experiences learned a lot about issues to be resolved and opportunities for improvement. Major findings:

- Communication before the start of the measuring period needs serious attention. Managers and employees have to understand the purpose and the procedure. The communication strategy needs to be aligned to the organisational culture.
- Motivation to participate (and keep participating) differs strongly between employees and between (groups within) organisations. This may affect the response rate.
- Participation is not perceived as burdening; providing the data only takes a few minutes per day and works smoothly (with some exceptions in the beginning, due to technical flaws).
- Especially in a corporate organization, data security and the processing of personal data can be a major issue.
- A huge diversity of smartphones and tablets, using different platforms as (i.e. iOS, Android), is being used in the workplace. This makes it necessary to pay special attention to flexibility and robustness of the software.
- The system needs to be fool proof in every sense: registration and installation procedure; textual explanations; data entry.
- In many organisations still not all employees are using a smartphone or tablet. Sometimes, they do not want to install the application on their mobile device, especially when it is their private possession. An alternative way to participate has to be offered via a regular website.
- The questionnaires have to be adjusted to the situational context for every single project. Types of workplaces, types of activities – and how these are called – appear to differ strongly between organisations and locations.
- Contextual information (i.a. workplace occupancy rates, organizational culture, work processes, building lay-out, implementation process) is required in order to interpret and compare findings that derive from data analysis correctly.

Based on these findings, the software has been improved (version 1.2 is now available) and a protocol for implementation has been worked out. At this moment, data from the first field study are analysed in detail, providing clues for further optimising the questionnaires regarding their content and structure.

3.5 First results

In this stage and within the scope of this paper, only a brief selection of the first results can be presented, without going into detail, just to offer some insight into the nature of these results. These results derive from the first large-scale field study, conducted at a Dutch public sector institution. After the preparatory process, 114 employees participated, providing a total of 3.480 sample points during a measuring period of 10 workdays. The analyses of the data revealed several interesting findings i.a. regarding concentrated work:

- The majority of all work was perceived as 'individual work that requires high concentration', far more than assumed by the designers of the work environment.
- Satisfaction ratings for this type of activity were low in many occasions.
- This dissatisfaction highly correlated with the use of workstations in open workspaces and shared rooms.
- It also correlated with individual differences regarding need for privacy.
- Private rooms, which were specifically intended for it, were used to perform this type of activity quite seldom (also on moments when occupancy rates were known to be low).

The results also showed some puzzling discrepancies between stated and revealed workplace preferences with respect to different types of activities. Surprisingly, a (mis)match between stated preference and actual workplace choice appeared to be a rather weak predictor of workplace (dis)satisfaction.

By systematically comparing consecutive sample points, switching between different types of activities and workplaces could be analysed. On average, the frequency of switching between different types of workplaces appeared to be quite low. In the majority of the cases, switching to a different type of activity did *not* coincide with switching to a different type of workplace.

4 FUTURE PERSPECTIVES

Now that this new tool for measuring and optimizing workplace utilization has proven to be applicable in practice and able to yield high-quality data, we can outline some future perspectives for further research, theory development, and application in ABW practices.

By conducting more field studies in other organisations, using the same approach, we will enlarge the database. This will enable us to draw more precise and reliable conclusions about user behaviour, user perception and related psychological, physical and social/organisational factors. At the same time, this will create opportunities for analysing relevant differences between organisations and work environments. All of this might contribute to the development of a more comprehensive and empirically founded 'workplace theory' that can help explain and predict behavioural patterns within ABW environments and related effects on output variables like job performance, satisfaction, health and well-being.

At an organizational level, this knowledge is useful to improve design and decision-making processes that precede the implementation of ABW environments. Consultants and designers will be able to predict user behaviour and related effects more accurately, given a specific

situation and population. Consequently, their advice, briefs and designs will be better aligned with these circumstances. In the future, ABW environments will hopefully be more tailor-made and more evidence-based.

From now on, organizations can use the MyPlace2Work tool to evaluate their current ABW environment. Based on a detailed and integrated analyses of user characteristics, user behaviour and user satisfaction, they can identify problems and develop measures to solve these. A major advantage of the tool is that it helps choosing between (or sometimes combining) interventions targeting physical improvements (e.g. improving acoustics or adding seclusion rooms for concentrated work) and interventions targeting behavioural change (e.g. enforcing house rules or training computer skills). The tool can also be used to monitor workplace utilisation periodically or to measure the effectiveness of applied interventions (before and after measurements).

Last but not least, MyPlace2Work is a potentially useful tool for raising awareness and stimulating behavioural change at an individual level. When participants receive their personal report after the measurement period, they may learn something about their specific needs concerning various types of activities and to what extend they are fulfilling these needs as a consequence of their current behavioural patterns (habits). As far as their needs are not fulfilled, they will probably concern or try-out alternatives more consciously or take initiative to discuss their issues with their manager. This way, the tool may stimulate a bottom-up process, helping to optimize the utilization of an ABW environment.

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