

How CREM can measure added value of building design; Knowledge sharing in research buildings

133

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Abstract

Purpose - In present day society, focused on innovation, knowledge sharing (KS) is essential. Corporate Real Estate Management (CREM) needs to provide accommodation designed for people to meet more often and share both tacit and explicit knowledge. Most workplace descriptions do not provide quantitative information on how the design actually stimulates KS. They cannot be implemented straight into a design nor convince general management in budget discussions. This paper tests the suitability of spatial network methodologies to provide this proof.

Design/methodology/approach - After developing a conceptual model from literature, the model is tested with a case-study of one large research driven organisation in the Netherlands. For each possible dyad between 138 employees (= 9453 dyads), several KS indicators and workplace aspects are studied with statistical analyses.

Findings - KS is clearly related to the allocation of people to the rooms and workplaces in a research building. Bumping into each other does not appear the reason for this relation. Up to distances of 22 meters dyads share average or higher amounts of knowledge. It is ambiguous whether the spatial network analysis methodology is relevant for measuring added value of the workplace for KS.

Originality/value - This paper provides empirical evidence on a 'softer' added value of the workplace, which is scarce. Previous studies relied mainly on qualitative descriptions of the workplace, while this paper tests a methodology to quantify the workplace in measurable aspects and correlate them statistically to organisational outcome measures.

Keywords Corporate Real Estate Management, Knowledge sharing, Added value, Spatial network analysis, Building design

1. Introduction

Only a few decennia ago, CREM decisions about real estate used to be made ad hoc, with no overall strategy in mind. Real estate is a costly resource for organisations, often the second largest behind labour cost (Pole and Mackay, 2009). Therefore, it needs to be managed strategically and not measured solely with financial input

indicators. Lindholm and Leväinen (2006) identified 5 additional (non-financial) ways in which CREM can add value (benefit) to the organization. Besides direct return ('Reducing costs') and indirect return (increase in the 'Value of assets'), these are 'Promoting marketing and sales', 'Increasing innovation', 'Increasing employee satisfaction', 'Increasing productivity' and 'Increasing flexibility'. But as De Vries et al (2008) showed, it is still reducing costs that is aspired most. CRE managers just know more about reducing costs than increasing revenue (Brown, 2008).

There is an important knowledge gap of empirical evidence in the field of real estate research on the 'softer' added values (Peponis *et al.*, 2007; Price, 2009; Blakstad *et al.*, 2009). Previous studies relied mainly on qualitative descriptions of the workplace, making it hard to compare them (Franz & Wiener, 2005). There is a need to quantify the workplace in measurable aspects, and correlate them statistically to organisational outcome measures. Looking at the modern western world, there is one added value in particular that organisations seem to strive for these days, namely innovation. In a Corenet 2010 survey, CRE managers were asked to rank the 7 possible real estate strategies. After reducing costs and increasing productivity and flexibility (mostly efficiency/financial measures), encouraging employee innovation was the most important strategy focussing more on effectiveness of the organisation. Therefore this paper will focus on this added value.

Both Berends (2003) and Van den Bulte and Moenaert (1998) point out that the importance of communication for successful innovation is well acknowledged by both practitioners and researchers. Communication and social networks are a mediator between innovation and places (Kauttu, 2003; Wineman *et al.*, 2009). It is not expected that the workplace can stimulate innovation of organisations directly. Instead, it should stimulate innovative behaviour like knowledge sharing (from here on called KS) to stimulate organisational learning and innovation. As Nenonen (2005) points out "...there is still a lack of an approach, which combines the elements of workplaces and the fundamental structure of the learning process and knowledge creation...". This is something that this paper aims to help with.

The next section will describe KS and the indicators that will be used in this paper to study the association between the workplace and KS. Then previous studies on workplace and added value are used to develop a conceptual model. Before the test of this conceptual model and results are described, the methodology used to quantify the workplace in measurable aspects (called spatial network analysis) is described. This paper ends with conclusions, recommendations and implications for the field of CREM.

2. Knowledge sharing

Epistemologists have traditionally looked at knowledge as "*justified true belief*", which dates back to Plato and is still used as a definition (Nonaka & Takeuchi, 1995; Berends, 2003). To justify personal beliefs, a meeting must take place between people, during which something is shared. Most studies assume that the more meetings take place, the more knowledge is shared. But after taking a closer look at knowledge components, this proves not necessarily to be true. There is a common

distinction in most knowledge management literature between explicit knowledge (information) and tacit knowledge, in accordance with Polanyi (1966). Especially the more tacit component of knowledge can only be shared through spending time together in the same environment (Nonaka and Konno, 1998). Short interactions are not enough and a deeper collaboration is required. But often, meetings are not studied with enough detail to see whether knowledge is actually shared and which type of knowledge is shared.

Berends (2003) did do an in depth study on KS and identified 5 categories of activities that take place during work in a research building and during which knowledge is shared:

- Descriptions,
- Actions,
- Questions,
- Proposals,
- Evaluations.

The difference between sharing explicit or tacit knowledge is not studied, but can be described as the wilfulness of actually wanting to achieve something together or just exchanging information. For this paper it is assumed, that giving descriptions is an activity to share explicit knowledge, without needing a deeper collaboration. It is expected that the other 4 activities do require collaborative behaviour and thus provide tacit KS. Besides the KS activities, also the duration, location and intentionality of a meeting is relevant, plus the issues that were addressed, to be able to study the KS process and components in more depth.

3. Developing a conceptual model

With regard to the support that the workplace can give KS, innovation and knowledge management literature emphasize that face-to-face interaction and physical proximity are key to sharing tacit knowledge, but do not study this in depth. So, the workplace literature proving a positive influence on KS (or using synonyms/sub-activities like cooperation) has been interpreted through content analysis, to identify in more detail the relevant CRE aspects. The results of the content analysis are split in local effects (called co-presence) and global effects (called position in the building), for which the relevant CRE aspects are underlined in the summary below. Most (short) meetings at work take place between dyads (= one on one). But so far, very few studies, except the early work of Allen (1977), have looked at dyads; mainly taking the individual as their subject of observation. Hardly any studies include both co-presence and the position in the building. But this paper will do so.

Co-presence

The effect of co-presence can be viewed in the light of the theory of cognitive apprenticeship: "Working in visual proximity created increased opportunities for

young staff to 'learn by observation' from older, more experienced staff." (Becker et al., 1995) Project rooms can be a very helpful instrument (Heerwagen et al., 2004; Blakstad et al., 2009), but the effect also takes place in (other) open layouts (Spiliopoulou and Penn, 1999). Working in proximity makes it easier to ask questions, perform actions and go through the repetitive team work of making suggestions and evaluating together. So the first CRE measure for a dyad is whether their workplaces are in the same room.

If people can see each other (intervisibility) at their workstations, they can collaborate, share tasks and ideas more easily and provide assistance (Jassawalla and Sashittal, 1998), because they are more aware of other people's need for help (Nonaka and Konno, 1998; Brager et al., 2000; Sailer et al., 2007). This awareness increases KS activities as making suggestions, expressing observations or referring to relevant knowledge sources.

Aural accessibility (hearing distance) is also relevant. Working in the same project room provides accessibility, but also normal workspaces that are visually open enhance face-to-face interaction through seeing and overhearing (Ward and Holtham, 2000; Rashid et al., 2006; Markhede and Koch, 2007; Sailer et al., 2007).

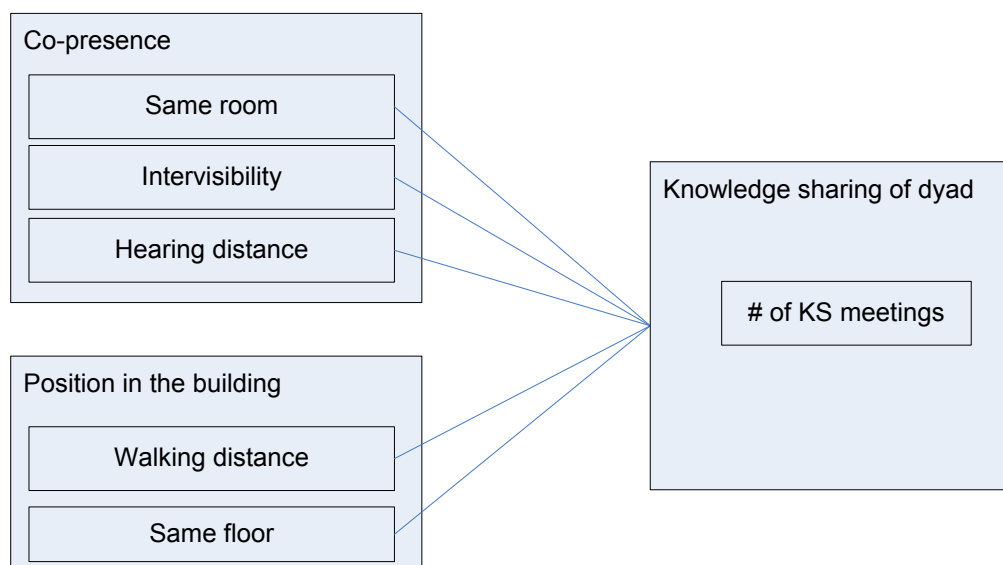
Position in the building

People in close proximity (walking distance) interact more, because they bump into each other when moving around in the vicinity of their workplace. During these 'chance' interactions, KS activities as giving descriptions and reporting about others can take place. Allen (1977) pinpointed the limit for a 'chance' meeting effect at about 30 meters.

The frequency of meetings between people who work on different floors inside a building is lower than between people on the same floor (Parsons, 1976 in: Rashid et al., 2006; Spiliopoulou and Penn, 1999). This effect becomes smaller when the floors are bigger (Grajewski, 1992; Becker et al., 1995). Allen and Henn (2007) even say that people on different floors might just as well be in different buildings.

The qualitative content analysis of literature led to the conceptual model for this paper (see Figure 1), which is studied quantitatively with a case study. First, the number of meetings during which at least 1 of the 5 KS activities took place is obtained for each possible dyad of two employees. Then, the KS process and components are studied in more depth for the CRE measure with the strongest association with the amount of KS meetings. But first the next section describes the methodology used to measure distances between dyads in computer drawings.

Figure 1. Conceptual model



4. Spatial network analysis

Three of the CRE aspects in the conceptual model are not so difficult to generate, namely whether the workplaces share intervisibility and whether workplaces of dyads are in the same room (for co-presence) and/or on the same floor (for position in the building). The other two aspects, however, require calculations of distances that are very laborious to do by hand, especially the walking distance between each dyad (for position in the building). Luckily, “*Recent years have seen the development of more sophisticated analytic techniques for describing spatial layouts and their properties.*” (Wineman *et al.*, 2009). This field of research is evolving both in qualitative studies (e.g. Kojo and Nenonen, 2009) and quantitative studies (which is the aim of this paper). One of the quantitative techniques belongs to the area of spatial network analysis and is called space syntax analysis. The most relevant space syntax technique in this case is visual graph analysis (VGA), which is derived from Isovist analysis, and explained below.

An isovist as defined by Benedikt (1979) is “*the set of all points visible from a given vantage point in space and with respect to an environment*” (see Figure 2). Turner *et al.* (2001) used isovists, placed on a regular grid, to derive a visibility graph, which is a “*graph of mutually visible locations in a spatial layout*” (see Figure 3). The darker areas are seen from fewer points in the total layout than the lighter areas. So, a lot of the workplaces in figure 3 are located in areas that are seen by very few people moving through this example office layout. And the visible (lighter) areas are hardly allocated to workplaces. An appealing side of isovists and visibility analysis is that they provide a description of space as how the user perceives it, interacts with it and

moves through it (Turner, 2001; Turner, 2003) and have the potential to reveal more of the life that occurs in a space than by just studying the space itself (Peatross, 2001).

Figure 2. Example of isovists at eye-level from 2 different workplaces

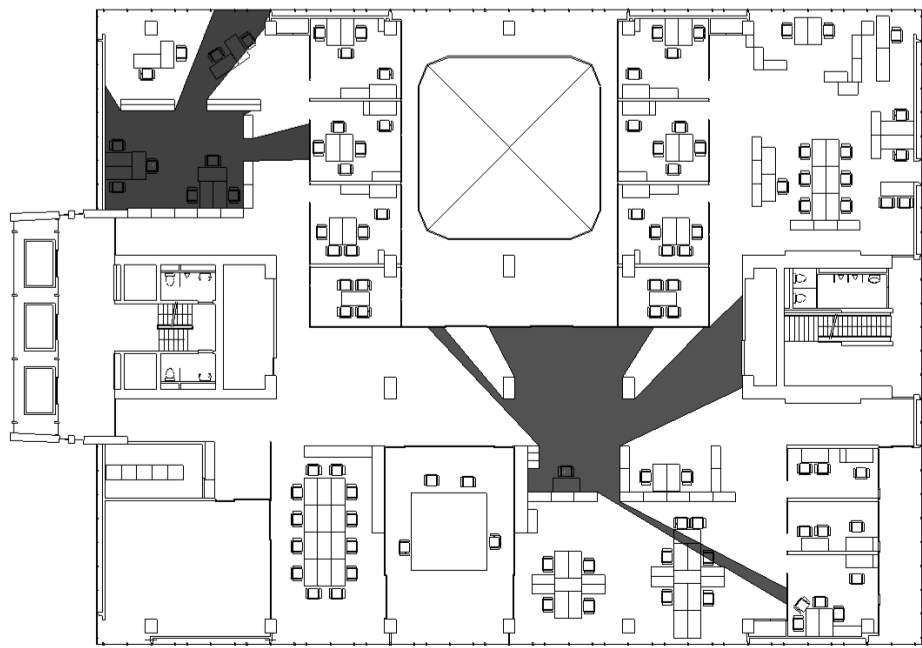
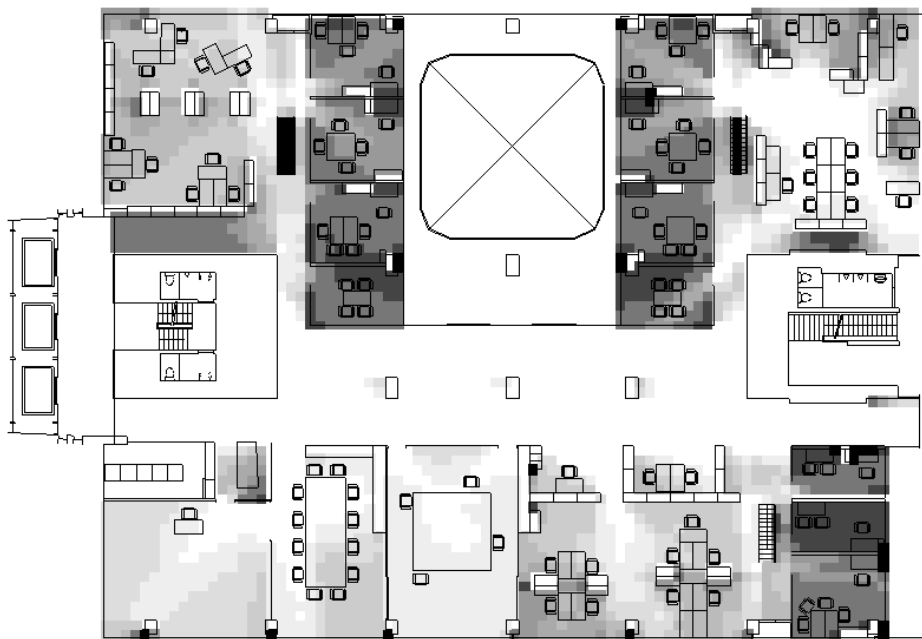


Figure 3. A visibility graph example



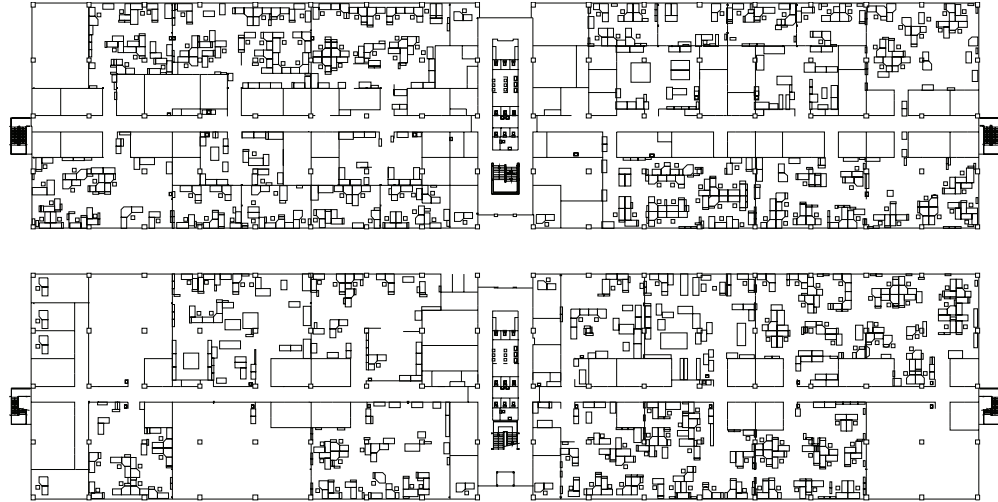
Spatial network analysis uses the VGA grid to determine metric distances. This is a close approximation of the actual metric distance, because it measures distance from the centre of one grid square to the centre of another, but can move around obstacles in the drawing. Matela and O'hare (1976 in: Shpuza, 2006) found it to be the best suitable to approximate circulation routes in buildings. The relevant VGA measures for this paper are 'metric straight line distance' to measure hearing distance and 'metric shortest path distance' to measure walking distance. A software program called Depthmap (version 7.12) was used, developed specifically by Turner (2001) to derive these (and other spatial) measures. Depthmap can read architectural drawings made in AutoCAD. Turner *et al.* (2001) distinguish between a visibility graph and permeability graph (= visibility graph at floor level, to include furniture and other obstacles). By making different layers within an AutoCad drawing, different VGA graphs can be made, because in Depthmap each layer can be turned on/off before running the analyses. To generate the 'hearing distance' a visibility graph is used, and for 'walking distance' a permeability graph. Since Depthmap does not work with dyads, an individual analysis has to be done for each person, generating his/her distances to all the other persons on the floor. These results can be imported into SPSS, and allocated to each dyad.

5. A test of the conceptual model – case study

The research organisation chosen as a case is one of the world's leading providers of document management and printing for professionals, with their headquarters in the Netherlands. The organisation is active in approximately 100 countries and employs some 22,000 people worldwide. The building with most researchers is called 3G and therefore was chosen as the subject of this case-study. At the time of the data collection, 269 employees had a workplace in the 3G building (excluding general staff, e.g. secretaries), which were all approached at their workplace to ask if they wanted to participate. All participants filled in a logbook on KS meetings during one regular workweek. In total 138 logbooks were returned which is a 51% response rate. The logbooks contained 918 meetings between 138 participants, which form 9453 possible dyads.

Building 3G has 2 floors (see Figure 4) with large and small rooms, ranging from single-person rooms to open areas with up to 29 workplaces. Small lab areas without daylight are concentrated around the corridors, and a few large lab areas with less specific climate conditions are located in areas similar to the offices. The participants are spread out over all rooms. A grid of 0,50 x 0,50 meters was placed over the entire layout of both floors covering 30217 gridsquares. The distance of 0,50 meter is justified by Franz and Wiener (2008), saying it lies between the average human step length (+ 0,6 m) and body width (+ 0,45 m). To do a VGA analysis, it is necessary to generate distances over more than one floor, connecting people vertically through stairs and elevators. Each grid square is appointed an original number, so each workplace gridsquare can be linked in SPSS to the participant using it.

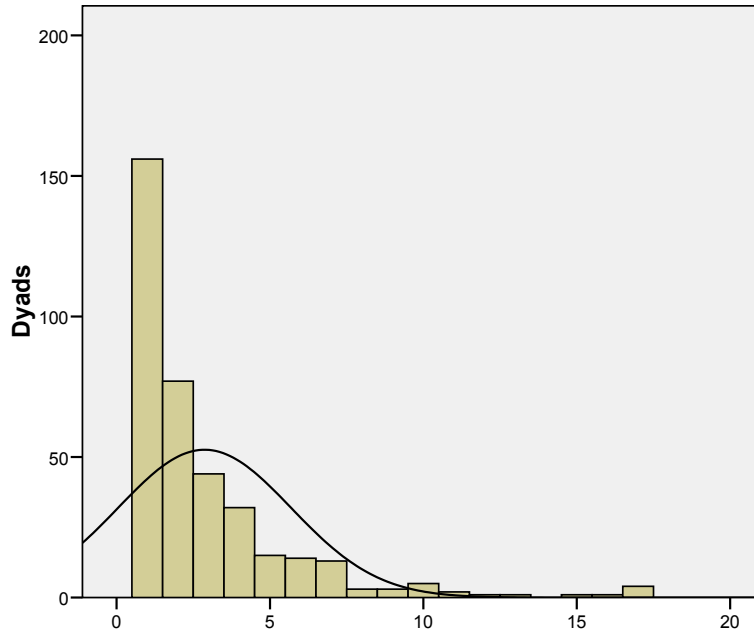
Figure 4. Layout building 3G



5.1 Data description

Not all 138 participants have had KS meetings with each other during the week that was studied. Of the 9453 dyads, only 372 have shared knowledge with each other, which is only 4%! The dyads that did share knowledge, had an average of 3 KS meetings that week ($SD = 3$), with a minimum of 1 and a maximum of 17. This variable does not have a normal spread (see Figure 5). During 56% of the meetings knowledge was shared by asking and answering questions, while the other 4 KS activities only took place in about 20% of the meetings. On average, people spend 45 minutes of their day involved in unplanned meetings (with a minimum of 1 min./day and a maximum of 6 hrs. + 38 min./day). So that is over 10% of a normal workday of 8 hours and could have quite an effect on the performance of these people. Most KS took place during very short meetings of less than 15 minutes and 78% of the meetings took place at a workplace.

Figure 5. Number of KS meetings dyads



Naturally, not all dyads are located in the same room. In this case, 570 dyads (=6%) share a room. Not all workplaces within the same room can also see each other (intervisibility) although the difference is small in this case (521 dyads = 5.5%). The maximum hearing distance in a room depends on many factors, but generally lies between 5 and 10 meters (Keränen *et al.*, 2008; Wenmaekers *et al.*, 2009). Looking at a histogram of the straight line distance between all the dyads in the same room (see Figure 6) it becomes clear that most dyads sit within 10 meters distance (69%) and even 27% sits within 5 meters. The walking distance between dyads varies from 1,1 meter up to 148 meter ($M = 61$, $SD = 29$; see Figure 7). The dichotomous measure 'being on the same floor' is about evenly spread (48% of the dyads work on the same floor and 52% do not).

Figure 6. Distance between dyads sharing a room

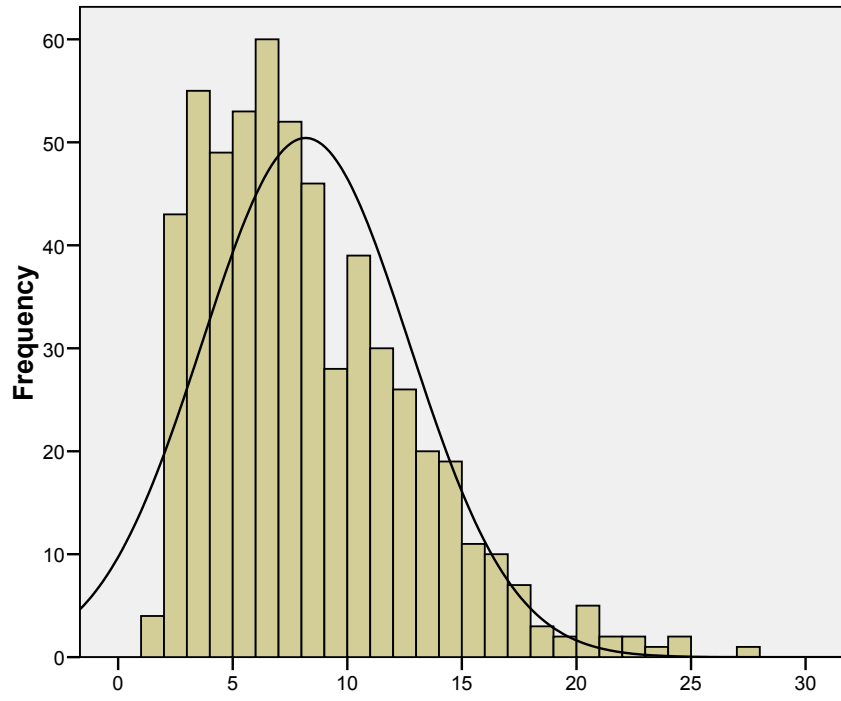
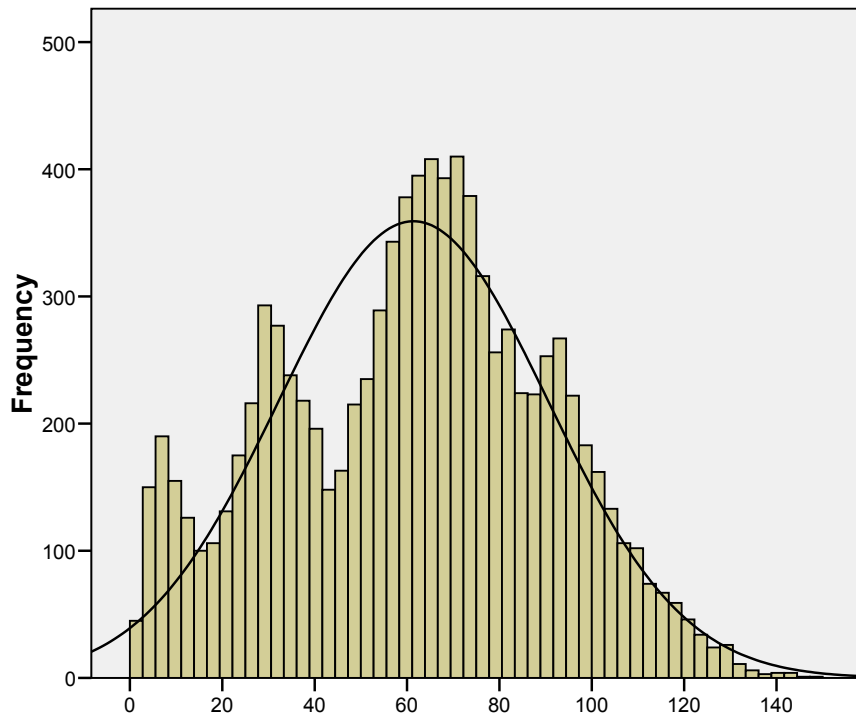


Figure 7. Walking distance in the building



To test the conceptual model, a hypothesis of association with the amount of KS meetings will be tested for each individual measure. Since the amount of KS meetings is not spread normal, the model is tested with Spearman's correlation. The Spearman test uses ranks to test for association and does not depend on the assumption of an underlying Normal distribution or any other distribution. Spearman correlation is valid for both linear as curvilinear relationships, but not for hyperbolic. Both interval measures (the rest is dichotomous) appear to have a curvilinear association with KS, so there is no reason not to use Spearman's test.

5.2 Results

In the conceptual model, co-presence of dyads was operationalised with 3 measures:

1. Workplaces are in the same room (yes/no)
2. Intervisibility of workplaces (yes/no)
3. Hearing distance between workplaces (m)

As Table 1 shows, all measures have a significant correlation with the amount of KS meetings. But they also all correlate with each other. In this case sharing a room and intervisibility measure the same thing (.953), both correlating with the amount of KS meetings equally (.46). For dyads sharing a room (N=570), the hearing distance correlates only a little less with the amount of KS meetings (.42) than sharing a room itself did.

Table 1. Correlation co-presence and # of KS meetings dyads

| Spearman's rho | | # of KS meetings | Same room | Intervisibility | Hearing distance |
|------------------|-------------------------|------------------|-----------|-----------------|------------------|
| # of KS meetings | Correlation Coefficient | 1.000 | .460(**) | .465(**) | -.422(**) |
| | Sig. (2-tailed) | . | .000 | .000 | .000 |
| | N | 9453 | 9453 | 9453 | 570 |
| Same room | Correlation Coefficient | | 1.000 | .953(**) | . |
| | Sig. (2-tailed) | | . | .000 | . |
| | N | | 9453 | 9453 | . |
| Intervisibility | Correlation Coefficient | | | 1.000 | -.259(**) |
| | Sig. (2-tailed) | | | . | .000 |
| | N | | | 9453 | 570 |
| Hearing distance | Correlation Coefficient | | | | 1.000 |
| | Sig. (2-tailed) | | | | . |
| | N | | | | 570 |

** Correlation is significant at the 0.01 level (2-tailed).

Position in the building was operationalised with two measures:

1. Walking distance between workplaces (m)
2. Same floor or not (yes/no)

As Table 2 shows, both measures correlate with the amount of KS meetings. In this case walking distance correlates negatively with the amount of KS meetings (-.27), and having a workplace on the same floor positively (.18). But both correlations are not very high and their mutual correlation is even stronger (-.37).

Table 2. Correlation position in the building and # of KS meetings dyads

| Spearman's rho | | # of KS meetings | Walking distance | Same floor |
|------------------|-------------------------|------------------|------------------|------------|
| # of KS meetings | Correlation Coefficient | 1.000 | -.270(**) | .178(**) |
| | Sig. (2-tailed) | . | .000 | .000 |
| | N | 9453 | 9453 | 9453 |
| Walking distance | Correlation Coefficient | | 1.000 | -.368(**) |
| | Sig. (2-tailed) | | . | .000 |
| | N | | 9453 | 9453 |
| Same floor | Correlation Coefficient | | | 1.000 |
| | Sig. (2-tailed) | | | . |
| | N | | | 9453 |

Going back to the conceptual model, the measures that correlate with the amount of KS meetings are:

Co-presence

- Sharing a room/intervisibility .460
- Hearing distance within room -.422

Position in the building

- Walking distance within building -.270
- Same floor or not .178

Clearly, co-presence has a stronger association with the amount of KS meetings than position in the building. The most relevant measure is whether a dyad shares a room, which is not a measure that needs a complicated spatial network analysis method. Dyads from the same room have 1.4 KS meetings on average (SD = 2.68) and from different rooms 0.03 KS meetings (SD = .30). Both these means are very low, because also 348 (61%) of the dyads that shared a room, did not have a KS meeting. Of the 372 dyads throughout the building that shared knowledge, only 14 were located on different floors. This makes the average number of KS meetings for dyads from different floors 0 (SD = .07). So KS between people on different floors is nearly extinct.

A boxplot shows how the number of KS meetings decreases with distance within the room (see Figure 8) and walking distance throughout the building(see Figure 9).

Not counting the outliers, only dyads within hearing distance share knowledge and dyads with 3 or more KS meetings have a walking distance of less than 22 meters.

Figure 8. Distance within the room and the # of KS meetings

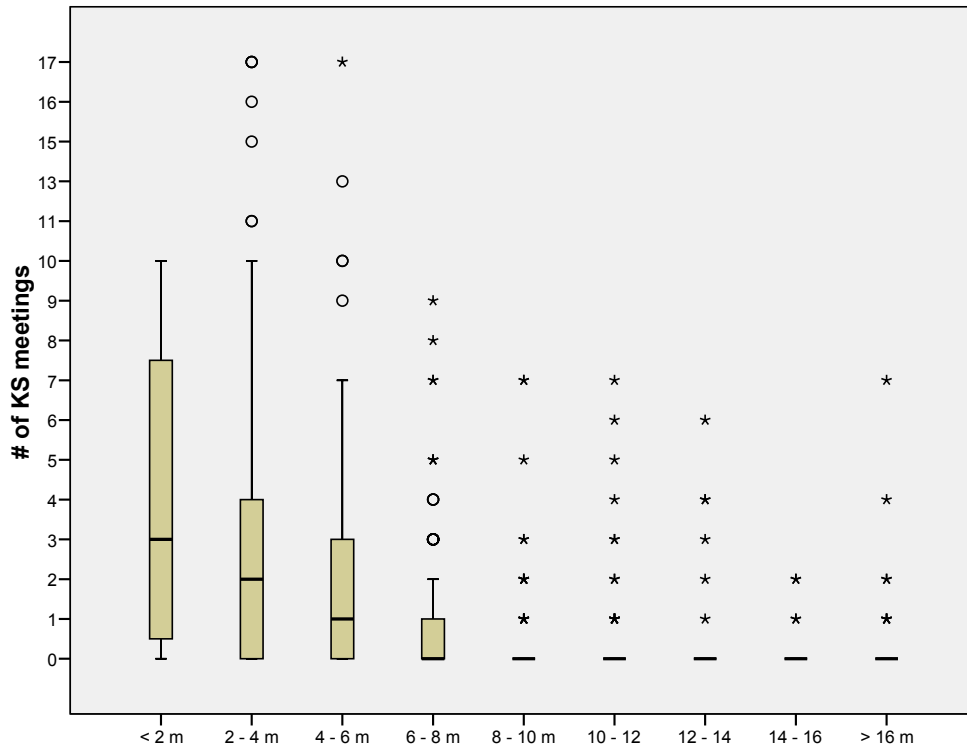
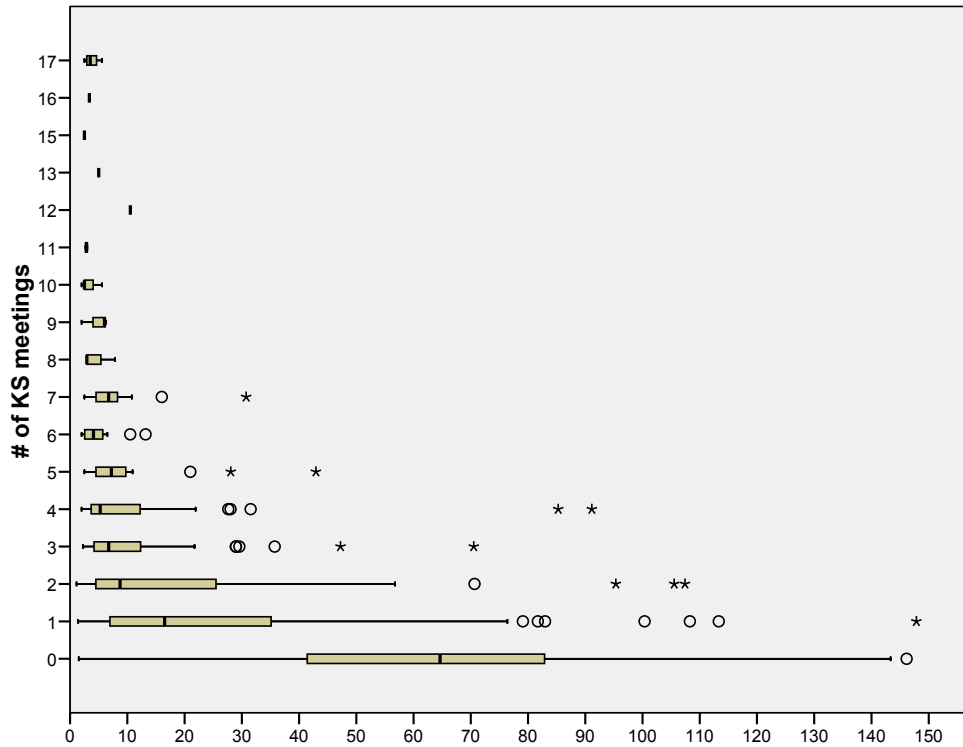
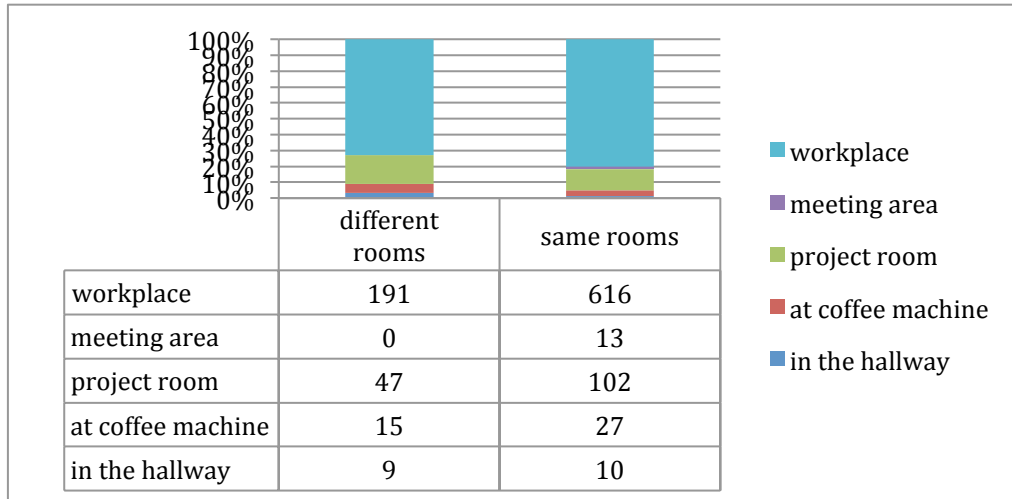


Figure 9. Walking distance and the # of KS meetings



For the CRE aspect with the strongest association with the number of KS meetings (same room or not), the KS process and components are analysed in more depth. A χ^2 -test shows that the behaviour through which knowledge is shared (the KS activities) does not differ between dyads working in the same room and dyads with separate rooms/areas; $\chi^2(4, N=1385) = 8.03, p = .09$. Although dyads from different rooms ask each other more questions, and propose/evaluate less, the differences are not statistically significant so nothing can be concluded on tacit versus explicit knowledge components. Looking at the location of the meetings (see Figure 10), significant differences do come forward. A χ^2 -test shows that the people from different rooms share more knowledge in the hallway, at the coffee machine and in project areas than dyads sharing a room; $\chi^2(4, N=1385) = 15.85, p < .01$. The fact that only dyads from the same room use meeting areas for unplanned meetings suggests that they move to a meeting area if the workplace is too disturbing or unsuitable for the meeting.

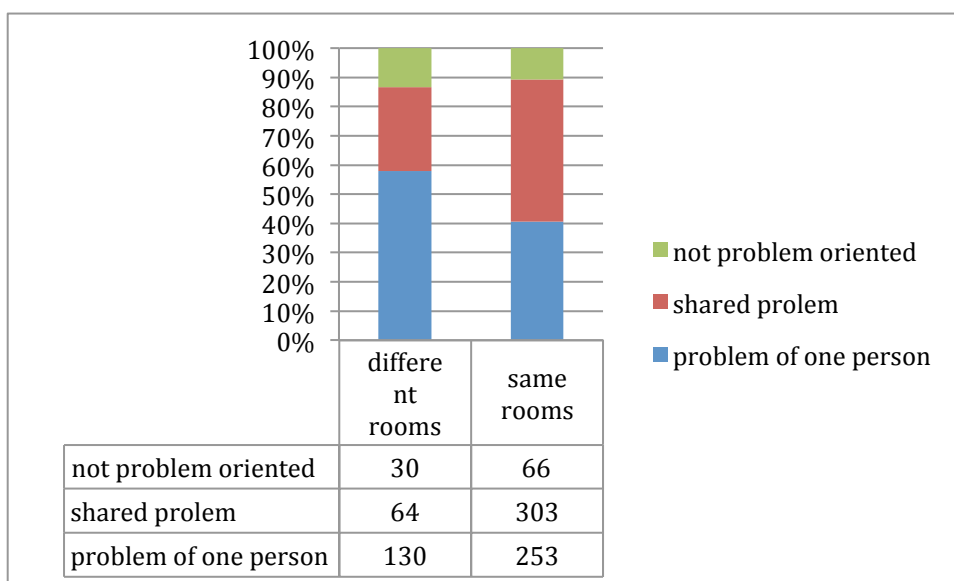
Figure 10. Observed frequencies of KS location and same room or not



Surprisingly, the amount of coincidental meetings that led to KS versus intentional visits to share knowledge was not significantly different for employees in the same room as for employees from separate rooms; $\chi^2(2, N=845) = 0.26, p = .61$. So the thought that people in the same room share more knowledge because they bump into each other coincidentally more often, is not supported here. They also intentionally look for a certain roommate to share knowledge.

A χ^2 -test of the issues addressed (see Figure 11) shows that people in the same room do share more knowledge about shared problems, while dyads from different rooms more often share knowledge to help the other one with their problem; $\chi^2(2, N=846) = 27.49, p < .01$.

Figure 11. Observed frequencies of issues addressed and same room or not



6. Conclusion and recommendations

KS is clearly related to the allocation of people to the rooms and workplaces in a building. Sharing a room was the most important condition for dyads to share knowledge, but, obviously, it is not feasible for all dyads to share a room. Even more so, since sitting within hearing distance was essential (for the organization studied). So creating too large open areas will not have an even effect on all dyads inside. Bumping into each other does not appear the reason for the effect of sharing a room, since dyads not sharing a room have a similar amount of unintentional KS meetings. Up to distances of 22 meters (within a room or in adjacent rooms) dyads share average or higher amounts of knowledge, but at longer distances the KS is below average. That people sharing a room exchange knowledge specifically on shared problems is due to the fact that organizations collocate departments or teams in rooms/sections. This does not reckon with the importance of cross-functional KS as shown in the learning spiral of Nonaka and Takeuchi (1995). The case study showed that people not sharing a room still help each-other with problems that are not shared. Unfortunately no further inferences can be made on differences in sharing explicit and tacit knowledge.

It is ambiguous whether the spatial network analysis methodology is relevant for steering on added value of the workplace for KS. It is laborious when used on dyads, and the 'easy' quantitative measure 'sharing a room' has a stronger association with KS than hearing and walking distances. It appears that for organisations with rooms/areas that are not very large, the easy measure of sharing a room is sufficient to steer on knowledge sharing between certain dyads. But the trend towards large open areas on office floors, makes the hearing distance more and more relevant. For organisations with more than a handful of employees, this does require a methodology like spatial network analysis to be able to steer on KS between each dyad. Also, larger areas will place people in the same room from different teams, which do not share problems, and thus might use different KS activities.

This study showed that CREM can also be helpful in increasing revenue, and not only in reducing costs. Hopefully, it will help them convince their clients of their added value for softer values, like innovation and knowledge sharing. As this is an important goal for most modern organizations, CREM should work together with other important business units to improve it. The reluctance of many organisations to allow CREM a seat at the strategic table during those discussions could cause a competitive disadvantage. Especially in current economically hard times, every disadvantage could mean the difference between survival and bankruptcy.

This study also shines a new light on the upcoming trend of introducing New Ways of Working. These activity based office concepts, where employees are free to sit (and come and go) where and whenever they like, might be a potential inhibitor of the KS process. They often have large open areas (too large according to our results), and the number of meetings might decrease, due to absence of certain colleagues to share knowledge with. Whether ICT will compensate for this effect is not yet clear. Neither is the effect of people not having an assigned seat, which might disturb continuous co-presence (and cognitive apprenticeship). This needs further research.

Further research with this methodology for quantifying workspace is necessary to test the relevance for cross-functional KS (between different departments), for other added values like productivity, flexibility, etc. and for KS of individuals. If it does have strong associations with these added values, software could be designed for CREM to use it in proving added value of the softer side of the workplace. Combined with studies on expressing these added values in financial indicators, a stronger argument for general management could be presented.

Some recommendations for further studies on the added value of workplaces for KS are:

- Repeating this study in more cases (different types of organizations, different countries) and longitudinal studies (before/after changes in workplace),
- Developing software for allocating personnel to rooms/workplaces based on organizational aims/goals for knowledge sharing,
- Studying the optimal room size for knowledge sharing, other ways to distinguish explicit and tacit knowledge, and cross-functional KS more in depth.

To conclude this paper, a last remark on innovation. KS is only part of this tacit process and it is to be expected that the workplace also influences things like creativity and inventiveness. If this paper has shown one thing, it is that the field of added values of the workplace can still use a lot of different academic studies before it is clarified.

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