

NordDesign 2014
August 27 – 29, 2014
Espoo, Finland / Melbourne, Australia

Reasoning processes involved in ICT-mediated design communication

Pieter Pauwels¹, Jolanda Morkel², Rens Bod³

¹*Department of Architecture and Urban Planning
Ghent University, Belgium
pipauwel.pauwels@uva.nl*

²*Department of Architectural Technology and Interior Design
Cape Peninsula University of Technology, South Africa
morkelj@cput.ac.za*

³*Institute for Logic, Language and Computation
University of Amsterdam, the Netherlands
rens.bod@uva.nl*

Abstract

Conversational interaction is central to architectural design practice. New information and communication technologies (ICT) change the designer's traditional way of communicating and interacting. In this paper we investigate how communication in the design process might be supported using ICT. With this aim, we study a text-based Skype conversation between a design teacher and a design student. We consider this conversation as part of an architectural design process and analyse it using linkography. From the linkograph analysis, specific features are identified that apply specifically to text-based Skype interactions. We conclude that online text-based Skype interaction can be one of the many possible interactions by means of communication media (sketching, conversation, modelling, and so forth) during the design process, and provides a distinct set of characteristics that might be considered by the designer.

Keywords: *architectural design, design process(es), protocol analysis, reasoning, reflective practice*

1 Reflective practice in design

Understanding how designers think and how the design process works has been the topic of many research initiatives during previous decades. Several appropriate overviews are available that describe the historical evolutions in these research initiatives and their outcomes [1,2]. Some of the key points in this domain of research are drawn from the theories outlined by Nigel Cross [3], Bryan Lawson [4], Donald Schön [5], and Herbert Simon [6]. Central elements in these theories are (1) the intensive interaction between designer and design context, and (2) the reflective, '*learning-while-doing*' character of the design process. In learning-while-doing, designers build up knowledge in direct reference to concrete experiences. This knowledge might be related to '*a designerly way of knowing*' [3]. Designers make design decisions in newly encountered design contexts on the basis of this kind of

knowledge. Through their ongoing interaction with new design contexts, their ‘*reflective practice in design*’, designers continuously adjust their designerly way of knowing. These adjustments obviously have a significant effect on future design decisions.

Reflective practice in design builds on the combination of an external world (right in Fig. 1) and the human mind (left in Fig. 1), between which *interaction* is crucial. The reflective practice in design, as schematically presented in Fig. 1, can be traced back to the work by Schön on the designer as a reflective practitioner [5]. It is indicated how designers are in continuous reflective interaction with their surrounding world. By making certain actions, responses or reactions are expected that allow designers to reflect on their actions, not only regarding the media they are interacting with, but also in relation to their own general socio-cultural backgrounds. These responses allow designers to react again, or rather to make new hypotheses and actions, against the same or other elements of interaction.

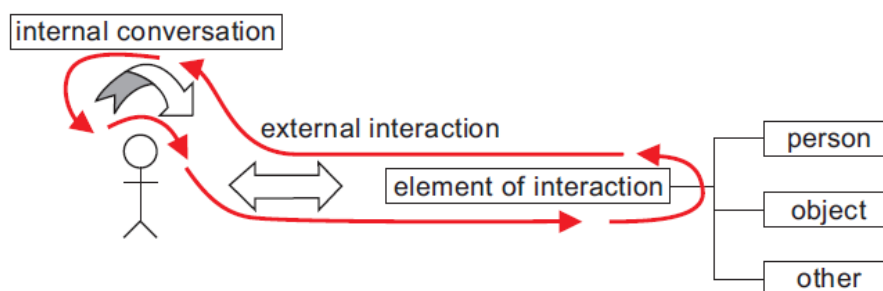


Figure 1: The actor, in this case a designer, is continuously involved either in an internal conversation with the self or in an external interaction with external elements of interaction, being any person, object or other that can be found in the world surrounding the actor.

With every external interaction, or every loop through the red arrow in Fig. 1, a certain evaluation or reflection is performed by the actor, in this case the designer, about the external interaction. In most cases, not only is there an evaluation or reflection performed *after* the interaction, there is also a form of reflection performed *before* the interaction, in the sense that the actor consciously or unconsciously considers what he or she expects as a reaction from the external element of interaction. One might consequently argue that any external interaction inherently includes a form of internal conversation. A loop of external interaction then includes the following stages:

- *Hypothesis*: how is the current design situation understood (internal conversation)
- *Prediction*: what behaviour is expected from the design situation when making a specific design action (internal conversation)
- *Experiment*: make an action in order to confirm or refute the prediction made, and the corresponding hypothesis (external interaction)
- *Learning*: store the result of the experiment for future reference (internal conversation)

When making ‘experiments’ as an architectural design practitioner, a myriad of interaction media is available, including traditional media such as paper-based sketches, physical models and regular face-to-face conversations. With the increasing adoption of information and communication technologies, alternative interaction media become available, including 3D modelling applications, CAD software, the Internet and Skype conversation software. Figure 1 distinguishes between three types of interaction media, namely ‘person’, ‘object’ and ‘other’. Each of these interaction media has different features, affordances and effects on the

decision-making process of a designer, hence our aim to study one of the newer interaction media: Skype text-based conversations.

In this paper, we will focus on a particular interaction medium for architectural design, namely the digital text chat medium by means of Skype. We will do this via a research experiment that consists of a design student (Andy), a design teacher (Elisa), and a specific design task. The research question behind this experiment is the following: *how is communication structured during the architectural design process when using text-based Skype as an interaction medium.*

In our experiment, we analyse the considered design process using think-aloud protocols and linkographs. We dig into the links of the linkograph, trying to identify ‘design episodes’ and analyse to what extent such design episodes can be subdivided into smaller design episodes in which design experiments are performed, within which, in turn, respective design decisions (design moves) are made.

2 Case study

The case study that is used here is part of an architectural design studio that took place during 2011 in the Department of Architectural Technology at the Cape Peninsula University of Technology (CPUT), South Africa. It is similar in approach to the case study that was documented in [8]. Design student Andy is one of the students who received the assignment to design a community hub as described in the following design brief (see also [9,10]).

“[D]esign a small, low tech, low cost, sustainable, multi-functional and easily assembled shelter structure that will act as the prototype for a public landmark facility. This landmark may be repeated in a variety of community locations. These ‘communication hubs’ will provide sheltered places and landmarks that will offer the relevant communities access to information as well as opportunities for learning, communication and social interaction. [...] A masonry service core of 1m² and 5m high must be lockable after hours. Its main function is the provision of a wi-fi spot. [...] The remainder of the structure must contain gum poles and marine ply as the main materials -these are provided for free.” [10].

During this design studio face-to-face interactions are organised among design students and the design teacher. These critique or tutorial sessions allow students to articulate their thinking and receive formative feedback in order to further develop their designs. For design students who are not able to attend the face-to-face interactions, online formative critique conversations (‘crits’) are set up through Skype. The students are then encouraged to use Skype as a tool for discussing their designs, receiving feedback, and so forth. They are supposed to use Skype as a design (thinking / articulation / conceptualisation) tool. On the other end of the Skype call is the teacher, Elisa, who provides the students with formative feedback and critical remarks to prompt the students’ design reasoning.

The specific Skype call that we study here consists of a dialogue with 128 Skype chat messages that were exchanged over a time span of about one hour (0h59m49s). This Skype call was reformatted in an Excel spreadsheet for linkograph analysis, following the guidelines in [11,12]. Reformatting the Skype call into the spreadsheet reduced the number of Skype instances from 128 to 111 instances. Each instance hereby contains but one sentence or less. Also, chat messages that were unrelated to the actual design process, mainly at the beginning and end of the Skype call, were eliminated from the data set. Both the original Skype call and

the spreadsheet used for linkograph analysis can be found online [13]. A small extract of the original Skype call transcript can be found in Fig. 2.

As stated in the design brief, the design students had to provide for a function for the community hub, in addition to it providing wi-fi access. For this extra function, design student Andy chose '*artistic performance in an open air dance theatre*'. This choice was taken at the very beginning of the design process, sometime before the analysed Skype session took place. Following on from this functional choice and drawing on the material required by the brief ('marine ply'), Andy formulated the concept of a '*dancing ship*'. As marine ply is typically used for constructing boats, it was argued that a boat reference could be justified for the hub design. The primary aim of the considered Skype call was to clarify this initial design concept of a dancing ship. This happened through subsequent decisions related to function, technology and the resultant form of the community hub. While making these design decisions, Andy and Elisa discussed several of the sections, plans and sketches that Andy had produced earlier.

[9:45:16 PM]
Elisa: The third page shows the plan
[9:45:25 PM]
Elisa: and wi fi tower in the centre
[9:45:33 PM]
Elisa: separating 2 zones
[9:45:37 PM]
Elisa: stage and back stage?
[9:45:39 PM]
Andy: I wanted to use it as a sort of "backdrop" for the performances. Where music etc is controlled from as well as using it to separate changing and performance spaces
[9:45:52 PM]
Andy: yes
[9:45:57 PM]
Elisa: It makes sense
[9:46:07 PM]
Elisa: However, must it be in the centre?

Figure 2: Part of the transcribed records of the Skype design call between Andy and Elisa.

During the Skype session design teacher Elisa indicated that, to achieve congruence and clarity of design through an underlying architectural language, the idea of dance and movement implied by the concept should ideally be evident in the plans, sections and three-dimensional form of the building. Andy's concept '*dancing ship*' might therefore inform a dynamic rather than a static attitude to approaching the community hub design, that would be evident, not only in the resultant form, but also in the plans, sections and elevations.

3 Linkography

Processes of design thinking are most commonly analysed with protocol studies [14,15]. With this method, a track record is obtained from designers involved in design activity through think-aloud protocols [16]. Example studies can be found in [17,18]. Although diverse methods exist to analyse protocol studies, linkography can be considered as one of the most successful. Linkography is a method for representation and analysis of design processes focusing on links between design ideas. The method was first introduced to protocol analysis for assessing the design productivity of designers [19]. After further developments [20-22], linkography is now established as a quantitative evaluation technique in protocol analysis to study designers' cognitive activities.

In producing a linkograph, the recorded design protocol is subdivided in small ‘design moves’, each of which is recorded in a sequential order (Fig. 2). Goldschmidt defines a ‘design move’ as “*a step, an act, an operation which transforms the design situation relative to the state in which it was prior to that move.*” [20]. Second, the protocol study is analysed for associations between distinct design moves. These associations are represented by links in the linkograph. The design process can then be looked at in terms of the patterns in the linkograph which display the structure of design reasoning. Using the Link Index (LI) and Critical Moves (CM) parameters, a quantitative analysis can be made of the protocol study [20,23].

As linkographs connect design moves to earlier design moves, using a network of backlinks and forelinks, they clearly show the origin and evolution of design concepts and ideas. In such an ideation process, design thinking heavily relies on (often intuitive) associations and analogies [24] between element(s) in the current design move in the current design episode and element(s) in previous design moves in previous design episodes. In this wider context of analogies, ‘previous design episodes’ should be understood as episodes that were experienced before, *also outside design activity*. The links in linkographs thus represent such analogies and they therefore show how associations and analogies influence the design process. By using the linkography method on a Skype text chat in the context of a design process, we therefore hope to find out to what extent the Skype text chat, as an interaction medium, limits / stimulates the ideation process in terms of fewer / more links in the linkograph.

4 Results and discussion

In this section, we briefly document the linkograph that was generated for the chat session (Fig. 3), after which we analyse the links and the linkograph content.

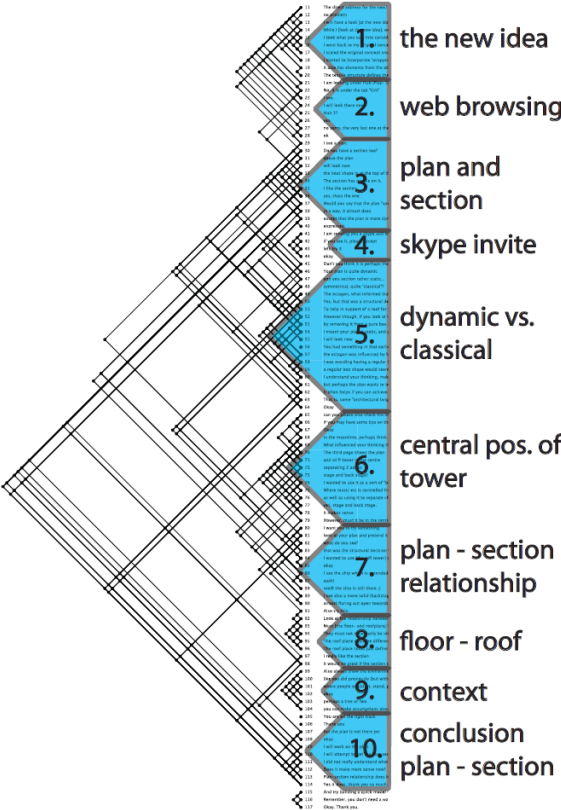


Figure 3: The linkograph that was obtained for the entire Skype conversation, illustrating the identified design episodes.

4.1 Design episodes within the Skype conversation

In the Skype conversation 10 distinct design episodes could be identified (Fig. 3). Design episodes are originally defined as “[describing] segments of activity aimed at reaching a certain goal; [they] are usually decisions concerning design elements. Each episode contains a unique goal (design element) that will be structured and solved during an episode. When the goal is accomplished or changed, that design episode ends.” [25]. Each of the identified episodes in the linkograph concerns specific design elements and aims at explaining, structuring or solving the goal that corresponds to that design element. For instance, in the first episode, the goal is to give a brief overview of the newly developed design idea; in the third episode the goal is to explain or understand the structure of both plan and section; and so forth.

It appears that the reasoning process that was outlined in the beginning of this paper (Fig. 1), in which a designer engages in sequential loops of internal conversation (validation, sense-making, hypothesis, reflection) and external interaction (prediction, experiment, learning), can be mapped on the process in each separate design episode. In every design episode a certain element of the design is observed, predictions are made regarding the given design element, actions in terms of external interaction (Skype conversation statements) are made, and both parties engaged in the conversation are learning. The following interpretation can be made for the earlier identified design episodes:

- In design episode 5, the plan and section of Andy’s community hub are observed. From this observation, it is hypothesised that the plan appears more static than the section and hence they do not correlate. From this hypothesis, it is predicted that the plan displays more classical properties. After confirming this prediction, and therefore also the initial hypothesis, a new characteristic of the design strategy is discovered or learnt, namely that the plan is more static than the section.
- In design episode 6, the central position of the tower in the floor plan is observed. Considering the content of design episode 5, it might have been hypothesised that the Wi-Fi tower is located in the center so that it deliberately makes the plan more static. From this hypothesis, the prediction is made that there is no real reason to place the tower in the center of the plan, besides a mere formal reason.
- In design episode 7, the complete plan-section relationship is observed. The design moves made here are similar to the design moves that are made in design episode 5. Here, the hypothesis might have been that the plan would improve if it were articulated in the same architectural language as the section. The prediction is made that dynamic (non-orthogonal) formal elements in the section can be employed also in the plan, resulting in a more dynamic plan, congruous with the section.
- In design episode 8, the relationship between roof plane and floor plane is considered. The initial hypothesis put forward by teacher Elisa appears to be that the design be improved by offsetting the roof and floor plane in a non-parallel configuration. This appears to lead to a sort of internal conversation in which this option is tested. In this design episode, the option is confirmed, thereby confirming also the initial hypothesis.

4.2 Design episodes within design episodes

The design episodes considered in Fig. 3 are of a relatively abstract and high-level nature. The previous section indicated what may constitute a hypothesis, a prediction and an experiment in each of the distinguished design episodes (episodes 5-8). However, these indications are rather speculative, as a result of the abstract nature of the design episodes. To clarify, it might be possible to distinguish diverse smaller design episodes *within* each design episode. In this case, whenever a certain prediction is made, this prediction might be subdivided in diverse smaller hypotheses that can be tested.

We will analyse this proposition for design episode 6 (see Fig. 4 for reference). The design episode starts with a specific (design) experience. In this case, the design experience corresponds with the observation of the location of the Wi-Fi tower in the plan. It is observed by design teacher Elisa that the Wi-Fi tower is located in the center of the stage. This is understood as a possibly not well-considered location for this tower, so Elisa starts hypothesising / explaining why it is located there. Although she might have a hypothesis in mind, it is not mentioned explicitly in the linkograph. Instead, Elisa directly proceeds to making predictions and corresponding experiments.

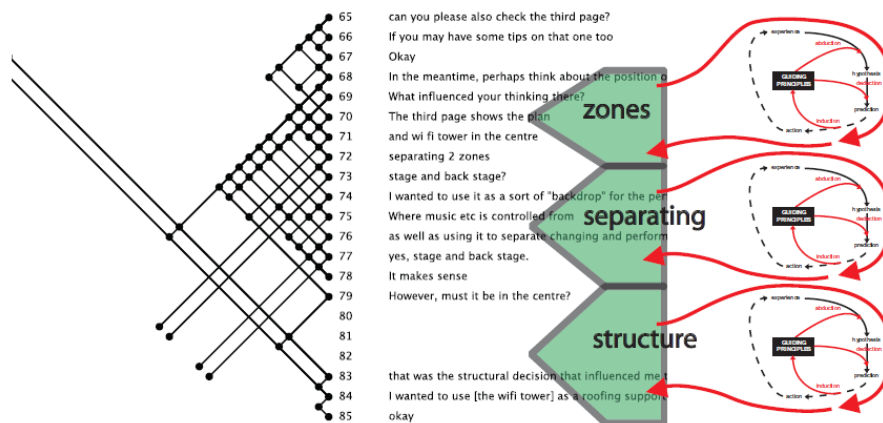


Figure 4: The part of the linkograph that corresponds to the central position of Wi-Fi tower episode.

The predictions and corresponding experiments address various aspects of the main hypothesis. This initial hypothesis was described in the previous section as follows: *“it might have been hypothesised that the Wi-Fi tower is located in the center so that it deliberately makes the plan more static. From this hypothesis, the prediction is made that there is no real reason to place the tower in the center of the plan, besides a merely formal reason”*. It is thus tested, using the Skype text chat medium, whether or not there are valid reasons for placing the wi-fi tower central. Elisa tests one after the other whether Andy might have placed the tower central because of (1) zoning considerations, (2) separation considerations, and finally (3) structural considerations (Fig. 4). Whereas the first two experiments have a negative outcome (no reason found for central location), the third experiment has a positive result (central location because of structural reasons).

If design episodes can be configured in layers or levels, then the main hypothesis that is considered in the design episode in Fig. 4 should correlate with the upper-level prediction (Fig. 3). This is true for the current case, considering the leading / initial hypothesis as described in the previous paragraph (‘no real reason to place the tower in the center of the plan, besides a mere formal reason’) and three experiments made afterwards (Fig. 4 – zones, separating, structure).

4.3 Layering design episodes

If it is possible to consider smaller design episodes on a lower level, it is perhaps also possible to consider them on a higher level (see Fig. 5). Indeed, one main design episode can be outlined covering the smaller design episodes of Fig. 3. In this overarching episode, the plan and section are observed. From this observation, it is hypothesised that the plan might be articulated to be more dynamic. This hypothesis leads to the prediction that the plan can improve if it adopts the same dynamic architectural language as the section. This prediction is then passed to a lower level, so that it can be appropriately tested. In the last episode, the initial hypothesis is finally explicitly confirmed and design student Andy is advised to “*integrate the design*” using the “*plan-section relationship*”. This higher level episode might be understood as a tangible display of an intrinsically intangible ‘guiding principle’ [4] that steers the designer in making decisions on a lower level of design episodes.

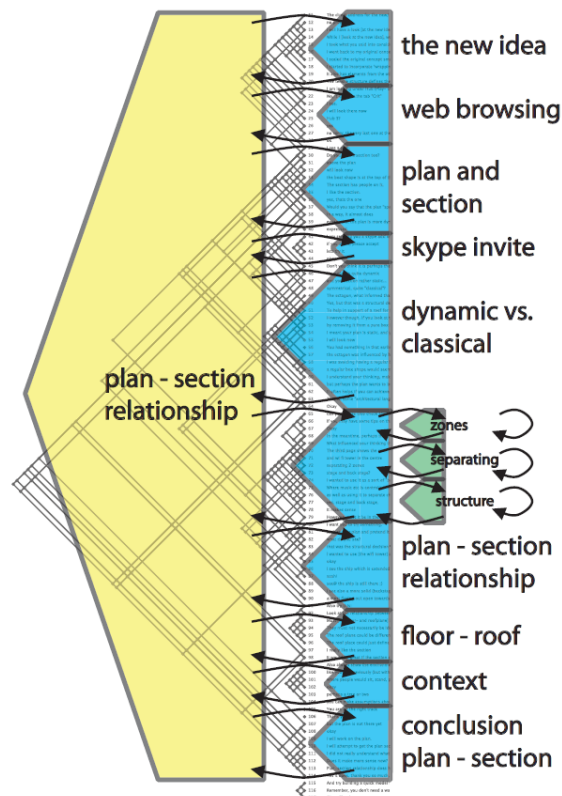


Figure 5: The overarching design episode that can be considered, schematically visualised in combination with the underlying lower level design episodes.

If this overarching level (Fig. 5) can indeed be considered, then it is possible to distinguish various such high-level design episodes and explain the design process as a sequential process of high-level experiments, in which new configurations and ideas come up and are tested. As such, also the previous weeks and months of the ideation process, which resulted in the ‘*dancing ship*’ concept, may be considered and combined with the studied Skype conversation for a more holistic analysis of the complete design process.

5 Conclusion

As indicated before, an architectural design practitioner may use a myriad of available interaction media when making ‘experiments’ (Fig. 1). This is confirmed in the schema in Fig. 5. Whereas relatively abstract reasoning processes are taking place in design episodes on the left of Fig. 5, more specific reasoning processes are taking place in the design episodes on

the right of Fig. 5. So, the interface with the surrounding design environment lies on the extreme right of the schema in Fig. 5.

In the case of our Skype text-based chat experiment, the external interaction consists of text-based messages with another person via a digital screen. It could just as well be the lines sketched on the paper in front of the designer; the sounds and visuals perceived when talking to one another in person; the visual display of a 3D modelling application; and so forth. There are, of course, differences between diverse media for designing. Sketching supports the design process in a different way than conversation does; 3D modelling in a modelling application facilitates design differently to building a physical model; as with a face-to-face conversation compared to a text-based Skype conversation.

In addition to the graphic material (including sketches, models, diagrams, drawings etc), the face-to-face conversation relies heavily on tone of voice, facial expression and gestures [7]. The online text-based medium (Skype chat) presents challenges because of the absence of the possibility to convey tone of voice, gestures and facial expressions. The tool requires careful textual formulation in order to ensure clarity of communication. However, on the other hand, it provides an opportunity for clear articulation and conceptualisation of abstract thinking, which is not naturally achieved in face-to-face conversations. Third, designers taking part in the Skype conversation are able to talk in parallel, something which hardly happens in face-to-face conversations. This results in a different linkograph profile, in which links between design moves have greater 'time delays' in their links.

To conclude, we indicated through the case study that not only do different conversations exist: the internal conversation (with the 'self') and external interaction (with external media, i.e. people, objects, sketches, and so forth) exist, but that they are interrelated. Any external interaction inherently includes a form of internal conversation, in the sense (1) that it might be preceded by a form of internal hypothesising and predicting and (2) that it might be followed by a form of internal evaluation and learning. In doing experiments, certain external media are chosen to work with. In choosing for a text-based chat medium, certain disadvantages (lacking gestural hints) and advantages (clear articulation, power relations played down) occur, as outlined above. So, the text-based chat medium is an appropriate medium, as long as its users know how to work with it and, more importantly, learn how to use it as a scoped but valuable interface to test their ideas against.

References

- [1] Bayazit, N., "Investigating design: a review of forty years of design research", *Design Issues*, Vol.20, pp 16–29, 2004.
- [2] Cross, N., "Forty years of design research", *Design Studies*, Vol.28, pp 1–4, 2007.
- [3] Cross, N., "*Designerly Ways of Knowing*", Springer-Verlag, London, UK, 2006.
- [4] Lawson, B., "*How Designers Think - The Design Process Demystified. Fourth edition*", Architectural Press, Elsevier, Oxford, UK, 2005.
- [5] Schön, D., "*The Reflective Practitioner: How Professionals Think in Action*", Temple Smith, London, UK, 1983.
- [6] Simon, H., "*The Sciences of the Artificial. Second edition*", The MIT Press, Cambridge, MA, 1996.
- [7] Lymer, G., Lindwall, O., & Ivarsson, J., "Space and discourse interleaved: intertextuality and interpretation in the education of architects", *Social Semiotics*, Vol.21, pp 197–217, 2011.

- [8] Morkel, J., “Architectural design learning through online conversation: a case for the use of facebook”, In: *Proceedings of the Design Development and Research Conference at CPUT*, pp 222–227, 2011a.
- [9] Morkel, J., *2nd year class of 2011: HUB*, Accessible online: <http://2ndyearclassof2011.blogspot.nl/>, 2011b.
- [10] Morkel, J., *CPUT 2nd year 2011 - a community hub – consolidated brief*, Accessible online: http://issuu.com/jolandamorkel/docs/consolidated_brief_1?viewMode=magazine, 2011c.
- [11] Pourmohamadi, M., *LINKOgrapher*, Accessible online: <https://sites.google.com/a/linkographer.com/linkographer/>, 2011.
- [12] Pourmohamadi, M., & Gero, J., “LINKOgrapher: An analysis tool to study design protocols based on FBS coding scheme”, In: *Proceedings of the 18th International Conference on Engineering Design*, pp 294–303, 2011.
- [13] Morkel, J., & Pauwels, P., *Experimental data of a design process taking place in a text-based Skype chat session: Elisa and Andy in 2011*. Accessible online: <http://users.ugent.be/%7Eepipauwel/experimentaldataskypemorkelpauwels2013.html>, 2014.
- [14] Ericsson, K., & Simon, H., “*Protocol Analysis: Verbal Reports as Data*”, MIT Press, Cambridge, MA, 1993.
- [15] Cross, N., “Design cognition: Results from protocol and other empirical studies of design activity”, In: C. Eastman, W. McCracken, & W. Newstetter. (eds). *Design Knowing and Learning: Cognition in Design Education*, Elsevier, Oxford, pp 79-104, 2001.
- [16] van Someren, M., Barnard, Y., & Sandberg, J., “*The Think Aloud Method: A Practical Guide to Modelling Cognitive Processes*”, Academic Press, San Diego, CA, 1994.
- [17] Ennis, C., & Gyeszly, S., “Protocol analysis of the engineering systems design process”, *Research in Engineering Design*, Vol.3, pp 15–22, 1991.
- [18] Kavakli, M., & Gero, J., “The structure of concurrent cognitive actions: A case study of novice and expert designers”, *Design Studies*, Vol.23, pp 25–40, 2002.
- [19] Goldschmidt, G., “Linkography: assessing design productivity”, In: R. Trappl (ed). *Cybernetics and Systems 90*, World Scientific, Singapore, pp 291–298, 1990.
- [20] Goldschmidt, G., “The designer as a team of one”, *Design Issues*, Vol.16 , pp 189–209, 1995.
- [21] Goldschmidt, G., “Capturing indeterminism: Representation in the design problem space”, *Design Studies*, Vol.18 , pp 441–445, 1997.
- [22] Goldschmidt, G., “The backtalk of self-generated sketches”, *Design Issues*, Vol.19, pp 72–88, 2003.
- [23] Goldschmidt, G., “Criteria for design evaluation: A process-oriented paradigm”, In: Y. Kalay (ed). *Evaluating and Predicting Design Performance*, John Wiley & Sons, New York, NY, pp 67–79, 1992.
- [24] Heylighen, A., & Segers, N., “An architectural shift+F7 – supporting concept development through design cases”, In: *Proceedings of the ARCC/EAAE International Conference of Architectural Research*, pp 134–143, 2004.
- [25] Seitamaa-Hakkarainen, P., “Revealing design thinking through protocol data”, In: *Produkt, Fenomen, Upplevelse. Proceedings of a Nordic Symposium*, pp 180 – 198, 1997.