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# Analogy As a Means of Communicating

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# ANALOGY AS A MEANS OF COMMUNICATING

## ABSTRACT:

The issue which impacts most significantly on the process of reaching shared understanding, through the design discussion in the team, is the ability of team members to communicate their design ideas and technical concepts with other members of the team. The ability to effectively participate in the forum of a design team unquestionably requires an ability to communicate design ideas and discipline specific information. The study, reported in this paper, considers one of the communication strategies available to the designer, which contributes to effective communication within the design team context, the paper will focus on analogy or the metaphor.

In research, to date, on problem solving in scientific research teams [Dunbar, 1995] two levels of analogy have been identified. In this study of Multi-disciplinary Design Teams it was established that the team members used a third level of analogy, this relating to the use of "metaphors" drawn from outside the specific design domain the team is working within.

The industry based research identified both the importance and complexity of the role of analogy has as a communication practice, but what do our students know about its use and do they know how to use it effectively? This paper looks at the use of analogy and considers ways of introducing our graduates to an understanding of analogy as an effective part of their range of communication strategies.

**Keywords: Design Teams, Communication strategies, Analogy, Curriculum Design**

## 1. INTRODUCTION

An important consideration in the organisation of a Multi-disciplinary Design Teams (MDDTs) is the procedure of re-organisation of knowledge, attributable to participation in these teams. The reorganisation of design knowledge most frequently occurs at design team meetings where designing involves interaction between the team members, across the disciplinary boundaries. It is in the actions of these meetings that ideas of individuals become the shared understanding of the team. Consequently as a result of a team's design meetings it would be expected that an individual's knowledge, established prior to the meeting, would change and be augmented as a result of the collaborations and experiences of participation in the meeting. Dunbar [1995] in research relating to scientific research groups established that individuals were more likely to change their thinking about a problem as a consequence of comments from a team discussion than would be evident in a person working individually. The team has an impact on the individual as a designer, also design thinking.

## 2. THE MULTI-DISCIPLINARY DESIGN TEAM CONTEXT

Design practice involves dealing with such muddled and "wicked" situations (Schön, 1983; Cross, 2001; Lawson, 2005; Thackara, 2005). The design activity involves dealing with a diversity of situations and problems these include dealing with:

- incomplete knowledge of contexts
- inadequate information
- new technologies
- new materials
- design collaborators of diverse and differing experience

Research of design practice confirms that designers who successfully carry out complex design tasks adopt a "designerly" way of thinking and acting (Buxton, 2007; Moggridge, 2007). There has also been a more wide-ranging and increasing awareness in what is seen as an escalating complexity in our society, its demands and how to deal with it (Friedman, 2005; Gladwell, 2005; Pink, 2005; Coburn, 2006).

Lawson (1997) identified collaboration as a large component of a designer's working time, this acknowledgement created a move towards applying research methods to gain a deeper understanding of this activity and the range of skills required to effectively contribute collaborative design (Wischnig, et.al, 2013). In the process of gaining an understanding of design team activities, Kvan (2000) considers collaboration as an alliance to complete a mission or solve a problem.

Collaborative teamwork historically refers to a short term alliance (i.e. for a single project) between parties or companies. Cooperation is the term used to describe the relationship between two parties that would exist for more than one project (Love, Irani et al. 2002), being a more informal arrangement (Kvan 2000). Collaboration (project teams) and cooperation (operational teams) may have similar connotations but they are not interchangeable as they have fundamentally different definitions (Kvan 2000). Maher et. al. (2000a) report three different styles of design collaboration, within a collaborative design experiment, as shown in Table 2. These concepts have an impact on the level of success the types of analogy outlined below will have on creating shared understanding, as a component of the range of effective communication strategies that a designer brings to an MDDT

Collaboration Style	Description
Constant collaboration	Designers work on the entire design entity while consulting with each other.
Intermittent collaboration	Designers work on different sections of the design, and check with each other intermittently.
Leader controlled collaboration	There is an establishment of a leader who directs the members to specific design tasks

Table 2: Differing Collaboration Styles (as indicated by Maher et al. 2000a)

As such the complexity of a design team cannot be conveyed to students simply by placing them in teams to do collaborative work a small number of times during their degree. Admittedly students will not be able achieve a full understanding of design team participation, little lone MDDT collaboration, but this does not negate the importance of exposing students to the activity of design collaboration and assisting them in understanding what they have experienced through their collaborative activities and how this is of importance to their development.

The issue which impacts most significantly on the process of reaching shared understanding, through the design discussion in the team, is the ability of team members to communicate their design ideas to other members of the team. In the context of an MDDT the ability to effectively participate in a design team involves an ability to communicate design ideas and discipline specific or technical, information in the most effective way possible. The study, reported in this paper, identifies the diversity of communication strategies, see Table 1, which contribute to effective communication within the design team context, the paper will employ Analogy as a them whereby to consider verbal communication specifically but communication overall as an attribute needed by designers and taught in design programs.

Verbal Strategies	Visual Strategies
1. Technical Language	3. Gesture
2. Analogy <ul style="list-style-type: none"> <li>• Project Specific</li> <li>• Domain Specific</li> <li>• External to Domain</li> </ul>	4. Graphics - Sketching
	5. Existing Graphics
	6. Actual Objects

Table 1: Communication Strategies Employed by the Team

In the study of MDDTs, reported here, it was established that the team members used three levels of analogy, this new to communication research, the third type was the use of "metaphors" drawn from outside the specific design domain the team is working within.

The industry based research the importance of the role of analogy as a communication practice, but what do our students know about its use and do they know how to use it effectively, or for that matter the other communication strategies? This paper looks at the use of analogy and considers ways of ensuring that our graduates have a capacity to understand and use analogy as an effective part of their communication strategies. Although this paper focusses on analogy it is doing so as a themed approach to the broader issue of communication. Any communication strategy could be used as a focus and all have their value, analogy has been chosen as the vehicle to better understand the broader issue of communication in MDDTs as it is one of the limited verbal strategies.

### 3. WHAT IS ANALOGY

One of the primary reasons for using analogy or metaphor in communication exchanges would be the need to make the intended message clearer, thus increasing the possibility of achieving the desired outcome of a shared comprehension between the 'maker' and the 'appreciator' (Cohen, 1978), or the 'sender' and 'receiver' (Fiske, 2010). When someone employs analogy or metaphor when transmitting a message they participate in a conceptual mapping exercise that often relies on a strategy of using 'familiar concrete domains to discuss less familiar or abstract domains ...' (Gentner et al 2001, 202).

The terms of reference that analogy and metaphor share is their role in establishing a relational alignment between 'two represented situations'. The easiest way to explain the concept of this alignment is to say that it 'consists of an explicit set of correspondences between the representational elements of the two situations' (Gentner et 2001, 200). Often aligning the 'two situations' involves linking 'abstract language to embodied knowledge', and this process allows the sender and receiver to

then ‘tap into ... their rich experiences of the world and social systems as the basis for inference’ (Feldman, 2006, 212).

Because analogy and metaphor are ‘both modes of relational thinking’ (Hirsch, 2014, 26) some might consider them as ‘the same thing’. However, others may think of them ‘as two different forms of reasoning’ (Hirsch, 214, 26). So, it may be useful here to provide a basic definitional frame for both of these terms, and then briefly tease out some of their characteristic traits.

A succinct definition for ‘analogy’ is: ‘a resemblance between two different things, frequently expressed as an extended simile’ (Hirsch, 214, 26). In order to suggest a *similarity* or alignment between ‘two different things’, analogical thinking often expresses this ‘as an extended simile’, suggesting that this type of thinking involves an ‘extended associative process’ (Hirsch, 2014, 26). One might also conclude that analogical thinking is ‘nonlinear, non-consecutive and indirect’ (Hirsch, 2014, 26).

In order for an analogy to perform its work of extended association, a receiver of the message needs to clearly understand the association the sender is drawing on, and part of this verification process involves the receiver ‘testing’ the analogical ‘proposition against lived experience’ (Hirsch, 26). In order to navigate and interpret our lived experience, we use analogies in ‘an effort to make sense of the new and unknown in terms of the old and known’ (Hofstadter and Sander 2013, 3).

Using metaphor also helps us to make sense of the new, and this involves in an associative process as well. In traditional terms, metaphor is defined as ‘a figure of speech in which one thing is described in terms of another’ (Hirsch, 2014, 372). Its etymology can be traced back to the ‘Greek *metaphora*, which means ‘carrying from one place to another’ (Hirsch, 2014, 372). As Argano points out; the ‘classical view of metaphor (since Aristotle)’ was to see it as performing a literary function— ‘the device of dramaturges and fruit of the poetic imagination’ (2009, 30). Or put another way: ‘Metaphor is for most people a device of the poetic imagination and the rhetorical flourish—a matter of extraordinary rather than ordinary language’ (Lakoff and Johnson, 1980, 3). However, current cognition and communication theories have assisted in critiquing and debunking this limiting domain categorisation, and metaphorical thinking is now regarded across various disciplines ‘as a fundamental mode of cognition’ (Modell, 2009, 6).

The way that metaphorical thinking works is that it ‘transfers the connotations of one thing (or idea) to another. It says A equals B’ (Hirsch, 2014, 373). The ‘A equals B’ utility of metaphor can be explained with reference to I.A. Richards’ early work where he described a metaphor as ‘shift, a carrying over of a word from its normal use to a new use’ (1929: 221). Richards identified the two parts of this transference as involving a *tenor* and *vehicle*. In Richards’ model, ‘the tenor stands for what is being talked about. It is the subject. The vehicle stands for the way it is being talked about and carries the weight of the comparison’ (Hirsch, 2014, 373).

However, when looking at the functional modes of analogy and metaphor use, Gentner suggests ‘metaphors are typically used for expressive-affective purposes’ and ‘analogies are used for explanatory-predictive purposes’ (Gentner et al, , 40). Both analogy and metaphor can function as highly effective communication conduits as long as the receiver is able to comprehend the attributable pattern between the ‘two different things’ first envisaged by the sender.

In an industry-based context where design team members need to send accurate and efficient messages to colleagues working across different domain areas, the use of analogical and metaphorical thinking may generate more concrete and consistent understandings as team members creatively co-opt each as active participants in the meaning-making process.

### 3.1. ANALOGY IN DESIGN COMMUNICATION

The role of analogy in the collaborative design process is not well documented in the literature (Dunbar and Schunn 1990; Hickman 1990). In research done to date on problem solving in scientific research teams two levels of analogy were identified. The first level of analogy relates to the use of examples drawn from the specific project. In the scientific context this would be the specific domain or experiment the research team is working on. The second level of analogy identified in the science research domain was when the scientist mapped the entire system of relationships from one domain to another, for instance, two domains being from distant classes which belonged to a subordinate category, e.g. phage viruses and retroviruses are mapped together (Dunbar 1994, 382).

The analogy used in design teams, for the purpose of creating shared understanding, proved a successful tool as often it was used when an initial communication where technical language, which is discipline specific, may not have achieved a successful outcome with designers from other disciplines.

Table 3, below, provides a breakdown of the percentage of times the Industry Design team, monitored in this research, used the different communication strategies. It may appear a small percentage of time that Analogy was employed but in context there were >14,000 design interactions coded over the 12 month project.

Communication Strategies	Percentage of Use
Technical language	64.0%

Project analogy	2.8%
Domain analogy	3.3%
External analogy	3.0%
Gesture	2.3%
Sketch	5.6%
Prepared graphics	18.3%

Table 3: frequency of use of the communication strategies is shown in table

In the observations performed, in the study reported here, it was evident that the use of analogy by members of the design team included two levels comparable to those identified by Dunbar. Unlike the scientists of Dunbar’s research, however, a third level of analogy, drawn from outside the domain(s), was apparent. Therefore three levels of analogy categories were developed for the study:

- Primary level – project-specific analogy;
- Secondary level – domain-specific analogy;
- External analogy – analogy from outside the domain.

Primary Level Analogy

The primary, project specific, level of analogy relates to references made by team members to aspects of the current project being addressed. When an issue arose and needed clarification, the initiating member made reference to an aspect of the project that the team had previously solved while working on that (same) project. Examples of the primary level of analogy used include:

- “use the same locking system as we used on the floor panels”;
- “yes its the same as we used to join the wall panels”;
- “why don’t we use the same system as we used at the driver’s cab end”;
- “no, using the same assembly process for the hopper window as for the car fixed windows will not work”.

Secondary Level Analogy

The secondary, or domain specific, level of analogy employed by the team drew from the broader domain of locomotive or railcar production. In this level of analogy the team members made reference to railway projects that they had worked on in the past or that they may have had some experience with or have made reference to in the past. Examples of the second level of analogy used by the team members in the study include:

- “why don’t you cast the anti-climber like we did on the Sprinter project”;
- have you read the specs on the QR project? It’s the same system of braking as they used there;
- “its the same destination signing system as they use on the London underground”;
- “if we use the same degree of camber as we did on the phase 2 project it will end up bending the wrong way”.

External Analogy

The external level of analogy was outside to the rail manufacturing domain or industry. The team members when using this means of communicating concepts would draw from a diverse range of technological fields and in some cases, non-technological fields. This level of analogy draws from the members’ broader experience. Examples of this level include:

- “sikaflex, it’s the black sticky stuff that holds the windscreen of the car in place, you know it stays soft and doesn’t go hard”;
- “the communication cable, its about as thick as your thumb”;
- “why don’t we use the same chassis beam thickness as they use in buses?”;
- “the windscreen wiper is trapezoid just like the ones on the Mercedes car and the washer sprays out of the arms like on those other European cars”.

To look at the success rate of the use of analogy in the MDDT meetings provides an interesting insight to the design team activity. The success of Analogy used as the primary means of communicating in a design discussion is just under 60%, that does not sound overly effective when the total figure for effectiveness in gaining shared understanding is 84% but when put into the context of the range of communication strategies used it is one of the more effective verbal only strategies, when verbal communications strategies are used alone only 42% is understood ,so of the verbal only strategies the analogy cluster are comparatively successful in achieving shared understanding. The final conclusions drawn from the study is that there are a diversity of concepts requiring communication in a design team there is a great deal of complexity to these concepts and therefore there is a need for designers to have in their resources the ability to employ a broad range of communication strategies as simple technical descriptions will not suffice a designer in this situation. As design educators there is a need to expose students to the complexity of a design team but also raise their awareness of the range of communication strategies and how they can best support the achievement among their design collaborators.

## 4. TEACHING TEAMWORK

Learning of team-working skills can clearly influence the effectiveness of teams performance. It has therefore been suggested that the teaching of team development and teamwork skills is important but often overlooked attribute for our students to achieve for when they are working in teams (Clark 2006; Hansen 2006; Chakraborti, Boonyasai et al. 2008)). Hamlyn-Harris et al. (2006) identified that teamwork training improved teamwork satisfaction, and suggested that failure to provide students with appropriate training in collaborative learning is a primary reason why many students dislike team work. If teamwork is taught using a well-designed, structured, supportive and interactive framework within which students can design collaboratively and appreciate the complexity and have an understanding of ways to cope within this environment, there will be a greater prospect of students understanding the importance of teamwork to the successful practice of design. Achieving this during students' time at university will achieve better learning outcomes, also students will enjoy designing with their peers.

Teamwork learning experiences is seen as emulating work in the real world of professional practice where design is most often collaborative. This is in stark contrast to academic contexts, where the inclusion of teamwork into the curriculum is seen by students as contrived, especially when they have an expectation of being individually assessed. Not only is team project seen as more authentic, it can result in ideas and knowledge being combined collaboratively for design outcomes that are superior to those that individual students might arrive at (Barber 2004). The desire to include teamwork is due to the belief that it improves student learning, specifically in the area of social behavioural skills, higher order thinking and the promotion of inclusive learning (Cohen 1994). The application of teamwork also develops critical thinking (Gokhale 1995; Dochy, Segers et al. 1999; Sluijsmans, Dochy et al. 1999), active learning (McGourty, Dominick et al. 1998), provides the opportunity to confront more substantial projects (Goldfinch and Raeside 1990), and peer led learning experiences within the team (van den Berg, Admiraal et al. 2006). As well as providing engagement with technical skills it is often the 'generic' skills that are enhanced in this learning experience (McGourty, Dominick et al. 1998; James, McInnis et al. 2002). Design collaboration is one of the foremost team skills.

Despite the well documented positives of the teaching approach, it has its issues including; social loafing, free-riding or free-loading, where the combined output of the team is less than would be expected from combining the output of individual team members (Kravitz & Martin, 1986), this may be further contributed to by problems of team discipline or even further exacerbated by assertive members of the team. Also the issue of team members who are academically weaker or less motivated to contribute becoming "passengers" gaining a free ride other in the team (Goldfinch & Raeside, 1990). Solving these issues will go a long way to gaining a more positive teamwork learning experience that encourages active participation by all team members (Cohen, 1994). Many issues exist for the student working in teams, despite these issues, exposure to the teamwork experience in a managed and reflective way will dispel some of the students concerns, having appropriate assessment strategies will enhance students' confidence in teamwork, but for the purpose of responding to the issue of communication skill development and understanding the following approach has been successfully employed.

## 5. THE TEACHING INITIATIVE

The experience of working in a team is an important part of the learning experience of a design student, but, simply grouping students together and involving them in a team project is not an effective learning environment. Though it is difficult for us to involve students in long term MDDT environments it is possible for us to introduce students to the activity of design in a *managed* way, a structured curriculum approach over the length of their studies.

Assisting students to appreciate the importance of effective communication and the role of analogy and other communication strategies, is important. Through the application of video it is possible to expose students to their communication performance in both an interesting but informative manner. The initiative involves videoing students in a significant team project so as to capture their design team activity. Following the design session students are provided with an instructional session of the strategies of communication and their relative effectiveness and provided with a framework to assist them in analysing their own team's performance. Students then watched their design session and focussed their attention on understanding the range of communication strategies and the effectiveness of their communication strategies. Using a themed approach, such as design analogy, students view their use of the strategies and can come to appreciate how effective it was at gaining shared understanding. Looking at a theme at a time provides a structure approach rather than looking at all strategies at one time.

Students at first did not feel comfortable watching their performance but when asked to apply the framework to better understand the types of communication used and then evaluate their effectiveness provided the students with the opportunity to be pragmatic. Through provision of allocated time for the reflective engagement with their design team activity and through focussing on the issue of communication the students did start to appreciate the value of thinking through the process of choosing a communication strategy that was more likely to be effective in achieving shared understanding with their team collaborators. Introducing students to a more informed approach

provided them with insights into how to do their job better and improved their confidence in confronting the team environment.

Of interest was the students' engagement with the concept of analogy. In considering the communication strategy and the different types of analogy that were available, they were able to identify the importance of using analogy carefully, especially the "external analogy" strategy. Students could see that it was better used during design discussion rather than using it as an initial response to a question. What also became apparent to the students was that they were limited in the range of analogy they could use because of their lack of experience in working together in teams and how having the opportunity to work in teams would improve the range of analogy they could use.

Providing students with an informed way of engaging in design collaboration through the use of focussing on the components of the design team activity and providing an understanding of the range of skill they need, in this case communication, then students will see the value of the team experience. Analogy was an effective theme for students to be better able to understand design communication strategies.

Teaching design team skills requires a managed approach and an appreciation of the communication strategies and the ability to engage students in reflection with frameworks that support their ability to engage in understand their design experience more fully.

## REFERENCES:

- Barber, P. (2004). *Developing and assessing group design work: a case study*. International Engineering and Product Design Education Conference, DELFT. Netherlands.
- Buxton, B. (2007). *Sketching user experience – Getting the design right and the right design*. San Francisco: Morgan Kaufman.
- Chakraborti, C., R. T. Boonyasai, et al. (2008). "A systematic review of teamwork training interventions in medical student and resident education." *Journal of general internal medicine* 23(6): 846-853.
- Clark, P. G. (2006). "What would a theory of interprofessional education look like? Some suggestions for developing a theoretical framework for teamwork training 1." *Journal of Interprofessional Care* 20(6): 577-589.
- Coburn, P. (2006). *The change function – Why some technologies take off and others crash and burn*. New York: Penguin Books.
- Cohen, E. G. (1994). "Restructuring the Classroom: Conditions for Productive Small Groups." *Review of Educational Research* 64(1): pp. 1-35.
- Cross, N. (2001). *Designerly ways of knowing: Design discipline versus design science*. *Design Studies*, 17(3), 49-55.
- Dochy, F., M. Segers, et al. (1999). "The Use of Self-, Peer and Co-assessment in Higher Education: a review." *Studies in Higher Education* 24(3): 331-350.
- Dunbar, K., "How Scientist Really Reason: Scientific Reasoning in Real World Laboratories", in Sternberger, R.J. & Davidson, L., (1995), "Mechanisms of Insight", MA:MIT Press, 1995, pp365-395.
- Feldman, Jerome A. (2006) *From Molecule to Metaphor: A Neural Theory of Language*, Cambridge MA: Massachusetts Institute of Technology.
- Fiske, John (2010) *The John Fiske Collection: Introduction to Communication Studies*, Third Edition, New York: Routledge
- Friedman, T. L. (2005). *The world is flat: A brief history of the twenty-first century*. New York: Farrar, Straus and Giroux.
- Gentner, Dedre, Holyoak, Keith J. and Kokinov, Biicho N (2001) *The Analogical Mind: Perspectives from Cognitive Science*, USA: Massachusetts Institute of Technology.
- Gladwell, M. (2005). *Blink: The power of thinking without thinking*. New York: Little, Brown and Company.
- Gokhale, A. (1995). "Collaborative Learning Enhances Critical Thinking." *Journal of Technology Education* 7(1): pp. 22-30.
- Goldfinch, J. and R. Raeside (1990). "Development of a Peer Assessment Technique for Obtaining Individual Marks on a Group Project." *Assessment and Evaluation in Higher Education* 15(3): 210-231.
- Hamlyn-Harris, B. J., B. J. Hurst, et al. (2006). "Predictors of team work satisfaction." *Journal of Information Technology Education* 5: 299-315.
- Hansen, R. S. (2006). "Benefits and problems with student teams: Suggestions for improving team projects." *Journal of Education for Business* 82(1): 11-19.
- Hirsch, Edward (2014) *A Poet's Glossary*, New York: Houghton Mifflin Harcourt Publishing Company.

- Hofstadter Douglas and Emmanuel Sander (2013) *Surfaces and Essences: Analogy as the Fuel and Fire of Thinking*, New York: Basic Books.
- James, R., C. McInnis, et al. (2002). *Assessing Learning in Australian Universities*. Melbourne, Centre for the Study of Higher Education and The Australian Universities Teaching Committee.
- Kravitz, D. and Martin, B. (1986). Ringelmann rediscovered: The original article, *Journal of Personality and Social Psychology*, Vol 50(5), 936-941
- Kvan, T. (2000). "Collaborative design: What is it?" *Automation in Construction* 9: 409-415.
- Lakoff, George and Johnson Mark (1980) *Metaphors We Live By*, Chicago: The University of Chicago Press.
- Lawson, B., "How Designers Think: The Design Process Demystified", Butterworth Architecture Oxford UK, 1990
- Love, P., Z. Irani, et al. (2002). "A model for supporting inter-organisational relations in the supply chain." *Engineering, Construction, and Architectural Management* 9(1): 2-15.
- Maher, M., S. Simoff, et al. (2000). *Understanding virtual design studios*. London, Springer.
- McGourty, J., P. Dominick, et al. (1998). *Incorporating Student Peer Review and Feedback into the Assessment Process*. 28th Annual Frontiers in Education Conference, Tempe, Arizona, American Society for Engineering Education and Institute of Electrical and Electronic Engineers.
- Modell, Arnold H. (2009) 'Metaphor—The Bridge Between Feelings and Knowledge', *Psychoanalytic Inquiry: A Topical Journal for Mental Health Professionals*, 29:1, 6-11.
- Moggridge, B. (2007). *Designing interactions*. Cambridge, MA: MIT Press.
- Pink, D. H. (2005). *A whole new mind: Moving from information age to the conceptual age*. New York: Riverhead Books.
- Richard, I.A. (1929) *Practical Criticism: A Study of Literary Judgment*, New York: Harcourt, Brace and World.
- Schön, D. A. (1983). *The reflective practitioner*. New York: Basic Books.
- Sluijsmans, D. M. A., F. Dochy, et al. (1999). "Creating a Learning Environment by Using Self-, Peer- and Co-Assessment." *Learning Environments Research* 1(3): 293-319.
- Thackara, J. (2005). *In the bubble: Designing in a complex world*. Cambridge, MA: MIT Press.
- van den Berg, I., W. Admiraal, et al. (2006). "Peer assessment in university teaching: evaluating seven course designs." *Assessment & Evaluation in Higher Education* 31(1): 19-36.
- Wiltschnig, S., Christensen, B. & Ball, L., (2013) Collaborative problem-solution co-evolution in creative design, *Design Studies*, 34:5, 515-542