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Visual Thinking Styles and Idea Generation Strategies Employed in Visual Brainstorming Sessions

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Abstract

This paper presents the findings of visual analyses conducted on 369 sketch ideas generated in three 6-3-5 visual brainstorming sessions by a total of 25 participants, following the same design brief. The motivation for the study was an interest in the thematic content of the ideas generated as groups, and the individual representation styles used for the sketches. The analyses revealed the determinants of individual visual thinking styles as: idea types, sketching patterns, sketching styles, annotation styles, and performances in producing design solutions. The idea generation strategies of the participants were: using analogies, diversifying the design solutions, determining the usage context, and working with themes. The effects of group dynamics on the performances of the participants were: management of the idea generation effort, reflections of the idea contents explored within groups, and reflections of the representation styles of peers. The paper finally identifies four profiles of idea generators and discusses the implications of the findings.

Key words

visual thinking styles; idea generation strategies; freehand sketching; 6-3-5 brainstorming method

1. Introduction

Our graduate course on design methods offers short-term educational projects that incorporate various creativity and evaluation methods within the design processes. The processes begin with brainstorming sessions for exploring the problem space and solution areas. Some of the brainstorming techniques used, require systematic sketching of ideas. 6-3-5 is one of these techniques used for generating many sketch ideas within a short time as a group. This paper presents the findings of visual analyses conducted on the outcomes of three 6-3-5 sessions using the same design brief. The outcomes composed galleries, from which the participants were able to select ideas to be developed in the following stages of the design process. The effectiveness of the method in producing numerous ideas, and the richness of the idea content raised an interest in the

representation styles and idea generation strategies that the participants employed. Another interest was whether working as a group had effects on the performances of the participants, considering that, asking participants to generate a succession of ideas by themselves within a predetermined time may not be as effective as asking them to do the same task within a group setting. Daalhuizen, Person and Gattol (2014) explain that, in order for students to benefit most from their learning experiences, tutors must understand their personal experiences in using methods, their method mindset, and performances in carrying out design tasks. The sketches were visually analysed with the aim of gaining insights on the rapid idea generation performances of the participants, to be used in the conduct of the course.

1.1 Sketching

Sketching is a type of drawing used for quickly and effectively representing ideas in a pictorial form, and is highly related with design fields that require a form-related search for the realisation of ideas. Freehand sketches are an important part of visual thinking. While thinking by drawing, designers:

- Externalise design problems and facilitate problem solving (Tovey, Porter and Newman, 2003);
- Organise their cognitive activity and the information they are making use of in the idea generation process (Tovey, 2012);
- Visualise an idea and explore its potentials (Aspelund, 2010);
- Generate new ideas, as sketching leads to further sketching (Tovey, et al., 2003);
- Document the ideas (Schenk, 2014);
- Use the documentation to review the process and reconsider earlier ideas (Tovey, 2012); and
- Represent the design ideas for communication with others (van Eck, 2015).

Drawings involved in sketching are different than those used in the fields of art, or some fields of design in terms of their role in the process, usage of media, and implementation (Tovey, 2012; Schenk, 2014). Purcell and Gero (1996) explain sketching to be particularly related to the preliminary design phase. Early sketches seek for concept development and are not done to provide visual communication with others; therefore, they are more abstract, unstructured, uncertain, and placing constraints, due to the limited knowledge on the problem area and unset goals for the design (Tovey, 2012). Freehand sketches are dense and ambiguous as they are used in a creative open-ended exploration of the design problem, and this facilitates a variety in search, also preventing early fixations (Rodgers, Green and McGowan, 2000). Moving further into the design process, the design ideas will become more concrete, structured and detailed, and various other types of drawings will be used to represent them (Purcell and Gero, 1996).

The sketching process uses various modal shifts, including thinking, drawing and examining (Cross, 2006). Sketching contributes to the production of design ideas based on two phenomena: **emergence** and **reinterpretation** (Menezes and Lawson, 2006). **Emergence** is about the

sketchmaker generating new ideas based on new thoughts that appear from the drawings. **Reinterpretation** is about the ability to transform, develop and generate new ideas as sketching takes place.

1.2 Visual brainstorming

Brainstorming is a method that exercises creative thinking within groups, for the generation of many goal-oriented ideas benefiting from the flow of discussions in an uninhibited environment. Ideas generated in brainstorming sessions stimulate the generation of further ideas; besides, as a benefit of brainstorming, ideas suggested earlier in the session are improved upon (Cross, 1995), using various creativity techniques. Cross (1997) describes the procedures of creative design as: combination (combining different features into a solution), mutation (modification of the form/structure into a new solution), analogy (abstracting the behavioural features of a solution and applying it for the generation of a new one), first principles (identifying the actual requirements and processing these into solutions), and emergence (recognising the emerging behaviour of a structure and building a solution on it). These processes, particularly when restructuring of entities are required, are best supported through sketching of ideas (Verstijnen, Van Leeuwen, Goldschmidt, Hamel, and Hennessey, 1998).

Pahl and Beitz (1996) already suggest sketching as a way of documenting ideas discussed in brainstorming sessions. Likewise, visual variants of brainstorming have been suggested using sketching as the main resource for idea generation, such as 6-3-5 by Rohrbach, and the Gallery Method by Hellfritz (cited in Pahl and Beitz 1996); and Braindrawing and Right-braining (Gause and Weinberg, 1989). As a visual brainstorming method, 6-3-5 is used for rapid idea generation in groups within a short time (Wright, 1998). The participants are each given a sheet with a chart containing cells to produce sketches in rounds, passing the sheet to the neighbour on the right, every five minutes (Figure 1). “6” in the name stands for the number of participants in the group, “3” stands for the number of sketches to be produced in a round, and “5” stands for the minutes given to each round. At the end of the 30 minutes (6x5) session, all the 18 (6x3) cells of each six sheet are completed, resulting in a total of 108 (18x6) sketch ideas.

The design task that the 6-3-5 method requires is a sequential generation of sketch ideas, where, in a group of six, each participant makes a total of 18 sketches. Aspelund (2010) explains that deciding on a number of sketches (e.g. twelve), producing them quickly and returning to earlier ones for improving upon them is a way for keeping the ideas fresh, and helps overcome the sketchmaker’s inadequacies in terms of visual representation skills. In such a pace, ideas can be generated best up to a point, where the peak of sketches would be around three quarters, after which energy drops. This effort is likely to yield two or three ideas that can be worked on. Besides, as Yilmaz and Seifert (2011) indicate, through sketches, it will be possible to observe the design thinking process of designers in some respects.

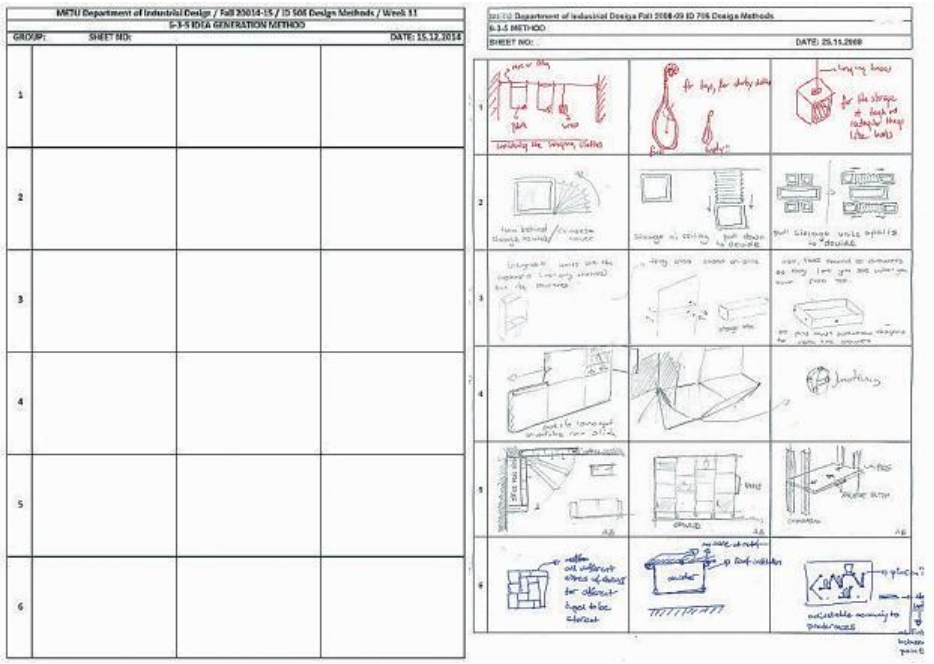

Figure 1. Left: Example of a blank 6-3-5 sheet. Right: Example of a filled 6-3-5 sheet.

2. The Methodology

Three idea generation sessions were conducted in three successive years, among five groups of 25 graduate students using the 6-3-5 method (Figure 2). The same design brief was given to all groups. The design process began with the distribution of the brief, project calendar and strategies to be followed, and a short discussion on the problem area, after which the 6-3-5 method was carried out. Further research, creativity and evaluation methods were conducted in the following two weeks of the course in order to complete the process with design proposals. This paper is mainly concerned with the outcomes of the 6-3-5 visual brainstorming sessions, which were numerous design ideas generated on 25 sheets using freehand sketches.

2.1 The design brief

The design brief read as follows:

> "ADJUSTABLE STORAGE UNIT AND ROOM DIVIDER
>
> We will develop ideas for a product that combines a storage unit and a room divider to be used in homes. You will determine the user group, use environment, purpose of use, style, materials and production methods for the product. The requirements are:
>
> The product should be adjustable to be used in different locations in a room.
>
> The storage units (racks, shelves, cupboards, etc.) should be adjustable in terms of height, position, number and combination."

This topic was chosen for the design task, considering that such products are available for use in homes, offices, and educational settings, and therefore that participants would be familiar enough with the combined functions of *space dividing* and *storing* in order to generate initial design ideas. The *adjustability* of the storage units and of the divider, as well as the *variety* of the storage types were given to allow creative problem solving. As the participants did not carry out research beforehand and were not informed of the problem area in terms of user needs, use environment, material choices and production methods, they were left free in determining the context and style for this product.

Figure 2. Left: Group E during the 6-3-5 session. Right: Group E examining their 6-3-5 gallery.

2.2 The participants

Two groups attended the first session, one group attended the second session, and two groups attended the third session (Table 1). The participants were graduate students attending the course and the sessions were conducted on class days. Their ages ranged from 21 to 36, with an average of 22.7. Fourteen participants had an industrial design background; four had a design background in other fields; six had an engineering background, and one had a background in economics. All participants tried out the 6-3-5 method for the first time.

Table 1. Group compositions and number of cells.

		Background in a design-related field	Non-design background	Female	Male	Total no. of participants	Cells per sheet	Total no. of cells	Completed no. of cells
Session 1	**Group A**	2	2	4	0	4	12	48	43
	Group B	3	2	4	1	5	15	75	69
Session 2	**Group C**	4	1	3	2	5	15	75	75
	Group D	4	1	3	2	5	15	75	74

Session 3	**Group E**	5	1	2	4	6	18	108	108
	TOTAL	**18**	**7**	**16**	**9**	**25**		**381**	**369**

Although the 6-3-5 method recommends six participants, this was not possible for each session due to the number of students taking the course. Therefore, groups were formed ensuring the generation of a minimum of twelve successive sketches (Aspelund, 2010) by the participants in the group of four. Participants in groups of five generated 15 successive sketches, and those in the group of six generated 18 successive sketches for the design task. Five participants did not complete all their cells; therefore the total number of cells filled with sketches were 369. The outcomes were collected as photocopies and also saved in digital format.

2.3 Analysis of the outcomes

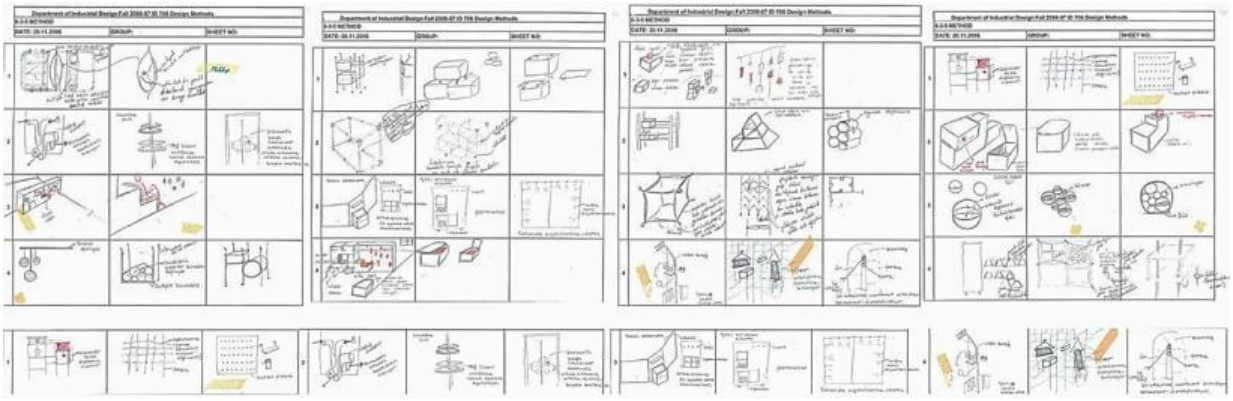

Figure 3. Top: Complete gallery for Group A. Bottom: Individual strip for Participant A2.

Various studies in the literature on sketching for idea generation, individually or in groups, were reviewed in terms of their visual analysis procedures. (Kavakli, Scrivener and Ball, 1998; McGown, Green and Rodgers, 1998; Do, Gross, Neiman and Zimring, 2000; Rodgers, Green and MacGown, 2000; Tovey, Porter and Newman, 2003; van der Lugt, 2003; van der Lugt, 2005; Menezes and Lawson, 2006; Yilmaz, Seifert and Gonzales, 2010; Yilmaz and Seifert, 2011, Bar-Eli, 2013; Leblebici-Başar and Altarriba, 2013; Eris, Martelaro and Badke-Schaub, 2014; Sun, Xiang, Chai, Wang, and Huang, 2014). Based on this review, both qualitative and quantitative approaches were adopted for the visual analyses of the 369 sketches generated in the sessions. Two copies of the original sheets were made. In one set, the sheets were brought together in the order of rotation to follow the complete gallery of ideas generated within a group, for a thematic content analysis. In the other set, the rows of cells produced by each participant were cut and brought together in the order of the rounds, forming a strip displaying the evolution of ideas in a sequence, and isolating the sketches for revealing their sketching characteristics (Figure 3). The analyses were conducted by the author alone, as the moderator of the sessions.

3. Visual thinking styles

The analyses revealed the various determinants of the individual visual thinking styles as idea types, sketching patterns, sketching styles, annotation styles, and performances in producing design solutions.

3.1 Idea types

Participants sketched their ideas in three types; whole, partial and detail (Figure 4). These were determined by the quantity of the sub-functions that the sketch ideas addressed. Sketches of whole ideas showed the design solution in its entirety, and included all the sub-functions expected, namely a structure, features for storing and features for separating. A total of 136 cells contained sketches of whole ideas. Sketches of partial ideas were those that reflected only one sub-function, or two, of the design solution, which could be storing, separating, or, a structure bringing these together. A total of 83 cells contained sketches of partial ideas. Sketches of detail ideas were those that provided a detail design solution for one of the sub-functions. These were grouped as details for structural elements or storage units, moving mechanisms, material suggestions, ways for setting-up or converting features, and sections. A total of 150 cells contained sketches of detail ideas.

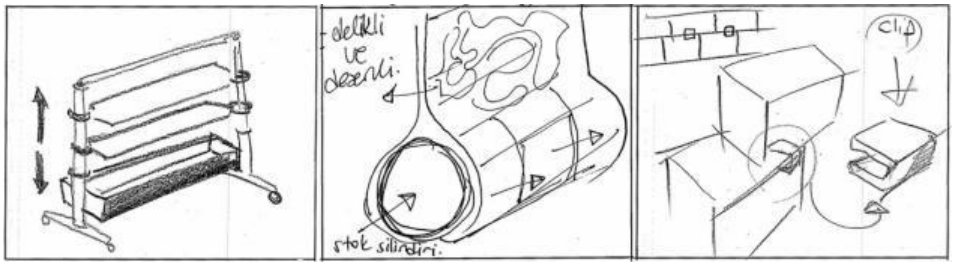

Figure 4. Left: Whole sketch idea (Group D, Participant 1, Cell 9). Centre: Partial sketch idea (GC-P2-C11). Right: Detail sketch idea (GC-P5-C3).

The participants used all types of sketches, (with one exception of a participant using only two types), with variations in the tendencies. Eleven participants displayed sketches that were detail-oriented. These participants either generated detail ideas then combined them, or generated whole or partial ideas then solved details. Ten participants produced sketches that were whole, followed by a close amount of partial sketches. Producing mostly whole and partial sketch ideas displayed an effort in covering all the sub-functions of the overall design solution. Four participants produced an equal amount of whole and detail sketches. These participants produced whole ideas first, then moved onto exploring details chosen from the sketch.

3.2 Sketching patterns

Tovey (2012) explains that designers use rapid sketches to transform images in a cyclic manner, meaning that as each sketch is produced, new images are generated in the mind, and explored with further sketches. The sketching patterns observed in the individual sequences of idea generation were suggestive of this cycle.

A pattern observed was **decomposing whole ideas**. The five participants using this pattern made a design suggestion, decomposed this into sub-functions, and then solved details. They continued doing this in cycles. Another pattern was **combining detail ideas**. The fourteen participants using this pattern generated details for the sub-functions then combined these into overall solutions. A third pattern was **returning to whole ideas**. The three participants using this pattern sketched a number of ideas developed in equal level at the beginning of the session, then explored them in turns. The fourth pattern was **continuous successive thinking**. The two participants using this pattern explored one design solution throughout the session, diversifying it by adding, removing, combining or changing details in each cell. The final pattern was **unrelated successive thinking**. The participant using this pattern generated a succession of equally developed design solutions, all unrelated in terms of idea content.

3.3 Sketching styles

The sketching styles observed were diagrammatic, representational, symbolic, or doodling (Figure 5). Diagrams are a type of drawing generally using geometric elements to represent phenomena, spatial boundaries, behaviour, and components, as well as the design problem in abstract terms, to organize cognitive activity (Do et al., 2000). Tovey et al. (2003) classify diagrammatic drawings and representational drawings as undetailed drawings and relate them to the concept development stage. Schenk (2014) explains doodling and scribbles as adaptable and disposable speedy drawings, made to make abstract concepts tangible, and stimulate ideas that follow.

Diagrammatic sketches identified in the analyses were those that geometrically represented the structure of the features, explaining how the features would come together, change position in relevance to each other and fit in a space. These sketches were generally an initial study for an idea, some of them were 3D arrangements of components, and preceded the more detailed sketches made in the following cells. **Representational sketches** were those that figuratively described design solutions. These sketches were three-dimensional, some were rendered, and some included spatial features of the background. **Symbolic** sketches were those that were made in order to analogically illustrate how the idea could work in principle, and not what the final design solution would look like. This type of sketching was generally used by participants from a non-design background, in order to illustrate what they thought could be a good solution to the design problem. A fourth type identified in the analyses were **doodling** sketches, some made aimlessly, others repeating a sketch made earlier, or a sketch made by a peer observed on the sheet. The features of the sketches were difficult to identify. These sketches were mainly an attempt to fill in a cell, or made with the expectation of coming up with an idea.

Various drawing elements (Ching and Juroszek, 2010; Bowkett, 2013) were used for the sketches, depending upon the training and skills of the participants in visual representation. These elements were contour lines and lines used in differing thicknesses in order to emphasize; and hatches and crosshatches for reflecting surface properties, and conveying light or shade. Monochrome rendering was particularly used for symbolic and representational sketches to give three-dimensionality. Only one participant used an additional colour to emphasize small features of the design solution. Use of colour was neglected, probably due to short time and as the sketches were not made for communication. Some sketches included symbols indicating directions of movement

and rotation. Arrows were used to refer to cells of sketches made by other participants. Numerical indicators were used to show stages of usage.

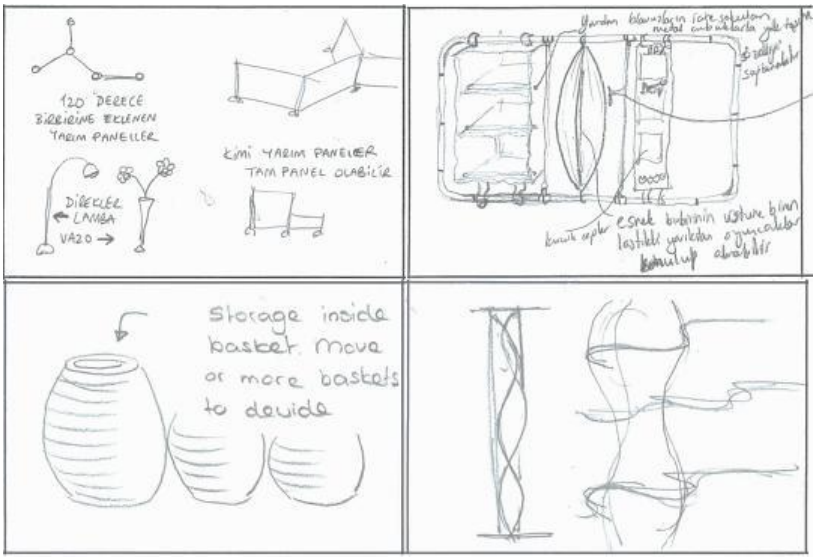

Figure 5. Top Left: Diagrammatic sketch (GB-P3-C8). Top Right: Representational sketch (GA-P1-C1). Bottom Left: Symbolic sketch (GE-P1-C8). Bottom Right: Doodling sketch (GE-P4-C16).

3.4 Annotation styles

Designers tend to use textual descriptions to support their sketches, making it easier to understand and inform the observer about the meaning, context and scale of the drawings (McGown et al., 1998). All participants used occasional annotations in their sketches. The annotation styles observed were **multiple-word sentences**, **single-word annotations** or titles given to each cell or idea (Figure 6). Although not exclusive, participants with lesser skills in visual representation showed a tendency in using excessive multiple-word sentences for further explaining the ideas.

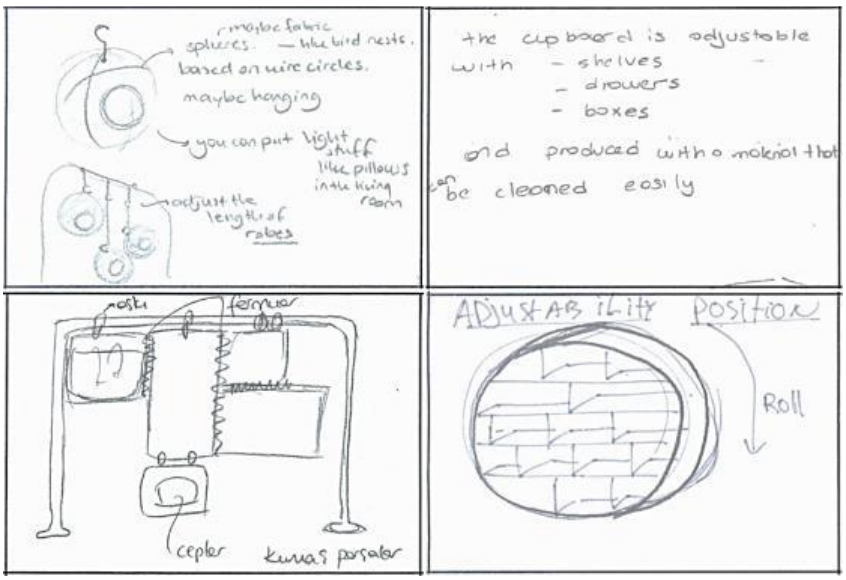

Figure 6. Top Left: Sketch with multiple-word sentences (GD-P4-C1). Top Right: Idea represented with verbal descriptions only (GE-P2-C11). Bottom Left: Sketch with single-word annotations (GB-P1-C2). Bottom Right: Sketch with title (GD-P1-C7).

Annotations were used to describe the idea, explaining how, where and by whom it is used, and what is being stored; give reasons for design decisions; give references to designers' products and styles; refer to analogies (e.g. Lego, tangram, matryoshka doll); provide additional information that could not be pictorially represented, e.g. material properties, movements, extra features, and hidden details; and provide spatial references, such as the view angle (top view, side view), and components of the space (wall, floor).

3.5 Performances in producing design solutions

The sketches were examined for the design solutions that they contained. A design solution was considered to be an idea displaying characteristic and describable physical features reflecting a conscious decision about how a feature should work, move, or look like. The design solutions in the sketches were identified by individuating (Goel, 1995; cited in McGown et al., 1998) each feature that suggested a new design contribution, and which appeared for the first time in the sequence of sketches. It was seen that most sketches contained multiple design solutions regardless of whether the ideas were whole, partial or detail.

Table 2. The number of design solutions generated per group.

		Minimum no. of design solutions	Maximum no. of design solutions	Total no. of design solutions	No. of participants per group	AVERAGE no. of design solutions per participant
Session 1	**Group A**	16	32	97	4	24.25
	Group B	17	35	122	5	24.4
Session 2	**Group C**	21	28	119	5	23.8
Session 3	**Group D**	20	45	152	5	30.4
	Group E	20	41	179	6	29.83

Table 2 shows the minimum and maximum numbers of design solutions generated within each group, and the averages. The variation in the numbers within groups were partially related to participants' design and representation skills. The lowest numbers of design solutions in each group were all produced by participants from a non-design background. These participants were not equipped with the strategic thinking skills in rapid idea generation that designers gain during their education. A major factor was whether the participant was able to find a starting point to generate ideas.

4. Idea generation strategies

The design brief remained insufficient in providing a problem space for the participants in which they could explore the design problem and identify a starting point for idea generation. Mentioning functional requirements in the brief led participants to mostly search for functional solutions and mechanism details. Therefore, it was seen that some participants used certain strategies in determining a solution space in which to carry out their design exploration. These were, using analogies, diversifying the design solutions, determining the usage context, and working with themes.

4.1 Using analogies

Goldschmidt (1998; cited in Menezes and Lawson, 2006) indicates that designers commonly look for precedents from domains other than the design situation and use analogical reasoning as a strategy for interpreting possible design solutions. Analogies were a major source for initiating idea generation, and were used for addressing additional sub-functions identified for the design problem, such as configuring, attaching/detaching, opening and closing storage units. Nineteen participants used one or more **written analogies** with an accompanying sketch of an inspired design solution. Seven participants used **illustrated analogies**, in order to refer symbolically to an already available design solution.

4.2 Diversifying the design solutions

Once being able to generate an initial idea, participants employed certain strategies in order to diversify their design solutions. These were variating, deriving, combining, and modifying. **Variating** design solutions was about offering solutions for the same sub-problem that differ in working principle. **Deriving** design solutions was about offering solutions that have similar principles but have evolved into different physical features reminiscent of the original idea. Combining design solutions was about selecting solutions already offered in previous cells and bringing them together. **Modifying** design solutions was an extension to these three strategies; it was about changing and adapting the solutions according to their new configurations.

4.3 Determining the usage context

Eight participants began the session indicating a user, use environment, or item to be stored (Figure 7). Five of these participants were highly determined in their context and made visual or verbal indications throughout almost all their cells. Twelve participants used such indications half-way through or further along the session. Five participants did not indicate any reference to a context throughout their sessions.

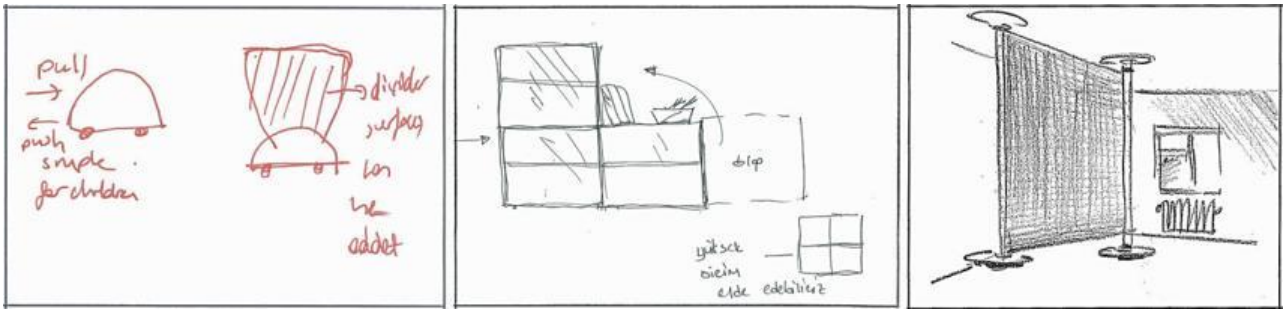

Figure 7. Left: Written indication of "children" as users (GE-P6-C7). Centre: Visual indication of items to be stored (GB-P5-C9). Right: Visual indication of a use environment (GC-P1-C11).

The users indicated in the sketches were children and young adults, including families, teenagers, flat-sharing students and artists/craftspeople. Users were mostly indicated in written and only two participants made drawings of users. The use environments were indicated in written or pictorially as living rooms, house entrances, bathrooms, children's rooms, separation for living room and kitchen, separation for living room and working room, and separation for living room and bedroom. Visual indications of use environment included spatial features such as wall and ceiling, or items such as radiator and washing machine. The items to be stored were indicated in written or pictorially as toys, accessories, bags, clothes, laundry, books, newspapers, magazines, keys, photos, plants, rolled papers, arts&crafts materials, tools, sports equipment, pillows, napkins, lights, glasses, TV, and bathroom products.

4.4 Working with themes

Sun, Xiang, Chai, Wang and Huang (2014) describe 'creative segment' as the episode of sketching in which an inspiration is found in the mind, expressed with a brief drawing, and serves the sketch maker as visual feedback for exploring the idea further, until the exploration of this particular idea ends. Yilmaz and Seifert (2011) use the term 'units of concepts' to refer to episodes in which ideas are generated and explored in reference to the design heuristics adopted by the designer.

In this study, the exploration episodes of ideas are referred to as 'themes'. If a design idea was explored in more than one cell, this was considered to be a theme. Continued exploration of an idea indicated a particular focus of the participant, and the solution space determined for design exploration.

Four types of themes were identified. Participants mostly worked on their own **generated themes**. These were the individual approaches of participants in responding to the design problem. Some participants used **borrowed themes**, those that were generated by other participants in the group but used by a participant in that round, to work on, or combine into own idea. In terms of their solution origins the themes were either familiar, or transferred. Familiar themes were those exploring design solutions that are available in real life for this type of furniture, including shelves, trunks, and furniture wheels. **Transferred themes** were those that involved analogical reasoning,

and explored solutions available in real life for products other than furniture, including bellows, curtains, and mazes.

The design solutions explored by the participants grouped under the following theme topics:

- **Structural solutions**;
- **Adjustability** of units;
- **Configuration** of units;
- **Accessibility** of units;
- **Storage and display** of items;
- **Spatial configurations** of structure;
- **Visual effects**;
- **Additional features** for extra functions;
- **Multifunctionality**; and
- **Adaptation** of structure and units.

It was observed that for some participants multiple themes were explored in equal effort and amount, whereas for some participants, there were main themes, and miscellaneous themes explored briefly. The number of themes explored for participants ranged from one to eight.

5. The effects of group dynamics

In his study on the functions of sketching in group design sessions, van der Lugt (2005) identifies the significance of *thinking* and *storing* sketches in supporting the creative process in idea generation, where *thinking* sketches stimulate the individual's re-interpretive cycle of ideas as they are being generated, and *storing* sketches stimulate the use of ideas generated earlier in the session and made accessible to the group. Although the design task did not involve collaboration, sketching within a group setting for this task had its effects on the performances of the participants. These were identified as, management of the idea generation effort, reflections of the idea contents explored within groups, and reflections of the representation styles of peers.

5.1 Management of the idea generation effort

Working as a group supported some participants in managing the effort made on idea generation. This was seen as managing their time, distributing the design effort into three cells for each round, and keeping up with the pace of the task for the further rounds. Participants who had difficulties in rapid idea generation were able to observe after the first round, the amount of effort their peers made in completing their first three cells (Figure 8). Participants who gave minimum effort in the first round, generated more involved sketches in the following rounds. Finally, participants who

tried to convey too much information in their initial cells in the first round, distributed the density of their sketches into three cells in the following rounds.

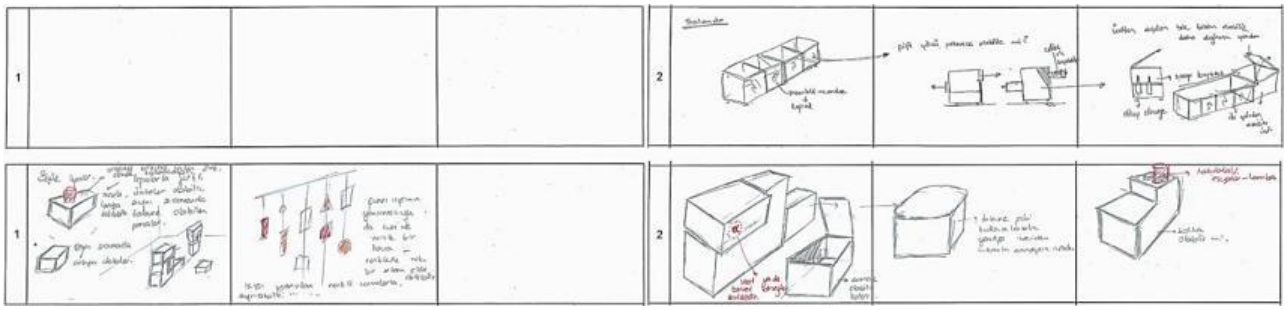

Figure 8. Top: The cells in the first two rounds for GB-Participant 5. Bottom: The cells in the first two rounds for GA-Participant 3.

5.2 Reflections of the idea contents explored within groups

Working as a group had effects on the themes and contexts in which ideas were explored. Although participants had their individual thematic contribution, groups also worked around common themes.

In **Group A**, the general contexts explored were children's rooms and adults' homes. The common themes were structural solutions, spatial configuration, adjustability, unit configuration, accessibility, storage/display, and multifunctionality. In this group, no common design solution was identified. This may be due to this session being carried out in four rounds only, mainly giving time for participants to represent their immediate ideas.

In **Group B**, all participants made reference to context, exploring children's rooms and adults' homes. The common themes were structural solutions, unit configuration, accessibility, storage/display, visual effects, and additional features. Design solutions converged, with similar variations for modular units, curtains with pockets, tension structures, and accessibility of units from multiple sides (Figure 9).

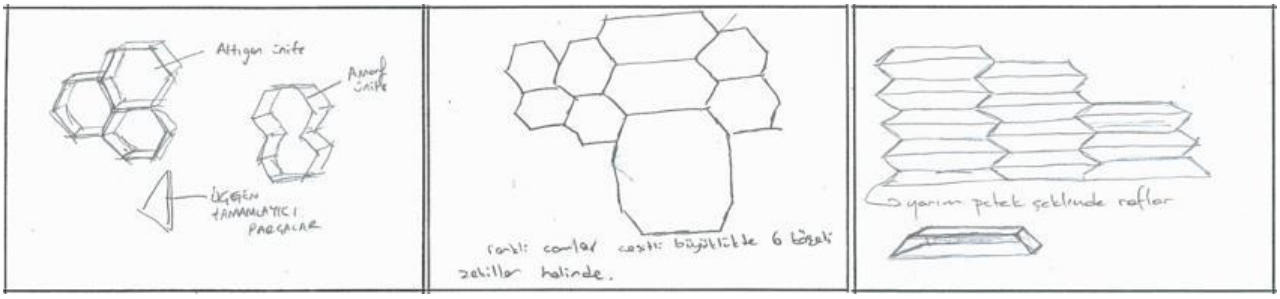

Figure 9. Converging design solutions for hexagon storage units in Group B. Left: P3-C4. Centre: P2-C9. Right: P4-C11.

In **Group C**, the general tendency was not to indicate any reference to context, and the design solutions were more of a functional nature. The common themes were structural solutions, adjustability, unit configuration, spatial configuration, visual effects, additional features, multifunctionality and adaptation. While two participants carried out their process independent of group influence, three participants were more responsive to each other's design solutions. Design solutions converged, with vertical rotating cylinders, hexagon units, repetitive usage of units, fold-away features, and prismatic volumes into which units fit (Figure 10).

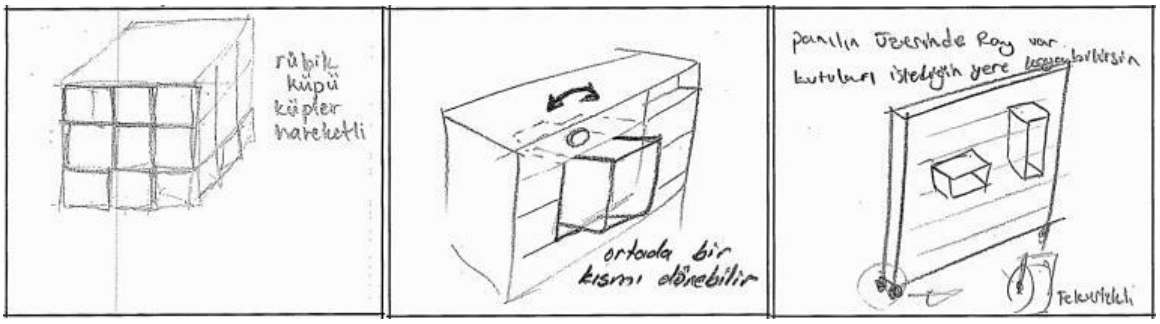

Figure 10. Converging design solutions for volumes into which units fit in Group C. Left: P3-C4. Centre: P4-C5. Right: P5-C7.

In **Group D**, one participant did not indicate any context and one participant made reference to a user in the final round; whereas three participants explored contexts throughout the session. The contexts explored were children, adults and teenagers. There was an abundance of structural solutions, besides solutions for spatial configuration and adjustability. The converging design solutions included vertical rotating cylinders, horizontal rolling cylinders, sliding and folding panels, tunnels and tents (Figure 11).

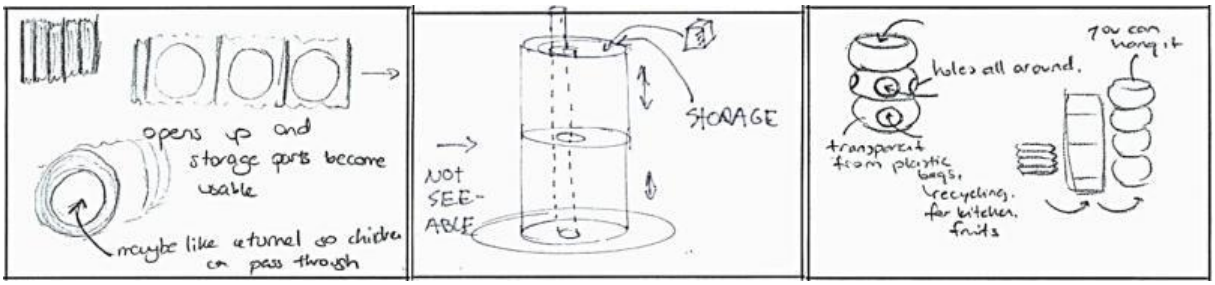

Figure 11. Converging design solutions for cylindrical storage units in Group D. Left: P3-C1. Centre: P1-C10. Right: P4-C15.

In **Group E**, one participant made no reference to context, three participants gave indications of context towards the end of the session, and only two participants gave regular reference to the user they addressed, which were, artists/craftspeople and families. The common themes explored were structural solutions, adjustability, spatial configuration, unit configuration, accessibility, visual

effects and adaptation. The converging design solutions were configurations of hexagon or cylindrical units, units around poles, and bellows for accessing units (Figure 12).

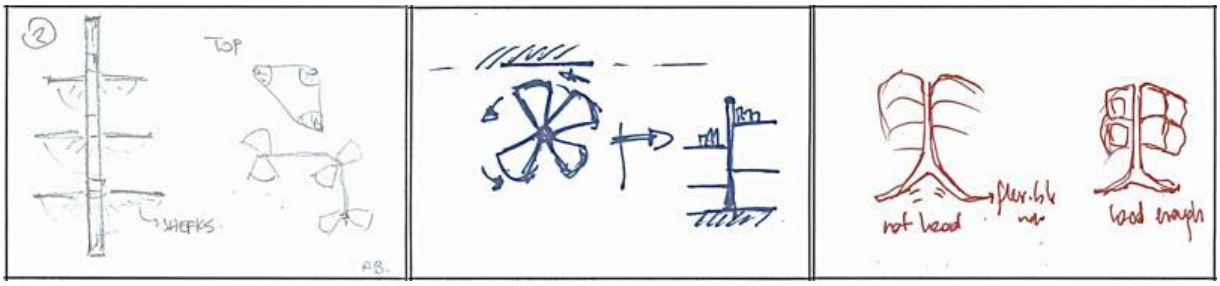

Figure 12. Converging design solutions for storage units around poles in Group E. Left: P4-C6. Centre: P5-C11. Right: P6-C14.

5.3 Reflections of the representation styles of peers

The effects of working as a group was also seen in the idea types and representation styles used by the participants. In **Groups A** and **B**, the general tendency was to work with a close distribution of all three idea types (whole, partial, detail), with an inclination towards detail ideas. In **Groups C** and **D**, the general tendency was to work on whole ideas in particular. In **Group E**, the general tendency was to work on details in particular, with 64 out of 108 cells dedicated to detail ideas.

The participants were able to observe from one another the level of detailing used and the amount of information given in the sketches for explaining ideas. It was seen that there was an adjustment of the level of detailing and styles of the sketches as the sessions proceeded. Particularly in groups C and E, the sketching style and quality approached for some participants, making it difficult to differentiate which sketch strip belonged to which participant. These groups were composed of participants with strong skills in visual representation.

On the other hand, some participants aimed for differentiating themselves through their sketching styles, with usage of symbols, rendering, shadowing, or changes in line quality. One participant put his initials on all his cells, whereas one participant gave titles to all her cells to indicate her objectives. There were some participants who did not use annotations in the first few rounds. All participants used annotation in the final rounds. These examples were seen as evidence of the effects of group dynamics on: using similar representation styles and handling common ideas 'like the others'; or, finding particular ideas and other ways of visual representation in order to be 'different than the others'.

6. Conclusion

Overall it was seen that, given such a design task, the effort of participants, particularly those from a design education background, was goal-oriented. The majority of participants were detail-oriented. The general tendency was to decompose the design problem, generate ideas for sub-

functions and then combine them. The rapid idea generation process of the participants were not random but contextualised. They mostly problematized the design brief by identifying features of the context to support their design exploration. Participants were mostly able to work with multiple themes that is demonstrative of the designers' ability in using *parallel lines of thought* (Lawson, 2000). In order to use time effectively, although participants communicated immediate ideas, they were selective about the design solutions and only further explored those they found worthy.

The participants handled the task displaying types of idea generation effort. **Independent idea generators** were those who were goal-oriented. They did not have difficulties in initiating the process, and were able to express and explore their immediate ideas systematically, making little or no use of group influence, apart from keeping up with the pace. **Collaborative idea generators** were those who were responsive to others' ideas, although not dependent on them. They occasionally used others' solutions as a starting point for idea generation, for continuing the exploration, or decomposing them to explore a detail. **Over-sensitive idea generators** were those who were much concerned with what the others in the group were doing, and how they were doing these. Most had difficulties in beginning the process, and some had difficulties in using strategies that would support them in diversifying their ideas. Finally, **effective idea generators** were those who used the dynamics of the group setting in terms of both idea generation and communicating the design solutions. Having strong skills in visual representation and being quick learners, they were effective in transferring themes and using strategies for idea diversification.

The findings of this study were used in the course for improving the conduct of the method in the following years. Students were asked to define the problem context by identifying users, use environments and purposes of use through group discussions, and the brief was adapted accordingly. Additional briefs in different problem areas were developed for the effective conduct of the method. A research phase and a structured brainstorming session were added to the design process before the conduct of the method. The findings also contributed to feedback given to students on their rapid idea generation performance. Cutting off the individual rows from the 6-3-5 charts and bringing them together as a strip displaying the sequence of sketches, is since being used as a complementary activity following the conduct of 6-3-5. Students examine their design ideas as a group to identify the features of their sketching, their approaches to the design problems and the origins of their ideas, for an awareness of their individual visual thinking styles and idea generation strategies for such tasks. They are also advised on how to improve the representational qualities of rapid freehand sketches, and diversify design ideas.

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