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Collective design reasoning strategies used in a creative group discussion session for effectiveness

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Abstract

The Controlled Input Method is a brainstorming technique that adopts both a nominal and an interactive approach, which has been indicated in the literature as making creative group discussion sessions effective. A brainstorming session using the Controlled Input Method was carried out as the initial stage of the design process of a graduate-level design project in an educational setting. The brainstorming session was found effective in terms of productivity. The documentation of the session was qualitatively and quantitatively analysed for identifying the factors contributing to the session's effectiveness. The analyses revealed seven discussion topics on the problem area, three solution areas gathering design ideas, seven statement types used in the documentation, and two problem frames situating the discussions, contributing to the identification of fifteen strategies used in collective design reasoning. The strategies are discussed in terms of content creation, problem exploration and idea generation as functions of design reasoning, and in reference to divergence, convergence, quantity, situatedness, and goal-orientedness, as indicators of effectiveness.

Keywords
Controlled Input Method, Creative group discussions, Design reasoning, Effectiveness of brainstorming.

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1. Introduction

Creative group discussions are generative discussion sessions carried out in groups, for the goal-oriented exploration of particular topics. In the field of design, creative group discussions may be carried out in various stages of the design process and for different purposes, such as problem exploration, idea generation, design detailing or evaluation (Pahl & Beitz, 1996; Wright, 1998). Studies on creative group discussions in the design context have emphasized the methods used and outcomes produced (e.g. Bonnardel & Didier, 2020; Kazakci et al., 2015; Murphy et al., 2022). There is also an increasing interest in discussions generated during the design process. Many studies analyse conversation content in order to understand how communication and negotiation contribute to design, with a focus on the social aspects of collaboration in design (e.g. Matthews & Heinemann, 2012; Oak, 2011), designerly thinking skills reflected in the conversations (e.g. Lloyd & Oak, 2018; McDonnell, 2018) and the forming of shared mental models (e.g. Nik Ahmad Ariff et al., 2012). This paper is an attempt at exploring the topic in terms of the design reasoning involved in achieving effectiveness for a creative group discussion session in the generation of situated content and usable design ideas.

Design reasoning is purposefully using reasoning and imagining simultaneously, deciding on the timing and amount for each depending on the nature and requirements of the situation, in mental operations such as problem solving, concept formation, making logical inferences, planning, deliberating, interpreting, carrying out argumentations, decision-making, creating, form giving and evaluating (Cramer-Peterson & Ahmed-Kristensen, 2016; Roozenburg & Eekels, 1995). The mental operations that constitute design reasoning are carried out towards design cognition that is the integration of designerly thinking processes and design representations achieved through the synthesis of knowledge, information and experiences (Goldschmidt & Weil, 1998), and manifested through the designerly practices of framing, which are moving, reflecting and reframing (McDonnell, 2018).

Design reasoning can become observable to a degree, when the design cognition process takes place in an interactive creative group discussion setting and is externalised through various communication channels among the participants, such as verbal communication. The paper describes a study on the identification of the design reasoning strategies for effectiveness in self-reported creative group discussions carried out in a brainstorming session using the Controlled Input Method. This session was the initial stage of a six-week graduate-level design project on shelf-ready packaging (SRP) solutions for baby food jars. The brainstorming session was carried out immediately after the project brief was distributed, with the goal of exploring the problem area and obtaining a set of design ideas that could be pursued for the project. Various group and individual idea generation methods for expanding the solution space, followed by design development and evaluation methods for selecting the final design solutions were used for the remaining stages, and the expected outcome was a full-scale model of the final SRP design solution individually submitted by all participants. At the end of the project, while making a review of the design process and its outcomes, the author was able to determine that the brainstorming session had reached this goal: 12 out of 13 final design submissions made for the project used ideas generated in this brainstorming session.

Based on this recognition, this paper is mainly concerned with the outcomes of the brainstorming session using the Controlled Input Method, and argues that the session was productive in terms of the content of the creative group discussions carried out, and therefore effective in problem exploration and idea generation. The paper maintains that the effectiveness of the session owes to the collective design reasoning that took place during the discussions and enquires into the underlying mechanisms, referred to in this paper, as the design reasoning strategies. Accordingly, the study described in this

paper explores the effectiveness of this session with the aims of 1) establishing the design reasoning strategies that the participants used during the discussions, and 2) describing the collective design reasoning process that helped achieve this effectiveness.

In pursuing its aims, the paper reviews the literature on effectiveness in creative group discussions and brainstorming as a method in conducting group discussions, setting the theoretical framework for the study. The paper then describes the study, covering the data collection and analysis procedures. The data of the study is verbal (written) and visual (sketched) discussion content, individually documented by the participants during the session. The methodology used for data analysis adopts both qualitative and quantitative approaches in identifying the topics covered, solution areas developed, statement types used and problem frames formulated in the discussion documentation. The findings provided insights into the collective design reasoning strategies involved in the discussions, and their contribution to the effectiveness of the session. The strategies are expected to widen the understanding of the collective design reasoning process in creative group discussions and contribute to the planning and moderation of such sessions in design education and practice, for effectiveness.

2. Literature review

In order to establish a theoretical framework for the study, literature review has been carried out on creative group discussions, how effectiveness has been defined for creative group discussions, factors that contribute to effectiveness in creative group discussions, problems that may arise during creative group discussions hampering effectiveness, and methods used for overcoming these problems.

2.1. Effectiveness of creative group discussions

The expectation from creative group discussions is the generation of a substantial number of ideas, which seems to be considered as a manifestation of effectiveness. On the other hand, Sutton and Hargadon (1996) state that the productivity of a creative group discussion cannot be considered as limited to the efficiency at idea generation alone. They acknowledge the contribution of face-to-face discussions to the morale and motivation of groups. In a study conducted at a leading product design company, they identify various contextual factors that contribute, such as motivation, skills and expertise of participants, past and future task interdependence, and, whether and how the ideas are made use of. The efficiency of collaborative creativity is highly related to group establishment, meaning, for group members to have had continuous interaction in the past therefore being used to producing together, and the operationalization of the brainstorming session allowing group creativity to perform realism within context (Levine et al., 2015).

Effectiveness in design collaboration is possible when collaborators can all apply their skills and knowledge on the design task, and abilities for working collaboratively towards a common goal (McDonnell, 2012). Progress in creative group discussions is the result of the systematic pursuit of certain propositions, timely evaluation of design moves, early confrontation of problematic issues, and evaluation of the consequences of a line of reasoning (McDonnell, 2018). In effective discussions members show skills in allowing others to answer questions they have raised, or picking up on a line of thought brought forth by another, and building on it (Goldschmidt, 1995). Situated evaluations taking place during discussions actually help in forming and elaborating on the problem frameworks, through which members are able to stimulate one another's divergent thinking and integrate individual ideas into the creative output (Harvey & Kou, 2013). Participants in creative group discussions are seen to employ interactional strategies that support effective design collaboration such as negotiating during design moves; acknowledging that the contributions are tentative; accommodating disagreements by postponing resolution and keeping on designing; and including emerging design possibilities within the progressing design (McDonnell, 2012).

Successful group discussions display coherent development in the pattern of conversation (Dong, 2005). Coherence means that two discourse entities in a discussion are topically related, and the connections between the elements of the perceived whole are identifiable (Menning et al., 2018). Achieving coherence in team settings requires collaborative effort, through constant assessment of, and agreement upon the discourse carried out. If the discourse entities are closely connected, coherence is high; if they are distantly connected, coherence is low. Low coherent statements act as disruptive stimuli and lead to mental focus shifts by directing team members' attention to new topics (Menning et al., 2018). This in turn allows divergence during idea generation, as innovative meaning emerges between concepts, and focus shifts are extended to multiple planes allowing interpretative freedom and associative behaviour (Menning et al., 2018).

2.2. Divergence and convergence in creative group discussions

It is believed that idea generation mainly involves divergent thinking. On the other hand, evaluation-centred discussions based on convergent thinking may also take place in a productive manner; Harvey and Kou (2013) explain evaluation-centred discussions to be an important aspect of collective creativity, during which individual ideas can be filtered and integrated into a group perspective, and novel ideas can be identified and built on. Goldschmidt (2016) associates divergent thinking with unfocused ideation for the consideration of various aspects for a topic, and convergent thinking with focused ideation that evaluates a particular aspect for a topic. Both types happen in cycles of design moves, which are segments that reflect a unit of categorizable thought (Goldschmidt, 2016). Each design move involves forelinks, representing divergent thinking, and backlinks, to a lesser percentage, representing convergent thinking. As new ideas are being generated, earlier ideas are also considered and thus, new ideas are elaborated on with reference to past development.

Experienced designers typically search for solutions early within the design process, while still developing an understanding of the problem, explained as problem-solution co-evolution (Darke, 1984; Dorst & Cross, 2001; Lawson, 2000; Lawson & Dorst, 2009; Wiltschnig et al., 2013). This is seen in the group context as well. Stempfle and Badke-Schaub (2002) explain the thinking sequence of design teams as generating an idea, immediately followed by the evaluation of the idea and its acceptance if it is found satisficing, with the purpose of reducing complexity, and saving time and cognitive effort when facing incomplete information.

Larey and Paulus (1999) explain that when groups arrive at a consensus during creative group discussions, they tend to restrict their focus of attention. Harvey and Kou (2013) explain this as the tendency of members to converge around those ideas found worth of pursuing, so that they can build on them. In group discussions, many ideas are produced (divergence), but for a limited number of topics (convergence) discussed for an extended time (Bouchard et al., 1974; cited in Larey & Paulus, 1999). This simultaneous use of divergent and convergent thinking is an ability that designers develop in time (Tovey, 2012), and requires that designers continuously frame and reframe how they see the world (Carroll et al., 2012).

2.3. Problem framing in creative group discussions

Problem framing is the determination of a frame through which designers initially view the problem space and identify the core features to address (Cross, 2011; Dorst, 2011; Paton & Dorst, 2011; Schön, 1983). Once solving the problem as seen through the frame, designers move on to new frames they set for themselves. This process contributes to their mental representation of the design problem (Björklund, 2013), and the determination of priorities early on in the process (Cross, 2011). Naming of these priorities supports design moves and serves to bind together the fragments in a group discussion (McDonnell, 2018). Frame establishment takes place in the early design episode, where "what to design"

is decided upon (Stumpf & McDonnell, 2002). The process takes place as: problem framing, naming issues to attend within the frame, generating moves towards a solution, and reflecting on the outcomes of these moves. During argumentation individual frames are shared within the team for carrying out moves and integrating reflection in the process (Stumpf & Mc Donnell, 2002). The team may at times generate conflicting frames. Then, during argumentation persuasion and linguistic skills are used for sharing opinions, beliefs and values in creating the context. To overcome frame incompatibility, dissociations take over, creative changes in the input are used, and established concepts are separated into new ones. In settings where individual frames do not conflict, they converge towards a team frame (Stumpf & McDonnell, 2002). Successful frame establishment can affect the design process and the quality of its outcomes positively (McDonnell, 2018). Therefore, during design collaboration the team needs to be aware of the dominant frames that emerge, and reinforce them for their sustainment (Stumpf & McDonnell, 2002).

2.4. Difficulties of conducting creative group discussions

There are difficulties in conducting creative group discussions, such as finding the right procedure to follow, managing the group, documenting the session, and making use of the outcomes. There are the risks of losing ideas if not well documented, or not exploring them to their full potential. The group dynamics may hinder the effective participation of all, as production blocking may happen in the presence of other speakers (Paulus & Dzindolet, 1993), or the ideas of speakers may restrain the chain of thoughts of others lacking the required knowledge background (Paulus & Brown, 2007). Groups may divide into smaller ones carrying out separate discussions (Osborn, 1963). Sidestepping may occur (Kowaltowski et al., 2010), and discussion topics may diverge from the main problem area (Paulus et al., 1993). Participants may be reluctant in sharing ideas for competitive reasons, or due to evaluation apprehension, which is the anxiety of being criticised (Osborn, 1963). There may be those who free-ride, relying on the effort of others in the group (Larey & Paulus, 1999; Osborn, 1963), or those who believe their contribution will be overlooked, explained as dispensability of contribution (Diehl & Stroebe, 1987). Conflicts and disagreements may arise within a group requiring resolution (Cross & Clayburn Cross, 1995; Kurtzberg & Amabile, 2001). Besides, the group's performance level may remain at that of the member with least productivity (Larey & Paulus, 1999).

2.5. Brainstorming as a creative group discussion method

In terms of the difficulties mentioned above, brainstorming is an effective method for creative group discussions, as it encourages the participation of all, and organises discussions towards a common goal. The method was introduced by the advertising executive Osborn (1963) to facilitate creative thinking in groups, and is used for problem exploration, idea generation and decision making within a short time. The method expects the contribution of a group of people from diverse backgrounds, and leads to a flow of ideas generated through associations triggered by discussions (Osborn, 1963). The four rules characterising this method are ruling out criticism while ideas are being suggested; allowing free-wheeling of discussions so that inspiring ideas can be offered; aiming for quantity of ideas, as quality ideas are expected to turn up among many generated; and striving for the combination and improvement of ideas offered in the session (Osborn, 1963).

The effectiveness of brainstorming has often been subject to study particularly in the fields of psychology, collective creativity and organisational behaviour. Many studies have reported on the effects of subject personalities (Furnham & Yazdanpanahi, 1995), procedure instructions (Paulus et al., 2011; Rietzschel et al., 2014), task description, performance self-assessment of subjects (Diehl & Stroebe, 1987), idea exchange (Paulus & Yang, 2000), group goal-setting and feedback (Eisele, 2012), group effectiveness, idea selection (Faure, 2004), idea evaluation

(Putman & Paulus, 2009), and duration of sessions (Henningsen & Miller Henningsen, 2013). Such experimental studies are generally conducted in laboratory settings, testing social factors affecting the discussions, among individuals, and members of nominal and interactive groups of small size (e.g. three or four members).

A main issue of debate has been whether nominal (members work individually within a group) or interactive (discussions take place between members) brainstorming works best in terms of quantity and quality of ideas. Experimental studies show that nominal brainstorming produces more ideas in number compared to interactive brainstorming, whereas others indicate that the quality of the ideas generated in interactive discussions are better (i.e. good, original, unique, creative, feasible) (Diehl & Stroebe, 1991; 1987; Harvey & Kou, 2013; Larey & Paulus, 1999; Levine et al., 2015; McMahon et al., 2016; Paulus et al., 1993; Rietzschel et al., 2014; Rietzschel et al., 2006; Sutton & Hargadon, 1996). An adopted approach for effective group discussions is following techniques that allow both interactive and nominal brainstorming (Faure, 2004; Osborn, 1963; Paulus, 2000; Wodehouse & Maclachan, 2014). An incubation time carried out individually, during interactive group discussions, allows the participants to retrieve discussed ideas from memory, combine them with ideas they generate, and feed them with their individual repertory of knowledge (Paulus & Brown, 2007).

2.6. Brainstorming techniques

Throughout years, variants of the brainstorming method have been developed to ensure its effectiveness depending on the nature of the problem that is handled. Examples include the 6-3-5 Method, Gallery Method (Pahl & Beitz, 1996), Brainwriting Pool (Roozenburg & Eekels, 1995), Braindrawing (Gause & Weinberg, 1989), Crawford Slip Method, Delphi Method (Kowaltowski et al., 2010), computer-mediated electronic brainstorming (Denis & Valacich, 1993) and Controlled Input Method (Wright, 1998), aiming to overcome the negative effects of social factors, and production blocking in particular.

Following structured brainstorming procedures is known to result in more creative solutions compared to unstructured brainstorming procedures (Gray et al., 2019). Wright (1998) specifies that a casual approach to brainstorming may result in the loss of potential benefits, and recommends the Controlled Input Method, which ensures that each member contributes to, and also documents the discussions. The method follows a procedure in which discussions are carried out in 11-minute rounds (Wright, 1998): the first member who speaks, has three minutes to make design suggestions, and produce sketches if necessary, during which no other member can speak. In the following five minutes, the group members are allowed to speak without criticism and ask questions to develop the proposed ideas. A further three minutes are then given for members to process the discussions individually, taking notes and making sketches. This procedure is repeated for all members, after which the ideas are compiled from the notes.

The Controlled Input Method has been used occasionally for projects carried out in this graduate course for allowing both nominal and interactive brainstorming. Over time a variant of the method has been developed with the educational objectives of managing time, and encouraging verbal and visual documentation. It is this variant that was used in the study presented in this paper (see Section 3.2.3).

2.7 Theoretical framework for effectiveness of brainstorming sessions

As seen from the literature, many studies have been conducted on effectiveness in creative group discussions, associating with productivity in particular. Although many factors for effectiveness been identified, few of these studies explain the design reasoning involved. Based on the literature review, this paper accepts the effectiveness of brainstorming sessions as productivity owing to successful group establishment and frame establishment. Group establishment is a result of the functions of: productive interaction in the past (Levine et al., 2015) with the same group, task interdepen-

dence (Sutton & Hargadon, 1996) for knowing how the output is going to affect the following steps of the process, and operationalization (Levine et al., 2015) for performing realism within context in the discussions.

A supportive group establishment occurs when the group members: have motivation and willingness to participate; are able to apply their skills and knowledge; show collaborative working abilities; share an understanding of the goal (McDonnell, 2012); are able to pick up on others' lines of thought to build on earlier discussions (Goldschmidt, 1995); accommodate disagreements for the progression of ideas (McDonnell, 2012); refrain from premature criticisms (Osborn, 1963); and carry out constant assessment in the form of situation evaluation (Harvey & Kou, 2013) and negotiation for design moves (McDonnell, 2012) for agreement on issues to address and coherence in the discussions.

Frame establishment in an interactive group discussion context is a result of the functions of: simultaneous use of divergent thinking and convergent thinking for coherence (Goldschmidt, 2016; Menning et al., 2018; Tovey, 2012); problem-solution co-evolution to reduce complexity, restrict focus of attention and save time and cognitive effort against incomplete information (Dorst & Cross, 2001; Lawson, 2000; Lawson & Dorst, 2009; Stempfle & Badke-Schaub, 2002; Wiltschnig et al., 2013;); problem framing for a collective mental representation of the design problem (Cross, 2011; Dorst, 2011; Paton & Dorst, 2011; Schön, 1983); collective naming of what to design (Stumpf & McDonnell, 2002); and collective decision making on the issues to be addressed (McDonnell, 2018). Consensus in these is desirable (Dong, 2005; Larey & Paulus, 1999), though agreement on all issues is not particularly required. Rather, the objective is coherence in the content, which may slightly diverge and even conflict towards alternative solution areas (Menning et al., 2018).

Successful group establishment and frame establishment facilitate high performance in problem exploration and idea generation in interactive and nominal group discussions. These performances manifest in creative group discussions with reference to the diversity of topics covered (divergence), extent to which topics are explored (convergence), number of ideas generated (quantity), their relevance to the design problem (situatedness), and their usability in the following stages of the process (goal-orientedness).

This paper argues that these manifestations are a result of the design reasoning strategies used in the generation of creative group discussion content and the findings are examined accordingly. This theoretical framework makes it possible to bring a design reasoning perspective to effectiveness in creative group discussions, which is identified as a gap in the literature. The study that follows, investigates design reasoning in creative group discussions through this framework.

3. Methodology

Based on the above-described theoretical framework, a study was planned with the aim of investigating the effectiveness of brainstorming in terms of frame establishment, resulting from collective design reasoning for productivity. The study involved the conduct of a nominal and interactive brainstorming session, and an in-depth analysis of the discussion documentation that consisted of written notes and sketches produced by the 13 participants during the session on a total of 156 A4-size sheets. The research question was:

- How did collective design reasoning take place in the creative group discussions towards productivity?

3.1. Participants and setting

The session was carried out in an educational setting familiar to the participants (the usual classroom for the course). The brainstorming session was attended by 13 graduate students all holding a bachelor's degree in industrial design. There were eight female students and five male students. Ten were from Turkey, and three were from the Netherlands. Discussions were carried out in English. All having a background in industrial design education, the 13 participants were accustomed to carrying out creative group

discussions, which provided them the necessary method mindset (Daalhuizen et al., 2014). The participants had collective creativity experience in an earlier short project carried out for the same course and represented an established group (Levine et al., 2015). The session was the initiating phase of a design process that the participants knew would continue for a period of time and participants were aware of the task interdependence (Sutton & Hargadon, 1996). Besides, the systematic brainstorming procedure called for constructive thinking styles that involved generating discussions and documenting them simultaneously in writing (constituting the data set for the study). These factors contributed to explaining the high performances of participants in terms of group establishment.

3.2. Design problem

The brainstorming session was carried out for corrugated cardboard (CC) shelf ready packaging (SRP) solutions for baby food jars. Shelf-ready packaging is a type of retail packaging for fast-moving consumer goods that has an extensive usage, covering transportation from manufacturer to retailer, where it is directly used for displaying product content on market shelves (Dujak et al., 2014; Romanik, 2013). A typical SRP solution for baby food jars is shrink wrapped cardboard trays holding from six to twenty jars. The project brief called for design solutions that would make it easier for market staff to arrange shelves with jars, and for consumers to visually and physically access them.

3.3. Brainstorming procedure

The session was moderated by the author. This involved the distribution of the project brief, a short discussion on the topic using images and examples of SRPs and baby food jars, distribution of the brainstorming procedure brief, explanation of the rules of brainstorming, and suggestions on what the participants can talk about (e.g. storing and displaying the product, users, environment, materials, immediate ideas for design solutions, review of similar products). The remaining moderation was limited to starting the session, keeping time, and supervision in adhering to the brainstorming rules.

The procedure followed for the session was a variant of the Controlled Input Method. In this variant procedure, each round was given 5 minutes. The first speaking participant had three minutes to think aloud, make design suggestions, and produce sketches on the whiteboard if necessary, during which s/he carried out nominal brainstorming on the problem area, while the other participants were not allowed to interrupt and silently took notes on distributed sheets. In the following two minutes, interactive brainstorming took place; the other participants were allowed to speak without criticism and ask questions to develop the proposed ideas, while processing the discussions as notes and sketches. This procedure was repeated for all members. As there were 13 participants, the session was held in 13 rounds.

Participants sat randomly in a circle around a large desk; the first participant volunteered to speak for the first round, and the following rounds continued with the person on the right, until all participants took turns. As the moderator started time keeping, the first participant started thinking aloud, with no initial probe question. At the end of three minutes, the moderator announced that the think aloud period had ended, and that the two minutes of interactive group discussion period had begun; then announced that these two minutes had ended, and the following round of three minutes for the next participant to think aloud had begun, and so on. Time was kept using a chronometer, and the duration was a total of 65 minutes (13 participants x 5 minutes).

3.4. Data collection and nature of the data

A4 size sheets were distributed for participants to take notes and make simple sketches during the rounds of discussions. On each sheet was a chart containing three table columns titled "Summary", "Comments and Criticisms", and "Notes and Suggestions". Each participant would fill in a separate

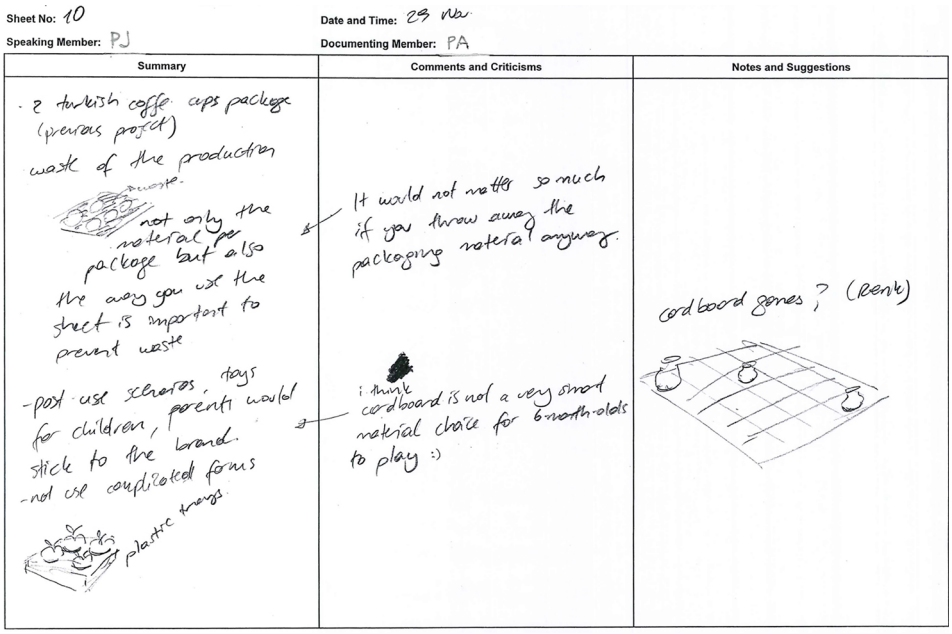

Figure 1. *A documentation sheet filled in the session (Round 10, Participant A).*

sheet for each round of discussions. As the participants would not be taking notes in their own rounds, each was distributed 12 sheets. At the end of the session, 156 sheets were collected (13 participants x 12 sheets) that included written statements and some sketches (Figure 1).

The session documentation produced qualitative data comprised of verbal and visual notes taken on separate sheets for each round, by the participants listening to: 1) their peer thinking aloud during nominal brainstorming, and 2) the group discussions during interactive brainstorming. The nature of this data is not an exact recording of what was being said, but an account of the discussions individually processed by the participants. These documentation sheets included common accounts of think aloud statements followed by statements made during interactive discussions, and individual accounts of each documenting participant's interpretations and contributions (processed statements produced after individual verbal and non-verbal thought).

3.5. Data analysis procedure

The data set was subjected to two consecutive analysis procedures carried out by the author alone. The analyses were planned to be both qualitative and quantitative, looking at the formal qualities as well as content of the data. The goal of the analyses was to determine the origination, development and finalization of the discussion segments, through which it would be possible to trace the collective design reasoning process.

3.5.1. First data analysis

The first analysis included qualitative thematic and content analyses (Krippendorf, 2004; Savin-Baden & Howell Major, 2013). The aim of this initial analysis was to obtain insights into the group's performance in content creation for problem exploration and idea generation. This required the identification of the discussion topics to assess the diversity of issues addressed and the extent to which these issues were explored, and of the solution areas to assess the diversity and quantity of solutions.

All written statements (404) were transferred into digital format using the Microsoft Excel program. The sketches (81) were identified as depicting an idea (e.g. design solution, detail, mechanism), context (e.g. environment, user), or situation (e.g. opening, removing, stacking), and added to the list of statements as written descriptions. The resulting 485 statements were listed according to the respective rounds, and also according to participants.

The lists were cross-examined using open coding to identify the discussion topics. The topic units identified from all the statements were categorised according to problems put forth, issues

addressed, explanations made, examples given, users indicated, use environments described, solutions offered, and further actions suggested. The statements for topic categories were then counted for frequency of mention to display the importance that participants gave to them. The statements were then distributed according to rounds for mapping topic, category and subcategory interdependence. The statements providing design solutions were further investigated for their design idea units, and these were thematically grouped into solution areas. This process required repeated reviews of the lists and reorganisation of the codes, towards a saturated thematic categorisation of the discussion content. The process ended with the determination of discussion topics and solution areas.

3.5.2. Second data analysis

In order to reveal the design reasoning involved in the discussions, a second formal content analysis was planned for identifying the types of statements used in the documentation, and relating these types to the discussion content. The aim was to identify the purpose of use of these statements and how they contributed to the progression of the discussions.

The 485 statements were re-examined for the formal qualities and sentence types, according to rounds. Among the statements were those of only one word, such as an exclamation adjective like "*Interesting* (Participant I, Round 2)" or a declaration noun like "Decoration (PE, R13)". There were declarative non-finite clause statements, such as "Not to drop the packs (PF, R5)". The majority of statements were complete sentences, some long, such as the imperative sentence "*A pack should include ingredient and amount that matches physical nutrition needs of baby* (PH, R6)" and others short, such as the declarative sentence "Handles can be nice (PK, R3)". There also were interrogative sentences, like "*How many jars are carried in the bag?* (PM, R8)".

Types of statements were first identified on the list of rounds. This initial breakdown was cross-checked on the list of participants. This initial examination revealed four types of statements, independent of sentence types and in terms of purpose, as remarks, objectives, problems and solutions. Following, statement types were categorised in a new list, with the rounds in which they were produced and the participants that produced them indicated in columns. On this list, statements were classified into discussion topics to reveal the differences of expression once the contents were the same. This helped refine the statement categories and identify subcategories based on how they were expressed, and what they indicated. The finalised lists were transferred back to lists of statements according to rounds, ending with the identification of the types of statements used for the discussions by all participants in each round. The final lists made it possible to identify the development trajectory of the problem frames, also displaying the origination, development and finalization of segments for each discussion topic.

Overall, the analyses were iterative rather than linear, and the results of the first and second analysis procedures were cross-checked in structuring and refining the findings. Data analysis was

Table 1. *Topics of discussion and their sub-categories.*

CONTENT
A. Packaging (262)
A1. Packaging concept (65)
→ A.1.1. Packaging type (45)
→ A.1.2. Multipacks (20)
A.2. Description (125)
→ A.2.1. Components (73)
→ A.2.1.1. Cover (23)
→ A.2.1.2 Flap (10)
→ A.2.1.3 Handle (21)
→ A.2.1.4. Shrink wrap (11)
→ A.2.1.5. Other (8)
→ A.2.2. Physical features (52)
→ A.2.2.1. How be? (8)
→ A.2.2.2. Inclined (9)
→ A.2.2.3. Box-like (9)
→ A.2.2.4. One jar removable (9)
→ A.2.2.5. Diverse shapes (17)
A.3. Protection (31)
A.4. Modification (41)
→ A.4.1. Immediate Use (35)
→ A.4.2. After use (6)
B. Packaging Content (105)
B.1. Jar (54)
B.2. Jar cap (9)
B.3. Food content (42)
C. Material (88)
C.1. Material types (43)
→ C.1.1. Types (4)
→ C.1.2. Corrugated cardboard (22)
→ C.1.3. Glass (10)
→ C.1.4. Other (11)
C.2. Production (7)
C.3. Effective usage (34)
D. Waste Management (52)
D.1. Re-use (27)
D.2. Recycle (17)
D.3. Deposit (8)

CONTEXT
E. Supermarket (208)
E.1. Supermarket context (6)
E.2. Display (142)
→ E.2.1. Stackability (46)
→ E.2.1.1. Stackability (13)
→ E.2.1.2. Shelving (6)
→ E.2.1.3. Stackability of packs (23)
→ E.2.1.4. Stackability of jars (4)
→ E.2.2. Visibility (96)
→ E.2.2.1. Visibility (36)
→ E.2.2.2. Visibility of brand (22)
→ E.2.2.3. Visibility of content (38)
E.3. Marketing (47)
→ E.3.1. Promotion (8)
→ E.3.2. Gifts (39)
E.4. Logistics (13)
F. Home (24)
F.1. Home context (9)
F.2. Storing (15)
G. People (55)
G.1. Market staff (5)
G.2. Consumer (13)
G.3. User (37)
→ G.3.1. User identification (30)
→ G.3.2. Safety (3)
→ G.3.3. Feeding (4)

concluded when the categorizations for topics, solution areas, statement types and problem frames provided a coherent and saturated structure.

4. Findings

At the end of the analyses, seven main discussion topics, three solution areas, seven statement types, and two problem frames were identified.

4.1. Discussion topics

Two main themes were determined for the discussion content, dividing into seven topics, 22 categories and 45 subcategories (Table 1). The main theme of concept gathered the topics of *packaging* (A), *packaging content* (B), *material* (C), and *waste management* (D), and the main theme of context gathered the topics of *supermarket* (E), *home* (F), and *people* (G). Table 2 shows the numbers of topic mentions in the 22 categories, and Figure 2 shows the distribution of the seven topics into rounds.

The topic with the highest number of mentions was packaging, followed by the topic of supermarket. The topics of packaging and packaging content were covered in all 13 rounds; supermarket and people were covered in 12, and material and waste management were covered in 11. The topic with least coverage was that of home, as this was used for supporting the exploration of secondary uses for the SRP. Discussions in five rounds covered all seven topics, discussions in six rounds covered six, one round covered five, and one round covered four topics. The rounds with the lowest numbers of topics covered, involved more converged discussions.

The discussion content can be summarised as follows. In Round 1, the speaking participant mentioned difficulties she had as a former supermarket employee, in preparing shelves by placing small products one-by-one, thus suggesting "multipacks" (packaging with multiple products). In Round 2, the speaking participant mentioned user experience, informing the group that baby food jars are generally bought in quantities and in different flavours. Hence, the *packaging* concept of "combination multipacks" was raised and carried into the discussions. Discussions on the topic of *packaging* included descriptions of SRP examples available in the market; protection of the packaging content from factory to market; and *modification* possibilities for using the packaging during shopping, shelving, and storing.

Discussions on the topic of *packaging content* included alternative jar shapes and sizes; space saving; standing out among competing brands; ensuring visibility of jars; and providing product information for consumers.

Table 2. *Mention frequency of topics according to rounds.*

	A Packaging				B Packaging Content			C Material			D Waste Management			E Supermarket				F Home		G People		
	A1	A2	A3	A4	B1	B2	B3	C1	C2	C3	D1	D2	D3	E1	E2	E3	E4	F1	F2	G1	G2	G3
R1	6	21	1	1	1	0	0	2	0	3	5	1	0	2	16	0	1	1	0	2	2	0
R2	7	1	0	5	8	0	11	0	0	0	4	0	0	0	26	0	1	1	0	0	4	3
R3	2	16	5	6	4	0	1	12	1	3	0	0	0	0	0	0	0	0	0	0	0	1
R4	4	17	0	3	2	0	3	2	1	1	0	6	5	0	15	1	2	0	1	0	1	1
R5	1	6	6	0	1	0	3	0	0	0	0	1	0	0	15	0	1	3	11	1	0	2
R6	14	4	0	1	1	0	6	0	0	1	4	0	0	1	4	6	1	0	1	0	1	15
R7	3	17	3	0	5	0	4	7	1	1	0	0	1	0	8	0	0	0	0	1	1	0
R8	5	3	2	2	16	7	1	6	1	0	1	0	0	0	2	0	2	0	0	0	0	5
R9	6	6	1	2	0	0	6	0	0	1	0	0	0	1	32	1	4	0	0	1	1	0
R10	4	8	0	0	7	0	3	2	0	5	1	6	2	0	5	2	0	2	0	0	1	0
R11	0	3	5	2	2	0	2	13	3	8	1	2	0	0	3	26	0	0	0	0	1	7
R12	5	15	7	5	6	2	1	0	0	10	7	0	0	1	16	1	1	2	0	0	0	0
R13	8	8	1	14	1	0	1	3	0	1	4	1	0	1	0	10	0	0	2	0	1	3
	65	*125*	*31*	*41*	*54*	*9*	*42*	*47*	*7*	*34*	*27*	*17*	*8*	*6*	*142*	*47*	*13*	*9*	*15*	*5*	*13*	*37*

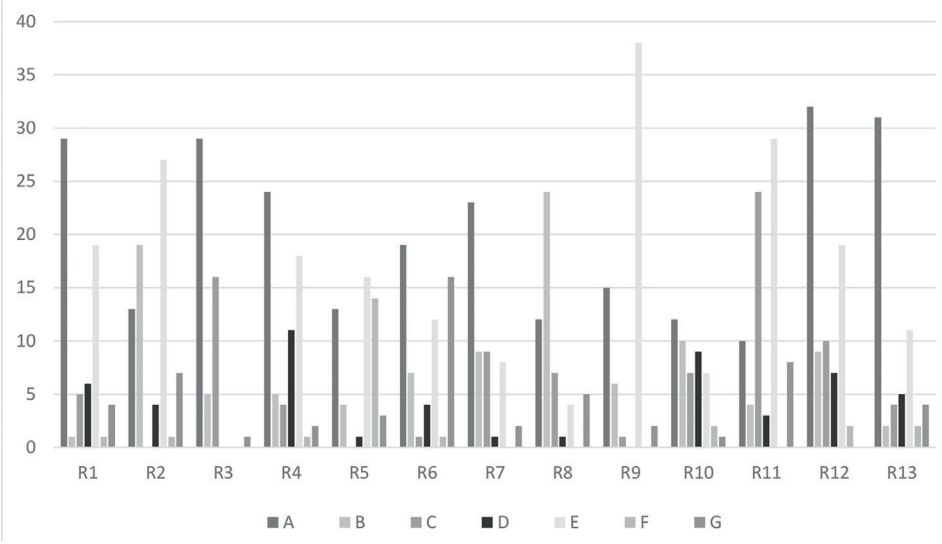

Figure 2. *Distribution of topics according to rounds.*

Discussions on the topic of *material* included material properties; production standards for corrugated cardboard (CC); advantages and disadvantages of glass food packaging; providing sturdiness of packaging; avoiding excessive usage of material; avoiding material wastage during shelf set-up; and avoiding additional packaging material. Discussions on the topic of *waste management* included reuse possibilities of waste CC; recycling of the packaging materials; and deposits on boxes.

The *supermarket context* was depicted as a competitive shopping environment where the person spends time in front of shelves to interact with the packaging. Discussions on the topic of *supermarket* included the logistics process of SRP; *displaying* the SRP and its content; and arranging shelves for accessibility, categorisation, and brand distinction. Discussions included *product marketing* strategies such as displaying in original ways, and giving collectible gifts in the packs.

Discussions on the topic of *home* were on ways of *storing* the jars and space saving. Discussions on the topic of *people* included easing the stackability of packs and arrangement of shelves for *market staff*; attracting the *consumer* who has limited time for shopping and is environmentally sensitive; and providing easy interaction for the *user* with the packaging for removing, carrying, and storing jars.

4.2. Solution areas

Three main themes gathering seven solution areas were determined from the discussion content (Table 3). For the theme of *packaging design*, the solution area of *features of the packaging* covered ideas for box-type packaging for many jars; irregular-shaped packaging allowing removal of single jar; unusual box shapes for arranging jars in different ways; and boxes with openings to see the jar content inside. The solution area of *features of the packaging components* explored ideas for flaps, covers, handles and base, with solutions offered for structural reinforcement, stackability, jar protection, and jar stabilization.

For the theme of *product marketing*, the solution area of *packaging concept* covered ideas for combination multipacks with three to six jars, for daily or weekly nutrition; trial packs; packs that can be combined with other types; and fill-in-yourself packages. The solution area of graphical solutions on packaging and jar labels explored ideas for visibility of food type and product information; identifiability and brand competition; and food categorisation of jars on shelves. The solution area of *sustainability concerns* explored ideas for layout designs avoiding production and set-up waste; and reusing empty packaging for shopping and storing.

For the theme of *modifiable packaging*, the solution area of *modifying for packaging-related uses* explored ideas for the modification of the packaging or its parts by the consumer during shopping, such as combining packs of different contents; removing empty parts of packaging; expanding a folded package to fill in with jars; and tearing off part of pack to purchase in less amount. The solution area of *converting into other uses* explored ideas for

Table 3. *Solution areas and their sub-categories.*

Packaging Design (60)	Features of the packaging (25)
	Features of components (35)
Product Marketing (45)	Packaging concepts (11)
	Graphical solutions (19)
	Sustainability concerns (15)
Modifiable Packaging (42)	Modifying for packaging-related uses (18)
	Converting into other uses (24)

Table 4. *Types of statements and their sub-categories with examples (Participant Code, Round No.).*

Information Statements (69)	
Fact (12)	Amount of baby food changes as baby grows. (PF, R2)
Observation (13)	Some parents take notes of what their babies eat. (PF, R6)
Presumption (14)	Not used every day, emergency food. (PD, R2)
Description (verbal 9)	Plastic parts that hold together six-pack drink bottles. (PC, R3)
Description (visual 21)	*Drawing of a plastic apple tray.* (PA, R11)
Problem Statements (61)	
Actual situation (38)	Cardboard looks cheap and messy; thick, not slick. (PI, R13)
Probability (12)	Could be hard to arrange recycling as it involves different materials. (PK, R10)
Query (11)	If you buy one jar, what about the remaining package that rests on the shelf? (PM, R9)
Objective Statements (76)	
Aim (38)	Should be easy to categorise in the market shelves. (PM, R2)
Design suggestion (19)	The design may allow the user to store boxes easily at home. (PM, R5)
Directive (12)	Baby food has to be seen easily and directly. (PG, R2)
Constraint (7)	Corners of multipacks need to be protected. (PK, R7)
Affirmation Statements (59)	
Approval (38)	Breakfast, lunch and dinner together 3 jars is a good idea. (PJ, R6)
Consequence (14)	Will lessen trash. (PE, R6).
Repetition (verbal 5)	Labels are important. (PG, R2, referring to PB's think aloud statement)
Repetition (visual 2)	*2 drawings of a mineral water bottle handle for 6 (plastic piece).* (PM and PK in R3, referring to PC's think aloud statement)
Criticism Statements (74)	
Disapproval (31)	Selling with a box is not an efficient idea for those who need only one. (PG, R1)
Concern (30)	Will depositing be cheaper than using new jars for the producers? (PD, R7)
Suggestion (13)	How people store at home should be explored. (PA, R5)
Concept Statements (74)	
Ideational (36)	Multipacks containing many jars may be offered for customers to buy whole pack. (PE, R1)
Directional (verbal 31)	Categorisation according to a) brand; b) kind of ingredient and c) size. (PM, R2)
Directional (visual 7)	*Drawing of a board game with pieces.* (PA, R11)
Solution Statements (72)	
Partial (verbal 30)	Turn the frontside of the package so that the content inside will be visible. (PL, R4)
Partial (visual 15)	*Drawing of a foldable handle that also allows stacking on top of each other.* (PA, R9)
Whole (verbal 5)	Package should turn into a table to take regular notes and might be collectable. (PA, R6)
Whole (visual 22)	*Drawing of an inclined box with sliding jars.* (PM, R12)

Table 5. *Judgment over input and output statement numbers according to rounds.*

	Input	Judgment	Output	Judgment / (Input + Output)
R1	28	9	5	0,27
R2	24	10	7	0,32
R3	17	12	3	0,60
R4	18	11	10	0,39
R5	15	8	9	0,33
R6	13	11	13	0,42
R7	14	7	8	0,32
R8	11	15	11	0,68
R9	22	8	7	0,27
R10	12	6	8	0,30
R11	12	17	20	0,53
R12	11	12	23	0,35
R13	9	7	22	0,22
	206	*133*	*146*	

modifying empty packaging for different uses such as decorations and timetables; and turning waste CC into toys such as houses and board games.

4.3. Statement types

Seven main statement categories with 21 subcategories were identified for the 485 statements as *information, affirmation, criticism, problem, objective, concept*, and *solution* (Table 4). *Information* statements were those providing information on various aspects of the problem area. *Affirmation* statements were those indicating agreement on the input provided during discussions. *Criticism* statements were those bringing critical arguments to input requiring evaluation. *Problem* statements were those identifying a problematic issue in an input. *Objective* statements were those suggesting a design direction to follow. *Concept* statements were those offering an idea to pursue for the design solution. *Solution* statements were those describing a tangible design solution.

From these statements, those indicating *information, problem* and *objective* were taken as input (what participants provided as discussion content), those indicating *affirmation* and *criticism* were taken as *judgment* (what participants thought about discussion content), and those referring to a *concept* or *solution* were taken as output (what the participants generated as design ideas). How these statement categories distribute into the session was determined in order to display the change in the ratio of *input, judgment* and *output* statements according to rounds (Table 5; Figure 3).

It was seen that the number of input statements was high in the first rounds and gradually dropped as the session progressed. On the other hand, the number of output statements was low in the first rounds, and increased as the session progressed. This indicates that to be able to generate ideas, the participants first provided input for the discussions. As the session progressed, context related input accumulated; therefore, participants were able to use a lesser number of input statements and instead generate a higher number of output statements.

Judgment statements, on the other hand, were used at a regular level throughout the session. The highest number of *judgment over input and output statements* was obtained in Round 8 (r=0,68) indicating that evaluation dominated the discussions. In the following Round 9, the number of input statements increased, indicating an effort for reframing discussions. The lowest ratio of *judgment over input and output statements* was obtained in

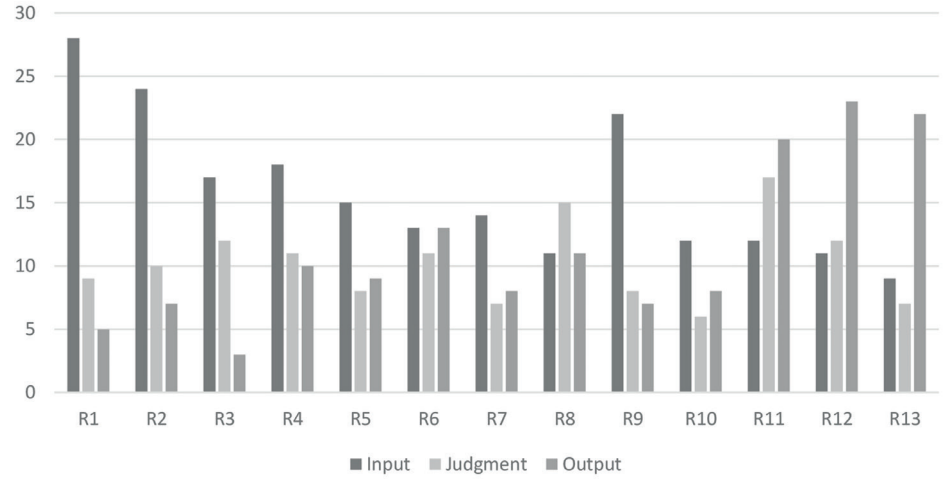

Figure 3. *Distribution of input, judgment and output statements according to rounds.*

the final Round 13 (r=0,22) indicating minimum level of evaluation. The highest numbers of output statements were generated in the final three rounds. Frame establishment, saturation of discussions, and anticipation of the end of the session may have played role in reaching a peak in idea generation.

4.4. Problem frames

Following, a timeline was prepared for displaying the interrelation between input and output statements offered by the speaking participants in the sequence of rounds (Figure 4) in order to identify the paths through which the problem frames developed. The timeline was cross-checked with the discussion topics produced for each round.

It was seen that the group adopted the two separate themes offered in the first two rounds of discussion and built on them as parallel frames. The pattern that appeared indicated that speaking participants began with providing input to the discussions, followed by output (10 out of 13 rounds). Based on content accumulation in the first three rounds, the speaking participant in Round 4 generated solutions only, for the two frames. In Round 5 that followed, the speaking participant built on the content by providing input only. Starting from Round 5, five out of nine rounds contained input for both frames. In Round 8, input for another frame was offered, together with output responding to it. This attempt did not find support and the frame was discontinued once that round ended. The discussion pattern of *input first, output next* continued in the remaining rounds.

The analysis contributed to the tracing of the patterns of topic, category and subcategory interdependence, revealing the following two problem frames. Frame 1) Re-usable Combo-multipacks: The consumer, who has limited time for shopping, identifies the preferred brand on shelf, locates the types of food from among the stacked packs, buys a ready combo-multipack or prepares one at the supermarket and uses the packaging for the storage of jars at home. The packaging is returned to the market for a deposit, or can be reused as a personal baby food jar carrier. The prioritised objective of this frame was *marketability.*

Frame 2) Minimum Production Waste with Post-use Possibilities: The packaging is manufactured with minimum production waste, transported to the market, stored on top of each other, placed on the shelves in special arrangements, removed using a handle, carried home and stored. The packaging has post-use possibilities in the home, and all materials involved are recyclable. The prioritised objective of this frame was *sustainability.*

Frame 1 found most coverage. In four rounds (6, 7, 9, 11), the generated output was a mixture of solutions that addressed both frames. In Rounds 6, 7 and 11, input was related to Frame 1, but output combined ideas generated for both frameworks, with links to past ideas offered for Frame 2. In three other rounds (10, 12, 13), output addressed both frames separately. As this was towards the end of the session, it can be said that the established problem frames had matured, making it easier for participants to generate distinct solutions for each.

5. Discussion: Design reasoning strategies for effectiveness

The findings provided insights into the design reasoning strategies employed by the participants of the brainstorming session for content

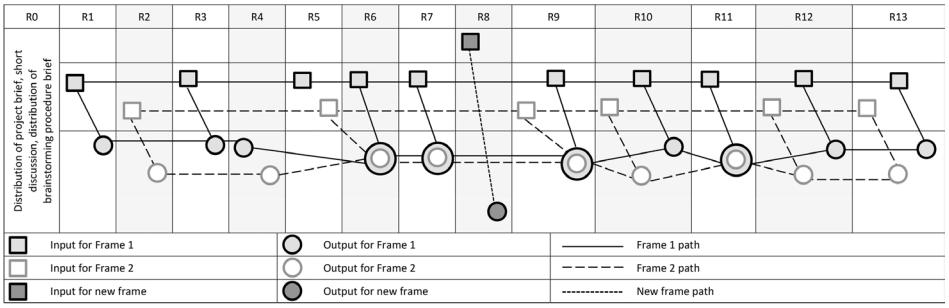

Figure 4. *Interrelation between input and output statements in sequence.*

creation, problem exploration and idea generation, with reference to the productivity indicators of divergence, convergence, quantity, situatedness and goal-orientedness.

5.1. Content creation

Content creation was the efforts of participants in making relevant contribution to the discussions by providing problem-related input and being actively involved in the discussions. This effort was facilitated with the systematic procedure followed for brainstorming, expecting the contribution of all, and allowing both nominal and interactive brainstorming. The following strategies were identified for content creation.

5.1.1. Relevant contribution

Offering input to the discussions first, for the output to follow (situatedness): Participants set the grounds for ideas first; they supplied discussion content with information related to the problem context that could provide justifications for design ideas that followed, and also principles for assessing them.

Providing individual interpretations based on diverse information sources (goal-orientedness): Participants made effort in diversifying the input they provided in each round, talking of different aspects of the design problem. These included descriptions, opinions, criticisms, suggestions and enquiries related to the problem area, in the form of personal experiences, observations, accounts of knowledge on topic, and scenario building.

5.1.2. Active participation

Reinterpreting the problem from individual perspectives (divergence): Each new round was an opportunity for the speaking participant to reinterpret the brief from own point of view and display own understanding of the problem in relation to the discussions made so far, setting context for the discussions of that round.

Adopting a role for the type of contribution made to the discussions (situatedness): Participants adopted roles (Cross, 2011; Brereton et al., 1996) as they offered input in each round, for the sake of the discussions. For example, while Participant A who volunteered to begin the session in Round 1, contributed with her experience as an ex-supermarket employee, Participant B in Round 2 contributed with her observations of her sister who at the time had a young baby. Based on the direction of the discussions, Participant G in Round 7 felt the need to remind the group of production constraints for cardboard packaging. Participant H in Round 8 offered provocative ideas that she knew would stir up the discussions.

5.2. Problem exploration

Problem exploration was the efforts that participants made in problem framing and problem naming, for ensuring that the discussions provided a complete picture of the context and situated the lines of thought, and the participants collectively identified problem frames and agreed early upon a main concept, thus setting grounds for relevant idea generation. The following strategies were identified for problem exploration.

5.2.1. Problem framing

Defining sub-problems to frame the problem comprehensively (divergence): Participants made effort in stepping out of the initial problem frame (supermarket) and varying the problem frames. For this, the problem area was broken down into sub-problems that included environments, props, people and functions, and that defined stages of usage (i.e. manufacturing packs, storing and transferring packs, opening and setting-up packs, arranging shelves, locating preferred products, reaching jars, preparing packs for purchase, transferring from supermarket to homes, storing, and managing waste). Re-framing the problem through these sub-problems in new rounds allowed covering a comprehensive product usage and life-cycle process, and diversifying content input.

Revising discussions from earlier rounds (convergence): Every few rounds, participants made a review of the discussions, acknowledging progress in reference to ideas generated so far. This was done to check the direction of discussions and keep in track with the brief; and also, to review the ideas and pick those that could be

built on. This ensured continuity of the lines of thoughts and building of the frames.

5.2.2. Problem naming

Using complementary problem frames for exploring the problem area (divergence): The session revealed two problem frames representing parallel lines of thought (Lawson & Dorst, 2009; Lawson, 2000). Frame 1 (packaging solutions for marketability) was more addressed within the session, as this was the main problem area defined for the brief. Frame 2 (packaging solutions for sustainability) was treated as complementary, and incorporated aspects of the problem area that seemed to require attention for a number of participants, but could not somehow integrate into Frame 1, therefore running in parallel instead of being discarded.

Collectively naming project objectives for a common understanding (goal-orientedness): The design brief did not indicate any project objectives. It was seen that participants required the guidance of such higher principles (Cross, 2011) in order to help name the problems to be explored. The participants collectively determined the project objectives successively (naming "marketability" half-way through, and "sustainability" towards the end), while building the problem frames in parallel from the start.

5.3. Idea generation

Idea generation was the effort that participants made in expanding the solution space by offering numerous and diversified ideas for design solutions that matched the problem frames. For this, participants strived for situating the design ideas within the two problem frames, and diversified the design ideas by decomposing and revaluating them as discussions progressed. Performance in idea generation made the productivity of the session more evident in terms of quantity. The following strategies were identified for idea generation.

5.3.1. Situating design ideas

Aiming for solutions while exploring the problem (goal-orientedness): Participants were solution-oriented (Kruger and Cross 2006). They offered design ideas from the first round, based on problems that the speaking participant described, which in turn provided discussion material and helped participants in exploring the problem while generating solutions for it (problem-solution co-evolution).

Agreeing early on the main concept for a common goal (convergence): An evident strategy for idea generation was the early establishment of the main concept of "combo-multipacks" in Round 2. Participants readily adopted this concept because they had already started idea generation in Round 1 ("multipacks for many jars"), and the speaking participant in Round 2 had picked up on the ideas from a different aspect ("combination of jars with different ingredients") adding further value. The willingness of participants in adopting this concept allowed them to frame the problem from their perspectives and offer variations of this concept as ideas to elaborate on.

Interrelating concept and context for idea generation (situatedness): Discussions were an interrelation of both context (e.g. environment, user, situation) and concept (e.g. multipack) in each round, which also made evident the exploration of the problem area together with the design solution. Participants supported idea generation for the design concept with descriptions of the context, which helped situate the ideas, justify the reasons for offering them, evaluate them for alternative suggestions and improve them.

Using judgment to keep on track (convergence): Participants used judgment in both problem exploration and idea generation. Judgment included affirmation (positive evaluation) as well as criticism. Individual documentation of the discussions allowed to be critical for later on rather than immediately speaking criticism out loud, and instead, constructively process the discussions. Therefore, during the interactive discussions that followed individual documentation, the group collectively built on ideas in reference to past discussions, and from time to time used mild criticisms for dead-ends (e.g. design ideas for shelves), to keep on track with the design brief. The main project objectives (i.e. market-

ability; sustainability) were the leading points of reference in judgment, among others (e.g. manufacturability, stackability, safety, accessibility).

5.3.2. Diversifying design ideas

Decomposing the concept for generating alternative design solutions (divergence; quantity): The main concept was decomposed into components (e.g. box, cover, flap, base, handle, inner separators) for exploration, leading to the generation of many ideas for packaging features. These partial ideas formed a pool from which to improve, transfer or combine into alternative design solutions during discussions.

Running parallel lines of thought for extending the solution space (convergence; quantity): Participants used the two problem frames simultaneously to follow through the development of diverse design ideas, complementarily and in reference to one another. This is known in design theory as using parallel lines of thought (Lawson, 2000; Lawson & Dorst, 2009).

Reinterpreting out-of-the-frame ideas into frame-relevant ideas (situatedness; quantity): Participants showed determination in keeping within the problem frames. They refused to pursue an alternative track suggested more than half way through the session in Round 8 (i.e. elimination of packaging altogether; changing jar material and cap shape), but instead of eliminating the ideas offered in that round, they processed them into usable outcomes (e.g. detachable silicone jar caps transformed into detachable CC packaging for groups of jars). The frames ensured continuity of ideas with links to the past.

6. Conclusion: Design reasoning process in the session

This paper attempted to address a gap in the literature in explaining design reasoning in creative group discussions, by establishing a theoretical framework for interpreting the findings of analyses carried out on the documentation of a nominal and interactive brainstorming session. The aim of the analyses was to identify the strategies that contributed to the effectiveness of the brainstorming session. The framework set the grounds for interpreting the discussion content in identifying the design reasoning strategies used by the session participants, and explaining the collective design reasoning process that took place.

The Controlled Input Method as the brainstorming technique used, required the structured participation of all participants, allowed them to think aloud on the topic for which design solutions were sought, carry out nominal brainstorming as well as interactive brainstorming systematically, and use their judgment privately to process the discussions, supported with visual thinking, after which they could offer them interactively. This process has provided a rich documentation for the discussions, as they were filtered, processed and built on. A total of 15 design reasoning strategies were identified, used by the session participants for content creation, problem exploration and idea generation. The design reasoning strategies helped to initiate and steer discussions, actualize context-relevant idea generation, ensure continuity within problem frames, and constructively evaluate ideas, acting as factors for the effectiveness of the brainstorming session.

The collective design reasoning process of the brainstorming session described in this paper can be explained as follows. As expected from the brainstorming technique used, speaking participants began their rounds by contributing their partial knowledge and experience on the topic, and understanding of the design brief. These individual interpretations acted as the various individual frames through which participants collectively extended the problem area. The participants showed tendency in first providing contextual input, then offering conceptual outputs, and this continued throughout the rounds. Adopting a solution-oriented approach, participants established and agreed upon the main concept early in the session, displaying convergent thinking. The concept was broken down into its components during discussions, in order to generate partial design solutions, displaying divergent thinking. While doing so, participants explored the solutions based on context descriptions and usage situations, which contributed to the construction of two alternative problem frames describing

life-cycles and usage processes for the final solutions. This in turn led to the identification of prioritized objectives forming grounds for the collective judgment of ideas carried out regularly, and keeping discussions on track. The process resulted in the generation of design ideas that concentrated on three major solution areas responding to these problem frames in the light of the prioritized objectives, thus making this an effective brainstorming session.

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