

Master Thesis
Software Engineering
Thesis no: MSC-2013-07
May 2013



**Universität
Zürich** UZH



Comparison of Interactive Group and Bilateral Communication for Idea Synthesis for Software Product Innovation

Neda Eshraghi

School of Computing
Blekinge Institute of Technology
SE-371 79 Karlskrona
Sweden

This thesis is submitted to the School of Engineering at Blekinge Institute of Technology in partial fulfillment of the requirements for the degree of Master of Science in Software Engineering. The thesis is equivalent to 2 x 20 weeks of full time studies.

Contact Information:

Author:

Neda Eshraghi

E-mail: neda.eshraghi@gmail.com

External advisor(s):

Dr. Norbert Seyff

University of Zurich

Department of Informatics, University of Zurich, Binzmuehlestrasse 14, 8050, Zurich, Switzerland

Phone: +41 (44) 635 6757

University advisor(s):

Dr. Samuel A. Fricker

School of Computing, Blekinge Institute of Technology

School of Computing
Blekinge Institute of Technology
SE-371 79 Karlskrona
Sweden

Internet : www.bth.se/com
Phone : +46 455 38 50 00
Fax : +46 455 38 50 57

ABSTRACT

Context: Organizations generate a number of solutions or ideas for a problem, by then select and synthesize some of these ideas for further development. Idea synthesis as an important phase of innovation process causes a reduction of enormous ideas to be considered by an interested company. Accordingly, innovation process can benefit from integration of ideas with restricted perspectives. Idea synthesis is effective when the defined product is novel, has high impact, is of low cost, and has good support from stakeholders. Idea synthesis is facilitated by the used of variety of structures. Interactive groups which require physical meeting of the participants are a facilitated forum for idea synthesis, where organizations try to utilize the multiple perspectives of groups. An alternative to this approach is bilateral communication between potential innovators. Bilateral communication is used by innovators that network with each other to identify related ideas and technologies in the context of open innovation. Software not only enables interactive groups and bilateral communication but also amplifies the performance of these structures by replacing them with online workshops or social networking. While both these structures are performed and justified through the use of software, it is not clear which of these structures is more effective.

Objectives: The aim behind conducting this research is to compare the effectiveness of interactive groups and bilateral communication for idea synthesis. Additionally, besides the factors that affect achieving an agreement among the group members in both structures, a consistent pattern of idea synthesizing can be identified through the observation of participants' behaviors,.

Methods: In this study two research methodologies were used; a controlled experiment and a multiple-case study. First, an experiment was conducted to compare the effectiveness of idea synthesis of interactive group and bilateral communication channel for software product innovation. A total of 78 software engineering students generated software based solutions for a problem individually and subsequently combined their ideas to improve their initial solutions, either through the interactive groups or bilateral communication. Second, a multiple-case study using the collected data from the participants' chat and questionnaires was conducted to identify the consistent pattern of idea synthesizing and the factors that affect achieving an agreement among the group members in both structures.

Results: Statistical analyses of experimental results show no difference between interactive group and bilateral communication channels significantly for idea synthesis. It was found that the groups in bilateral communication channels could not generate more effective ideas than interactive groups in terms of novelty, feasibility, impact value, and stakeholder support through the ideas synthesizing. The identified factors which influence agreement among the group members, both challenges and determinants, in interactive groups and bilateral communication channels are categorized separately. Barriers in achieving an agreement between participants are included in context of ideas and participants' interests in bilateral communication, while the barriers in interactive groups are features of ideas and participants' features. Moreover, an agreement between participants is yielded in context of ideas and participants' features in bilateral communication, while the agreement in interactive groups is yielded in context of ideas and participants' interests.

Conclusions: We conclude that there is no difference between interactive groups and bilateral communication for idea synthesis. The solutions achieved through both structures are not significantly different in terms of novelty, feasibility, impact value and stakeholder support. Moreover, achievement of an agreement in both structures not only depends on the context and features of ideas but also features of participants. On the one hand, the presence of ideas with consistent context and features besides motivated participants, interested in performing the idea synthesizing, lead to achieving an agreement. On the other hand, ideas with inconsistent context and features, lack of participants' interest in sharing and synthesizing idea, lack of communicating, and lack of time managing hinder achieving to an agreement.

Keywords: Innovation, idea generation, idea synthesis, interactive group, bilateral communication.

Acknowledgments

I would like to specially thank my local supervisor at Blekinge Institute of Technology Dr. Samuel Fricker who motivated me and supported me throughout this thesis project. His encouragement and support made me able to complete this thesis. I would like to thank Dr. Norbert Seyff who gave me the opportunity to be involved in the requirement engineering group at the University of Zurich. I am grateful for his valuable tips on conducting my research. I would also like to thank Dr. Tony Gorschek for his support during the initial stages of the thesis. The undeniable support of staff members from both University of Zurich and Blekinge Institute of Engineering is commended. I am thankful to my parents and my husband for their encouragement to continue my efforts.

Contents

ABSTRACT	II
LIST OF TABLES.....	VI
LIST OF FIGURES.....	VII
1 INTRODUCTION	8
2 BACKGROUND & MOTIVATION.....	10
2.1 AIMS AND OBJECTIVES	12
2.2 RESEARCH QUESTIONS	13
2.3 EXPECTED OUTCOMES.....	13
3 RESEARCH METHODOLOGY	14
3.1 RESEARCH DESIGN	14
3.1.1 <i>Literature review</i>	15
3.1.2 <i>Controlled experiment</i>	15
3.1.3 <i>Multiple-case study</i>	16
3.2 DATA ANALYSIS METHODS	16
3.2.1 <i>Quantitative data analysis</i>	16
3.2.2 <i>Qualitative data analysis</i>	17
4 LITERATURE REVIEW	18
4.1 TRADITIONAL LITERATURE REVIEW	18
4.2 SNOWBALLING.....	19
5 CONTROLLED EXPERIMENT	20
5.1 DEFINITION	20
5.2 EXPERIMENT PLANNING	20
5.2.1 <i>Context selection</i>	20
5.2.2 <i>Dependent and independent variables selection</i>	20
5.2.3 <i>Experiment topic</i>	20
5.2.4 <i>Hypothesis formulation</i>	21
5.2.5 <i>Selection of subjects</i>	22
5.2.6 <i>Experiment design</i>	22
5.2.7 <i>Standard design types</i>	22
5.2.8 <i>Instrumentation</i>	22
5.3 EXPERIMENT OPERATIONS.....	22
5.3.1 <i>Subjects</i>	22
5.3.2 <i>Preparation</i>	23
5.3.3 <i>Execution</i>	23
5.3.4 <i>Data validation</i>	23
5.4 RESULTS & ANALYSIS	24
5.4.1 <i>Quantitative Data Extraction</i>	24
5.4.2 <i>Quantitative Results & Analysis</i>	24
5.4.3 <i>Power estimation</i>	33
5.4.4 <i>Subjects' features</i>	34
5.5 VALIDITY THREATS	37
5.5.1 <i>Internal validity</i>	37
5.5.2 <i>External validity</i>	37
5.5.3 <i>Construct validity</i>	38
5.5.4 <i>Conclusion validity</i>	38
6 MULTIPLE-CASE STUDY.....	39
6.1 CASES SELECTION AND UNIT OF ANALYSIS.....	39
6.2 MULTIPLE-CASE STUDY PROTOCOL	39
6.2.1 <i>Data collection</i>	39
6.3 RESULTS & ANALYSIS	39
6.3.1 <i>Qualitative Results and Analysis</i>	39

6.3.2	<i>Idea synthesizing process</i>	40
6.3.3	<i>Consensus challenges and determinants</i>	44
6.3.4	<i>Subjects' satisfaction</i>	53
6.4	MULTIPLE-CASE STUDY VALIDITY THREATS	54
6.4.1	<i>Construct validity</i>	54
6.4.2	<i>Internal Validity</i>	55
6.4.3	<i>External Validity</i>	55
6.4.4	<i>Reliability</i>	55
7	DISCUSSION	56
8	CONCLUSION & FUTURE WORK	58
9	REFERENCES	60
	APPENDICES	64
	APPENDIX A- IDEA SYNTHESIS HOME ASSIGNMENT SLIDES	64
	APPENDIX B-EXPERIMENTER INSTRUCTION	67
	APPENDIX C- IDEA SYNTHESIS GENERAL INSTRUCTION	76
	APPENDIX D- PROJECT PROCEDURE.....	77
	APPENDIX E-GROUP IDEA SYNTHESIS INSTRUCTION	78
	APPENDIX F-BILATERAL IDEA SYNTHESIS INSTRUCTION.....	80
	APPENDIX G- INDIVIDUAL INNOVATION PROPOSAL.....	82
	APPENDIX H- INNOVATION PROPOSAL (SYNTHESIS)	84
	APPENDIX I-PRE-QUESTIONNAIRE	86
	APPENDIX J-POST-QUESTIONNAIRE	87

LIST OF TABLES

Table 1, Summary of related works	12
Table 2, Inclusion criteria	18
Table 3, Number of participants in each treatment	22
Table 4, Cluster Scoring	24
Table 5, Quantitative data (Descriptive statistics of experiment)	24
Table 6, Normality test for novelty	25
Table 7, Mean rank for idea synthesis novelty.....	27
Table 8, Mann-Whitney U test for novelty of idea synthesis.....	27
Table 9, Normality test for feasibility	27
Table 10, Mean rank for idea synthesis feasibility.....	29
Table 11, Mann-Whitney U test for feasibility of idea synthesis.....	29
Table 12, Normality test for Impact value	30
Table 13, Mean rank for idea synthesis Impact value.....	31
Table 14, Mann-Whitney U test for impact value of idea synthesis	31
Table 15, Normality test for Stakeholder support.....	32
Table 16, Mean rank for idea synthesis stakeholder support	33
Table 17, Mann-Whitney U test for stakeholder support of idea synthesis	33
Table 18, Statistical power analysis.....	34
Table 19, Subjects background knowledge about the experiment topic	34
Table 20, Descriptive statistics for subjects' background Knowledge.....	34
Table 21, Subjects' willingness to share their ideas.....	35
Table 22, Descriptive statistics for subjects' willingness to share their ideas.....	35
Table 23, Subjects' willingness to participate in the experiment.....	35
Table 24, Descriptive statistics for subjects' willingness to participate in the experiment	35
Table 25, Subjects' motivation to synthesize the idea	36
Table 26, Descriptive statistics for subjects' motivation to synthesize the idea	36
Table 27, Subjects' negotiation background knowledge	36
Table 28, Descriptive statistics for subjects' negotiation knowledge	36
Table 29, Subjects' relationship	36
Table 30, Descriptive statistics for subjects' relationship.....	37
Table 31, Consensus challenges of the bilateral communication structure.....	45
Table 32, Consensus challenges of the interactive group structure.....	48
Table 33, Consensus determinants in the bilateral communication structure	50
Table 34, Consensus determinants in the interactive group structures.....	52
Table 35, Subjects' satisfaction with the idea synthesis process.....	54
Table 36, Descriptive statistics for subjects' satisfaction with the idea synthesis process.....	54

LIST OF FIGURES

Figure 1 Research methodology	15
Figure 2 , Novelty of idea synthesis.....	26
Figure 3 , Feasibility of idea synthesis.....	28
Figure 4 , Impact value of idea synthesis.....	30
Figure 5 , Stakeholder support of idea synthesis	32
Figure 6 , Idea synthesis process in concurrent bilateral channels.....	41
Figure 7 , Idea synthesis process in sequential bilateral channels	42
Figure 8 , Idea synthesis process in interactive groups.....	44
Figure 9 , Percentage of subjects' satisfaction with the idea synthesis process	54

1 INTRODUCTION

The companies today encounter the environment which makes them to innovate not only to survive [1, 2, 3] but also to grow and to lead the market [3]. According to the Boston Consulting Group report (BCG), 72% of organizations surveyed by BCG had considered innovation as a top priority in 2010 [BCG]. Traditional approaches such as financial and physical assets [4] as well as product and service quality as the basic core expected by customers from different organizations do not constitute a competitive advantage any longer [5]. Instead innovation is a different approach for competing in new era of businesses [6].

The necessity of innovation is especially true for software companies which are the source of huge changes in different traditionally hardware- focused systems [2, 7, 8, 9]. In the era we are living in, the information technology is meshed with organizations' designs, processes and external relationships [10]. The characteristics such as flexibility, ease of distribution and adaptability make software an important facilitator of innovation [11]. It has created a revolution in different companies without considerable production cost [2, 11]. The globalization [12,13, 14, 3], shrinking product life cycle [15, 13, 3, 16], empowered customers [17], high knowledge intensity [13] and new technologies [12, 14, 15, 18] affected the companies producing software systems before other industries [13] and make them to be more creative to survive [3], effectively master, improve the existing products [19] and compete [3]. Without innovation, company's competitive advantages will drop to diminish [2] and company eventually will fail [4, 20]. Thus different companies can survive as long as the software company succeeds to innovate and attract new customers [11]. In order to link business and software engineering, the software product manager needs to lead the production of new ideas toward innovation [11].

Innovation refers to discovering opportunities which lead to profitable changes and transferring them to practice [21]. Though, a company requires creativity and new ideas, but having new ideas would not be enough unless converted to action [7, 22]. Product innovation includes the discovery of possibilities, the choice of idea combinations, and the acting to deliver the selected product to the market. In this process, discovering possibilities includes activities associated with traditional research activities and processes like benchmarking. The output of this phase is innovative ideas that must be combined. The second phase deals with identifying the combinations of ideas that are most potential to deliver value to the company and its stakeholders and also aligned with the company's strategy. Final phase in innovation process involves actual creation of value from the innovation which requires access to the resources and the introduction of changes [7].

Idea synthesis plays an essential role in the innovation process [23] by selecting and combining ideas to improve idea quality [24] and stakeholder support [25]. Now a day idea generation is no longer innovators and researchers' concern [23] because ideas can be acquired from customers, market and other stakeholders and resources [23]. Consequently, on the one hand the numbers of incoming innovative ideas can be enormous and it is neither feasible nor desirable to develop all ideas [23]. Therefore it is needed to select the most efficient ideas [23, 26]. On the other hand, some generated ideas are similar to each other and some are complementary. In fact, an individual idea is representative of restricted perspectives and by this way the integration of multiple perspectives is essential to respond to other concerned stakeholders [25, 27]. Innovation requires considering and merging diverse knowledge and personal skill perspectives [28, 29].

Idea synthesizing refers to the act in which two ideas (or more) or their elements are combined in order to achieve a product which may contain emergent properties [9]. In synthesizing ideas, group members have to attend to the shared ideas from their group members, connect their knowledge for relevant domains, and finally generate new ideas or improve their ideas based on previously generated ideas. Shared ideas can stimulate the generation of ideas from different domains or generation of other potential ideas relevant to the current domain [9, 30, 31]. In other word, idea synthesis provides opportunity to achieve a more effective idea than the initial generated ideas through connecting or combining different shared ideas [9].

Software enables new approaches to the complex tasks such as idea synthesis and innovation [8, 9, 27, 25]. Idea synthesis requires members to share their ideas, attend to the shared ideas, search for links among the shared ideas and finally create an idea based on the initial shared ideas [9]. All of these

steps make this the idea synthesis a complex task. However this task is facilitated by the use of a variety of group working structures, prior research has shown that the use of software in complex tasks such as idea generation and idea synthesis leads to more creative results [9, 32]. One of the basic ways of using software in group creativity is that each member shares and discusses his or her idea to the other group members through a shared screen [65, 66]. This process makes them able to access the other potential ideas for combination or even generation of new ideas [66].

Interactive group that requires physical meeting of the participants can be replaced by online workshops or social networking. Interactive group is a forum for idea synthesis [9], where organizations try to utilize the multiple perspectives of groups [25]. Interactive group allows for open and shared communication. The involved innovators inspire each other and contribute to idea synthesis [9, 30]. An alternative to this approach is bilateral communication between potential innovators [34, 35]. Bilateral communication is used by innovators that network with each other to identify related ideas and technologies in the context of open innovation [34]. Bilateral communication allows independent communication threads to emerge [36]. This parallelism may lead to radical product concepts [37]. It also may increase the feeling of having joined an idea which leads to greater support from those who were involved in that thread. Innovation through individuals (whose generated ideas are pooled which called nominal group) and interactive group is compared in prior researches [33, 38, 39, 40].

However, according to our knowledge research has not yet compared the interactive group and bilateral communication approaches. It is not clear which one will lead to synthesized ideas which are more novel, has high-impact, is of low cost, and has good support from stakeholders. Despite the important role of idea synthesis in the innovation process, so little researches have explored it experimentally, especially there is no study from the software perspective.

The purpose of this thesis is first to examine through which structures, interactive group or bilateral communication; participants are able to create effective synthesized ideas. Second it is attempted to identify the consistent pattern of idea synthesizing and the factors that affect achieving an agreement among the group members in both structures. Agreement for an idea increases the chance of that idea to be used in the idea synthesis. Achieving to an agreement is influenced by different factors which can be divided into two groups; consensus challenges which hinder agreement and consensus determinants which lead to achieving an agreement. Hence at the first step, this thesis reports a laboratory experiment which compares the interactive group and the bilateral communication structures with regard to idea synthesizing. Idea synthesis is successful when the defined product is novel, has high-impact, is of low cost, and has good support from stakeholders [23]. Then the participants' chats and questionnaires are studies qualitatively to identify the consistent pattern of idea synthesizing and the factors that affect achieving an agreement among the group members in both structures.

This study lets us make the following contribution:

1. A description of the effectiveness of two group structures, interactive group and bilateral communication, in synthesizing the ideas in software domain.
2. Definition of certain criteria for evaluation of idea quality instead of relying on the number of generated ideas and average quality of ideas.
3. Identification of factors that affect achieving an agreement in interactive group and bilateral communication

The remainder of this paper is organized as follows. We reviewed the relevant literatures in the second section. Our research method is presented in the third section. In the fourth, fifth and sixth section the literature review, the experiment and the multiple-case study are described respectively. The seventh section discusses about the results of the study. The last section reports the conclusion and answers the research questions.

2 BACKGROUND & MOTIVATION

Innovation depends on people's individual and collective knowledge [28]. Knowledge is defined as "relevant and actionable information which is based on partially experience" [28]. Our knowledge is distributed on a spectrum from tacit to explicit knowledge. The tacit knowledge is the unconscious or semiconscious knowledge, and the explicit knowledge is structured and codified knowledge of people [28]. The knowledge extension happens when different pieces of explicit knowledge and tacit knowledge are combined [15, 41]. In addressing a problem, individuals draw solutions upon their both tacit and explicit knowledge. The tacit dimension of individuals' knowledge makes each individual valuable [42, 43]. The individuals' tacit knowledge cannot be obtained unless through interaction [28].

Idea generation is only one stage of the innovation multistage process [43]. The innovation process is fulfilled when the ideas are discussed, promoted [43, 44, 45], and eventually a high quality idea is implemented [46]. In order to promote the ideas, they are needed to be exchanged and synthesized. Idea synthesis takes the pool and transforms it into a set of product concepts that are more concrete, less overlapping, and better understood than the initial ideas. That would allow better decision-making for innovation selection. The success of idea synthesis depends on the product quality with respect to its novelty, feasibility, impact value and stakeholder support on the product. The availability of diverse knowledge can lead to production of successful synthesized ideas. Through the interpersonal interaction, people with different experiences, skills, cultures and perspective convey their tacit knowledge [21]. This variety of perspectives stimulates new idea creation which activates innovation [4, 28, 42, 49].

The innovation process and the organization's role in idea generation and idea promotion have been investigated in multiple disciplines such as management, economics and social psychology [42, 47]. The social science literature has examined the popular brainstorming technique for idea generation and taking advantage of different insights and intuitions in a group of individuals [42, 47]. The management and economic literatures have focused on organizational forms for innovation and idea generation and idea promotion [47]. The idea synthesis is facilitated by the use of a variety of group structures such as interactive group, nominal group (the individuals whose ideas are pulled), hybrid group and bilateral communication.

Nicholas W. Kohn et al. [9] explored the role of building on other's ideas experimentally. The purpose of the study was to examine to what extent previously generated ideas can be combined via individual and interactive group structures. It also investigated the effect of the type of the initial idea (whether the ideas are rare or common) on the generated combinations. The performance of individual and interactive group structures for idea combination compared through two experiments while participants were presented with different types of ideas. The study results indicate that interactive groups generate fewer combinations. But these combinations are more novel and feasible than those generated by the individuals. Although the study examined the idea combination, this process was investigated in individual and interactive group structures.

Karan Girotra et al. [47] compared the effectiveness of the interactive group structures and a hybrid structure in which individuals first generated ideas for a given task and then worked as a group. The study also investigated the effect of building on others' ideas on the number of generating ideas and the quality of ideas. Instead of using research assistants to evaluate the quality of ideas, the study used a purchase-intent survey (which captures if consumers intend to purchase the product of the idea) and the business value of the product of the idea. The results showed that the hybrid structure outperforms group structure. But building on others' ideas is not effective in terms of the number and quality of generated ideas. However the focus of the study was not the software and the performance of the bilateral communication approach was not investigated.

Singh and Fleming [48] used patent data to compare lone inventors (people without any affiliation to anybody or any organizations) with interactive group. They used the number of received citations by each patent as the quality measurement. They also explored the effect of members' diverse experiences and the size of external collaboration networks on enabling novel combinations, reducing poor outcomes and ultimately the collaboration profitability. They found that the interactive groups are able to achieve more breakthroughs compared to individuals. They also showed that diverse experience in the team and the size of external networks increase the effect of the group working on

achieving a breakthrough. Although the study mentioned the network's effect on the innovation but it was not explored experimentally.

Furthermore, several studies have demonstrated that interactive groups generate feasible ideas rather than novel ideas [33, 50]. This implies that group members tend to select more frequent ideas [50]. In contrast to interactive groups, individuals show bias toward more novel ideas due to lack of social distraction [50] and careful processing.

Bilateral communication is the interaction between pairs of inventors in order to exchange the knowledge and skills [51, 34]. The bilateral communication structure (network structure) enables exchanging knowledge which is not feasible in the market and hierarchical structures due to implicit boundary of the organizations, individuals, companies and so on [52]. Bilateral communication facilitates innovation through the combination of different knowledge and skills of the partners of the alliance [51, 34]. However, it is discussed that the success of innovation in bilateral communication depends on to what extent the knowledge of partners complete each other [51, 34]. In bilateral collaboration, individuals look for partners who hold not only similar respective knowledge [51] but also complementary assets [36]. It suggests that in bilateral collaboration, while individuals do not involve in social distraction, they try to provide the missing elements through potential partners.

The findings suggest both interactive group and bilateral communication are potential structures in achieving the effective idea synthesizes. Open innovation in which the networks of firms are constructed is evaluated as an effective way in using the external and internal ideas in order to advance the achievements and sharing the risks [68, 69]. Interactive groups are also compared with nominal groups for idea combination in previous studies [33, 70]. According to these studies, interactive group are more successful in achieving feasible ideas compared to nominal groups [33, 70]. However, idea synthesis through bilateral communication and interactive group has never been compared experimentally which raise many the question of "which one is more effective than the other one?"

A company is confronted with the choice for how to innovate. Ineffective idea synthesis harms the idea pool of a company. Maintaining too many bad ideas leads to a stalled innovation process [2]. Dismissing too many potentially good ideas reduces the value generated by its innovation [52]. In both cases, the company risks losing in the competitive game against their better competitors. Software as the facilitator of the innovation needs to provide solutions which are aligned with the business strategy and new technology [11]. Hence, the software product manager as a key person who determines what is needed to be innovated and how to innovate it [53] needs to know the appropriate structures for innovation. Furthermore, the first characteristic of on-line innovation intermediaries (platforms which allow connecting solution seeker with relevant inventors e.g. Ideaken and Atizo) that needs to be defined is the structure of interaction among the participants [54]. Platforms such as Atizo is based on brainstorming and collaboration of different participants while others such Ideaken or Innocentive are based on bilateral communication between individual inventors and solution seekers [54, 55]. In this study the effort was made to compare interactive group and bilateral communication structure in the area of software innovation.

Even though there are a few publications about the idea synthesis, there are several gaps. First of all, these publications explore idea synthesis which is the focus of this study in other domains than software industry. Furthermore, the performance of interactive group and bilateral communication approaches for idea synthesis has not yet examined experimentally. The prior studies have examined the idea synthesis only through individual and group brainstormers. The summary of these works can be found in Table 1.

Research	Setting/Metho dology	Document type	Database	Result
N. W. Kohn et al.[9]	Lab, experimental	Journal article	Science Direct	Groups generate fewer but more novel and feasible combinations that individuals.

K. Girotra et al.[47]	Lab, experimental	Journal article	Management Science	Hybrid structure outperforms group structure. Building on others' ideas is not effective in the number and quality of generated ideas.
J. Singh et al.[48]	Patent data, empirical	Journal article	Management Science	Individuals achieve fewer breakthroughs than the group. Diverse experience in the team and the size of external networks increase the effect of the group working on achieving a breakthrough

Table 1, Summary of related works

Conventional face-to-face team working suffers from several disadvantages. One of its disadvantages is “*Evaluation Apprehension*” which refers to the fear of being evaluated by other group members negatively that leads participants to not share their ideas [39]. Another problem is “*Free-riding*” where decrease the individuals’ productivities because they feel that their ideas are not valuable [39]. The use (usage) of computer technology demonstrated an improvement in creativity of individuals and groups. [9, 65, 66]. Through computer technology, individuals present their ideas to the other group members via a public screen. This approach addresses many problems in conventional face-to-face team working and brings advantages such as making individuals to be anonym or archiving ideas in their original forms. In this study, we use Skype, a free VoIP tool; that allows user to communicate over the internet through instant messaging, voice and video. It is popular software and all services related to Skype are free. These have made Skype a very useful tool for enabling collaboration in our information-based society where information is distributed among diverse users who may be dispersed geographically [67]. To guarantee the recording of original information sharing we rely only on Skype’s text chat which supports all the features common in different instant messages applications such as , online status sign or using an avatar, and so on.

2.1 Aims and Objectives

This thesis aims at comparing the effectiveness of interactive groups and bilateral communication for idea synthesis. To compare the effectiveness, bilateral communication channel and interactive group are compared in terms of idea synthesis novelty, feasibility, impact value and stakeholder support. To achieve this aim we pursue following objectives:

- O1. Comparing the effectiveness of interactive groups and bilateral communication for idea synthesis in terms of product concept novelty.
- O2. Comparing the effectiveness of interactive groups and bilateral communication for idea synthesis in terms of product concept feasibility.
- O3. Comparing the effectiveness of interactive groups and bilateral communication for idea synthesis in terms of product concept impact value.
- O4. Comparing the effectiveness of interactive groups and bilateral communication for idea synthesis in terms of product concept stakeholder support.
- O5. Identifying the consistent pattern of idea synthesis in interactive group and bilateral communication.
- O6. Identifying the factors that hinder the consensus among group members in interactive group and bilateral communication.
- O7. Identifying the factors that help achieving the consensus among group members in interactive group and bilateral communication.

Comparing these structures in terms of the novelty, feasibility, impact value and stakeholder support of synthesized ideas helps us to have an accurate measurement of the quality of the synthesized ideas. Furthermore, through identifying the process of idea synthesis and factors that affect achieving agreement among the group members in both structures we will able to understand the strengths and weaknesses of each structure.

2.2 Research Questions

In this thesis, we plan to answer following research questions.

RQ1. Is interactive group more effective than bilateral communication for idea synthesis?

Description: The goal is to compare the effectiveness of bilateral communication and the interactive group for idea synthesis. We will evaluate effectiveness in terms of novelty, impact, cost, and stakeholder support of the conceived product.

RQ2. How idea synthesis is performed in bilateral communication and interactive group?

Description: However there are instructions for bilateral communication and interactive group members to synthesize the ideas, it is important to understand the steps that participants take to perform the idea synthesis task. This will help us in identifying factors which lead to either achievement or failure of the consensus among the group members in both structures.

RQ3. What factors influence achieving an agreement among the group members in bilateral communication and interactive group during the experiment?

Description: Consensus between group members in both treatments increases the utilization of the ideas in the idea synthesis task. When participants are not successful to convince their group members about their ideas, and to achieve an agreement in consequence, the chance of these ideas to be used in idea synthesis is reduced. This may lead to lose potential ideas to be synthesized.

2.3 Expected Outcomes

The thesis is expected to deliver following outcomes.

- A comparison of the effectiveness of facilitated workshops and bilateral communication. The idea synthesis effectiveness is evaluated in terms of novelty, feasibility, impact value and stakeholder support. This will be useful for companies that need to select one of the two approaches to support their innovation process.
- Identification of the steps that participants take to synthesize ideas within the bilateral communication and interactive group.
- Identification of factors that influence achieving the consensus among the group members within bilateral communication and interactive group.
- Discussion and conclusion on idea synthesis through bilateral communication and interactive group based on experiment and questionnaire findings.

3 RESEARCH METHODOLOGY

3.1 Research Design

The research method which was used to achieve the aim and objectives of this research is described in this section. The selected research approaches are justified through identifying their strengths. The alternative approaches are also presented. In this study the mixed methods (both quantitative and qualitative) strategy is used to achieve its aim. Through the mixed methods the strengths of one method can compensate or attenuate the weaknesses of the other method [58]. Survey method can be used alternatively, but is dismissed because we were not interested in subjective practitioner experiences, but in objective comparison of the idea synthesis structures and in understating how people do synthesis. The study design is conducted based on the following steps:

In the first step, a literature review is conducted to find the current knowledge about the idea synthesis. The threat of publication bias [59] of systematic literature reviews led us to select the traditional literature review to summarize and appraise the literatures related to idea synthesis.

In the second step a controlled experiment is conducted to answer RQ1. The motivation to conduct the experiment is that there is no empirical study that compares the interactive group and bilateral communication structures for combining the generated ideas. An experiment [60] is conducted to compare two treatments for idea synthesis, the interactive group and the bilateral communication. It is chosen to use experimentation because it allows us to compare two approaches in a focused manner by eliminating any confounding factors. The experiment is accompanied with pre and post questionnaire to collect information about not only the participants' backgrounds but also their feedback about the experiment. Each idea synthesis is clustered and ranked by a rater. Based on the distribution of the data a statistical hypothesis test is used to analyze the experiment data quantitatively. The quantitative results are reported in [section 5.4](#).

In the final step, a multiple-case study is conducted to answer RQ2 and RQ3. Based on textual data obtained from subjects' conversation during the controlled experiment and questionnaires, the content analysis method is used to analyze the data. This method is used to analyze different kinds of communication messages such as written and verbal communication [61]. Content analysis is used to "to distil words into fewer contentrelated categories. It is assumed that when classified into the same categories, words, phrases and the like share the same meaning" [61]. However methods such as grounded theory (GT) or phenomenology are the alternative approached but they aim at developing theory and understanding the experience in detail. But content analysis describes "specific context within which a distinct type of data can be gathered and analyzed" [62]. The qualitative results are reported in [section 6.3](#).

Overview of research methodology can be seen in the Fig. 2 below:

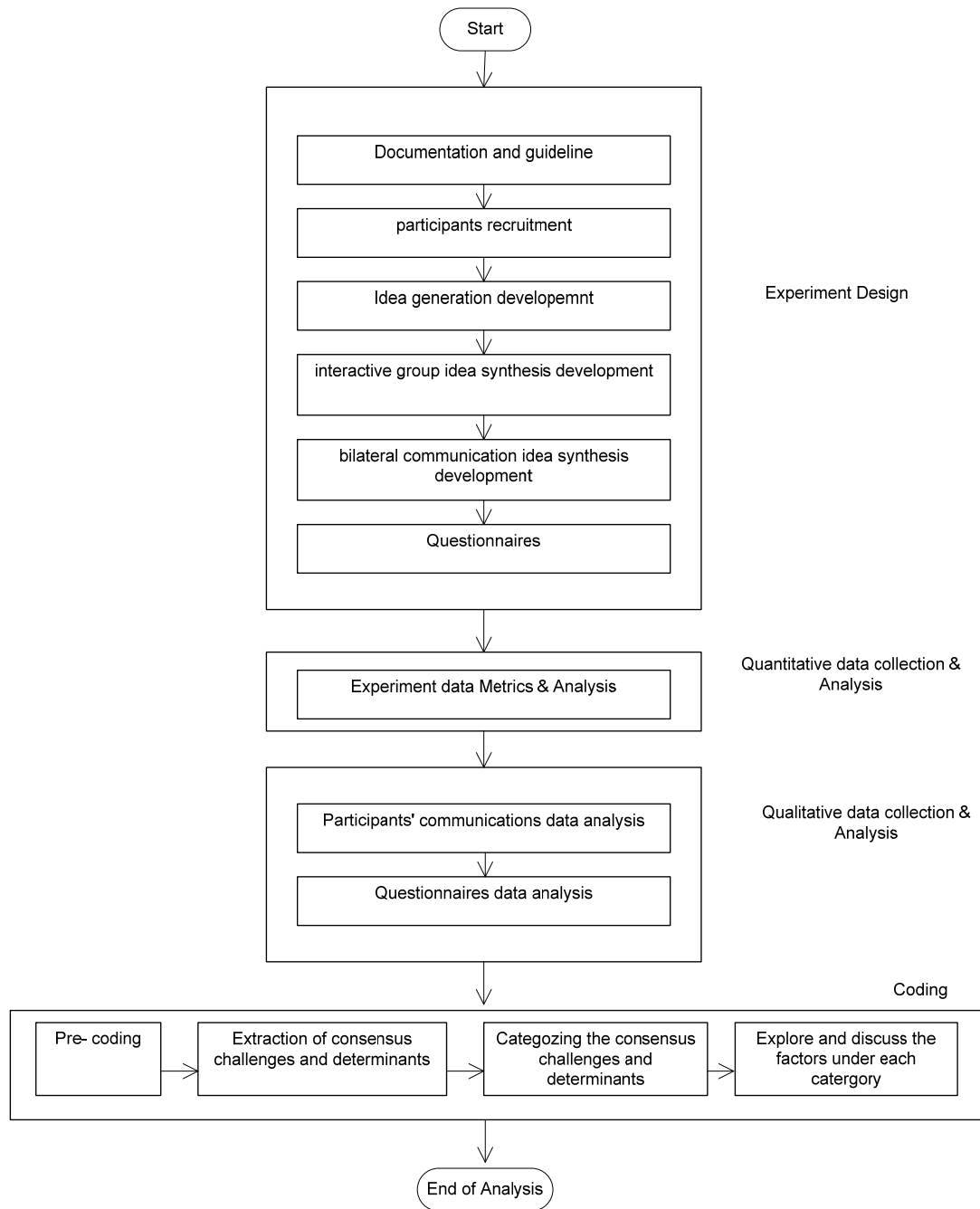


Figure 1 Research methodology

3.1.1 Literature review

Through the literature review, the reader is able to understand the area under consideration and to find information about the strengths and weaknesses of that area in the available researches [59]. The traditional literature review is conducted to summarize and appraise the literatures related to an area of interest [59]. This method aims at providing a clear overview of the literatures collectively with regard to the area under consideration based on some criteria [59]. Although the inclusion criteria may yield studies that are well excluded, to guarantee the validity of a literature review it is important to retrieve all relevant studies. Hence, we use the “Snowball” to overcome the poor yield of traditional literature review and to identify all eligible studies. In the [section 4](#) the traditional literature review and snowballing phases are described.

3.1.2 Controlled experiment

To compare the performance of bilateral communication and interactive group, an experiment is designed that allows us to manipulate the structure of idea synthesizing and measure the product concept of synthesized ideas in terms of novelty, feasibility, impact and stakeholder support. The

experiment results are interpreted from the researcher's viewpoints. The experiment is run using master students as the subjects of the experiment. The planned experiment is a multi-test within object study [60] where each subject is assigned to the test only once. Through such design, a single object is examined across a set of subjects. The multi-test within object makes us able to have a fully randomized experiment.

Through the questionnaire, the participants' attitude and behavior can be assessed [63]. The participants' feedback about the experiment is provided via post-questionnaire. The pre-questionnaire helps us in assessing participants' background knowledge and experience about the negotiation techniques, motivation and trust whereas post-questionnaire addresses participants' satisfaction with the idea synthesis structure they used and their knowledge about the experiment topic. With the help of the questionnaire the hidden factors that influenced the participants' performance and consensus is investigated.

3.1.3 Multiple-case study

In this study factors affecting achieving an agreement among group members will also be analyzed. Hence to achieve this objective, a multiple-case study is conducted with data collected from participants' chats and questionnaires during the experiment. Through the multiple-case study, the researcher is able to investigate a phenomenon not only within each case but also across the cases [80]. The advantage of multiple-case study over single-case study is that in a multiple-case study several cases are examined to understand the similarities and differences among the cases [80].

3.2 Data Analysis Methods

3.2.1 Quantitative data analysis

Quantitative data which deal with numbers can be analyzed with the help of statistic. In this study, quantitative data are acquired through ranking the submitted synthesized ideas from the subjects. The synthesized ideas are ranked by a software expert. The achieved quantitative results are analyzed based on descriptive statistics. The analysis of the data is based on the experiment design.

Since the experiment design is based on one factor, product concept of idea synthesis, and two treatments, interactive group and bilateral communication, data analysis is conducted with respect to this design. In order to analyze the data following steps are considered:

- Descriptive statistics
- Data reduction
- Hypothesis testing
- Power estimation

In the first step, through descriptive statistics the data points achieved from the experiment are described and processed quantitatively [60]. However descriptive statistics is used to present different features of the data set, the main goal is to find out how the data points are distributed. One approach to determine the normality of the data points is to look at the dataset's skewness and kurtosis. Often the skewness and kurtosis values are optimistic and the approximate values compared to the matched normal distribution of data. Thus, Kolmogorov- Smirnov test and Shapiro-Wilk test [71] were considered to determine if the data are normal. Since the Kolmogorov- Smirnov test is suitable for sample size greater than 2000, just Shapiro-Wilk test was performed.

The possible outliers are identified in the second step. It is aimed at checking the data points which are abnormally larger or smaller than the expected ones with regard to the other data points [60]. The outlier can be identified via descriptive statistics. Causes such as natural deviations in populations, human errors or poor experiment execution may lead to outliers. It is important to check the reason for each outlier to decide which one is appropriate to be removed from the dataset and which one are not [60]. The box plots as the graphical displays are used to describe the data behavior.

During the third step, the outcomes of the experiment are tested through a hypothesis testing to determine if they lead to the rejection of the null hypothesis. The P-value helps in seeing how significantly the test results for the two treatments are different. Usually the P-value or significant level (α) is 0.05. When the P-value of a certain statistical test is less than 0.05, the null hypothesis is rejected [60]. There are different parametric statistical tests (those that can be applied for dataset with a normal distribution) and non parametric statistical tests (those that have not dependency to any particular distribution of data) that can be used to achieve the significant level of data [60]. Since the

experiment design in this study is based on “one factor with two treatments”, T-test, F-test and as the parametric tests and Chi-1 and Mann-Whitney U as the non parametric tests can be applied [60].

The fourth step deals with power estimation. To select the most appropriate statistical test it is important to consider the experiment design and the test’s assumption (so called applicability) as well as the statistical test power which refers to the probability of a test that reject a false null hypothesis [60]. The high power indicates the lower probability of committing type II error (accepting the null hypothesis when it is false). In this study the G*power¹ is used to calculate the statistical power. Reasons such as accuracy of algorithms and convenient way of use made us to select this tool over other candidates such SPSS.

3.2.2 Qualitative data analysis

Qualitative data provide a general understanding of people behaviors and their causes [64]. Qualitative analysis is executed through the analysis of the pre/post questionnaires and participants’ conversations based on the content analysis method. The content analysis method is “a systematic and objective means for describing and quantifying phenomena” [64]. The content analysis describes and provides information about the process facts and critical consequences of the actions in the phenomenon [64]. The content analysis is performed based on following steps:

1. Selecting the unit of analysis: In the first step the units (words, sentences, phrases and so on) of analysis must be identified. In this study both words and sentences are selected to be analyzed.
2. Making sense of the data and whole: Next the materials are read repeatedly to obtain a sense of the whole.
3. Open coding: Words which contain the key concepts are highlighted. Based on the impression of the material, headings which contain different aspects of the context are made. This step is performed several times to achieve as many as headings.
4. Coding sheets & Grouping: The headings are put in the coding sheets. This way the groups are generated.
5. Categorization: Similar or related groups are categorized. The aim of categorization is “to describe the phenomenon, to increase understanding and to generate knowledge” [64].
6. Abstraction: analyzing the data in order to achieve a conclusion and generalization which describe the research.

¹ G*power3 was used to calculate statistical powers
<http://www.psych.uni-duesseldorf.de/abteilungen/aap/gpower3/download-and-register>

4 LITERATURE REVIEW

4.1 Traditional Literature Review

The related works are found through the literature review for this study. We used Creswell [58] guideline in reviewing literatures according to following steps:

1. Related keywords and their synonyms and terminologies to the research area were identified through electronic thesaurus and encyclopedias such as:
 - Merriam-Webster (<http://www.merriam-webster.com/>)
 - Thesaurus (<http://thesaurus.com/>)
2. To join different terms and synonyms, AND/OR Booleans were used. Following terms and synonyms were used in the searching:
 - Combination: combination, mix, synthesis
 - Idea: concept, conception, thought
 - Interactive group: teamwork, collaboration, cooperation, coordination
 - Group: collection
 - Bilateral: -
 - Innovation: -

By combining the keywords, search strings were formulated. It was aimed to get a reasonable number of more relevant articles. It was done through performing iterative search and modifying the search string in each iteration.

3. The primary studies were searched through the electronic databases which are :
 - IEEE Xplore
 - ACM Digital Library
 - Scopus
 - Springer
 - Google Scholar
 - WILEY

These databases are good recourses for capturing published journals in engineering, computer science, economics, psychology and management. These databases also cover books, journals, and conference proceeding and peer-review journal. Google Internet search engine was searched to acquire the body of materials such as presentation, workshops or articles which cannot be found in the electronic databases.

4. Potential primary studies were selected based on inclusion criteria. Studies came from both industrial and academic backgrounds. The most important parts that helped us in the selection of a particular article were the title and the abstract. In case the article's title or abstract was not helpful in decision making, the introduction and conclusion were read to make the final decision about the article. Inclusion criteria which were used to select studies that are most fitted to our topic are presented in Table 2.

Inclusion Criteria	
#	Description
1	The article is written in only in English
2	Full-text is available and we have access to it
3	The article presents the process of innovation
4	The article investigates innovation in software industry
5	The article compares idea generation in interactive group and individual structures
6	The article describes an idea generation approaches.
7	The article compares the idea generation in different structures
8	The article proposes a structure for idea generation
9	The article describes the process of idea combination in a one or more certain structure

Table 2, Inclusion criteria

4.2 Snowballing

Snowballing and reversed snowballing are recursive methods used to find old and new literatures in the area under consideration [79]. These methods are used in conjunction with a literature review to guarantee that all related articles are searched and aggregated. The snowball method is used to chase the references in the bibliographies and even the footnotes of basic sources. The reversed snowballing method is used to find literatures which cited the basic sources.

There is the possibility the all the relevant articles may not be achieved through the traditional literature review. Here the snowballing method plays its role as the complementary search strategy. In this study, the snowballing and reversed snowballing methods were started with the most related articles in idea synthesis [9, 47, 48]. These articles were potential to lead us to existing documents with a similar topic.

5 CONTROLLED EXPERIMENT

5.1 Definition

The subjects of the experiment include master students from the practical requirements engineering course. The independent variables of the experiment are the interactive group and the bilateral communication structures for idea synthesis whereas the dependent variables are the novelty, feasibility, impact value and stakeholder support of synthesized ideas.

The Wholin guideline [60] was used to compare the idea synthesis effectiveness in the bilateral communication and interactive group.

Objects of study: The objects of the study are idea synthesizing through interactive group and bilateral communication.

Purpose: The purpose is to compare the interactive group and bilateral communication structures for idea synthesizing.

Quality focus: The quality focus is the effectiveness of idea synthesis. The effectiveness means the synthesized idea novelty, feasibility, impact and stakeholder support.

Perspective: The experiment results are interpreted from the researcher's viewpoints.

Context: The experiment is run using M.sc students synthesizing ideas through the different structures.

5.2 Experiment Planning

5.2.1 Context selection

The context selection refers to the selection of the experimental environment [60]. Through the context, the subjects and the objects of an experiment are defined. In this experiment, there are 78 subjects and 1 object which is the idea synthesis. This implies that the context of the experiment is based on multi-test within object study where one object is examined across several subjects [60].

5.2.2 Dependent and independent variables selection

While the independent variable can be controlled and manipulated in the experiment the dependent variable are those that we are eager to study and measure in order to check the effect of the manipulation of the independent variables [60]. The experiment independent and dependent variable are as follows:

Dependent variables: Idea synthesis' novelty, feasibility, impact value and stakeholder support

Independent variables: Bilateral communication structure and interactive group structure

5.2.3 Experiment topic

The subjects were asked to in the first part of the experiment generate a software solution for reducing the energy consumption individually and improve it through synthesizing the idea. The topic is:

ENERGY CONSUMPTION: *The goal of energy consumption is to reduce the amount of energy required for products and services. Modern energy-efficient appliances, such as refrigerator, ovens and clothes washers have considerably reduced energy consumption. IT technology has potential to simulate and analyzed the energy-consumption through different software. Using software to manage the energy consumption will result in prevention of wasting non-renewable resources and reduction in buildings and factories expenses and as the result earn revenue. Following this background an important question arises: How IT can be used in order to reduce energy consumption in our daily life.*

While subjects were allowed to use the computer and internet resources, they were asked to apply the following criteria while working on the topic.

- Stay focused on the task. Concentrate on the problem at hand and avoid engaging in irrelevant thought processes and discussions.
- Provide evidence that the project is a good investment for different stakeholders (User(s), company).

- Think about ideas which increase the economic value by increasing the ratio of the benefits realized by performing your proposal to its execution costs.
- The proposed ideas should be compatible with the capabilities of software.
- The new ideas are desired i.e. those are not in the market today.
- Think of selling your idea to the experimenter. Hence think through the project in a systematic manner and write your idea in clear, simple language. This helps the experimenter and the potential partner to understand the project requirements.

5.2.4 Hypothesis formulation

The research problem and the experiment definition are formulized into hypothesis [60]. After conducting the experiment, data are collected and then the statistical analysis is conducted based on the defined hypothesis. Using a hypothesis testing method, the defined hypothesis is either accepted or rejected. Since it is aimed at comparing the bilateral communication and interactive group in terms of novelty, feasibility, impact and stakeholder support, following hypotheses are defined:

Null hypothesis, H0: The effectiveness of bilateral communication and the interactive group are not different in terms of novelty of synthesized ideas.

H0: Synthesized ideas novelty_{Bilateral communication} = Synthesized ideas novelty_{Interactive group}

Alternate hypothesis, H1: Synthesized ideas achieved through the bilateral communication are more novel than those achieved through the interactive group.

H1: Synthesized ideas novelty_{Bilateral communication} > Synthesized ideas novelty_{Interactive group}

Alternate hypothesis, H2: Synthesized ideas achieved through the interactive group are more novel than those achieved through the bilateral communication.

H2: Synthesized ideas novelty_{Bilateral communication} < Synthesized ideas novelty_{Interactive group}

Null hypothesis, H0: The effectiveness of bilateral communication and the interactive group are not different in terms of feasibility of synthesized ideas.

H0: Synthesized ideas feasibility_{Bilateral communication} = Synthesized ideas feasibility_{Interactive group}

Alternate hypothesis, H1: Synthesized ideas achieved through the bilateral communication are more feasible than those achieved through the interactive group.

H1: Synthesized ideas feasibility_{Bilateral communication} > Synthesized ideas feasibility_{Interactive group}

Alternate hypothesis, H2: Synthesized ideas achieved through the interactive group are more feasible than those achieved through the bilateral communication.

H2: Synthesized ideas feasibility_{Bilateral communication} < Synthesized ideas feasibility_{Interactive group}

Null hypothesis, H0: The effectiveness of bilateral communication and the interactive group are not different in terms of impact value of synthesized ideas.

H0: Synthesized ideas impact value_{Bilateral communication} = Synthesized ideas impact value_{Interactive group}

Alternate hypothesis, H1: Synthesized ideas achieved through the bilateral communication introduce higher impact value than those achieved through the interactive group.

H1: Synthesized ideas impact value_{Bilateral communication} > Synthesized ideas impact value_{Interactive group}

Alternate hypothesis, H2: Synthesized ideas achieved through the interactive group introduce higher impact value than those achieved through the bilateral communication.

H2: Synthesized ideas impact value_{Bilateral communication} < Synthesized ideas impact value_{Interactive group}

Null hypothesis, H0: The effectiveness of bilateral communication and the interactive group are not different in terms of stakeholder support of synthesized ideas.

H0: Synthesized ideas stakeholders support_{Bilateral communication} = Synthesized ideas stakeholders support_{Interactive group}

Alternate hypothesis, H1: Synthesized ideas achieved through the bilateral communication attract more stakeholders support than those achieved through the interactive group.

H1: Synthesized ideas stakeholders support_{Bilateral communication} > Synthesized ideas stakeholders support_{Interactive group}

Alternate hypothesis, H2: Synthesized ideas achieved through the interactive group attract more stakeholders support than those achieved through the bilateral communication.

H2: Synthesized ideas stakeholders support_{Bilateral communication} < Synthesized ideas stakeholders support_{Interactive group}

5.2.5 Selection of subjects

Generalizing the results of the experiment depends on the subjects of the experiment. The results can be generalized to a population when the selected subjects are the representative of that desired population [60]. Selection of subjects for an experiment is called sampling which can be conducted based on either probability or non-probability.

The simple random sampling is a standard method of sampling in which each subject with a known probability is selected randomly from the population. But due to lack of time and cost, the subject selection conducted based on the convenient sampling technique. In this non-probability technique, subjects are selected non-randomly in which the “nearest and most convenience persons are selected” [60]. However, the subjects’ personal information cannot be presented in this study.

5.2.6 Experiment design

Through an experiment, a set of tests are run. Experiment design describes how these tests are planned and run [60]. There are three general design principles: randomization, blocking and balancing [60]. To average the different factors such as subjects’ motivation, trust and background knowledge that may affect the experimental result, the randomization principle was applied to assign the treatments to the test subjects.

5.2.7 Standard design types

According to Wholin [60], the most commonly used designs for the experiment are:

- One factor with two treatments
- One factor with more than two treatments
- Two factors with two treatments
- More than two factors each with two treatments

In this experiment the aim is to compare two structures (interactive group and bilateral communication) for idea synthesis. Each subject was randomly assigned to only one treatment, either bilateral communication channel or interactive group. One object was used for both treatments, idea synthesis. Because the participants’ experiences from one treatment can affect their performances in the other treatment, the participants cannot be assigned to both treatments. Hence the experiment is designed based on the completely randomized design, one factor with two treatments [60]. However, the experiment was not balanced because the number of subjects per treatment was not equal.

5.2.8 Instrumentation

The experiment instrumentation which needs to be planned before the execution consists of three types: objects, guidelines and measurements [60]. Through the instrumentation the required tools for performing the experiment is provided and monitored [60]. In this study the experiment instruments include the instructions for idea generation and idea synthesis for subjects in both bilateral communication and interactive group, the idea synthesis forms and questionnaires (See [Appendix F](#), [G](#), [H](#) and [I](#)). The instructions of idea generation and idea synthesis were provided for subjects during the experiment as the PDF files through Google doc (See [Appendix C](#), [D](#) and [E](#)).

5.3 Experiment Operations

5.3.1 Subjects

A total of 78 subjects were recruited for the experiment. Subjects were master students from practical requirements engineering course in both Fachhochschule Nordwestschweiz (FHN) and Blekinge Institute of Technology (BTH). Subjects’ age ranged from 18 to 32 years of age, with a mean age of 23 years (SD=3.8) and came from both genders. As an extrinsic incentive, subjects received credit to perform the experiment as a home assignment for the course. The subjects were assigned to the groups and then the constructed groups were assigned to the treatments equally. A total of 16 groups were made, 8 groups of interactive group structure and 8 groups of bilateral communication structure. However the number of members in each group ranged from 3 to 6 members. The number of subjects in each treatment is presented in Table 3.

Treatment	Number of subjects
Bilateral communication channel	43
Interactive group	35

Table 3, Number of participants in each treatment

5.3.2 Preparation

Since the environment used for the experiment was the Skype software, a Skype ID was provided for the experimenter. The experiment was instructed to add all the subjects' IDs and execute the experiment. The topic of the experiment, guidelines, idea proposal forms and questionnaires were also prepared in advance. Subjects in bilateral communication and interactive group were provided with the same pre/post questionnaires and idea generation guidelines. But the idea synthesis guidelines were different in order to be able to compare bilateral communication channel and interactive group. An instruction of the experiment was prepared for the experimenter to guide the experimenter in executing the experiment (See [Appendix B](#)). Since it was impossible to instruct and control all participants at the same time, the experiment was run using only one group at a time. Hence the doodle tables were generated for subjects from Fachhochschule Nordwestschweiz (FHN) and Blekinge Institute of Technology (BTH) group in which each time slot embedded only one group. A presentation about the experiment was provided for the subjects. The presentation included the innovation definition, innovation process, idea synthesis necessity and the goal of the experiment (See [Appendix A](#)). It is to be noted that subjects were only told that they will be needed to synthesize the ideas in a group work and the difference between the group structures (Bilateral communication channels and interactive group) was not revealed. Subjects also were asked to reserve a doodle time slot which was limited to five participants and to fill a Google form in which they were asked to submit his or her email address and Skype ID. However, participants were able to contact the experimenter via email in case of problem or question. Besides, they were able to suggest another time which was not available through the doodle time slots. Once an available time slot or the one which was suggested by the participants was full, a confirmation email was sent to the participants. Through the confirmation email, the experiment was again introduced the briefly (See [Appendix C](#)). The subjects' Skype IDs were added to the contact list of the experimenter's Skype ID under their group's list. Before actual execution of the experiment with our test subjects, a test experiment was executed with 10 master's students of different programs (Computer science, Electrical engineering and Sustainable product-service system innovation) to see if there are flaws in the design of the experiment, instructions and pre/post questionnaires. Consequently the identified flaws were amended accordingly.

5.3.3 Execution

Once the subjects were online via Skype at the defined time, the idea generation instruction was sent to them from the experimenter. In the idea generation instruction, subjects were required to generate an idea for the experiment topic according to the given criteria after filling the pre-questionnaire (See [Appendix D](#) and [Appendix I](#)). Before receiving the pre-questionnaire form, the group members' Skype IDs and names were sent to each member. Subjects were asked to put their ideas on an idea proposal form (See [Appendix G](#)) and send it back to the experimenter. They were given 25 minutes to complete the idea generation task. After a short break the subjects in bilateral communication channel and interactive group, were given the different idea synthesis instructions (See [Appendix F](#) and [Appendix E](#)) in which the subjects were required to share and synthesize their ideas. The subjects in interactive group were instructed to share and synthesis their idea through only one group channel where all subjects in the group and the experimenter were invited. The subjects in bilateral communication channel were instructed to share and synthesis their ideas through bilateral channels where pair of subjects and the experimenter were invited. The interactive group and bilateral communication channels were created by the experimenter. The experimenter did not communicate with the subjects expect sending the forms/guidelines and answering subjects' questions. Again the subjects were asked to put their synthesized idea individually on an idea proposal form (See [Appendix H](#)) and send it back to the experimenter. They were given 25 minutes to complete the idea synthesis task. After a break of 5 minutes, the subjects were given the post-questionnaire form (See [Appendix J](#)). The length of the whole task in the experiment was about 1 hour and 45 minutes for both bilateral communication and interactive group.

5.3.4 Data validation

After executing the experiment and receiving the idea proposal from subjects in all groups, it was checked if all subjects filled the idea proposal and questionnaire forms. The topic of the experiment, guidelines and questionnaires were designed in a way that should be understandable. However, subjects were told to feel free to ask any question in case of any queries.

5.4 Results & Analysis

5.4.1 Quantitative Data Extraction

Though the quantitative data achieved through the experiment, it was attempted to answer RQ1 to compare the effectiveness of bilateral communication and interactive group structures for idea synthesis. Since the idea synthesis effectiveness is determined based on the idea synthesis's novelty, feasibility, value of impact and the stakeholder support, following sub-questions were made and answered in this section.

RQ1. Is an interactive group more effective than bilateral communication for idea synthesis?

RQ1.1 Does the interactive group members produce synthesized ideas which are more novel than synthesized ideas in the bilateral communication?

RQ1.2 Does the interactive group members produce synthesized ideas which are more feasible than synthesized ideas in the bilateral communication?

RQ1.3 Does the interactive group members produce synthesized ideas with higher impact value than the bilateral communication?

RQ1.4 Does the interactive group attract more stakeholder support for their generated ideas than the bilateral communication?

In order to reduce the complexity of ranking the data, the software expert defined five clusters based on the features of the ideas. Ideas that contained features such as using GPS, public areas suggestions, new applications, using alarm systems, recommender systems, controlling systems and tokens was clustered as the home automation. Other clusters were new devices, server farms, energy channeling and society. For each criterion (novelty, feasibility, impact value and stakeholder support) a certain synthesized idea received a score based on its cluster (Table 4). Subsequently each synthesized idea was rated according to its cluster. For example, an idea that defined a new device for reducing energy consumption was assigned to the "new device" cluster and therefore received 5 points for the novelty, 8 points for feasibility and 4 points for impact value. The stakeholder support score for each idea was achieved through counting the number of subjects in each group who borrowed that idea in their final solutions. Since the numbers of member in groups were different from each other, the stakeholders support scales were counted in percentage. A part of quantitative data is presented in Table 5.

Cluster	No. Ideas	Novelty	Feasibility	Impact
Home Automation	50	6	8	6
New Devices	16	5	8	4
Energy channeling	3	4	6	3
Server Farms	2	7	4	5
Solution for Society	6	6	6	7

Table 4, Cluster Scoring

Treatment	Cluster	Novelty	Feasibility	Impact Value	Stakeholder Support
Bilateral_idea1	Home-Automation	6	8	6	60
Bilateral_idea2	Server farm	7	4	5	40
Bilateral_idea3	New Device	5	8	4	40
InteractiveG_Idea1	Home Automation	6	8	6	33
InteractiveG_Idea2	Society	6	6	7	83
InteractiveG_Idea3	New Device	5	8	4	25

Table 5, Quantitative data (Descriptive statistics of experiment)

5.4.2 Quantitative Results & Analysis

In the following sections the results of the experiment are presented and analyzed based on the idea synthesis descriptive statistic in the experiment as well as pre/post questionnaires. In order to analyze the data following steps were considered.

- Descriptive statistics
- Data reduction

- Hypothesis testing
- Power estimation

5.4.2.1 Novelty

By the novelty we referred to the definition of innovation by Zaltman et al.'s (1973) “Any idea perceived to be new by the relevant units” [1]. So novelty can be subdivided into:

- Novel application: The proposed idea is new and its users have not used it before.
- Novel solution: The new way to do something

The novelty comes with the degree of newness started from incremental to radical innovation. When the product concept of an idea produces essential changes in the organizations or users’ activities, it would be categorized as the radical innovation. Whereas when an idea introduces fewer changes in the existing practices, it would be categorized as the incremental innovation.

5.4.2.1.1 Normality testing

In order to select the most suitable hypothesis testing for a data set, it is important to determine whether the data points are distributed normally or not. One approach to determine the normality of the data points is to look at the dataset’s skewness and kurtosis. Skewness represents the symmetry of distributed data and kurtosis represents the peakedness of distributed data. However using skewness and kurtosis to determine the normality of a data set is not always easy. Often the skewness and kurtosis values are optimistic and the approximate values compared to the matched normal distribution of data. Thus, Kolmogorov- Smirnov test and Shapiro-Wilk test [71] were considered to determine if the data are normal. Since the Kolmogorov- Smirnov test is suitable for sample size greater than 2000, just Shapiro-Wilk test was performed. The null and alternative hypotheses in this test include:

H0: Data is distributed normally.

H1: Data is not distributed normally.

If the value of the Shapiro-Wilk test is less than 0.05 then reject the null hypothesis otherwise null hypothesis is valid.

Table 6 represents the Shapiro-Wilk test’s significance values (.000) for both bilateral communication group and interactive groups in case of novelty which is less than 0.05. This indicates that there is no normal distribution in the dataset.

Treatment		Shapiro-Wilk		
		Statistic	Df	Sig.
Novelty of communication Idea Synthesis	Bilateral	.771	35	.000
	Interactive group	.515	35	.000

Table 6, Normality test for novelty

5.4.2.1.2 Data reduction

A box plot is an approach that helps to see if there is any observation with abnormal distribution and if it can be considered as an outlier. In each box plot, the upper side of the box indicates the upper bound (75th percentile) while the lower side of the box indicates the lower bound (25th percentile). The line in the middle of the box indicates the median of the dataset. The data set is skewed when the line is not placed in the middle of the box. Besides the upper and lower line indicate the minimum and maximum data points respectively. Any data points out of the maximum and minimum bound can be an outlier which is confirmed through some calculation.

In Fig. 2, several outliers for interactive group can be seen. It is needed to confirm if they are really outliers and then to decide if they can be removed from the data set or not. In order to find and confirm the outliers, the outlier labeling rule was used in which the lower quartile and the upper bounds are calculated from the lower bound and the upper bound using following equations [60, 71]:

$$Lower_quartile = Q_{lower} - 1.5 (Q_{upper} - Q_{lower})$$

$$Upper_quartile = Q_{upper} + 1.5 (Q_{upper} - Q_{lower})$$

The results for interactive group were 6.00 for both upper and lower quartile respectively. All the five data points that were distinguished as the outliers via SPSS (Fig. 1) were confirmed to be outliers, because all of them had the values which were smaller than the lower quartile (6.00). However since it was aimed to rank the ideas based on their novelty, we did not exclude any data from the data set. Among these five outliers, two of them with the same values of 4.00 were evaluated as not new ideas, two others with the same values of 5.00 were evaluated to be partially new and the last one with a

value of 5.00 was a new idea. The upper and lower quartile values of bilateral communication groups were 7.5 and 3.5 respectively. No data point was specified as the outlier in this data set.

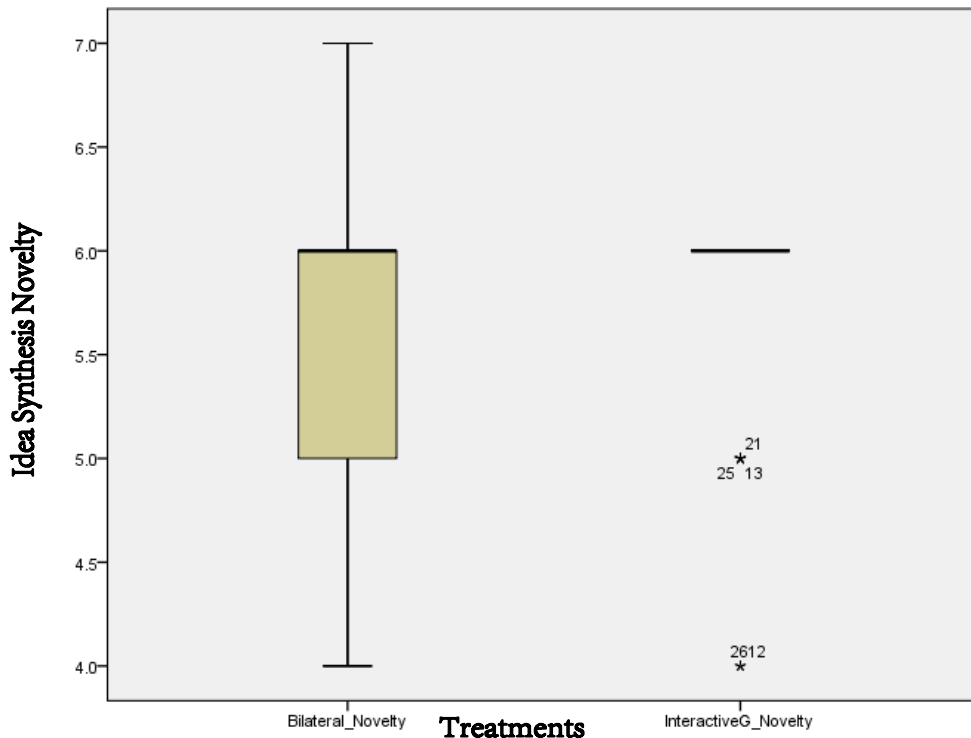


Figure 2, Novelty of idea synthesis

5.4.2.1.3 Hypothesis Testing

Through hypothesis testing we are able to decide about rejecting the null hypothesis. The statistic distribution of the dataset is important in selecting the best method of hypothesis testing [71]. In the following the process and results of hypothesis testing are explained.

Based on the normality testing via the Shapiro-Wilk test (section 5.4.2.1.1), it was revealed that data for novelty in both bilateral communication and interactive sample groups were not distributed normally. The independent sample T test is used to compare two independent groups when data points are ordinal. But it is used for dataset with normal distribution. The substitute for the independent sample t- test is the Mann-Whitney U test which is appropriate for testing the null hypothesis when there is no normal distribution in the data [71]. The Mann-Whitney U test was performed based on following steps:

- **Null and Alternative Hypotheses**

H0: There is no difference between the effectiveness of bilateral communication and interactive group structures in terms of novelty of synthesized ideas.

H1: There is a difference between the effectiveness of bilateral communication and interactive group structures in terms of novelty of synthesized ideas.

- **Decision rule**

Since the sample size is more than 20, z-approximation was calculated through the following equation to normalize the U value based on the significance level of 0.05 and is compared with the value of 1.96 in the Z table (the body in area column in the table).

$$z = \frac{U - m_U}{\sigma_U}$$

Where: $m_U = \frac{n_1 n_2}{2}$ And $\sigma_U = \sqrt{\frac{n_1 n_2 (n_1 + n_2 + 1)}{12}}$

If the value of Z is out of the (-1.96, 1.96) interval, we reject the null hypothesis.

- **Test statistic calculation**

“U” for bilateral communication and interactive group structures is calculated via following equation:

$$U = R - \frac{n(n+1)}{2}$$

So: $U_{Group} = 728$, $U_{Bilateral} = 777$

$$U_{Group} + U_{Bilateral} = n_{Group} * n_{Bilateral}$$

Z statistic is calculated using the U score from the above equation: $Z = -0.298$

• **Conclusion**

From Table 7, it can be seen that the mean rank of the Interactive group (39.97) is higher than the bilateral communication group (40.16) which indicates that the interactive group members produced synthesized ideas which are more novel than synthesized ideas in the bilateral communication group. To see if the difference is significant and to reject or accept the null hypothesis, it is important to look at the Z value and Asymp.Sig (2- tailed) value.

Ranks				
Group		N	Mean Rank	Sum of Ranks
Novelty	BilateralG	43	38.97	1675.50
	InteractiveG	35	40.16	1405.50
Total		78		

Table 7, Mean rank for idea synthesis novelty

Since the Z value (-0.298) is in the (-1.96, 1.96) interval and according to the output of SPSS Table 8, the “Asymp.Sig” value (0.766) is greater than 0.05, we can conclude that no statistically significant difference between the bilateral communication and interactive group structure in terms of novelty of idea synthesis can be assumed.

Test Statistics ^a	
	Novelty
Mann-Whitney U	729.500
Wilcoxon W	1675.500
Z	-.298
Asymp. Sig. (2-tailed)	.766

a. Grouping Variable: Group

Table 8, Mann-Whitney U test for novelty of idea synthesis

5.4.2.2 Feasibility

It was aimed to check whether the proposed idea was feasible with the software and measuring the risks.

5.4.2.2.1 Normality testing

In order to detect the normality of data for feasibility in bilateral communication and interactive groups, again Shapiro-Wilk test was used due to its power and precision for small dataset compared to the Kolmogorov- Smirnov test. The Shapiro-Wilk test’s null and alternative hypotheses are as follows:

H0: Data is distributed normally.

H1: Data is not distributed normally.

The null hypothesis is rejected when the Shapiro-Wilk test’s value is less than 0.05.

The normality test of the Shapiro-Wilk as shown in Table 9 indicates that feasibility for both bilateral communication and interactive groups is not distributed normally. Because the values of the Shapiro-Wilk test which is 0.000 for both bilateral communication and interactive groups is less than 0.05.

Treatment		Shapiro-Wilk		
		Statistic	Df	Sig.
Feasibility of communication Idea Synthesis	Bilateral	.375	35	.000
	Interactive group	.458	35	.000

Table 9, Normality test for feasibility

5.4.2.2.2 Data reduction

With the help of box plot the abnormal data points were specified.

As can be seen in Fig. 2, 4 data points for bilateral communication sample data and 3 data points for interactive sample data were specified as the outliers. The outlier labeling rule was used to verify if they are outliers or not.

Using the upper bound (75th percentile) and the lower bound (25th percentile) the upper and lower quartile was calculated (equation1).

$$Lower_quartile = Q_{lower} - 1.5 (Q_{upper} - Q_{lower})$$

$$Upper_quartile = Q_{upper} + 1.5 (Q_{upper} - Q_{lower})$$

For interactive group, the results were 8.00 for both upper and lower quartile respectively. Since the value of all four data points (6.0 for all) was less than 8.0, they were verified to be outliers. These data points are depicted in Fig. 3. For the bilateral communication group, both lower and upper quartile was 8.0. All data points which were depicted by plot box as the abnormal data points were confirmed to be outliers because their values (4.0, 4.0, 6.0, and 6.0) were less than 8.0. In order to compare the feasibility of the bilateral communication and interactive group data samples, again none of the outliers were removed from the data set.

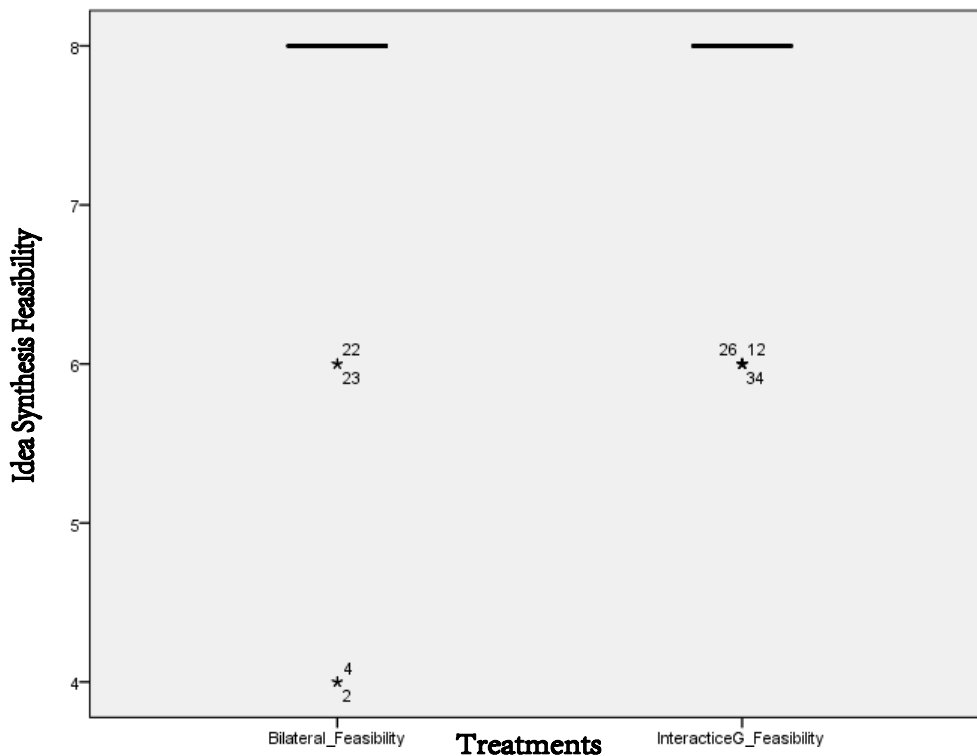


Figure 3, Feasibility of idea synthesis

5.4.2.2.3 Hypothesis Testing

To determine if the null hypothesis is true or false hypothesis testing is used. The selection of the hypothesis testing method depends on the distribution of the dataset [71]. From the [section 5.4.2.2.1](#) it was clear that for feasibility data distribution was not normal in both bilateral communication and interactive samples. The Mann-Whitney U test was used to compare two independent groups instead of independent sample. The independent sample T test is not suitable for data which is not distributed normally.

The Mann-Whitney U test was performed according to following steps to test the hypothesis:

- **Null and Alternative Hypotheses**

H0: There is no difference between the effectiveness of bilateral communication and interactive group structures in terms of feasibility of synthesized ideas.

H1: There is a difference between the effectiveness of bilateral communication and interactive group structures in terms of feasibility of synthesized ideas.

- **Decision rule**

Since the sample size is more than 20, the U value is normalized using the following equation on the significance level of 0.05 and is compared with the value of 1.96 in the Z table. If the value of Z is out of the (-1.96, 1.96) interval, we reject the null hypothesis.

- **Test statistic calculation**

“U” for bilateral communication and interactive group structures is calculated as follows:

$$U_{Group} = 788 \quad , \quad U_{Bilateral} = 717 \quad \text{Where} \quad U_{Group} + U_{Bilateral} = n_{Group} \cdot n_{Group} * n_{Bilateral}$$

Z statistic is calculated using the U score from the above equation: $Z = -.591$

- **Conclusion**

The mean rank values represented in Table 10 for bilateral communication and interactive groups show that bilateral communication group members (with the value of 40.33) generated synthesized ideas which are more feasible than synthesized ideas in interactive group (with the value of 38.49). Since data is not distributed normally, the Z value and Asymp.Sig (2- tailed) values were considered to decide if the null hypothesis must be rejected or not.

Group		N	Mean Rank	Sum of Ranks
Feasibility	BilateralG	43	40.33	1734.00
	InteractiveG	35	38.49	1347.00
Total		78		

Table 10, Mean rank for idea synthesis feasibility

As can be seen in Table 11, the Z value is -0.591 which is in the (-1.96, 1.96) interval. Besides, the significance value of feasible idea synthesis is 0.555 which is higher than 0.05. These values indicated that the null hypothesis cannot be rejected because the results are not statistically significant. Hence, the null hypothesis for feasibility of synthesized ideas in the bilateral communication group compared to interactive group is accepted.

	Feasibility
Mann-Whitney U	717.000
Wilcoxon W	1347.000
Z	-.591
Asymp. Sig. (2-tailed)	.555

a. Grouping Variable: Group

Table 11, Mann-Whitney U test for feasibility of idea synthesis

5.4.2.3 Impact value

Higher impact scores should be synthesized ideas that have a greater impact on the following:

- Value for users
- Value for suppliers
- Cost for suppliers

5.4.2.3.1 Normality testing

The Shapiro-Wilk test was used to check if data for impact value in both bilateral communication and interactive groups has a normal distribution or not. The Shapiro-Wilk test and Kolmogorov- Smirnov test are commonly used normality tests. But the Shapiro-Wilk test is more powerful and suitable for small datasets (sample sizes less than 50 and sample sizes as large as 2000) [72].

The Shapiro-Wilk test’s null and alternative hypotheses are as follows:

H0: Data is distributed normally.

H1: Data is not distributed normally.

The null hypothesis is rejected when the Shapiro-Wilk test’s value is less than 0.05.

The Shapiro-Wilk test significance values for impact values of bilateral communication and interactive groups is the 0.000 (Table 12) which is less than 0.05 meaning that both bilateral communication and interactive groups is not distributed normally.

Treatment		Shapiro-Wilk		
		Statistic	Df	Sig.
Impact Value of communication	Bilateral	.741	35	.000
Idea Synthesis	Interactive group	.701	35	.000

Table 12, Normality test for Impact value

5.4.2.3.2 Data reduction

Through the box plot, it is possible to look for abnormal observations and then check if it can be considered as the outlier or not. Fig.4 depicts 9 data points as the outliers. In order to make sure if they are outliers, the upper bound (75th percentile) and the lower bound (25th percentile) was used to determine the lower and the upper quartiles. According to the following equation:

$$Lower_quartile = Q_{lower} - 1.5 (Q_{upper} - Q_{lower})$$

$$Upper_quartile = Q_{upper} + 1.5 (Q_{upper} - Q_{lower})$$

Data points that are less than the lower quartile and those that are greater than the upper quartile are considered as the outliers. In case of impact value for interactive groups, the results for the lower and the upper quartiles are the same (6.0). 4 data points with the same value of 7.0 and 5 data points with the values of 3.0, 3.0, 4.0, 4.0 and 4.0 were confirmed to be the outliers because they were either greater than the upper quartile or less than the lower quartile. Since the goal was comparing the idea synthesis in bilateral communication and interactive groups in terms of impact value, none of the outliers were excluded from the dataset.

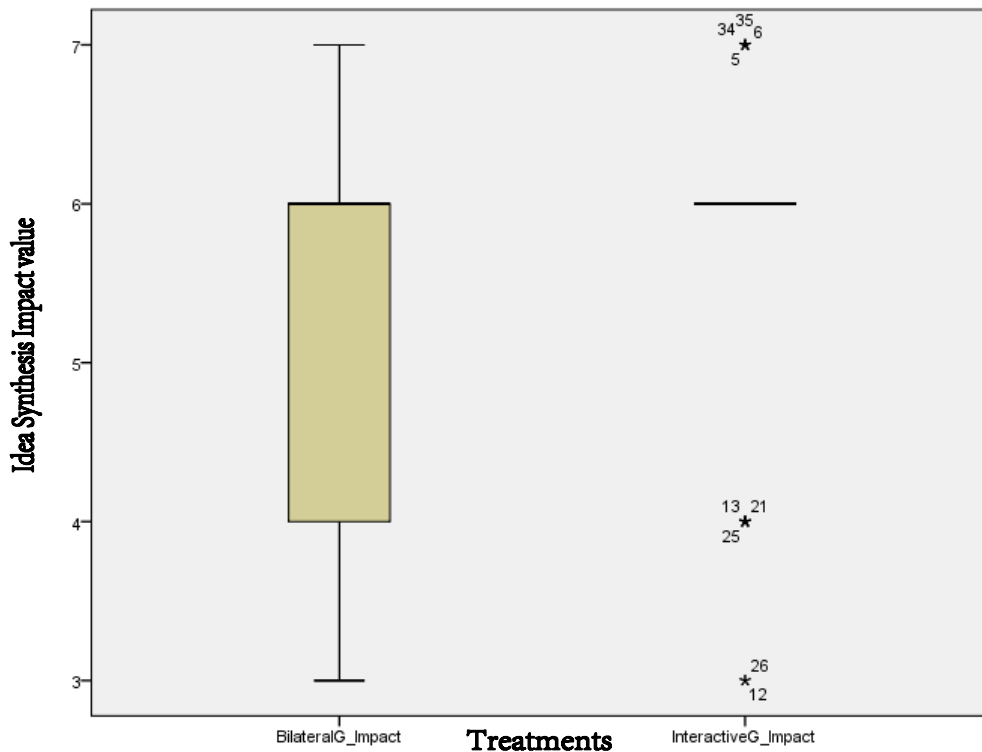


Figure 4, Impact value of idea synthesis

5.4.2.3.3 Hypothesis Testing

The next step after normality detection is hypothesis testing which enables us to reject or accept the null hypothesis. Since the goal was to compare two independent groups in which the ordinal data points were not distributed normally (see [section 5.4.2.3.1](#)), the Mann- Withney U test was used. The Mann-Whitney U test was performed according to the following steps:

- **Null and Alternative Hypotheses**

H0: There is no difference between the effectiveness of bilateral communication and interactive group structures in terms of impact value of synthesized ideas.

H1: There is a difference between the effectiveness of bilateral communication and interactive group structures in terms of impact value of synthesized idea.

- **Decision rule**

Since the sample size is more than 20, the U value is normalized using the following equation on the significance level of 0.05 and is compared with the value of 1.96 in the Z table.

If the value of Z is out of the (-1.96, 1.96) interval, we reject the null hypothesis.

- **Test statistic calculation**

“U” for bilateral communication and interactive group structures is calculated as follows:

$$U_{Group} = 643.5 \quad , \quad U_{Bilateral} = 861.5 \quad \text{Where} \quad U_{Group} + U_{Bilateral} = n_{Group} * n_{Bilateral}$$

Z statistic is calculated using the U score from the above equation: $Z = -1.298$

- **Conclusion**

Table 13 shows the mean rank of the impact value in bilateral communication and interactive group. The value of mean rank of the interactive groups (42.61) is slightly higher than bilateral communication’s mean rank (36.97) which indicates the interactive group members produced synthesized ideas with higher impact value than bilateral communication. To determine if the null hypothesis is true or false, the Z value and Asymp.Sig (2- tailed) value were considered.

Ranks				
	Group	N	Mean Rank	Sum of Ranks
Impact	BilateralG	43	36.97	1589.50
	InteractiveG	35	42.61	1491.50
	Total	78		

Table 13, Mean rank for idea synthesis Impact value

As can be seen in Table 14, the Z value is -1.298 which is in the (-1.96, 1.96) interval. Besides, the significance value of feasible idea synthesis is .194 which is higher than 0.05. From the Z value and the significance value we can conclude that no statistically significant difference between the bilateral communication and interactive group structures in terms of impact value of synthesized ideas can be assumed.

Test Statistics ^a	
	Impact
Mann-Whitney U	643.500
Wilcoxon W	1589.500
Z	-1.298
Asymp. Sig. (2-tailed)	.194

a. Grouping Variable: Group

Table 14, Mann-Whitney U test for impact value of idea synthesis

5.4.2.4 Stakeholder support

The stakeholder support refers to the number of similar ideas which were stated by the participants or ideas were borrowed from the others through the discussion sessions.

5.4.2.4.1 Normality testing

In order to select the most suitable hypothesis testing method for a data set it is important to determine whether the data points are distributed normally or not. Most commonly the Kolmogorov- Smirnov test and the Shapiro-Wilk test are used to determine if the data are normal. Since the Shapiro-Wilk test is suitable for sample size less than 50 or sample size with 2000 data points and our sample sizes were

less than 50, just Shapiro-Wilk test was performed. The null and alternative hypotheses in this test include:

H0: Data is distributed normally.

H1: Data is not distributed normally.

If the value of the Shapiro-Wilk test is less than 0.05 then reject the null hypothesis otherwise null hypothesis is valid.

For bilateral communication group and interactive groups in case of stakeholder support Table 15 (Shapiro-Wilk test) shows the Shapiro-Wilk test significance values (0.003 and 0.043 respectively). Both of the values are less than 0.05 which indicates that both datasets have not normal distribution.

Treatment		Shapiro-Wilk		
		Statistic	Df	Sig.
Stakeholder support of communication Idea Synthesis	Bilateral	.894	35	.003
	Interactive group	.936	35	.043

Table 15, Normality test for Stakeholder support

5.4.2.4.2 Data reduction

The abnormal data points were depicted through the box plot. As can be seen in Fig. 5, no data point for bilateral communication and interactive group sample data was specified as the outliers.

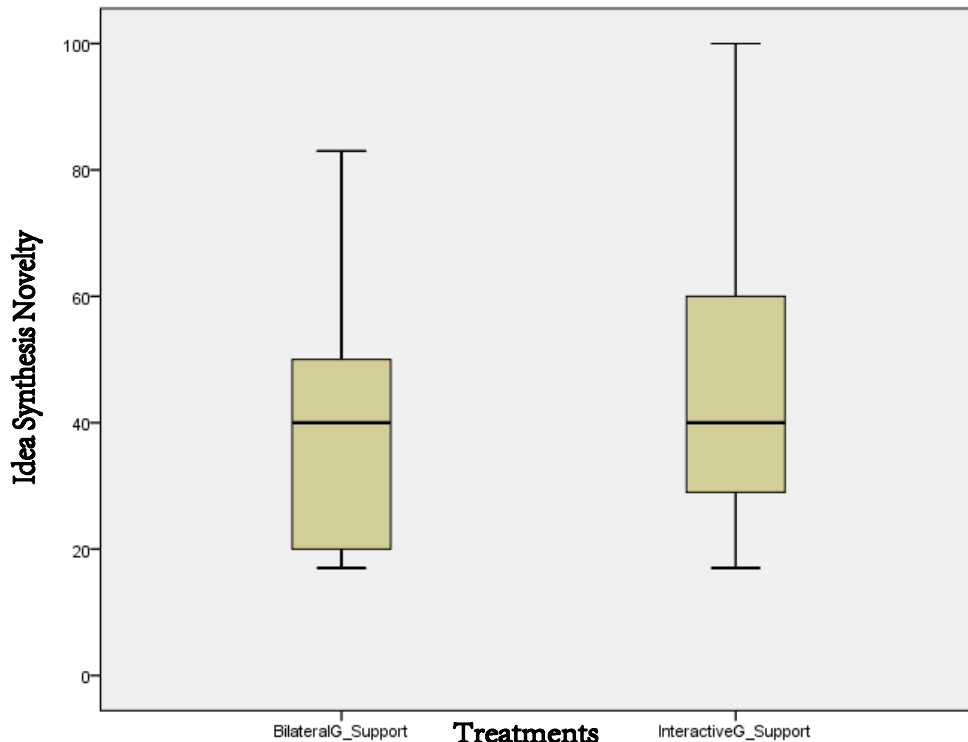


Figure 5, Stakeholder support of idea synthesis

5.4.2.4.3 Hypothesis Testing

To determine if the null hypothesis is true or false hypothesis testing is used. The selection of the hypothesis testing method depends on the distribution of the data [71].

Based on the normality testing via the Shapiro-Wilk test ([section 5.4.2.4.1](#)), it was revealed that data for stakeholder support in both bilateral communication and interactive sample groups were not distributed normally. The independent sample T test is used to compare two independent groups when data points are ordinal. But it is suitable for data with normal distribution. Hence the Mann-Whitney U test was substituted which is appropriate for testing the null hypothesis when there is no normal distribution in the data [60]. The Mann-Whitney U test was performed based on following steps:

- **Null and Alternative Hypotheses**

H0: There is no difference between the effectiveness of bilateral communication and interactive group structures in terms of stakeholder support of synthesized ideas.

H1: There is a difference between the effectiveness of bilateral communication and interactive group structures in terms of stakeholder support of synthesized ideas.

• **Decision rule**

Since the sample size is more than 20, the U value is normalized using the following equation on the significance level of 0.05 and is compared with the value of 1.96 in the Z table.

If the value of Z is out of the (-1.96, 1.96) interval, we reject the null hypothesis.

• **Test statistic calculation**

“U” for bilateral communication and interactive group structures is calculated as follows:

$$U_{Group} = 631, \quad U_{Bilateral} = 874 \quad \text{Where} \quad U_{Group} + U_{Bilateral} = n_{Group} \cdot n_{Bilateral}$$

Z statistic is calculated from the U score from the above equation: $Z = -1.232$

• **Conclusion**

From Table 16, it can be seen that the mean rank of the Interactive group (42.97) is higher than the bilateral communication group (36.67) which indicates that ideas attracted more supports via the interactive group compared to the bilateral communication group. To reject or accept the null hypothesis it is important to look at the Z value and Asymp.Sig (2-tailed) value.

Ranks			
Group	N	Mean Rank	Sum of Ranks
Support			
BilateralG	43	36.67	1577.00
InteractiveG	35	42.97	1504.00
Total	78		

Table 16, Mean rank for idea synthesis stakeholder support

Since the Z value (-1.232) is in the (-1.96, 1.96) interval and according to the output of SPSS, the “Asymp.Sig” value (0.218) is greater than 0.05, Table 17, we can conclude that there is no statistically significant difference between the bilateral communication and interactive group structures in terms of stakeholder support.

Test Statistics ^a	
	Support
Mann-Whitney U	631.000
Wilcoxon W	1577.000
Z	-1.232
Asymp. Sig. (2-tailed)	.218

a. Grouping Variable: Group

Table 17, Mann-Whitney U test for stakeholder support of idea synthesis

5.4.3 Power estimation

In statistic, power refers to the probability of rejecting the null hypothesis when it is false via a test [73]. Whenever the power increases, the chance of rejecting a false null hypothesis increases. Statistical power depends on the following criteria:

- Statistical significance: refers to the probability of rejecting the null hypothesis when it is valid. The most commonly used value is 0.05
- Effect size: refers to the degree of the treatment effect.
- Sample size: refers to the number of subjects in the experiment. Samples with larger number of subject results more powerful tests.

Table 18 represents the important factors for the estimation of the power of our tests. As can be seen the effect size for all dependent variables is small (novelty=0.002, feasibility=0.011, Impact value=0.231 and stakeholders=0.331). The sample size required for each dependent variable is also presented (for novelty, impact value and stakeholder support 78 test subjects is required and for feasibility 80 test subjects is needed). Achieved power indicates that the study has 5%, 5%, 16.5% and 28.8%

probability for novelty, feasibility, impact value and stakeholders support respectively to reject the related false null hypothesis.

Dependent Variables	Effect Size	Sample size required	Achieved Power (1- β err prob.)
Novelty	0.002	78	0.050
Feasibility	0.011	80	0.050
Impact Value	0.231	78	0.165
Stakeholders Support	0.331	78	0.288

Table 18, Statistical power analysis

5.4.4 Subjects' features

Through pre and post questionnaires, we aimed at providing sufficient data about the participants' background and also understating the participants' motivation and satisfaction behind their answers. The participants were asked to answer questionnaires and provide feedback based on their experiences before and after the experiment.

Subjects' background, culture, their experience in negotiation and information elicitation as well as their relationship with their group members were asked through the pre-questionnaire. The subjects experience in the experiment and their satisfaction about their group structure were provided via post-questionnaire mostly based on a five-point scale. The five-point scale was included: very good or definitely agree= 1, good or agree= 2, fair or unsure= 3, poor or disagree= 4 and very poor or definitely disagree= 5.

The mean, mode and the positive/negative/neutral percentage levels were calculated from the achieved data. The negative percentage refers to "Strongly disagree" and "Disagree" answers while positive percentage refers to "Strongly agree" and "Agree" answers. The neutral corresponds to "Unsure" answers. The questions regarding participants' knowledge about the experiments' topic, trust, motivation, their negotiation knowledge and their relationship explained in the following. A subject's answer was considered if he or she submitted the complete form. The answers were categorized according to each variable. Each variable is followed by participants answer and the descriptive statistics acquired through the subjects replies.

5.4.4.1 Participants' background knowledge

To understand about subjects' knowledge about the experiment topic, they were asked to determine the level of their knowledge about the experiment topic (reducing energy consumption using software).

Statistics					
Treatment	Very poor	Poor	Fair	Good	Very good
Bilateral communication	5	19	11	7	0
Interactive group	1	12	13	6	2

Table 19, Subjects background knowledge about the experiment topic

Descriptive Statistics					
Treatment	Mean value	Mode	Positive Response (%)	Neutral Response (%)	Negative Response (%)
Bilateral communication	2.48	2	16.7	26.2	57.1
Interactive group	2.88	3	23.5	38.2	38.2

Table 20, Descriptive statistics for subjects' background Knowledge

The descriptive statistics of collected data (Table 20) indicates that the more than half of the bilateral subjects (57.1%) did not have any background knowledge about the experiment topic. But 23.5% of responses from interactive groups indicate that participants had some knowledge in the experiment topic. 26.2% of bilateral subject and 38.2% of interactive group subjects evaluate their knowledge about the experiment topic stood on neutral ground.

5.4.4.2 Trust

Table 21 shows the responses of the subjects that answered whether they are open in sharing their ideas with his or her group members:

Statistic					
Treatment	Strongly disagree	Agree	Unsure	Disagree	Strongly disagree
Bilateral communication	22	19	0	1	1
Interactive groups	12	15	5	1	1

Table 21, Subjects' willingness to share their ideas

Descriptive Statistics					
Treatment	Mean value	Mode	Positive Response (%)	Neutral Response (%)	Negative Response (%)
Bilateral communication	4.30	4	95.35	0	4.65
Interactive group	4.03	4	79.41	14.71	5.88

Table 22, Descriptive statistics for subjects' willingness to share their ideas

The descriptive statistics of collected data indicates subjects in bilateral communication are more open to share their ideas compared to the subjects in interactive groups (Table 22). 95.35% of positive responses showed that subjects had not any problem with sharing their ideas with their group members. However, one of the subjects was not sure about sharing his or her idea and another one disagreed with sharing his or her idea. Subjects' responses from the interactive groups indicates a rather mixture where 79.41% of subjects were open in sharing their ideas while 14.71% of participants were not sure about sharing their ideas and the remaining 5.88% of them were reluctant in sharing their ideas within their group members.

5.4.4.3 Motivation

To assess the subjects' motivation, we first checked their motivation in participating in the experiment and after the experiment they were asked if they were motivated in synthesizing the ideas in their groups. The question was measured on the two point scale: "It is interesting to participate" correspond to positive answer and "I feel forced to participate" correspond to negative answer. Table 23 shows the subject's response that answered whether they were forced to participate in the experiment or not:

Statistic		
Treatment	"I feel forced to participate"	"It is interesting to participate"
Bilateral communication	20	23
Interactive group	13	21

Table 23, Subjects' willingness to participate in the experiment

Descriptive Statistics				
Treatment	Mean value	Mode	Positive Response (%)	Negative Response (%)
Bilateral communication	1.47	1	53.49	46.51
Interactive group	1.38	1	61.76	38.24

Table 24, Descriptive statistics for subjects' willingness to participate in the experiment

As can be seen in Table 24, the subjects in interactive group (61.76%) were more motivated to participate in the experiment than the subjects in bilateral communication channels (53.49%). The subjects' motivation to participate in the experiment can influence the quality of initial generated idea.

The motivation for idea synthesizing factor was measured through a three point scale system (Not motivated, Not much and Motivated) where the negative percentage corresponds to "Not motivated" answers and positive percentage refers to "Motivated" answers. The neutral corresponds to "Not

much” answer. Table 25 shows the responses of the participants that were asked to determine their motivation in synthesizing the ideas:

Statistic			
Treatment	Not Motivated	Not Much	Motivated
Bilateral communication	2	15	26
Interactive groups	5	14	15

Table 25, Subjects’ motivation to synthesize the idea

Descriptive Statistics					
Treatment	Mean value	Mode	Positive Response (%)	Neutral Response (%)	Negative Response (%)
Bilateral communication	2:29	3	60.47	34.88	4.65
Interactive group	2:56	3	44.12	41.18	14.71

Table 26, Descriptive statistics for subjects’ motivation to synthesize the idea

The descriptive statistics of collected data (Table 26) indicates that subjects in bilateral communication channel were more motivated to synthesize the idea than the subjects in interactive group. 4.65% of bilateral communications’ subjects were not motivated to synthesize the idea while in interactive group 14.71% of subjects were not motivated to synthesize the ideas in their group.

5.4.4.4 Negotiation knowledge

Table 27 shows the responses of the participants to the question which wanted them to determine their level of knowledge in negotiation techniques:

Statistics					
Treatment	Very poor	Poor	Fair	Good	Very good
Bilateral communication	3	16	18	5	1
Interactive group	2	9	17	4	2

Table 27, Subjects' negotiation background knowledge

Descriptive Statistics					
Treatment	Mean value	Mode	Positive Response (%)	Neutral Response (%)	Negative Response (%)
Bilateral communication	2.65	3	13.95	41.86	44.19
Interactive group	2.85	3	17.65	50	32.35

Table 28, Descriptive statistics for subjects’ negotiation knowledge

However the descriptive statistics of collected data indicates that about half of the subjects in both structures (50% in interactive groups and 41.86% in bilateral communication channels) have a fair knowledge about negotiation techniques, subjects in interactive groups benefited from higher level of negotiation knowledge (17.65%) than subjects in bilateral communications (13.95%) as represented in Table 28.

5.4.4.5 Subject’s relationship

Through this question, subjects were asked to determine who they know in their group. The subjects’ answer to the question was measured through a three point scale system (Nobody, Some and All) where the negative percentage corresponds to “Nobody” answers while positive percentage refers to “Some” and “All” answers. Table 29 shows the responses of the participants to the question asking if they know any of their group members:

Statistic			
Treatment	Nobody	Some	All
Bilateral communication	7	24	12
Interactive groups	3	24	7

Table 29, Subjects' relationship

Descriptive Statistics				
Treatment	Mean value	Mode	Positive Response (%)	Negative Response (%)
Bilateral communication	1.12	2	83.72	16.28
Interactive group	2.12	2	91.18	8.82

Table 30, Descriptive statistics for subjects' relationship

The descriptive statistics of collected data indicates that the most of the participants (91.18% in interactive group and 83.72% in bilateral communication) were familiar with each other before the experiment (Table 30).

5.5 Validity Threats

5.5.1 Internal validity

Internal validity concerns the relationship between the dependent variables and the treatment. In other words we must be sure that the outcomes are caused by the treatment and not the other factors which were not under the controlled [60]. There are several threats to internal validity, which need to be considered.

Since the subjects were not aware of the idea synthesis structure that they were going to use and the treatments (bilateral communication and interactive group) were assigned to the groups randomly, we consider the social threats to internal validity low.

The mortality threat to internal validity in this study is not expected. Since the subjects of the experiment were students who received credit to fulfill the experiment, they either participated in experiment from the beginning to the end or did not participate at all. This caused that subjects did not drop out during the experiment.

Control group bias threat related to internal validity is dismissed since the study aimed at comparing the idea synthesis structures and there is no favor to one of the structures compared to the other one. This means that the subjects in both structures had the same feeling.

5.5.2 External validity

The external validity is concerned with generalizing the conclusion. C. Wohlin defines external validity: "it refers to the condition that limits our ability to generalize the results of our experiment to industry practice" [60].

Subject selection threat related to external validity refers to selection of test subjects who are not representative of the population. However the subjects of this study were the master students, many of them had the experience of team working in different environments consciously or unconsciously. This reduces the threat of subject selection to the generalizing of the conclusion.

Wrong experimental setting and materials could be another threat to external validity. Using "Reducing energy consumption" as the experiment topic may not be an example of the real industry problem due to its generality. Nevertheless, we needed to have a topic which was easy and general enough for all subjects to make a solution for. This topic was consistent with the topics that had been used in previous empirical studies related to idea combination. Furthermore, we could not conduct the experiment in the real industry environment due to the limited time and availability.

The third type of threat to external validity deals with the selection of time and place for the experiment, known as history and treatment [60]. Due to limited time of students (subjects of the experiment) and also the geographical distance between the subjects and the experimenter, it was not possible to conduct the experiment at a certain time. To address this problem, the experiment was designed in a way that makes the subject able to perform the experiment based on their most suitable time. Moreover the experimenter was available during the experiment to answer any queries from the subjects.

It should be mentioned that the experiment used the "Energy consumption" as the topic of the experiment to compare the effectiveness of bilateral communication and interactive group for idea synthesis in very limited time. But the real world software projects possess much longer duration of time and more specific topics. Hence, the validity of the experiment outcomes can be considered limited since the study is limited.

5.5.3 Construct validity

Construct validity refers the ability of observations or measurement tools to actually measure the concept or theory behind the study [60].

The first threat related to construct validity is inadequate preoperational explication of constructs. It is important to define the constructs to measure the idea synthesis effectiveness. In order to take this issue out of the equation, it is attempted to define the whole study constructs well enough for each experiment dependent variable. A synthesized idea is novel when the idea is a novel solution or a novel application. Similarly, when a synthesized idea is feasible with the software and measuring the risks, it is considered as a feasible synthesized idea. The impact value of a synthesized idea is evaluated through measuring the impact value of the synthesized idea for users or supplier or the synthesized idea cost for the suppliers. Finally the synthesized idea stakeholder supports are determined through the number of similar ideas which were stated by the participants or ideas which were used in idea synthesis and discussion sessions.

As can be seen for each dependent variable, constructs are defined in a way that leads to generalizing the results to the concept of experiment. This definition also helps in removing the mono-method bias threat since it provides more multiple types of measurement for each dependent variable (novelty, feasibility, impact value and stakeholder support).

Another threat to construct validity could be the evaluation apprehension. This refers to anxiousness or enthusiasm of people to be evaluated which influences their performance (so the outcomes would not be because of the treatment). The instant message and the Skype IDs were used instead of face-to-face discussion to dismiss this threat. Moreover the subjects were instructed to avoid judgment.

5.5.4 Conclusion validity

Conclusion validity is the possibility to reach a correct conclusion about relationship of treatment and outcome in experiment [60].

Low reliability of measurements is one important threat to conclusion validity which in this study, it is addressed through defining all possible measures to evaluate the dependent variables. For example to evaluate idea synthesis novelty, it is considered whether the idea is proposing either a totally new solution or new application for the experiment topic.

The second important threat could be the low statistical power of the tests. As can be seen in [Section 5.4.3](#) the low statistical power of the test (30%) reduces the chance of finding significant results in the study. In the same section, it was revealed that a large enough sample size (80 test subjects) helps to overcome this problem and achieve significant. However 78 test subjects were recruited, the low statistical power of the tests has still remained as a threat to conclusion validity.

In order to secure the statistical analysis of quantitative data any threat, the SPSS tool which is a robust statistical tool.

6 MULTIPLE-CASE STUDY

Apart from the controlled experiment, a multiple-case study is also conducted to identify the consistent pattern of idea synthesizing and the factors that affect achieving an agreement among the group members in bilateral communication and interactive groups. Through the multiple-case study, the differences and similarities between and within cases can be identified [80]. In addition to the advantages of single case study, multiple-case study improves the generalizability of the results through repeating the study procedure [81].

6.1 Cases selection and unit of analysis

In this study the unit of analysis is the conversation of multiple groups in bilateral communication and interactive group. The researcher directly observes the groups' communications of multiple bilateral communication groups and interactive groups. All the group members in both structures are informed about the presence of the experimenter. The experimenter except answering the participants' questions does not contribute to any discussion. All the group conversations are logged and analyzed to find the steps adopted by group members to synthesize the ideas in both structures. It also helps to identify the factors influence achieving agreement among the group members. The data collection process is described in the following.

6.2 Multiple-Case Study Protocol

6.2.1 Data collection

Data is collected in two ways: direct observations and questionnaires.

6.2.1.1 Direct Observations

Sharing and discussion of the initial generated ideas may lead to synthesizing these ideas. Hence each group discussion in interactive group and in bilateral communication is observed without any participation in the discussion. For this purpose, participants were asked to use Skype in order to communicate and discuss their ideas. The experimenter attended all the group discussion (in both structures), but did not contribute to any discussion. Using the Skype features, all the participants communications were and logged. Through the observation and study of the participants' chats, it is possible to understand how the idea synthesis is conducted in groups through different structures. Moreover, since achieving to an agreement among the group members influence the idea synthesis, factors which hinder or facilitate achieving to an agreement in each structure can be identified. Open-ended questions in the post questionnaire are used to collect the participants' feedbacks about the experiment (See [Appendix J](#)).

6.2.1.2 Open-ended questions

Open-ended questions in the post questionnaire help to understand the participants' challenges in each structure and also to collect their opinions and preferences about the structure they attended. The post questionnaire form consists of nine close-ended questions and two open-ended questions. The participants have ten minutes to complete the post questionnaire form. Through the closed-ended question, information about the participants' motivation, relationships and their feedback about the experiment is collected. The qualitative data are collected through two open-ended questions in post questionnaire. In the first questions participants are required to answer why they are satisfied/unsatisfied with the group structures they attended. Through the second question, the participants are asked to share their opinion and additional information about the experiment with us. Through these questions, participants are able to explain the reasons for their satisfaction or dissatisfaction about the ideas synthesis structure they attended. They are also able to state the problems they faced in the structure they used and make suggestion to improve the structure.

6.3 Results & Analysis

6.3.1 Qualitative Results and Analysis

Qualitative analysis was executed through analysis of participants' conversations and their responses to the open-ended questions in the post questionnaires based on the content analysis method. Through

analyzing these two sources of data, it was attempted to understand how the subjects in interactive group and bilateral communication channels performed the idea synthesis task. Furthermore, the factors achieving an agreement among the participants for each structure are revealed. In this section the following questions are answered:

- RQ1: How idea synthesis was performed in bilateral communication channel?
- RQ2: How idea synthesis was performed in interactive group?
- RQ3: Which challenges led the consensus be failed among the members in bilateral communication and interactive group?
- RQ4: Which factors led to the consensus among participants in bilateral communication and interactive group?

6.3.2 Idea synthesizing process

6.3.2.1 Idea synthesizing process in bilateral communication channels

Participants in bilateral communication channels shared their ideas with their group members either concurrently or sequentially. Fig. 6 depicts the process that most of the bilateral communication's participants followed when performing the idea synthesis task. 74.4 % of subjects participated in the bilateral communication channel shared their ideas with all the available bilateral channels in their groups concurrently. It means that subject sends his or her idea to the other channels at the same time. After sharing the ideas if the subject is replied by his or her group member, they start to discuss about their ideas otherwise the subject waits for the group member reply:

Bilateral subject1: *Hey, what's your idea?*

Bilateral subject2: *wait, I'm discussing with another channel. I'm coming in five min or so.*

Or

Bilateral subject1: *there are two groups of this group, we are currently discussing in the other one, sorry I didn't get to write to you*

Bilateral subject2: *no problem*

Sharing idea in each channel follows by searching for the parts that can be combined. Ideas with potential parts such as using a system which is applicable in another idea or different solutions for a same context that can be combined are discussed briefly to convince both bilateral members about the ideas benefits, cost and risks:

Bilateral subject1: *So we share a similar idea, about reducing cost on datacenters / servers. I'm not sure ships are the best way, because of the technology to transfer data would be difficult. But at least thinking of cold place is good*

Bilateral subject2: *yeah but maybe we can take the energy from the waves. Can you explain me why the boat is not a good idea?*

Bilateral subject1: *I was thinking of how you transmit data. You can't use wire, and satellite is very expensive*

Bilateral subject2: *yeah you're right. Maybe nowadays it's not a real good idea. Agreed?*

Bilateral subject1: *Yes*

Or

Bilateral subject1: *That's a good idea, but don't have some risk?*

Bilateral subject2: *I don't see any risks ... but it needs some research ... this can be expensive. You have to be insure that it will work under any condition*

Bilateral subject1: *yes of course, that is can be very expensive*

Bilateral subject2: *maybe you can offer to rent a server system; it could be cheaper than buying it*

Bilateral subject1: *Yes*

Or

Bilateral subject1: *I think that our ideas are possible to connect for a cheaper develops. We can computerize the house and the car in the same system*

Bilateral subject1: *in case of the smart devices? That's right*

If the participants are not able to find any part in their ideas which could be used to improve their idea, they end the conversation and move to another channel:

Bilateral subject1: *okay, my idea is about datacenter. Do you know a way how to combine our solutions? I don't know how my idea can help you*

Bilateral subject2: *has left*

Or

Bilateral subject1: *Ok, as your idea is not related to mine I can't think of something to mix between us. Anyway your idea seems interesting :)*

Bilateral subject2: *Thank you, yours is interesting too*

When an idea is discussed and both members became convinced about the ideas, the members terminate the conversation and either move to another channel or does not involve in any other communication through the bilateral channels. Nevertheless, about 20 % of the bilateral communication channels were used to just share the ideas and participants did not discuss their ideas. As the result there were no sign of agreement or disagreement.

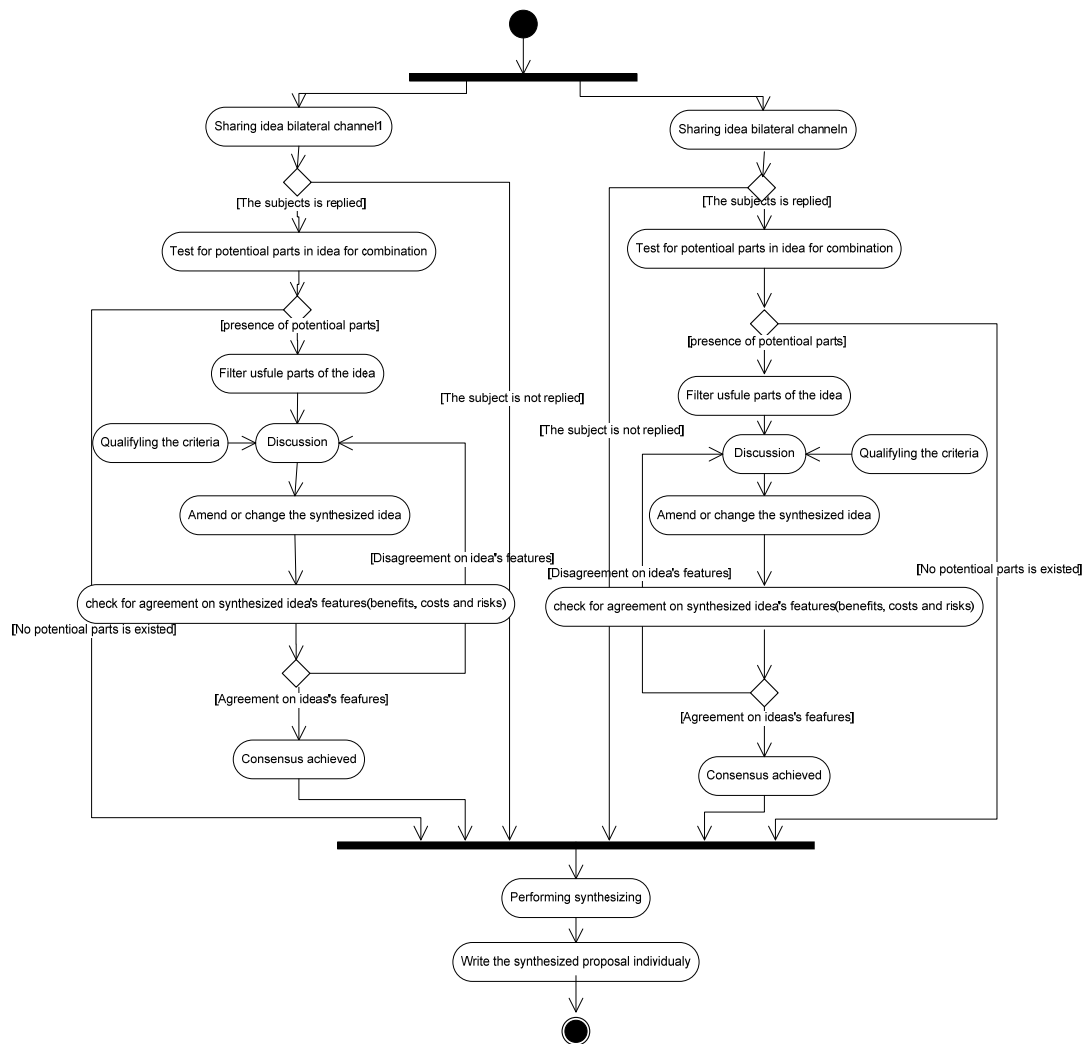


Figure 6, Idea synthesis process in concurrent bilateral channels

Fig. 7 illustrates the bilateral channel idea synthesis process in which participants share their ideas with the group members in a sequential manner. This means that the subject starts by sharing his or her idea with only one channel at a moment and moves to another idea channel when one conversation has been finished. After sharing the idea with one channel the subjects either switch to another bilateral channel to discuss their ideas with regard to the remained time or does not proceed to any other channels. As can be seen there is no difference in ideas between the participants who shared their ideas with other channel concurrently or sequentially.

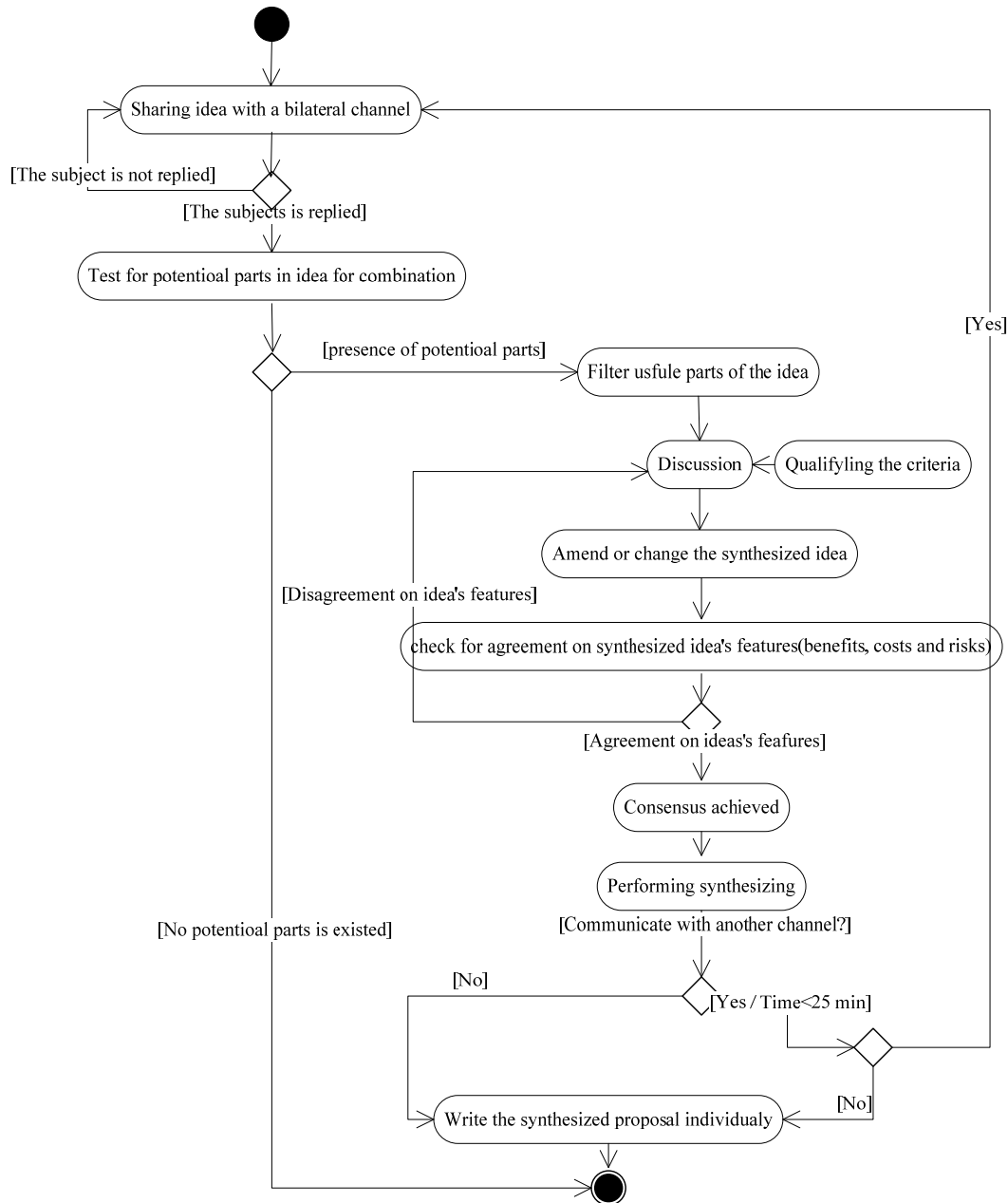


Figure 7, Idea synthesis process in sequential bilateral channels

As can be seen in both processes, subjects after sharing their ideas, focus on searching for parts in their group members' ideas which can be combined with their own ideas. Ideas which do not contain any good parts, lead to the end of the conversation. Otherwise they start to extract the useful parts and discuss in order to convince each other.

6.3.2.2 Idea synthesizing process in interactive group

From the Fig. 8 we can see how the idea synthesizing is performed in interactive groups. In this process after sharing the idea, subjects check if the idea is an IT solution. If the idea does not come from the IT field, subjects start to discuss about the idea in order to convert it into an IT solution.

Interactive-Group subject1: *So there is a wide area for the need of education and information. ;D*

Interactive-Group subject12: *This would benefit you, because it would reduce the cost of government and energy*

Interactive-Group subject13: *The software solution is a website creating awareness*

Or

Interactive-Group subject1: The subject1's idea

Interactive-Group subject2: *what is the software doing?*

Interactive-Group subject1: *software makes energy consumption of the house with solar energy redirects*

Afterward the group members focus on searching and extracting the parts in the shared ideas which lead to the combinations. Ideas and the useful parts are discussed with regards to their benefits, cost and risk.

Interactive-Group subject1: *how much it will cost*

Interactive-Group subject2: *By using smart home manufacturers we can fund the budget of the project. It can make money through online advertising...*

Interactive-Group subject2: *What are the risks?*

Interactive-Group subject1: *expensive*

Interactive-Group subject3: *Maybe we can make it open source...*

Or

Interactive-Group subject1: *What are the opportunities and benefits for our society in your opinion?*

Interactive-Group subject2: *Society. I have a better way of life, more a green life, and reducing costs for everyone and good feeling about it*

The discussion is followed by the suggestion of idea synthesizes from group members. Synthesized ideas are discussed and again combined to achieve a combination which is contained almost all members initial ideas. The final synthesized idea is written via one of the members to the group and again the members discuss about the ideas benefits, costs and risks. This final idea synthesis is approved when most of the members declare their agreements.

Interactive-Group subject1: Subject declared the achieved idea synthesis

Interactive-Group subject2: *it may somehow fit to the other solutions*

Interactive-Group subject1: *That way, everyone's idea is used.....*

Interactive-Group subject2: *agree*

Interactive-Group subject3: *yes*

Interactive-Group subject4: *YES*

Interactive-Group subject5: *yes*

Interactive-Group subject6: *yes*

Or

Interactive-Group subject1: Subject declared the achieved idea synthesis

Interactive-Group subject2: *hm yes I think so*

Interactive-Group subject3: *:D hah*

Interactive-Group subject4: *hmm*

Or

Interactive-Group subject1: *We could somehow merge all ideas together,* Subject suggested an idea synthesis.

Interactive-Group subject2: *good point*

Interactive-Group subject3: *Well, that sounds fine enough for me*

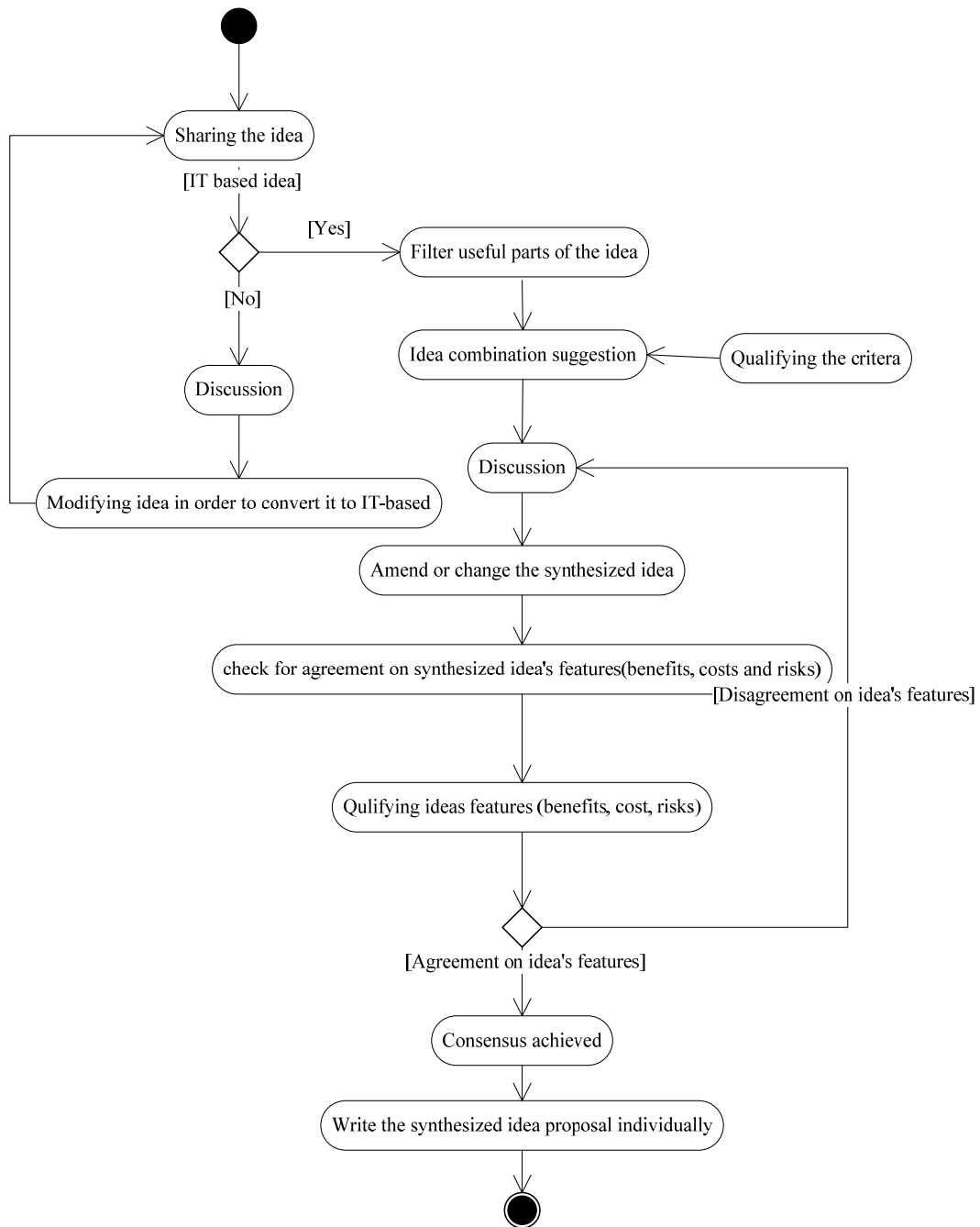


Figure 8, Idea synthesis process in interactive groups

6.3.3 Consensus challenges and determinants

6.3.3.1 Consensus challenges

6.3.3.1.1 Bilateral communication channel challenges

The analysis of bilateral communication channels' communication revealed a range of challenges that affected achieving to the consensus among bilateral communication channel's members. Achieving to an agreement is a factor that motivates participants to use approved idea in the idea synthesizing task. The categorized challenges are presented in Table 31. The challenges and impacts under each category represent the most elements that led failing of the consensus among the members.

Category	Challenge	Impact	Rationale / Mechanism
Context	Idea cluster	Withdrawing the idea	Inconsistent ideas hindered not only the consensus but also continuing the conversation. As the result these ideas could not be combined.
	Idea with limitation	Withdrawing the idea	Ideas with special applicability could not be combined with all group members' ideas.
	Similar ideas	Not performing the idea synthesizing	Ideas which addressed similar solutions with similar features were not discussed and considered as the same ideas. No combination achieved from these ideas
	Ideas realization features	Withdrawing the idea	Poor idea features in realizing such as its cost and risk failed the consensus and were not considered qualified to be combined
Participant s' features	Not sharing the idea	The loss of potential ideas	An idea which was not shared could not participate in any discussion and combination
	Lack of communication	The loss of potential parts of an idea	Sharing ideas without any discussion caused an ambiguous consensus.
	Unilateral communication	The loss of potential parts of an idea	Sharing idea from only one side of the communication channel and no response from the other side resulted in leaving the conversation without any agreement. Besides subjects who did not receive their group member's idea were not able to perform idea synthesizing.
	Written communication	The loss of ideas	Using instance messaging restricted subject's expression and communication speed. This decreased members' ability to convince each other and also other communications opportunities.
	Communication planning	Lack of communication with all members in bilateral communication channels	Due to lack of planning and management, subjects were not able to convince their group members and also lost the opportunity to communicate with the all of the bilateral channels.
	Time management	Failing to communicate with all group members	Due to lack of time, subjects were not able to convince their group members. Subjects who faced the lack of time ended the conversation quickly without enough discussion or simply were not able to communicate with other members in their group.
	Low self-confidence & Reliance on others	The loss of ideas Coordination	Subjects who underestimated their own ideas ended the communication quickly or stopped discussing about their own ideas.

Table 31, Consensus challenges of the bilateral communication structure

The category of participant's features contains the majority of challenges. Consensus is happened when ideas are shared and disused. Not sharing the ideas from one or both members of a bilateral communication channel decreased the number of ideas for combination. Also avoidance of discussion caused the loss of useful parts in shared ideas. During the experiment, while some subjects broadcast their idea to all of the group members, some other did not share their ideas with all of the group members instead with some of the group members. This caused that subject has

not access to all the idea in his or her group which reduce the likelihood of finding good parts in different idea in order to combine them.

Bilateral subject: *I have given an idea to all my partners, or I have told them which problems did I found and offer a solution. But only one of my partners has given me a problem on my system. I think that is not fair.*

Or

Bilateral subject: *I received no feedback from anyone whatsoever. I just commented on their idea, but they never did on mine.*

Or

Bilateral subject1: *do you know the Subest3' idea?*

Bilateral subject2: *no, He didn't write me... ..*

Or

Bilateral subject: *I have given a ideas to all my partners, or I have tell them which problems did I found and offer a solution. But only one of my partners has given me a problem on my system. I think that is not fair.*

Written communication reinforced these effects through restricting members' expressions and communication speeds.

Bilateral subject: *I do not feel satisfied; because a bilateral chat without voice is not useful. It would be better to speak, or have a chat with everyone at one time*

Or

Bilateral subject: *It's not easy to communicate just trough chat. I will never do that, for me it's too unpersonal and I want at least a communication with phone.*

Communicating with several people in a limited time requires planning and management. Subjects who spent a lot of time to communicate with one of the member lost the opportunity to communicate with the rest of the group member(s). Also some members started to communicate with all group members in different channels at the same time which make them confused.

Bilateral subject: *In fact I have to say that I can't work like that. To improve 4 different ideas with 4 different people in 4 different chat windows is more confusing than productive.*

Or

Bilateral subject: *It would be better to speak, or have a chat with everyone at one time*

Or

Bilateral subject: *But it was a little bit stressful to chat with 5 users and impossible to really discuss with all of them.*

Or

Bilateral subject: *I wrote that to the wrong person; I clicked the wrong name ;)*

Or

Bilateral subject: *It's much more useful, if the participants can talk to each other or if all participants are in the same group. So the ideas can be combined once, and you do not have to repeat everything four times.*

Or

Bilateral subject: *it was hard to discuss with 5 participants at one time. It would have been better to discuss it with only two or three*

Or

Bilateral subject: *I would have preferred to have a discussion with everybody at the same time. Each one exposes his idea. Then we take each idea and we discuss it.*

Lack of time is considered as a challenge to achieve an agreement among the group members. Subjects who faced the lack of time ended the conversation quickly without enough discussion or simply were not able to communicate with other members in their group.

Bilateral subject: *We didn't have much time to discuss our ideas. However, it definitely helped to see the ideas of the other members.*

Or

Bilateral subject: *Not enough time to discuss the ideas and write it down. It is too hard to make suggestions to the other users.*

Or

Bilateral subject: *because of the little amount of time we had, I think it's a good solution, it added to the first idea.*

Or

Bilateral subject: *In my opinion there was too less time to really understand and discuss all the received ideas.*

Or

Bilateral subject: *It was confusing at the beginning. But the principal difficulty for me was the lack of time to do something better.*

Or

Bilateral subject: *It felt rushed with the time limits*

Or

Bilateral subject: *It would be very helpful if we had a little more time to think clearly and collect our thoughts.*

Or

Bilateral subject: *Sorry, but it is impossible to find good ideas in 25 minutes when there are energy engineers around the world who try to find the same ideas we had and most probably already had them.*

Or

Bilateral subject: *The time was limited to read all the documents and talk to all the group members in the second part, maybe have 25 min for talking and then 10 min for filling out the documents*

Furthermore, when a subject was not satisfied with his or her idea, did not discuss about his out her own idea. This caused that useful part remained uncovered.

Bilateral subject: *I think my idea is weak; Subject3's is like mine but wider*

Or

Bilateral subject: *well I'm not really happy with my idea as it's already quite commonly used...*

The context of the idea influenced the consensus among the members and achieving idea synthesis. On the one hand, ideas addressing saving energy in different contexts were considered unrelated. For example discussion of the idea related to the home automation system and those that were related to server farms ended up with no consensus and subsequently achieved no combination.

Bilateral subject: *okay, my idea is about datacenter. Do you know a way how to combine our solutions? I don't know how my idea can help you*

End of discussion.

Or

Bilateral subject: *Ok, as your idea is not related to mine I can't think of anything to mix between us. Anyway your idea seems interesting :)*

Or

Bilateral subject: *It depends of which person I talked, some didn't give any idea. Some had an idea but really different so nothing could be exchanged*

Ideas with limited applicability or poor features also caused disagreement and did not result any combination. For example when an idea proposed to equip all devices such as microwave, toaster and so on with sensors and Bluetooth, the group members considered the idea expensive and complex:

Bilateral subject1: *I think that not all the electronic devices are manageable from a mobile phone...*

Bilateral subject2: *It can be innovated maybe?*

Bilateral subject1: *I don't think that anybody will buy interested, to expensive...*

Or

Bilateral subject1: *The idea is ...*

Bilateral subject2: *Have you thought how to control ...*

Bilateral subject1: *no, I have not thought of that.*

End of discussion.

Or

Bilateral subject: *No one submit a good idea to improve the main idea.*

Furthermore, there was no point in the discussion of ideas with exactly the same context and features.

Bilateral subject1: *Sounds like we have similar ideas with the mobile apps, Sebastian*

End of discussion

Or

Bilateral subject: *We almost have all the same idea, so I'm not so satisfied*

6.3.3.1.2 Interactive group challenges

To see what challenges hindered the consensus among the members of the interactive group, the communication between the group's members were analyzed. The challenges affected the performance of the idea synthesis. The categorized challenges are presented in Table 32. The challenges under each category represented the most elements that led the consensus among the members be failed.

Category	Challenge	Impact	Rationale / Mechanism
Context	Privacy violation	Withdrawing the idea	Revealing the users' information and publish it led to disagreement.
	Ideas realization feature (cost and its guarantee to be available)	Withdrawing the idea	Ideas with poor features such as its complexity cost and risk hindered the consensus. These ideas were not considered qualified to be combined.
Participants' features	Communication language	Withdrawing the idea	English as the second language of the subjects reduced their ability in convincing their group-mates. Lack of understanding the idea accurately and completely deprived idea to be combined with the others.
	Written communication	The loss of ideas	English as the second language of the subjects reduced their ability in convincing their group-mates. Lack of understanding the idea accurately deprived idea to be combined with the others.
	Lack of leadership	Chaos and disorder Coordination:	Inconsistent question answering led to disordering in group communication. The group was unable to achieve any conclusion.
	Lack of conclusion	The loss of ideas or its useful parts and subjects dissatisfaction	The lack of an exact conclusion led subjects to overlook the others' ideas and stick to their own ideas.
	Time management	Failing to discuss about all ideas and as the results the loss of ideas' useful parts	Due to lack of time, subjects were not able to discuss and convince their group members. Subjects who faced the lack of time ended the conversation quickly without enough discussion.

Table 32, Consensus challenges of the interactive group structure

As can be seen most of the challenges are related to the participant's features. Communicating in English which was the second language of most of the participants reduced their ability in communicating and thus their ability in convincing their group members:

Interactive group subject: *communicate in German would make it easier and faster to communicate*
Or

Interactive group subject: *Next time in German please*

Written communication influenced the quality of subjects' conversations and their ability in convincing each other about their ideas and its features through restricting members' expressions and communication speeds.

Interactive group subject: *I feel restricted by the fact that there was no verbal communication. Everything is so slow and takes so long.*

Or

Interactive group subject: *This should be done with voice chat; I'm restricted in my expression and communication speed when using text.*

Since it was an online self-organizing group discussion, subjects had problem in answering and questioning. In some the groups, one of the members led the group voluntarily. The leader organized and managed idea sharing and idea discussion. Hence, the group was able to achieve a conclusion. Groups without any leader faced with the disorder.

Interactive group subject: *I think there is a little disorder in the meeting, some members talk little, and other talks much.*

Or

Interactive group subject: *I think we can talk one by one.*

Or

Interactive group subject: *It's not enough time to seriously discuss and enhance an existing idea. The more everybody was talking without moderation. So it was a bit of a chaos in the end. But to be honest, the idea wasn't that bad in the end. I was able to adapt my idea with someone others idea.*

However participants mentioned that the process was helpful in informing them about others' ideas and also others members' opinion about the different aspect of different ideas, the lack of an exact conclusion via the group discussion led participants to stick to their own ideas instead of improving them through the synthesizing.

Interactive group subject: *There was good participation, but not that much outcome.*

Or

Interactive group subject: *good ideas but no conclusion*

Or

Interactive group subject: *we didn't make a final solution. Some should lead strongly to it.*

Besides, subjects faced with the lack of time to communicate and to write the proposal:

Interactive group subject: *It was so much fun and so little time to discuss in this group. The second part could have lasted 10 minutes longer. But I do not know how others felt in the same situation and how much it depends on the group itself.*

Or

Interactive group subject: *Please provide more time for discussion in the future assignments.*

Or

Interactive group subject: *give us a little more time. Maybe 2 hours especially more time for the individual part*

Or

Interactive group subject: *For fast experiment it was good, but for generation of something more real - more time was necessary. Maybe just some 10-20 minutes more to given 25.*

Second category contains challenges related to the context of the ideas. Ideas with high cost, implementation risk or high complexity or not novel enough were not accepted among the group members.

Interactive group subject: *ok. So it is very similar to the previous one... and this concept has been around for years now, so not very cutting edge.....*

Or

Interactive group subject1: *The problem with this approach is mainly cost, because...*

Or

Interactive group subject2: *I think the idea is pretty well but you shouldn't underestimate the costs!*

Or

Interactive group subject3: *yeah that's true but you should first be sure that you can guarantee the availability*

The ideas which proposed to publish users' data were considered as the privacy violation and as the result hindered the consensus among group members:

Interactive group subject: *I had this idea also, but refused it because people may don't want to share the data about how much they consume + it's time consuming to get this data and publish it*

Or

Interactive group subject: *It was only for private use. Must think about privacy policy.*

6.3.3.2 Consensus determinants

6.3.3.2.1 Bilateral communication consensus determinants

The factors that led to achieving an agreement between bilateral communication members were revealed through the analyzing of the communication of group members in bilateral communication channels. These factors are categorized and presented in Table 33. The consensus determinants and impacts under each category represent the most elements that led the consensus between members in bilateral communication channels.

Category	Consensus determinants	Impact	Rationale / Mechanism
Context	Ideas clusters	Development of the initial ideas	Ideas which address the same problem used each other's features to be developed.
	Ideas realization features	Development of initial idea	Merging ideas with different features to achieve an idea with upgraded realizing features.
Participant s' features	Subject's self-confidence about his/her idea	Discussion and improvement of that idea	A subject who was more confident with his/her idea led the discussion and convinced his/ her group member and improved the idea.

Table 33, Consensus determinants in the bilateral communication structure

The category of ideas context contains the majority of consensus determinants.

Ideas which addressed the same context could complete each other and be developed through merging with each other.

Bilateral subject1: *Ok, So we share a similar idea, about ...*

Bilateral subject2: *yeah we have thought about the same problem for energy consumption*

Bilateral subject1: *I'm not sure ships is the best way, because of the...*

Bilateral subject2: *yeah but maybe we can take the energy from...*

Bilateral subject1: *Anyway combining my idea with yours about green energy is perfect*

Bilateral subject1: *so maybe we can put... agreed?*

Bilateral subject1: *Yes*

Or

Bilateral subject1: *Hi! My idea consists...*

Bilateral subject2: *my idea is like yours but for all the house or building*

Bilateral subject1: *ah, ok*

Or

Bilateral subject1: *Sounds like we have similar ideas. How would you get the software ...*

Bilateral subject2: *I see. If there was a single ap ...*

Bilateral subject1: *That would be even better!*

Ideas' features also led to improvement of the initial ideas. For example, an idea which contains cheaper solutions was discussed to be combined with others ideas.

Bilateral subject1: *So this idea is actually similar to yours but it is used in the large scale (cities, countries etc.) in contrary to yours in the house*

Bilateral subject2: *But is possible that ...*

Bilateral subject1: *so let's merge*

Bilateral subject2: *I think that our ideas are possible to connect for a cheaper develop*

Bilateral subject1: *that's right*
 Or
Bilateral subject1: *The idea is based on...*
Bilateral subject2: *The idea is to ...*
Bilateral subject1: *I don't really get the idea...you have...*
Bilateral subject2: *yes the ...*
Bilateral subject1: *ok, how do you safe energy with that system?*
Bilateral subject2: *I'm thinking more about to make it cheap and simple, to be able to make money from it, it will just monitoring yes.*
Bilateral subject1: *ok*
 Or
Bilateral subject: *I am satisfied because, the ideas are good. You will hear about something that you didn't have in mind.*
 Or
Bilateral subject: *It's very good, because new ideas are generated and I can rebuild my own idea again.*

Participants' features as the second category contains determinants related to the participants' features. Subjects, who were satisfied with their idea, were able to discuss and convinced their group members about their own idea. This caused the improvement of their ideas and selling their ideas to the other group members.

Bilateral subject1: *The general idea is ...*
Bilateral subject2: *The idea is to...*
Bilateral subject1: *How will that actually lead to energy savings?*
Bilateral subject2: *It will record ...*
Bilateral subject1: *Well, it seems as it would work.*
 Or
Bilateral subject1: *The idea is based ...*
Bilateral subject2: *A system that ...*
Bilateral subject1: *Have you thought how to...*
Bilateral subject2: *good point*
 Or
Bilateral subject1: *The idea is...*
Bilateral subject2: *Have you thought...*
Bilateral subject1: *It would.....*
Bilateral subject2: *I think that it would be a good idea.*
 Or
Bilateral subject: *I am satisfied because it's very flexible*
 Or
Bilateral subject: *While the discussion we could generate an absolute new idea on the ideas from both of us and the idea still works in association with my idea.*

6.3.3.2.2 Interactive group consensus determinants

The analysis of interactive groups' communication revealed a range of determinants that led to the consensus among the group's members. The consensus determinants are categorized presented in Table 34.

Category	Consensus determinants	Impact	Rationale / Mechanism
Context	Similar points in the ideas	Achieving to consensus	Ideas with a solution in the similar context or features could be discussed to be improved and even combined.
	Ideas realization feature (cost and its guarantee to be available)	Development of initial ideas	Improving ideas' features through merging them with others ideas.
Participants' features	Group leadership	Sharing all ideas and discussion of them orderly	A leader organizes the question answering and

			helps to achieve a conclusion.
	Subject's cooperation interests	Development of synthesized ideas and its features	Subjects' motivation in achieving the idea synthesized help in improvement of not only the shared ideas but also the suggested idea synthesis.
	Use of all ideas	The suggestion of synthesized ideas which contain all of the amended initial ideas	Subjects interested in achieving the synthesized ideas which constructed from all group members' ideas and led to the satisfaction of all the group members.

Table 34, Consensus determinants in the interactive group structures

The category of participant's features contains the majority of challenges.

Groups which had a leader (one of the subjects who coordinate the idea sharing and question answering) were able to collect all the group members' ideas and discuss about the ideas. This helped to synthesize ideas and to achieve a conclusion which was approved by the group members.

Interactive group subject1: *I think we can talk one by one,*

Interactive group subject2: *yes, who is it going to be first?*

Interactive group subject1: *maybe Interactive group subject3 first*

Or

Interactive group subject1: *my idea is...*

Interactive group subject2: *Maybe we can combine it with another idea. What's your idea Interactive group subject3?*

Or

Interactive group subject1: *maybe there should be some set of ...*

Interactive group subject2: *yes why not*

Interactive group subject3: *yea, that's true, anyone has other suggests?*

Interactive group subject2: *no I am covered*

Interactive group subject4: *Done*

Interactive group subject5: *trying to combine everything above into synthesized document*

Or

Interactive group subject1: *May be the application can give an....*

Interactive group subject2: *or maybe even ... Interactive group subject3 and 4 what do you think?*

Interactive group subject3: *yea*

Interactive group subject4: *I agree with you*

Or

Interactive group subject1: *I'm feeling two solutions emerging right now...*

Interactive group subject2: *Agree*

Interactive group subject3: *Yes*

Interactive group subject4: *Yes*

Interactive group subject5: *Yes*

Interactive group subject6: *Yes*

The subjects' interest in cooperation and discussion caused improving and discovering of good parts in each idea to be combined and achieving an agreement among the group members.

Interactive group subject1: *I thought about IT...*

Interactive group subject2: *Maybe we can combine this idea with ...*

Interactive group subject3: *And we should have an app for that!*

Interactive group subject4: *and server to store data*

Interactive group subject2: *So there is a wide area for the need of education and information ;D....*

Or

Interactive group subject1: *The software solution is a website creating awareness like the education....*

Interactive group subject2: *Website is so oldschool nowadays; every solution should have an app!*

Interactive group subject1: *Yah. Ok...*

Interactive group subject3: *Connecting people to energy using an app ...on an iPad*

Interactive group subject1: *Which a lot of people have*

Or

Interactive group subject1: *how much it will cost*

Interactive group subject2: *the system*

Interactive group subject3: *By using smart home manufacturers we can fund the budget of the project...It can make money through online advertising...*

Interactive group subject3: *What are the risks?*

Interactive group subject1: *expensive... Maybe we can make it open source...*

Using of all the group members' idea was another consensus determinant. The idea synthesis which constructed from all subjects initial ideas made group member convinced and satisfied.

Interactive group subject1: *I'm feeling two solutions emerging right now. 1)*

Interactive group subject2: *it may somehow fit to the other solutions*

Interactive group subject3: *That way, everyone's idea is used.....*

Second category contains determinants related to the context of the idea.

Ideas which address the problem in the same context or similar features were discussed to be improved and combined with other ideas.

Interactive group subject1: *I think my idea is similar to yours*

Interactive group subject2: *we can put the 2 application together*

Interactive group subject1: *sure*

Interactive group subject3: *I see,*

Interactive group subject3: *my idea is simple...*

Or

Interactive group subject1: *as idea is: ...*

Interactive group subject2: *familiar with mine. We can give advice.. the application gives advice on ...*

Interactive group subject3: *I understand*

Ideas with high cost, implementation risk or high complexity were discussed to be improved or combined with the other ideas to be amended. Reasonable ideas feature were approved by the group members.

Interactive group subject1: *Sensor is the problem maybe...*

Interactive group subject2: *But for each device there should be a separate sensors*

Interactive group subject3: *The sensor can be...*

Interactive group subject2: *maybe there should be some set of sensors...*

Interactive group subject1: *Yes why not. a family of sensors and devices...*

Interactive group subject4: *yea, that's true. Some set of sensors that would ...*

Interactive group subject2: *I like this*

Interactive group subject4: *I love that*

Interactive group subject1: *Sure*

Interactive group subject3: *I agree*

Or

Interactive group subject1: *I had this idea also, but refused it because...*

Interactive group subject2: *it was only for private use. You see ... but comparing it with others (must think about privacy policy) may be good idea*

Or

Interactive group subject1: *as idea is: ...*

Interactive group subject2: *the risk is that we need the requirements from the companies on...*

Interactive group subject3: *yes that's the problem.*

Interactive group subject4: *But the product will be cheap. I mean it should be easy to mount*

Interactive group subject1: *yes*

Interactive group subject2: *yes*

6.3.4 Subjects' satisfaction

Table 35 shows the responses of the subjects that answered whether they are satisfied with idea synthesis process they contributed:

Statistic					
Treatment	Definitely dissatisfied	Dissatisfied	Unsure	Satisfied	Definitely satisfied
Bilateral communication	3	9	14	14	3
Interactive groups	1	1	12	16	4

Table 35, Subjects' satisfaction with the idea synthesis process

Descriptive Statistics					
Treatment	Mean value	Mode	Positive Response (%)	Neutral Response (%)	Negative Response (%)
Bilateral communication	3.12	4	39.53	32.56	27.91
Interactive group	3.62	4	58.82	35.29	5.88

Table 36, Descriptive statistics for subjects' satisfaction with the idea synthesis process

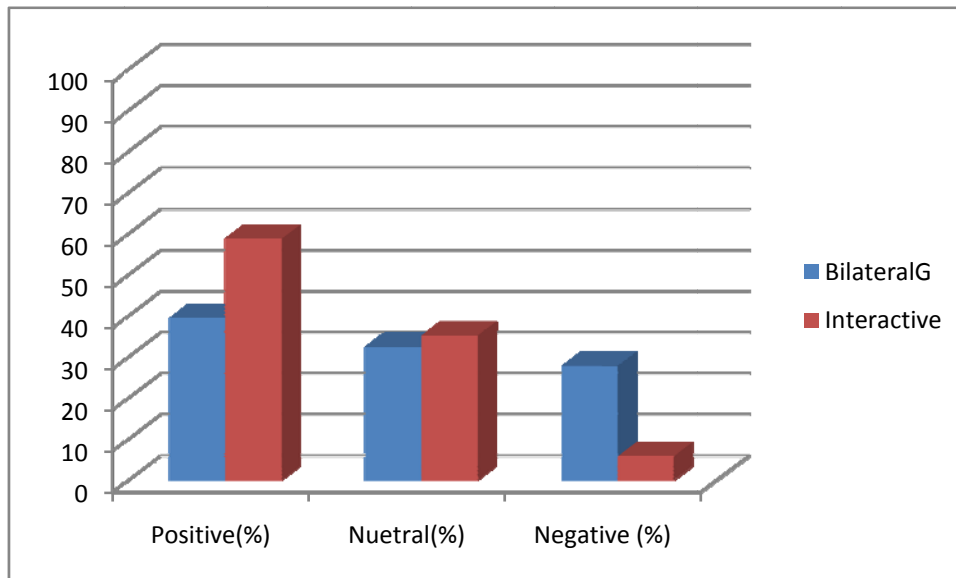


Figure 9, Percentage of subjects' satisfaction with the idea synthesis process

The descriptive statistics of collected data (Table 36) indicates that subjects in interactive group (58.82%) were more satisfied than subjects in bilateral communication channel (39.53%). However, an approximate percentage of subjects in both structures (32.56% in bilateral communication channel and 35.29% in interactive group) mentioned that they were unsure if the process was satisfactory or not. The descriptive statistics shows that many subjects in bilateral communication channels (27.91%) were unsatisfied when compared to the interactive group (5.88%). In order to understand why the number of satisfied subjects in the bilateral communication channels is low compared to the interactive group's subjects and to identify the problems in the interactive group structure which reduced the subject's satisfaction, the subjects' conversations and their answers to the post-questionnaire question (the ones that asked subjects satisfaction/dissatisfaction reasons and their comments about the whole experiment) were analyzed. The problems mentioned by the subjects and described in [section 6.3.2.1](#) influenced the subjects' satisfaction in the both structures.

6.4 Multiple-case study validity threats

6.4.1 Construct validity

Data collection based on subjective judgment and lack of sufficient measurement tools are threats to the construct validity [81]. To reduce this threat first, two sources of data were used in this study. Most of the data were collected from the direct observation of the participants' chats. Second, the

accuracy of the collected data through observation was checked and validated via the participants' responses to the open-ended questions in post questionnaire.

6.4.2 Internal Validity

Internal validity refers to "the extent to which the reported findings accurately reflect the concept under investigation" [81]. In other words, the research finding should not be affected by factors other than the planned ones. This threat is eliminated through replication of the study with several cases. However, the duration of the experiment may influence the participants' behavior and responses. Total duration of idea generation, group discussion and questionnaire completion which is about 1 hour and 45 minutes may cause that participants lose their interest in completing some of these tasks. To dismiss this threat, participants were given a break for 5 minutes after idea generation part and another break for 5 minutes after idea synthesis part.

6.4.3 External Validity

The external validity is concerned with generalizing the conclusion. R. Campbell et al. define external validity: "the extent to which the findings from a small number of cases can be generalized" [81]. Since this research used multiple-case study, the generalizing of the finding is enhanced through the replication procedure. The detailed information of participants' responses and dialog are presented in a narrative way to make the readers able to evaluate the utility of this study and its results in their own situation.

6.4.4 Reliability

According to R. Campbell et al., reliability refers to "the extent to which consistent results would be obtained if the same procedures were followed by different researchers" [81]. To enhance the reliability of the study, the multiple-case study is designed through delineating of the related research questions and the approaches of collecting data ([section 6.2](#)). The analysis of data is explained in [section 7.3](#).

7 DISCUSSION

The experiment and a follow-up survey were conducted to not only compare the effectiveness of the interactive group and the bilateral communication for idea synthesis in terms of novelty, feasibility, impact value and stakeholder support in addressing the RQ1 but also to identify factors that affect achieving an agreement among the group members in both structures through collecting the subjects' feedbacks and viewpoints in answering the RQ3. Additionally, through the content analysis it was attempted to address RQ2 to extract the consistent pattern of the idea synthesizing in both treatments.

The results of the experiment showed that no statistically significant difference is found between the bilateral communication and interactive group for the dependent variables namely synthesized ideas novelty, feasibility, impact value, and stakeholder support. However, the quantitative data and box plots shows that the interactive group is slightly better than bilateral communication in case of stakeholder support but due to insignificant results through Mann-Whitney-U test and the low statistical power of the test, the related null hypothesis cannot be rejected. The result of the hypothesis testing for each of the dependent variables revealed that neither of the null hypotheses related to RQ1 was rejected. One important reason for the study not being able to reject the null hypothesis is low statistical power of the test. It was revealed the statistical power of the test is 0.30 which imply that due to small effect size, we have only 30% chance of finding statistically significant results ([Section 5.4.3](#)).

Furthermore, the post questionnaire results indicate that the some of the subjects in bilateral communication structure prefer to perform idea synthesis through interactive group. This was revealed from the subjects' responses to the question which asked them to provide feedback based on their idea synthesizing process experience. As some bilateral communication participants mention: *"it was hard to discuss with 5 ppl at one time. It would have been better to discuss it with only two or three"*, *"I would have preferred to have a discussion with everybody at the same time. Each one exposes his idea. Then we take each idea and we discuss it"* and *"It much more useful, if the participants can talk to each other; or if all participants are in the same group. So the ideas can be combined once, and you do not have to repeat everything four times"*. However, lack of leadership and communication management in both interactive group and bilateral channel discussion respectively was an issue as it can be seen in [section 6.3.3](#).

Another possible explanation of the low idea synthesis effectiveness is that the quality of synthesized idea was related to the quality of the available ideas; as two bilateral participants note *"No one submit a good idea to improve the main idea"* and *"the others are well known (not less good, but not new)"*. Consistent with previous research on bilateral communication, what makes the bilateral communication successful is the extent the partners complete the missing resources (here the knowledge) of each other [51, 34]. There is no point in sharing when partners hold identical assets (here knowledge) and, it is too difficult to have a successful result when the partners are far from each other and have ir-related assets [51, 34]. The results from questionnaire also show that the interactive group subjects were more familiar with the experiment topic and the negotiation techniques. This caused in generation of more effective initial ideas by interactive group members than initial ideas generated by bilateral communication members. One of the interactive participant notes *"It was interesting to see how other people think of this theme. Also because I know what they have done before (job)"*.

We used the electronic and writing procedure for idea generation and idea discussion to ease the idea synthesis, but reading and writing process restrict the participants in discussing and combining their ideas. As one participant in bilateral channel notes *"This should be done with voice chat, I'm restricted in my expression and communication speed when using text"*. Similarly one of the interactive group participant states *"I am Unsure I do not like Skype chat I prefer real conversation"*. However according to [9, 69] this problem can be addressed through the use the group of eight members.

Furthermore, the effectiveness of ideas synthesis is enhanced when not only individuals attend to the shared ideas and are motivated to synthesize the ideas [75] but also when they are open to share their ideas [77,78]. As one of the bilateral channel member states *"Knowing each other help to be serious in virtual communication. And I didn't know other people in the chat. First contact to teammate"*

should be physical.” This is consistent with some past research; the effectiveness of a bilateral collaboration depends on partners’ relational embeddedness [36]. This means choosing partners is risky and partners who have similar routing and way of thinking are more likely to construct a successful collaboration [36]. Frequent cooperation leads to these similarities [76] and also cause trust between partners [36]. The frequent cooperation provides knowledge about partners’ competencies which is important in completing or improving information [36].

In [section 6.3.3](#) we have listed the consensus challenges and determinant in interactive groups and bilateral communication channels. Sufficient explanation is provided to outline what challenges hinder the consensus in both interactive group and bilateral communication channels and what factors are the consensus determinants in these two structures. In brief, it must be understood that both structures require planning and management skills to lead the discussion and a certain level of commitment from all involved participants. Negative points such as disorder and chaos in the interactive group structure and confusion in bilateral communication structure are possible to be addressed through the use of discussion facilitator.

8 CONCLUSION & FUTURE WORK

In this study, we compare the effectiveness of two group structures for idea synthesis for software product innovation. First, the group of individuals synthesizes the generated ideas as a team. Alternately, in a bilateral communication structure, the individuals synthesize the generated ideas through bilateral communication channels. Both structures have the same duration of time to perform the idea synthesis task. In contrast with some past research that did not use any specific performance metric (generally the number of generated ideas or average quality of ideas), we specify the quality of synthesized ideas in terms of novelty, feasibility, value impact and stakeholder support instead. It was found that there is no statistically significant difference between the bilateral communication channel and interactive group for effectiveness of idea synthesis. However in real world projects the success of idea synthesis depends on not only the software product manager's ability to manage the participants and the time but also having a history with the participants and their backgrounds. Selection of participants based on their previous cooperation experience and background leads to improvement of trust, motives and cooperation.

Our findings show the advantage of interactive group for idea combination which was suggested by previous researches is not supported when comparing with bilateral communication channels. However, several factors such as the management ability of the participant, the ideas contexts and participants' interest influence the idea synthesis process. These factors provide the basis for further research on idea synthesis process and enhancement. In our results it was demonstrated that both structures suffer from lack of management in time and communication. This suggests an opportunity for future research. The self-organized team working which was used in this research can be replaced with the facilitated workshops and team working which is most accepted by the software product managements and project leaders.

In the following each research question along with its answer is described briefly.

- **Research question 1**

Is an interactive group more effective than bilateral communication for idea synthesis?

The results of the experiment evaluate effectiveness of bilateral communication and interactive group structures for idea synthesis. The effectiveness of idea synthesis is evaluated based on synthesized ideas novelty, feasibility, impact value and stakeholder support. In brief, there is no statistically significant difference between the bilateral communication channel and interactive group for idea synthesis. The results of the experiment for synthesized ideas novelty, feasibility, impact value and stakeholder support are not statistically significant to reject the null hypothesis.

- **Research question 2**

How idea synthesis is performed in bilateral communication and interactive group?

In bilateral communication channels, subjects perform idea synthesis either concurrently or sequentially (74.4% and 25.6% respectively). There is no difference in ideas discussion between the participants who share their ideas with other channel concurrently or sequentially.

In interactive group, subjects after sharing their ideas check if the ideas are IT-based solution or not. Ideas which do not come from the IT field are discussed in order to be converted into an IT solution. Afterward the group members focus on searching and extracting the parts in the shared ideas which lead to the combinations. Finally the synthesized idea is suggested by one the group members and again discussed until be approved by most of the group members.

- **Research question 3**

What factors influence achieving an agreement among the group members in bilateral communication and interactive group during the experiment?

The consensus determinants in bilateral communication channels are: Ideas clusters, ideas realization features, subject' self-confidence about his/her idea.

The consensus determinants in interactive groups are: Similar points in the ideas, ideas realization feature (cost and its guarantee to be available), group leadership, subject's cooperation interests, use of all ideas.

The consensus challenges in bilateral communication channels are: Idea cluster, Idea with limitation features, similar ideas, idea realization, not sharing the idea, lack of communication, unilateral

communication, written communication, communication planning, time, low self-confidence & reliance on others.

The consensus challenges in interactive groups are: Privacy violation, ideas realization feature (cost and its guarantee to be available), communication language, written communication, lack of leadership, lack of conclusion, time.

9 REFERENCES

- [1] J.-A. Johannessen, B. Olsen, and G. T. Lumpkin, "Innovation as newness: what is new, how new, and new to whom?," *European Journal of Innovation Management*, vol. 4, no. 1, pp. 20–31, Mar. 2001.
- [2] T. Gorschek, S. Fricker, K. Palm, and S. Kunsman, "A lightweight innovation process for software-intensive product development," *IEEE software*, vol. 27, no. 1, pp. 37–45, 2010.
- [3] L. Gumusluoğlu and A. Ilsev, "Transformational Leadership and Organizational Innovation: The Roles of Internal and External Support for Innovation*," *Journal of Product Innovation Management*, vol. 26, no. 3, pp. 264–277, 2009.
- [4] E. W. Coakes, P. A. C. Smith, and D. Alwis, "Sustainable Innovation and Right to Market," *Information Systems Management*, vol. 28, no. 1, pp. 30–42, 2011.
- [5] J. Kandampully and R. Duddy, "Competitive advantage through anticipation, innovation and relationships," *Management Decision*, vol. 37, no. 1, pp. 51–56, Feb. 1999.
- [6] C. D. Charitou and C. C. Markides, "Responses to disruptive strategic innovation," *MIT Sloan Management Review*, vol. 44, no. 2, pp. 55–64, 2003.
- [7] P. Hyland and R. Beckett, "Engendering an innovative culture and maintaining operational balance," *Journal of Small Business and Enterprise Development*, vol. 12, no. 3, pp. 336–352, Jan. 2005.
- [8] J. Grudin, "Computer-supported cooperative work: history and focus," *Computer*, vol. 27, no. 5, pp. 19–26, May 1994.
- [9] N. W. Kohn, P. B. Paulus, and Y. Choi, "Building on the ideas of others: An examination of the idea combination process," *Journal of Experimental Social Psychology*, vol. 47, no. 3, pp. 554–561, May 2011.
- [10] E. Burton Swanson, "Information Systems Innovation among Organizations," *Management Science*, vol. 40, no. 9, pp. 1069–1092, Sep. 1994.
- [11] S.A. Fricker, "Software Product Management", ", in in Software for People, A. Maedche, A. Botzenhardt, and L. Neer, (Eds.), *Management for Professionals*, Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 53–81, 2012.
- [12] M. Kivimäki, H. Lämsäsalmi, M. Elovainio, A. Heikkilä, K. Lindström, R. Harisalo, K. Sipilä, and L. Puolimatka, "Communication as a determinant of organizational innovation," *R&D Management*, vol. 30, no. 1, pp. 33–42, 2000.
- [13] S. Nambisan, "Software firm evolution and innovation–orientation," *Journal of Engineering and Technology Management*, vol. 19, no. 2, pp. 141–165, Jun. 2002.
- [14] G. Akman and C. Yilmaz, "Innovative capability, innovation strategy and market orientation: an empirical analysis in Turkish software industry," *International Journal of Innovation Management*, vol. 12, no. 1, p. 69, 2008.
- [15] I. Nonaka and H. Takeuchi, "The knowledge-creating company," *Harvard business review*, vol. 85, no. 7/8, p. 162, 2007.
- [16] M. Assink, "Inhibitors of disruptive innovation capability: a conceptual model," *European Journal of Innovation Management*, vol. 9, no. 2, pp. 215–233, Apr. 2006.
- [17] A. Muller, L. Välikangas, and P. Merlyn, "Metrics for innovation: guidelines for developing a customized suite of innovation metrics," *Strategy & Leadership*, vol. 33, no. 1, pp. 37–45, Feb. 2005.
- [18] J. L. Carlo, K. Lyytinen, and G. M. Rose, "Internet computing as a disruptive information technology innovation: the role of strong order effects1," *Information Systems Journal*, vol. 21, no. 1, pp. 91–122, 2011.
- [19] H. Romijn and M. Albaladejo, "Determinants of innovation capability in small electronics and software firms in southeast England," *Research Policy*, vol. 31, no. 7, pp. 1053–1067, Sep. 2002.
- [20] P. Koudal and G. C. Coleman, "Coordinating operations to enhance innovation in the global corporation," *Strategy & Leadership*, vol. 33, no. 4, pp. 20–32, Aug. 2005.
- [21] V. Nee, J. Kang, and S. Opper, "A Theory of Innovation: Market Transition, Property Rights, and Innovative Activity," *Journal of Institutional and Theoretical Economics JITE*, vol. 166, no. 3, pp. 397–425, 2010.
- [22] D. A. Schon, "Champions for Radical New Inventions," *Harvard Business Review*, vol. 41, no. 2, pp. 77–86, Mar. 1963.
- [23] J. Görs, G. Horton, and N. Kempe, "A Collaborative Algorithm for Computer-Supported Idea Selection in the Front End of Innovation," in *2012 45th Hawaii International Conference on System Sciences*, 2012, pp. 217–226.

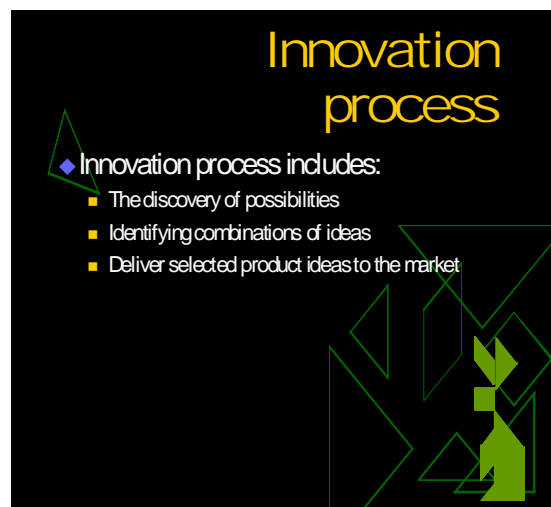
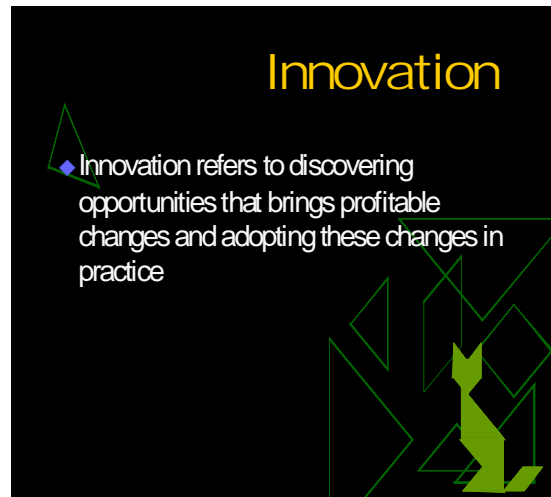
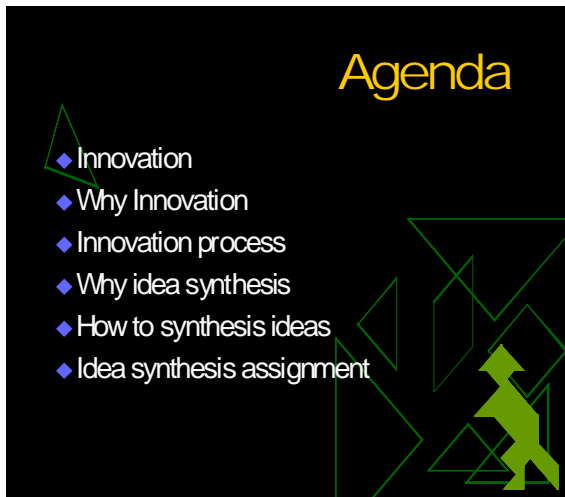
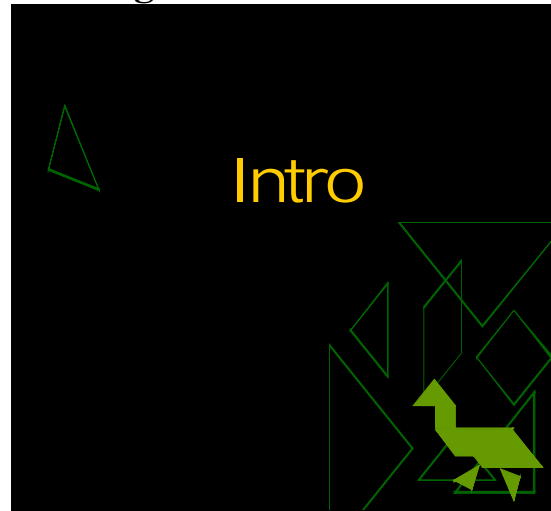
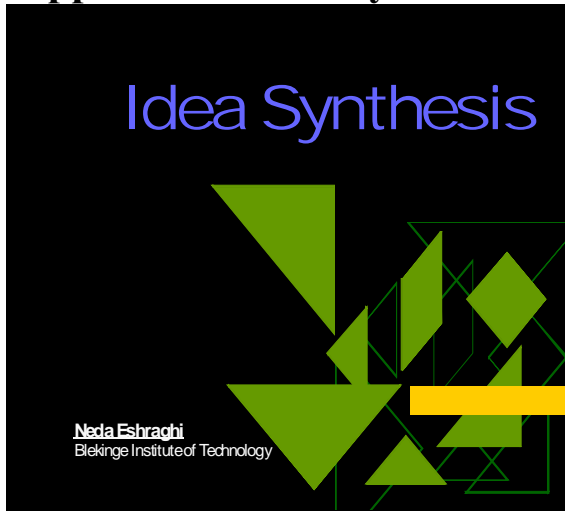
- [24] E. Lumsdaine and M. Lumsdaine, "Creative problem solving," *Potentials, IEEE*, vol. 13, no. 5, pp. 4–9, Jan. 1994.
- [25] A. Cummings, A. Schlosser, and H. Arrow, "Developing complex group products: Idea combination in computer-mediated and face-to-face groups," *Computer Supported Cooperative Work (CSCW)*, vol. 4, no. 2, pp. 229–251, 1995.
- [26] T. Bakici, E. Almirall, and J. Wareham, "The underlying mechanisms of open innovation intermediaries," in *R&D Management Conference, Manchester*, 2010, vol. 30.
- [27] L. Singer, N. Seyff, and S. A. Fricker, "Online social networks as a catalyst for software and IT innovation," in *Proceedings of the 4th international workshop on Social software engineering*, New York, NY, USA, 2011, pp. 1–5.
- [28] D. Leonard and S. Sensiper, "The Role of Tacit Knowledge in Group Innovation," *California Management Review*, vol. 40, no. 3, pp. 112–132, Spring98 1998.
- [29] J. Hautz, K. Hutter, J. Fuller, K. Matzler, and M. Rieger, "How to Establish an Online Innovation Community? the Role of Users and Their Innovative Content," in *2010 43rd Hawaii International Conference on System Sciences (HICSS)*, 2010, pp. 1–11.
- [30] E. F. Rietzschel, B. A. Nijstad, and W. Stroebe, "Relative accessibility of domain knowledge and creativity: The effects of knowledge activation on the quantity and originality of generated ideas," *Journal of Experimental Social Psychology*, vol. 43, no. 6, pp. 933–946, Nov. 2007.
- [31] P. B. Paulus and V. R. Brown, "Toward More Creative and Innovative Group Idea Generation: A Cognitive-Social-Motivational Perspective of Brainstorming," *Social and Personality Psychology Compass*, vol. 1, no. 1, pp. 248–265, 2007.
- [32] P. B. Paulus and V. R. Brown, "Toward More Creative and Innovative Group Idea Generation: A Cognitive-Social-Motivational Perspective of Brainstorming," *Social and Personality Psychology Compass*, vol. 1, no. 1, pp. 248–265, 2007.
- [33] E. F. Rietzschel, B. A. Nijstad, and W. Stroebe, "Productivity is not enough: A comparison of interactive and nominal brainstorming groups on idea generation and selection," *Journal of Experimental Social Psychology*, vol. 42, no. 2, pp. 244–251, Mar. 2006.
- [34] H. W. Chesbrough, "The era of open innovation," *MIT SLOAN MANAGE REV*, vol. 44, no. 3, pp. 35–41, 2003.
- [35] W. W. Powell, K. W. Koput, and L. Smith-Doerr, "Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology," *Administrative science quarterly*, pp. 116–145, 1996.
- [36] R. Cowan, N. Jonard, and J. B. Zimmermann, "Bilateral collaboration and the emergence of networks," *Management Science*, vol. 53, no. 7, pp. 1051–1067, 2007.
- [37] V. M. Story, E. C. Cameron, and K. Walsh, "The Importance of Relationships and Networks for Successful Radical Innovation," in *Exploiting the b2b knowledge network: new perspectives and core concepts, 23rd Industrial Marketing and Purchasing (IMP) Conference*, 2007.
- [38] P. B. Paulus and V. R. Brown, "Enhancing ideational creativity in groups," *Group creativity: Innovation through collaboration*, pp. 110–136, 2003.
- [39] M. Diehl and W. Stroebe, "Productivity loss in brainstorming groups: Toward the solution of a riddle," *Journal of Personality and Social Psychology*, vol. 53, no. 3, pp. 497–509, 1987.
- [40] D. W. Taylor, P. C. Berry, and C. H. Block, "Does Group Participation When Using Brainstorming Facilitate or Inhibit Creative Thinking?," *Administrative Science Quarterly*, vol. 3, no. 1, pp. 23–47, Jun. 1958.
- [41] E. A. Smith, "The role of tacit and explicit knowledge in the workplace," *Journal of Knowledge Management*, vol. 5, no. 4, pp. 311–321, Dec. 2001.
- [42] B. Bernstein and P. J. Singh, "An integrated innovation process model based on practices of Australian biotechnology firms," *Technovation*, vol. 26, no. 5–6, pp. 561–572, May 2006.
- [43] S. G. Scott and R. A. Bruce, "Determinants of Innovative Behavior: A Path Model of Individual Innovation in the Workplace," *The Academy of Management Journal*, vol. 37, no. 3, pp. 580–607, Jun. 1994.
- [44] A. H. V. de Ven, "Central Problems in the Management of Innovation," *Management Science*, vol. 32, no. 5, pp. 590–607, May 1986.
- [45] O. Janssen, E. van de Vliert, and M. West, "The bright and dark sides of individual and group innovation: a Special Issue introduction," *Journal of Organizational Behavior*, vol. 25, no. 2, pp. 129–145, 2004.
- [46] B. A. Nijstad and C. K. W. De Dreu, "Creativity and Group Innovation," *Applied Psychology*, vol. 51, no. 3, pp. 400–406, 2002.
- [47] K. Girotra, C. Terwiesch, and K. T. Ulrich, "Idea Generation and the Quality of the Best Idea," *Management Science*, vol. 56, no. 4, pp. 591–605, Apr. 2010.

- [48] J. Singh and L. Fleming, "Lone Inventors as Sources of Breakthroughs: Myth or Reality?," *Management Science*, vol. 56, no. 1, pp. 41–56, Jan. 2010.
- [49] K. Leggett Dugosh and P. B. Paulus, "Cognitive and social comparison processes in brainstorming," *Journal of Experimental Social Psychology*, vol. 41, no. 3, pp. 313–320, May 2005.
- [50] V. L. Putman and P. B. Paulus, "Brainstorming, Brainstorming Rules and Decision Making," *The Journal of Creative Behavior*, vol. 43, no. 1, pp. 29–40, 2009.
- [51] R. Cowan, N. Jonard, and J.-B. Zimmermann, "Bilateral Collaboration and the Emergence of Innovation Networks," *Management Science*, vol. 53, no. 7, pp. 1051–1067, Jul. 2007.
- [52] W. W. Powell, 'Neither market nor hierarchy: Network forms of organization'. In B. M. Staw and L. L. Cummings (eds.), *Research in Organizational Behavior*. JAI Press, Greenwich, CT, 12, pp. 295–336. 1990.
- [53] C. Ebert, "The impacts of software product management," *Journal of Systems and Software*, vol. 80, no. 6, pp. 850–861, Jun. 2007.
- [54] Bakici, T., Admirall, E., & Wareham, J. (2010). The underlying mechanisms of open innovation intermediaries. In *R&D management conference*, University of Manchester, 30 June–02 July 2010.
- [55] J. Howe, "The Rise of Crowdsourcing," *Wired*, June 2006.
- [56] K. Carley, "A Theory of Group Stability," *American Sociological Review*, vol. 56, no. 3, p. 331, Jun. 1991.
- [57] M. Ozer, "What do we know about new product idea selection," *Center for Innovation Management Studies*, 2005.
- [58] J. W. Creswell, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches*. SAGE, 2002.
- [59] E. Rhoades, "[Commentary on] Literature Reviews," *VOLTA REV*, vol. 111, no. 3, pp. 353–368, Fall 2011.
- [60] C. Wohlin, *Experimentation in software engineering: an introduction*, vol. 6. Springer, 2000.
- [61] H.-F. Hsieh and S. E. Shannon, "Three Approaches to Qualitative Content Analysis," *Qual Health Res*, vol. 15, no. 9, pp. 1277–1288, Nov. 2005.
- [62] R. Suddaby, "From the Editors: What Grounded Theory is Not," *ACAD MANAGE J*, vol. 49, no. 4, pp. 633–642, Aug. 2006.
- [63] Dawson, C., *Projects in Computing & Information Systems: A Students Guide*, Addison-Wesley, ISBN: 0-3212-6355-5 (June 2005).
- [64] S. Elo and H. Kyngäs, "The qualitative content analysis process," *Journal of Advanced Nursing*, vol. 62, no. 1, pp. 107–115, 2008.
- [65] R. B. Gallupe, G. DeSanctis, and G. W. Dickson, "Computer-based support for group problem-finding: An experimental investigation," *MIS quarterly*, vol. 12, no. 2, pp. 277–296, 1988.
- [66] R. Brent, L. M. Bastianutti, and W. H. Cooper, "Unblocking brainstorming," *Journal of Applied Psychology*, vol. 76, no. 1, pp. 137–142, 1991.
- [67] A. C. McFadden and B. J. Price, "SKYPE: A Synchronous Tool for Computer-Mediated Collaboration," *International Forum of Teaching and Studies*, vol. 3, no. 2, p. 37, Jul. 2007.
- [68] H. W. Chesbrough, *Open innovation: the new imperative for creating and profiting from technology*. Harvard Business Press, 2003.
- [69] A.-L. Mention, "Co-operation and co-opetition as open innovation practices in the service sector: Which influence on innovation novelty?," *Technovation*, vol. 31, no. 1, pp. 44–53, Jan. 2011.
- [70] A. H. V. D. Ven and A. L. Delbecq, "The Effectiveness of Nominal, Delphi, and Interacting Group Decision Making Processes," *ACAD MANAGE J*, vol. 17, no. 4, pp. 605–621, Dec. 1974.
- [71] J. W. Tukey, *Exploratory Data Analysis*. Addison-Wesley Publishing Company, 1977.
- [72] S. K. Kachigan, *Statistical Analysis: An Interdisciplinary Introduction to Univariate & Multivariate Methods*. Radius Press, 1986.
- [73] T. Dyba, V. B. Kampenes, and D. I. K. Sjøberg, "A systematic review of statistical power in software engineering experiments," *Information and Software Technology*, vol. 48, no. 8, pp. 745–55, 2006.
- [74] D. M. DeRosa, C. L. Smith, and D. A. Hantula, "The medium matters: Mining the long-promised merit of group interaction in creative idea generation tasks in a meta-analysis of the electronic group brainstorming literature," *Computers in Human Behavior*, vol. 23, no. 3, pp. 1549–1581, May 2007.
- [75] P. B. Paulus and H.-C. Yang, "Idea Generation in Groups: A Basis for Creativity in Organizations," *Organizational Behavior and Human Decision Processes*, vol. 82, no. 1, pp. 76–87, May 2000.

- [76] C. Garcia-Pont and N. Nohria, "Local versus global mimetism: the dynamics of alliance formation in the automobile industry," *Strategic Management Journal*, vol. 23, no. 4, pp. 307–321, 2002.
- [77] G. Piccoli and B. Ives, "Trust and the Unintended Effects of Behavior Control in Virtual Teams," *MIS Quarterly*, vol. 27, no. 3, pp. 365–395, Sep. 2003.
- [78] L. P. Robert Jr., A. R. Dennis, and Y.-T. C. Hung, "Individual Swift Trust and Knowledge-Based Trust in Face-to-Face and Virtual Team Members," *Journal of Management Information Systems*, vol. 26, no. 2, pp. 241–279, 2009.
- [79] S. Jalali and C. Wohlin, "Systematic literature studies: database searches vs. backward snowballing," in *Proceedings of the ACM-IEEE international symposium on Empirical software engineering and measurement*, New York, NY, USA, 2012, pp. 29–38.
- [80] P. Baxter, S. Jack, "Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers". *The Qualitative Report*, 13(4), 544-559, 2008.
- [81] R. Campbell, C.E. Ahrens, "Innovative community services for rape victims: An application of multiple case study methodology". *American Journal of Community Psychology*, 26, 537-571, 1998.

APPENDICES

Appendix A- Idea synthesis home assignment slides



Why idea synthesis

- ◆ We need to select most efficient ideas
 - Development of all ideas is neither feasible nor desirable
- ◆ Some generated ideas are complementary and some might be similar
- ◆ Innovation requires considering and merging diverse knowledge and personal ideas

How to synthesize ideas

- ◆ Communication and interpersonal interaction in different ways
- ◆ Benefit:
 - Sufficient understanding of different ideas towards the identification of most promising (combinations) of ideas

Idea synthesis assignment

Idea synthesis assignment

- ◆ The purpose of this assignment is to gain insight into the process of negotiation and idea synthesis.
- ◆ In this assignment you are expected to:
 - The first step: generate idea individually for a given problem
 - The second step: work in a group setting to synthesize your ideas

Process Overview

- ◆ A discussion on innovative ideas will be carried out via Skype.
- ◆ It will be in English through instant message and not voice chat.
- ◆ The whole assignment takes about 1 hour and 45 minutes.
- ◆ You have to pick an available time-slot now and provide your Skype ID and email-address.
- ◆ Discussions will start on the 22th November and run over 3 days.

Next Step 1

- ◆ Reserve a time-slot via the doodle link for performing the assignment.
 - <http://doodle.com/xm6n6wx55k7a58nr>
 - Please state your first name and your family name when booking the time-slot
- ◆ Note that each time-slot is limited to only five students. Hence if a time-slot is full, it becomes unavailable and you must book another one which is available. In case you have problems contact Neda Eshraghi.
- ◆ If you are a group of five people and you already have agreed on another time slot, please just make a suggestion.

Next Steps 2

- ◆ Use the following link :

<https://docs.google.com/spreadsheet/viewform?formkey=dZPMzFLUzhKWHJQTTBPOWRQZWx5dWc6VQ>

- To receive the initial instruction of the assignment
- To submit your Skype ID and email address

Important Deadlines

- ◆ Deadline for time reservation (Step 1) and submitting your Skype ID and email address (Step 2) is Wednesday, November 21, 2012 at 11.00 PM
- ◆ You will also receive a confirmation email regarding the date and time when you need to be online via Skype.

Questions

- ◆ In cases you have questions please contact

["neda.eshraghi@gmail.com"](mailto:neda.eshraghi@gmail.com)

Appendix B-Experimenter instruction

1.1 Idea Generation

The experiment consists of two parts. In the first part, participants are asked to generate and send individually their most prominent ideas or solution for the given topic to the experimenter. In the second part they must share and combine their ideas to achieve a better idea in two different structures. This technique is the second activity after idea generation and before idea implementation in the innovation process. It is used to achieve the most new, unique, original, feasible and creative ideas. It is not used to solve everyday problems.

Idea Generation

Step	Actor	Description	Materials	Duration	Artifacts
1	Experimenter	Before the experiment, ask all participants to make a Skype ID, send their names and Skype IDs to the experimenter. Also they are required to add the "experimenter_terminal" in their contacts.	"General Experiment Instruction for the participants" link, Skype software & Experimenter's Skype ID		Participants' e-mail addresses, names and Skype – IDs
2	Experimenter	Add contacts of all participants who approved to participate and made the Skype contact request before the experiment	Participants' Skype ID through the "General Experiment Instruction for the participants" link		List of participants' ID
3	Experimenter	Assigning each individual randomly to groups of 4 to 6.	List of participations' Skype ID		Groups of 4 to 6 participants
4	Participants & Experimenter	Get online in Skype (the start of the experiment)	Installed and access to Skype software,		
5	Experimenter	Sending idea generation instruction link to each individual	Idea generation instruction link		
6	Experimenter	Asking each participant to open and read the link	"Please open the given link and read the instruction, you will have 10 minutes.", message		
7	Experimenter	Making time for participants to read instruction		10 min	
8	Experimenter	Informing each individual about his or her group-members' Skype ID & name	Skype message, group members' ID & name		
9	Experimenter	Sending the Pre-Questionnaire link	Pre-Questionnaire link		
10	Experimenter	Asking each participant to fill and submit the Pre-Questionnaire form.	"Please open the given link and answer the given questions. You will have 10 minutes.", message		
11	Experimenter	Recording the time since the link is sent to the participants		10 min	

Step	Actor	Description	Materials	Duration	Artifacts
12	Participants	Filling and submitting the Pre- Questionnaire	Pre-Questionnaire link	10 min	Filled Pre- Questionnaire Forms
13	Experimenter	Sending the “Innovation Proposal (Individual)” form to each individual	“Innovation Proposal (Individual)” form		
14	Experimenter	Asking participants to download the “Innovation Proposal (individual)” form individually	“Please download the given file, fill it and send your proposal form back to the experimenter in 25 minutes”, message		
15	Experimenter	Sending a "START" message to the participants to start idea generation task	Individual Skype contacts, "START", message		
16	Experimenter	Recording the time since the message is sent for idea generation		25 min	
17	Participants	Generate new ideas and put the best on the form and keep a copy	“Innovation Proposal (Individual)” form	25 min	Filled “Innovation Proposal (individual)” form
18	Experimenter	Sending a "STOP" message to the participants to stop idea generation task	Individual Skype contacts, "STOP", message		
19	Experimenter	Receiving filled “Innovation Proposal”			
20	Experimenter	Making a break time	“Now, we will have a break for 5 minutes. In the next part, I will guide you through group channels in which you be invited.”, message	5 min	

1.2 Idea Synthesis

In the second part of the experiment, it is aimed to understand how generated ideas can be joined into still better ideas by grouping participants in two different settings. For this purpose, it is needed to make groups of participants for two structures; let them share, pick and combine the best pieces in their previously generated ideas and finally each of them sends his or her best final idea to the experimenter. After making groups, the experimenter must assign these groups to the bilateral and group settings randomly.

Group Idea Synthesis

Step	Actor	Description	Materials	Durati on	Artifacts
1	Experimenter	Creating a Skype group and Sending the message to each participant to determine the channel for sending the material and commands	Experimenter contact channel, "You will receive all the files and links through this channel", message		
2	Experimenter	Sending the message to each group to determine the communication channels via Skype group channel	"You can communicate with your fellow group members through this communication channel" message		
3	Experimenter	Sending the link of "Group idea synthesis instruction" to each group	Group Idea Synthesis Instruction link, Group channels		
4	Experimenter	Asking each group to open and read the link individually	"Please open the given link and read the instruction. You have 10 minutes.", message		
5	Experimenter	Making time for participants to read the instruction		10 min	
6	Experimenter	Sending the "Innovation Proposal (Synthesized)" form to the participants	"Innovation Proposal (Synthesized)" forms		
7	Experimenter	Asking participants to download the "Innovation Proposal (Synthesized)" individually	"Please download the given file, read and fill the form and send it back to me in 25 minutes"		
8	Experimenter	Sending a "START" message to the participants to start idea synthesis task	"START", message		
9	Experimenter	Recording the time since the message is sent for synthesizing task		25 min	
10	Participants	Sharing generated ideas and conducting idea synthesis	Skype Group	25 min	Generate d synthesis
11	Participants	Putting their best synthesized idea on the "Innovation Proposal (Synthesized)" form	"Innovation Proposal (Synthesized)" form	25 min	Filled "Innovati on Proposal

Step	Actor	Description	Materials	Duration	Artifacts
		and sending it individually.			(Synthesized)" form
12	Experimenter	Sending a "STOP" message to the participants to stop idea synthesis task	"STOP", message		
13	Experimenter	Receiving filled "Innovation Proposal (Synthesized)"			Participants proposals
14	Experimenter	Making a break time	"Now, we will have a break for 5 minutes. Next, please open the link that will be given in 5 minutes and answer the questions. You will have 10 minutes to submit your answers." Message	5min	
15	Experimenter	Sending the Post-Questionnaire link	Post-Questionnaire link		
16	Experimenter	Recording the time since the link is sent to the participants		10 min	
17	Participants	Filling and submitting the Post-Questionnaire Forms	Post-Questionnaire link	10 min	Filled Post-Questionnaire
18	Experimenter	Thanking participants	"Thank you for your participation. You will receive a feedback for your final proposal as soon as possible. The analysis of your proposal will be used for the goal of this research and all results will be compiled in a summary form to protect confidentiality. You will be able to work with your team member(s) in the future and develop your idea, but this would be out of this experiment and its agents." message	10 min	

Bilateral Idea Synthesis

Step	Actor	Description	Materials	Duration	Artifacts
1	Experimenter	Sending the message to each participant to determine the channels for the material and commands	Experimenter contact channel, "You will receive all the files and links through this channel", message		
2	Experimenter	Sending the message to all sub-groups to determine the bilateral communication channels	"To communicate with this person please use this communication channel", message		
3	Experimenter	Sending the link of "Bilateral idea synthesis instruction" to each sub-group	"Bilateral Idea Synthesis Instruction" link		
4	Experimenter	Asking each group to open and read the link individually	"Please open the given link and read the instruction. You have 10 minutes.", message		
5	Experimenter	Making time for participants to read the instruction		10 min	
6	Experimenter	Sending the topic and the "Innovation Proposal (Synthesized)" form to the participants	"Innovation Proposal (Synthesized)"		
7	Experimenter	Asking participants to download the "Innovation Proposal (Synthesized)" individually	"Please download the given file, read and fill the form and send it back to me in 25 minutes", message		
8	Experimenter	Sending a "START" message to the participants to start idea synthesis task	"START", message		
9	Experimenter	Recording the time since the message is sent for synthesizing task		25 min	
10	Participants	Sharing generated ideas and conducting idea synthesis via sub-group channels	Skype sub-groups	25 min	Generated synthesis
11	Participants	Putting the best synthesized idea on the "Innovation Proposal (Synthesized)" form	"Innovation Proposal (Synthesized)" form		Filled "Innovation Proposal (Synthesized)" form
12	Experimenter	Sending a "STOP" message to the participants to stop idea synthesis task	"STOP", message		

Step	Actor	Description	Materials	Duration	Artifacts
13	Experimenter	Receiving filled “Innovation Proposal (Synthesized)”			Participants’ proposals
14	Experimenter	Making a break time	“Now, we will have a break for 5 minutes. Next, please open the link that will be given in 5 minutes and answer the questions. You will have 10 minutes to submit your answers.”, message	5min	
15	Experimenter	Sending the Post-Questionnaire link	Post-Questionnaire link		
16	Experimenter	Recording the time since the link is sent to the participants		10 min	
17	Participants	Filling and submitting the Post-Questionnaire Forms	Post-Questionnaire link		Filled Post-Questionnaire
18	Experimenter	Thanking participants	“Thank you for your participation. You will receive a feedback for your final proposal as soon as possible. The analysis of your proposal will be used for the goal of this research and all results will be compiled in a summary form to protect confidentiality. You will be able to work with your team member(s) in the future and develop your idea, but this would be out of this experiment and its agents.”, message	10 min	

2. Experiment Regulation

2.1 Idea generation phase

- To achieve the participants list and their Skype IDs, the experimenter must ask participants to make a Skype ID, send their IDs and add the “Experimenter-Terminal” in their contact lists by sending the participants the General Experiment Instruction for the participants link (<https://docs.google.com/spreadsheet/viewform?formkey=dDZPMzFLUzhKWHJQTTBPOWR0ZWx5dWc6MQ>).
- The Experimenter should add participants’ Skype ID.
- The experimenter should randomly assign participants to groups of 4 to 6.
- The Experimenter should use the following information to use Skype
 - Skype ID: Experimenter_Terminal
 - Skype password: *****
- The experimenter must send the link containing general instruction to the experiment (https://docs.google.com/file/d/0B_aQ9xHp27aYZTRIVmdyRmZ6emc/edit).
- Participants will receive the link of Idea generation instruction.
- The experimenter must inform each individual about his or her group-members’ Skype user-ID.
- The experimenter must send the participants the pre-questionnaire link (<https://docs.google.com/spreadsheet/viewform?formkey=dDJQsXc0eFJsVkh2TWpRNnY4ZDdjVFE6MQ>).
- Participants will be given 10 minutes to fill and submit the pre-questionnaire.
- The experimenter must record the time since the link is sent for 10 minutes. During this time the experimenter should be ready to answer any question.
- Participants will receive the “Innovation Proposal” form.
- The experimenter must send a message to the participants to start by sending “START”.
- The experimenter must record the time since the message is sent for 25 minutes.
- At the end of 25 minutes, the experimenter must send the “STOP” message to stop generating ideas.
- The experimenter will receive the filled “Innovation Proposal (Individual)” forms from participants.
- The experimenter should make a break for five minutes.

2.2 Idea Synthesis Regulation

Group Idea Synthesis phase

- The experimenter must create a Skype group including participants and the experimenter himself or herself.
- Participants individually will be asked to download files.
- The experimenter must send the link of instruction for the group idea synthesis phase (https://docs.google.com/file/d/0B_aQ9xHp27aYRXNRd3dadG1nVUk/edit, Group Idea Synthesis Instruction).
- The experimenter must ask the participants through Skype, to open the link individually and read the instruction carefully.
- Participants will be given 10 minutes to read the instruction.
- Participants will be informed about the group communication channels which they are allowed to use via receiving invitations from each group channel.
- The experimenter must send the Innovation Proposal (Synthesized) form to the participants.
- The experimenter should ask participants through Skype, to download the “Innovation Proposal (Synthesized)” individually.
- The experimenter should send a message to the participants to start by sending “START”.
- The experimenter should record the time since the message is sent for 25 minutes.
- Each participant has 25 minutes to share and improve his or her idea via group discussion and finally submit it to experimenter through Skype.
- At the end of 25 minutes, the experimenter should send the “STOP” message to stop idea combination.
- The experimenter should make a break for five minutes.
- The experimenter should send the participants the Post-Questionnaire link (<https://docs.google.com/spreadsheets/viewform?formkey=dFNPMGZRMnJKUnk0UWdiTjFIS3hHLWc6MQ>).
- Participants will be given 10 minutes to fill in the Post-Questionnaire and submit it.

Bilateral Idea Synthesis phase

- The experimenter must create the sub-groups of 3 including pair members of the original group and the experimenter himself or herself.
- Participants individually will be asked to download files.
- The experimenter must send the link of instruction for the bilateral idea synthesis phase (https://docs.google.com/file/d/0B_aQ9xHp27aYSTFJQVhhNGZkbjQ/edit).
- The experimenter must ask the participants through Skype, to open the link individually and read the instruction carefully.
- Participants will be given 10 minutes to read the instruction.
- Participants will be informed about the bilateral communication channels which they are allowed to use via receiving an invitation from each sub-group channel.
- The experimenter must send the Innovation Proposal (Synthesized) form to the participants via Skype group channels.
- The experimenter must ask participants through Skype, to download the “Innovation Proposal (Synthesized)” individually.
- The experimenter must send a message to the participants to start by sending “START”.
- The experimenter must record the time since the message is sent for 25 minutes.
- Each participant has 25 minutes to share and improve his or her idea via sub-group channel and finally submit it to experimenter through Skype.
- At the end of 25 minutes, the experimenter must send the “STOP” message to stop idea combination.
- The experimenter must make a break for one minute.
- The experimenter must send the participants the Post-Questionnaire link (<https://docs.google.com/spreadsheets/viewform?formkey=dFNPMGZRMnJKUnk0UWdiTjFIS3hHLWc6MQ>).
- Participants will be given 10 minutes to fill in the Post-Questionnaire and submit it.

Appendix C- Idea synthesis general instruction



Universität
Zürich^{UZH}



October 27, 2012

General Assignment Instructions for the Students

Please read the following information carefully.

Student Investigators

Neda Eshraghi +41 (0)786098700, email nees10@student.bth.se

Academic Supervisor

Dr. Samuel A. Fricker, Asst. Prof., School of Computing, Blekinge Institute of Technology

Dr. Norbert Seyff, Asst. Prof., Dept. of Informatics, University of Zurich

Project Purpose and Procedures

This assignment is mandatory, held at Fachhochschule Nordwestschweiz (FHN). The purpose of the assignment is for you to gain insight into the process of idea synthesis. This assignment is divided into two parts which will be run over the Skype and in English.

Before the assignment you will receive a Skype contact request from the assignment responsible person with Skype ID: `Experimenter_terminal` who will guide you during the assignment and send you all required documents.

In the first part after submitting a questionnaire, you will be given a form which is called Innovation Proposal (Individual) from the `experimenter_terminal`. You are expected to generate a solution for a given problem according to a given criteria individually and write it down on this form in about 25 minutes. You are required to send your filled form back to the `experimenter_terminal`.

In the next part, you will be given another form which is called Innovation Proposal (synthesized). In this part you are expected to work in a group setting to improve your solution through synthesizing your own solution with the others' solutions in your group. Again in this part you will have about 25 minutes to improve your solution for the same problem according to the same criteria and write it down on the Innovation Proposal (synthesized) form. Again you need to send your filled form back to the `experimenter_terminal`.

You will receive the Skype IDs of your fellow group members and their names in the first part and will be invited to the group from the `experimenter_terminal`.

The assignment will be finished when you submit a post- questionnaire.

Confidentiality

The results will be compiled in a summary form to protect confidentiality. All the students' data will be protected from any reports, research papers and presentation.

Discomfort and risks

There are no risks involved in completing this procedure.

Benefits

You may have a better understanding of the goals of the idea synthesis. Through this assignment you will be able to extend your knowledge in the assignment topic.

Time involvement

Your participation will take approximately 1 hour and 45 minutes.

Appendix D- Project Procedure

This Assignment consists of two parts. In the first part:

- 1) You will receive your fellow group members' Skype ID
- 2) You are required to complete and submit the pre-questionnaire form in 10 minutes. This will begin right after you receive the pre-questionnaire link.
- 3) You will be asked to generate an idea with regard to the given criteria for a given topic individually in 25 minutes.

In the second part:

- 1) You will be asked to improve your idea with regard to the same criteria for the same topic in a group setting in 25 minutes.
- 2) You are required to complete and submit the post-questionnaire form in 10 minutes.

Idea generation instruction

In a minute you will be sent the assignment topic and an "Innovation Proposal (Individual)" form through the Skype. Your job is to think individually about this topic, put only the most prominent idea on the form and send the filled form back to the experimenter_terminal via Skype. Please keep a copy of your proposed idea for the next step. In the next step of the assignment, you will be asked to combine your idea with others' idea in a group.

Criteria

Please apply the following criteria while working on the topic.

- Stay focused on the task. Concentrate on the problem at hand and avoid engaging in irrelevant thought processes and discussions.
- Provide evidence that the project is a good investment for different stakeholders (User(s), company).
- Think about ideas which increase the economic value for the users by increasing the ratio of the benefits realized by performing your idea to its execution costs.
- The proposed ideas should be compatible with the capabilities of software.
- The new ideas are desired i.e. those are not in the market today.
- Think of selling your idea to the experimenter. Hence think through the project in a systematic manner and write your idea in clear, simple language. This helps the experimenter and the potential partner to understand the project requirements.

Procedure

1. Start thinking about the given topic and generate ideas once you receive the "START" message from the experimenter.
2. Write your most prominent idea in the given form (Innovation Proposal (Individual)).
3. Send the filled form back to the experimenter whenever you feel satisfied with your idea with respect to the given criteria.
4. Once you receive "STOP" message you have to stop idea submission.
5. You will have at most 25 minutes to generate and to submit your idea.

Notes

1. The Experimenter will not communicate with you via Skype, except sending the links, files and telling you to "START" and "STOP" commands.
2. You are allowed to use the computer and internet resources.
3. Please do not communicate with your group members at this part.
4. Please use simple phrases and do not worry about spelling or grammar.

Appendix E-Group Idea Synthesis Instruction

In this part we are interested in how ideas can be joined into still better ideas. In order to achieve an excellent idea, please don't be afraid to share and combine yours and others' ideas.

For this task, you will be assigned to a group of 4 or 5 and your job is to work with your fellow group members. Your group consists of you and other participants whose names and Skype IDs were sent to you in the previous step. We emphasize the importance of sharing your idea with others and synthesizing concepts found in other's ideas to achieve even a better result.

Criteria

Please follow the **same criteria** while working on the same topic.

- Stay focused on the task. Concentrate on the problem at hand and avoid engaging in irrelevant thought processes and discussions.
- Provide evidence that the project is a good investment for different stakeholders (User(s), company).
- Think about ideas which increase the economic value for the users by increasing the ratio of the benefits realized by performing your idea to its execution costs.
- The proposed ideas should be compatible with the capabilities of software.
- The new ideas are desired i.e. those are not in the market today.
- Think of selling your idea to the experimenter. Hence think through the project in a systematic manner and write your idea in clear, simple language. This helps the experimenter and the potential partner to understand the project requirements.

In **addition**:

- Make creative combinations.
- Avoid judgment.

Procedure

1. Start sharing your idea with your fellow group members once you receive "START" message.
2. To do so type your idea description and its benefits, costs and risks briefly on the computer through the group channel in which you are invited.
3. Improve your ideas from different perspectives in your group by attending to your group members' ideas, discussing about it, trying to pick the good elements and parts of your group members' ideas and combining them with your own idea. This will lead to an idea which is a merger of the two or more ideas which may contain some newly formed or prominent properties.
4. Whenever you feel satisfied with your idea with respect to the given criteria, write your ultimate result on the "Innovation Proposal (Synthesized)" form accordingly.
5. Send the filled form back to the experimenter.
6. Once you receive "STOP" message you have to stop idea submission.
7. You will have **at most 25 minutes to generate and to submit** your idea.

However it is a self-organized group working, we advise you to start idea sharing one by one after receiving the "START" message and try to dedicate at most 5 minutes for each idea to be said and considered. So, no idea will be missed and all of them will be considered.

Notes

1. Whole discussion must be carried out in **English**.
2. **Voice chat and talking are not** allowed. You must communicate with your group members by typing the idea into the group Skype channel.
3. The Experimenter will not communicate with you via Skype group, except telling you to "START" and "STOP" communicating and idea synthesizing.
4. All links, files and instructions will be sent to you from the experimenter channel (the experimenter contact window) and not the group channel.
5. You are allowed to communicate with your group members only through the Skype group in which you are invited.
6. You are allowed to even generate new ideas on the topic through synthesizing different ideas.
7. Attend that the "Innovation Proposal (Synthesized)" form is different from the "Innovation Proposal (individual)" form.
8. You are allowed to submit **only one proposal**.

9. You are able to send your final result before the end of 25 minutes but you have to wait until you receive the “STOP” message at the end of 25 minutes.
10. Please use simple and understandable phrases to explain your idea.

After a short break, you will be given a Post-Questionnaire. You have 15 minutes to fill in and submit the “Post-Questionnaire”.

Appendix F-Bilateral Idea Synthesis Instruction

In this part we are interested in how ideas of others can be joined into still better ideas. In order to achieve an excellent idea, please don't be afraid to share and combine yours and others' ideas.

For this task, you will be assigned to a group of 5 and your job is to work with your fellow group members through bilateral communication channels. The Skype IDs and names of the participants who you are able to make bilateral communication with will be sent to you in a minute. We emphasize the importance of sharing your idea with others and synthesizing concepts found in other's ideas to achieve even a better result.

Criteria

Please follow the **same criteria** while working on the same topic.

- Stay focused on the task. Concentrate on the problem at hand and avoid engaging in irrelevant thought processes and discussions.
- Provide evidence that the project is a good investment for different stakeholders (User(s), company).
- Think about ideas which increase the economic value for the users by increasing the ratio of the benefits realized by performing your idea to its execution costs.
- The proposed ideas should be compatible with the capabilities of software.
- The new ideas are desired i.e. those are not in the market today.
- Think of selling your idea to the experimenter. Hence think through the project in a systematic manner and write your idea in clear, simple language. This helps the experimenter and the potential partner to understand the project requirements.

In **addition**:

- Make creative combinations.
- Avoid judgment.

Procedure

There are four bilateral communication channels. These four channels have one member in common (e.g., you), in which you are invited by the experimenter herself or himself. For example, the first Skype group (i.e., the first channel) will consist of you and another member, and the second group will consist of you again and the third person. The third and fourth group will be created the same way. The bilateral communication dictates that you, as a member of all four channels, will communicate with the other members of the four groups.

1. Once you receive the "START" message from the experimenter, start sharing your idea with your fellow group members.
2. To do so type your idea description and its benefits, costs and risks briefly on the computer through the four group channels in which you are invited.
3. Improve your ideas from different perspectives in your group by attending to your group members' ideas, discussing about it, trying to pick the good parts of your group members' ideas and combining them with your own idea.
4. Write your ultimate result on the "Innovation Proposal (Synthesized)" form accordingly. Whenever you feel satisfied with your idea with respect to the given criteria,
5. **Send the filled form** back to the experimenter.
6. Once you receive "STOP" message you have to stop idea submission.
7. You will have at **most 25 minutes to generate and to submit** your idea.

However it is a self-organized group working, we advise to dedicate at most 5 minutes for each bilateral channel where the ideas will be said and considered. Therefore, you won't miss any idea which may contain valuable pieces.

Your ultimate result which may be rooted in your initial idea or even be a completely new idea, is potential to be selected for implementation.

Notes

1. The Experimenter will be a common member of all channels but he or she will not communicate with you via Skype groups.

2. All links, files, instructions and “START” and “STOP” commands will be sent to you from the experimenter channel (the experimenter contact window) and not the group channels.
3. You are required to share your ideas with your peers only in bilateral way. It means that you cannot make a conference or group chat.
4. You are allowed to even generate new ideas on the topic through synthesizing different ideas.
5. You are allowed to submit **only one proposal**.
6. Please use simple and understandable phrases to explain your idea.

After a short break, you will be given a Post-Questionnaire. You have 10 minutes to fill in and submit the “Post-Questionnaire”.

Appendix G- Individual innovation proposal

ENERGY CONSUMPTION

The goal of energy consumption is to reduce the amount of energy required for products and services. Modern energy-efficient appliances, such as refrigerator, ovens and clothes washers have considerably reduced energy consumption. IT technology has potential to simulate and analyzed the energy-consumption through different software. Using software to manage the energy consumption will result in prevention of wasting non-renewable resources and reduction in buildings and factories expenses and as the result earn revenue. Following this background an important question arises: How IT can be used in order to reduce energy consumption in our daily life.

Criteria

Please apply the following criteria while working on the topic.

- Stay focused on the task. Concentrate on the problem at hand and avoid engaging in irrelevant thought processes and discussions.
- Provide evidence that the project is a good investment for different stakeholders (User(s), company).
- Think about ideas which increase the economic value by increasing the ratio of the benefits realized by performing your proposal to its execution costs.
- The proposed ideas should be compatible with the capabilities of software.
- The new ideas are desired i.e. those are not in the market today.
- Think of selling your idea to the experimenter. Hence think through the project in a systematic manner and write your idea in clear, simple language. This helps the experimenter and the potential partner to understand the project requirements.

Procedure

1. Start thinking about the given topic and generate ideas once you receive the "START" message from the experimenter.
2. Write your most prominent idea in the given form (Innovation Proposal (Individual)).
3. **Send the filled form back to the experimenter** whenever you feel satisfied with your idea with respect to the given criteria.
4. Once you receive "STOP" message you have to stop idea submission.
5. You will have at most **25 minutes to generate and to submit** your idea.

Notes

1. You are allowed to use the computer and internet resources.
2. Please use simple phrases and do not worry about spelling or grammar.

Innovation Proposal (Individual)

1. **Your Skype ID:** _____

2. **Title:** *{A short title of the solution, idea, or innovation.}*

3. **Description:** *{A general description of your idea}*

4. **Visualize your idea:** *{A drawing that shows your imagination and makes your idea more understandable. It will prevent that your idea getting lost in translation to some else's mind. Your drawings don't need to be elaborate or fancy. You can use any simple shapes and symbols .in order to add your drawing to this document, you can create it in paint program or Microsoft Visio or even simply draw it on a paper, use you mobile to take a picture and copy and past you drawing here.}*

5. Benefit

5.1 **What are the opportunities and benefits for our society?** *{By the society, we mean a group of people with common cultural expectation, traditions, interests and shared activities.}*

5.2 **What are the opportunities and benefits for the user(s)?**

6. Idea realization

6.1 **What is the summary of costs for the proposed development?** *{For example staff, accommodation, IT equipment, information requirements, etc.}*

6.2 **What risks are involved in implementing the proposal and how will they be managed?**

NOTE:

- **Send the filled form back to the experimenter** through experimenter Skype contact, whenever you feel satisfied with your idea with respect to given criteria.
- You have **25 minutes to fill the form and send** it to the experimenter

Appendix H- Innovation proposal (Synthesis)

ENERGY CONSUMPTION

The goal of energy consumption is to reduce the amount of energy required for products and services. Modern energy-efficient appliances, such as refrigerator, ovens and clothes washers have considerably reduced energy consumption. IT technology has potential to simulate and analyzed the energy-consumption through different software. Using software to manage the energy consumption will result in prevention of wasting non-renewable resources and reduction in buildings and factories expenses and as the result earn revenue. Following this background an important question arises: How IT can be used in order to reduce energy consumption in our daily life.

Criteria

Please follow the **same criteria** while working on the same topic.

- Stay focused on the task. Concentrate on the problem at hand and avoid engaging in irrelevant thought processes and discussions.
- Provide evidence that the project is a good investment for different stakeholders (User(s), company).
- Think about ideas which increase the economic value for the users by increasing the ratio of the benefits realized by performing your idea to its execution costs.
- The proposed ideas should be compatible with the capabilities of software.
- The new ideas are desired i.e. those are not in the market today.
- Think of selling your idea to the experimenter. Hence think through the project in a systematic manner and write your idea in clear, simple language. This helps the experimenter and the potential partner to understand the project requirements.

In addition:

- Make creative combinations.

Procedure

6. Start sharing your idea with your fellow group members, discussing about it, trying to pick the good parts of your group members' ideas and combining them with your own idea once you receive "START" message.
7. Write your ultimate result in the "Innovation Proposal (Synthesized)" form accordingly whenever you feel satisfied with your idea with respect to the given criteria.
8. **Send the filled form back** to the experimenter.
9. Once you receive "STOP" message you have to stop idea submission.
10. You will have at most **25 minutes to generate and to submit** your idea.

Notes

5. You are allowed to even generate new ideas on the topic through synthesizing different ideas.
6. You are allowed to submit only one proposal.
7. Please use simple and understandable phrases to explain your idea.

Innovation Proposal (Synthesized)

1. **Your Skype ID:** _____

2. **Title:** *{A short title of the solution, idea, or innovation.}*

3. **Description:** *{A general description of your idea}*

4. **Visualize your idea:** *{A drawing that shows your imagination and makes your idea more understandable. It will prevent that your idea getting lost in translation to some else's mind. Your drawings don't need to be elaborate or fancy. You can use any simple shapes and symbols .in order to add your drawing to this document, you can create it in paint program or Microsoft Visio or even simply draw it on a paper, use you mobile to take a picture and copy and past you drawing here.}*

5. Benefit

5.1 **What are the opportunities and benefits for our society?** *{By the society, we mean a group of people with common cultural expectation, traditions, interests and shared activities.}*

5.2 **What are the opportunities and benefits for the user(s)?**

6. Idea realization

6.1 **What is the summary of costs for the proposed development?** *{For example staff, accommodation, IT equipment, information requirements, etc.}*

6.2 **What risks are involved in implementing the proposal and how will they be managed?**

NOTE:

- Send the filled form back to the experimenter through experimenter Skype contact and **not the Skype group**, whenever you feel satisfied with your idea with respect to given criteria.
- You have 25 minutes to fill the form and send it to the experimenter

Appendix I-Pre-Questionnaire

1. What is your Skype ID? _____

2. How old are you? _____

3. Please indicate your gender:

Male

Female

4. What is your current position?

Student

Employed

5. In which country have you been living during the last five years? _____

6. How would you rate your current skill in any instant messaging software (e.g. Yahoo messenger, AOL Instant Messenger (AIM), Facebook chat, etc)?

Very Poor

Poor

Fair

Good

Very Good

7. Do you like participating in meetings?

Not at all

Very little

Some

A fair amount

A lot

8. Whom do you know in your team?

All

Some

Nobody

9. Please state the Skype ID(s) of person(s) who you know in your group.

10. How would you rate your current knowledge in information elicitation techniques (e.g. document analyzing or finding information on the internet)?

Very Poor

Poor

Fair

Good

Very Good

11. How would you rate your current knowledge in negotiation techniques (e.g. win-win negotiation or proposition and discussion of alternative solutions)?

Very Poor

Poor

Fair

Good

Very Good

12. How would you rate your motivation to participate in the experimental session?

I feel forced to participate

It is interesting to participate

13. Is there anything you would like to share with us?

Appendix J-Post-Questionnaire

1. What is your Skype ID? _____

2. How satisfied are you with the idea synthesis process your group used?

Definitely dissatisfied Not difficult Easy Very easy Very difficult

3. Why do you feel satisfied with the idea synthesis process your group used?

4. How would you rate your background knowledge in the experiment topic?

Very Poor Poor Fair Good Very Good

5. How did the teamworking help the idea synthesis and improvement of your idea?

Not at all Very little Some A fair amount A lot

6. How difficult was the idea synthesis task?

Not much at A few Difficile Difficile A lot

7. How did others participate in the idea synthesis session?

A lot Not much at all A few

8. How motivated were you to synthesis ideas?

Motivated Not much Not motivated

Please indicate how much you agree or disagree with the following statements.

9. Generating ideas for the experiment topic was easy.

Strongly disagi Disagree Unsure Agree Strongly agree

10. I am confident about sharing my knowledge and ideas with people in my team.

Strongly disagi Disagree Unsure Agree Strongly agree

11. Is there anything you would like to share with us?
