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Design Students' Preferences and Conceptions of Idea Generation in Groups

Lassi A. Liikkanen[a,b]
lassi.liikkanen@hiit.fi

Matti K. Perttula[c]

Pekka Sipilä[c]
pekka.sipila@tkk.fi

[a] *Helsinki Institute for Information Technology P.O. Box 9800, FI-02015 TKK, FINLAND*

[b] *University of Helsinki Cognitive Science Unit P.O. Box 9, FI-00014 Univ. of Helsinki FINLAND*

[c] *Helsinki University of Technology Department of Mechanical Engineering P.O. Box 4100, FI-02015 TKK, FINLAND*

Abstract
Successful, innovative individuals are characterized primarily by two things: expert skills and high motivation. In Finnish technical universities the need to acquire specific skills of idea generation (IG) has been acknowledged and IG methods have been included into some design curriculums. However, no comprehensive reports exist on how students perceive creative team work and how well they master different IG techniques. In the documented study, we present a survey data from a sample (N=299) students representing different domains of design. We asked the undergraduates their opinions about ideation in groups and investigated their awareness of IG methods. We found that IG methods were generally known superficially and the familiarity was influenced according to the students' backgrounds. The students had varied opinions about collaborative work, usually liking and favoring it, but there were differences between departments and sexes. The responses indicated that after little experience in group IG, the subjects tended to fall for the illusion of group productivity, a phenomenon discovered by the social psychologists. Together our findings point out several directions for guiding design education towards cultivating both skills and attitudes underlying creative design.

Keywords: product design, idea generation, group work, design pedagogy

1 Introduction

Engineering companies of the 21st century face an increasing competition as they search for advantage over the rivals. A special trait of this competition is an ever-increased focus on innovation, which is seen as the primary tool to succeed in the game. It goes without saying that the generation of novel and practical ideas is the basis for renewal and change in companies' product range. A common context described in the literature for idea generation (IG) is a session or meeting, in which a group of persons come together for the sole purpose of generating ideas. IG therefore involves a social gathering, in which persons must work together as a team to achieve a mutual goal. IG in groups imposes other demands on group members apart from the core goal. In fact, it is often social interactions that cause groups to perform rather poorly in IG.

The situation in the industry puts pressure on both engineering education and methodology development. For instance, the Helsinki University of Technology has issued team product development courses as a part of the engineering curriculum. In these courses, design students learn how to function as a part of a group of designers striving for a shared goal. The first thing to be acknowledged is that design not only involves engineering skills, but also people skills – skills that help designers communicate and co-operate during the process of design. The other important part concerns providing students with methods and practices targeted primarily for tackling IG challenges. These are nowadays included in the main textbooks of the area (e.g. [1, 2], for a review of the methods, see [3]).

1.1 Background for the present study

Research in social and cognitive psychology has repeatedly demonstrated that groups tend to perform worse in IG than the same number of individuals working independently. This has been shown in several investigations of IG in small groups. (see, for instance, [4-8]). However, individuals participating in IG tend to perceive their increased productivity and are usually convinced that group situation yields the best results. This has been labelled as the illusion of group productivity by some researchers [9, 10]. This seems to be related to a bias in evaluating the portion of ideas generated by the individual. When working in small groups, users attribute a larger proportion of all ideas to themselves, whereas independent work leads to less biased estimates.

In this paper, we set out to understand preferences and conceptions of Finnish design students regarding IG in groups, and the extent of the illusion of group productivity among them. The investigation was addressed to identify whether these conceptions were held across different design disciplines. The motivation for the present work is derived from two sources. First, we believe that the conceptions and preferences will be reflected upon the working manners that these students will adapt in the future after being employed as professional engineers. If they indulge biased perceptions about group IG, then there might be a reason to enlighten their attitudes through education. Additionally, information about how well students studying at different, representative departments are aware of IG techniques should be useful in planning the curriculums of the future.

2 Method

2.1 Sampling and procedure

Participants of the study were university students that participated in design courses and a non-design course at the Helsinki University of Technology (TKK) and Tampere University of Technology (TUT), both located in Southern-Finland. The subjects completed a questionnaire on their preferences and conceptions regarding group IG. The questionnaire was administered during design related lectures for all participating students. This was done independently on six courses at TKK and TUT during the semester 2005-2006.

2.2 The instrument

We devised a custom survey instrument to identify design students' preferences and conceptions regarding IG in groups. This survey was called Preferences and Conceptions in a

Group, or PCG-questionnaire. The PCG-instrument contained 16 items (see Table 1 for details) regarding the two factors and a separate section about how well the IG methods were known. The items were originally thought represent three hypothetical classes:

1. *Group environment*: The extent to which subjects had experienced difficulties and benefits in the key issues identified by the previous research.

2. *Preferences*: These items assessed subjects' preference working in groups over working alone (or vice versa).

3. *Group efficiency*: Questions regarding the perceived efficiency of IG in group vs. alone

The items were answered on Likert scale ranging from 1 (totally disagree) to 6 (totally agree).

Table 1. The part of PCG instrument concerning preferences and conceptions (translated from a Finnish original)

CLASS number	**ITEM**	**QUESTION CONTENT**
Group environment		
2.1	Blocking	It is easy for me to bring forward my own ideas when I work in a group.
2.2	Self-criticism	I sometimes discard myself from presenting ideas.
2.3	Feedback	Group members usually give direct feedback when I present my ideas.
2.4	Workload	It is easier to work in groups, instead of alone, since the workload is partitioned among several persons.
2.5	Loafing	Everyone participates equally when working in groups.
2.6	Persistence	I devote more effort to my work, when I work in groups instead of alone.
2.7	Interference	Other's ideas limit my ability to produce ideas.
2.8.	Stimulation	Other's ideas help me to generate new ideas.
4.1.	Ease-of-production	It is easier to generate ideas in a group than alone.
Preferences		
3.1	Preference	I prefer working in groups rather than alone.
3.2	Enjoyment (Group)	I enjoy working in groups
3.3	Enjoyment (Alone)	I enjoy working alone
Group efficiency		
4.2	Fluency	The same number of persons generates more ideas alone than in a group.
4.3	Quality	Ideas generated by individuals are of higher average quality in comparison to ideas generate in a group.
4.4	Flexibility	Groups produce more diverse ideas than the same number of individuals.
4.5	Originality	Ideas generated by individuals are of higher average novelty in comparison to ideas generated in a group.

Additionally we inquired about the participants' familiarity with the following IG methods: Synectics, CORT, Morphological Analysis, Delphi Method, Six Thinking hats, Brainstorming, Gallery Method, TRIZ, and Method 6-3-5. Four choices were offered: *never heard of the method*, *knows by name*, *knows in detail*, and *has experience with the method*.

2.3 Analysis

The main analysis started from descriptive statistics and continued with using an exploratory factor analysis and a multiple analysis of variance (MANOVA) for studying the factors point scores across. The factor solution was computed using Maximum likelihood estimation and was VariMax rotated. The r. Independent variables of interest were the different design departments and contrasts between design and few non-design students. All statistical analyses have been carried out using SPSS 13.0 (SPSS Inc., 2005), excluding the estimation of the reliability of the factor solution, calculated in Survo MM (Survo systems, 2001).

3 Results

3.1 Participants

A total of 299 students contributed to the data set. Their mean age was 23.2 years (st. dev. = 1.6 years) and the other background characteristics are assembled in Table 2.

Table 2. Sample background characteristics

Category	N	%
Sex		
Male	224	75
Female	72	24
Not defined	3	1
Discipline		
Mechanical engineering	121	40
Software engineering	47	16
Architect	37	12
Electrical engineering	15	5
Other or N/A	78	26
Phase of the university studies		
First fifth completed	25	8
< 2/5 completed	53	18
< 3/5 completed	88	29
< 4/5 completed	74	25
> 4/5 completed	56	18
Not defined	5	2
IG experience		
None	13	4
1-2	53	18
-5	61	20
More than 5	172	58

3.2 Familiarity with the idea generation methods

Subjects' familiarity with the nine selected methods IG methods were assessed with four levels of acquaintance. Our analysis started with determining a familiarity-unfamiliarity contrast by collapsing three categories of familiarity into one class and comparing it against the "Never heard of" category. For the purposes of additional analysis (see 3.4) we also composed a sum variable by adding up all familiarity responses into a single familiarity index variable.

The majority of the students had never heard the most of the methods and only Brainstorming was known to more than a half of the respondents (96.3%, N=298, see Figure 1). The next best known method was Morphological analysis (33.7%), followed by methods Delfoi and 6-3-5 (23.2% and 22.2%). However, the later two were very close to Synectics, Gallery, TRIZ, and Six thinking hats methods. DeBono's CORT methodology was very largely unknown.

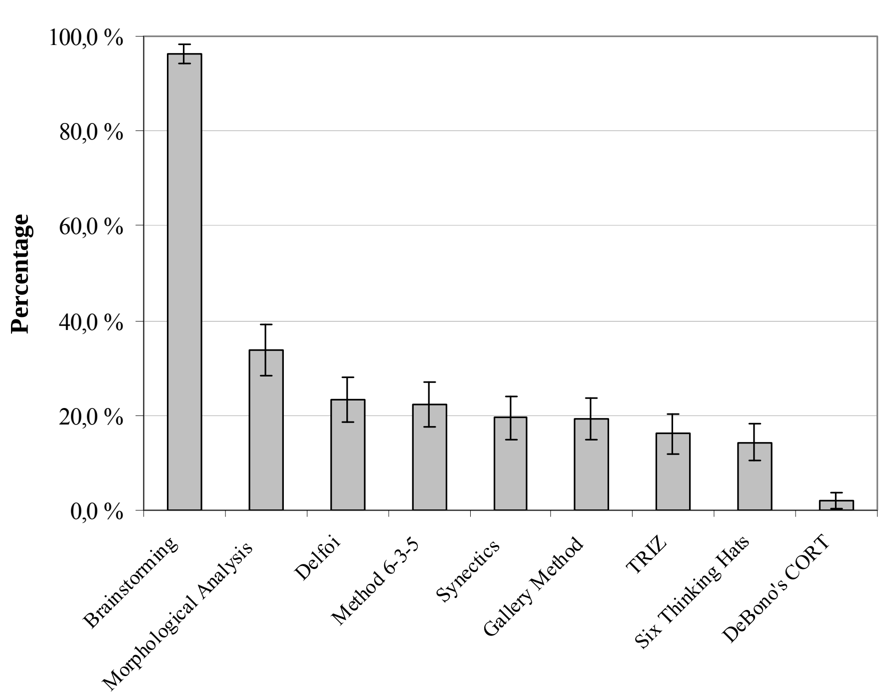

Figure 1. The percentages of respondents indicating some familiarity with an IG method. The error bars indicate the 95% confidence interval for proportion.

The inspection of the detailed information about familiarity (see Table 3 on the next page) showed that Brainstorming was the only method that had been extensively applied by the students (39.9%). The rest of the methods had been applied by less than five percent of students. The methods that had the lower 95% confidence interval above 1% were Gallery method and Six thinking hats. It is noteworthy that Morphological analysis, the method known second best, had been applied only by few people (1.7%). It appeared that people knew about the existence of methods, but hardly had any experience with them.

Table 3. Detailed levels of familiarity with different methods in a descending order of familiarity

Method			Level of familiarity		
	Familiar	Unfamilar	Has applied	Knows basics	Knows by name
Brainstorming	96,3 %	3,7 %	39,9 %	19,3 %	37,2 %
Morphological Analysis	33,7 %	66,3 %	1,7 %	2,0 %	30,0 %
Delfoi	23,2 %	76,8 %	1,0 %	1,3 %	20,9 %
Method 6-3-5	22,2 %	77,8 %	2,7 %	6,4 %	13,1 %
Synectics	19,5 %	80,5 %	0,0 %	1,3 %	18,2 %
Gallery Method	19,3 %	80,7 %	3,7 %	7,1 %	8,4 %
TRIZ	16,2 %	83,8 %	1,3 %	1,7 %	13,1 %
Six Thinking Hats	14,3 %	85,7 %	3,1 %	2,0 %	9,2 %
DeBono's CORT	2,0 %	98,0 %	0,0 %	0,0 %	2,0 %

To gain more insight into these figures, we compared students with a designer background to other, non-design students. However, no considerable differences in favour of the designers were found. In matter of fact, we found that students classified as designers were less familiar with Delfoi and Six thinking hats than the contrast group.

It appeared that also the department affected the individual’s awareness of IG methods. Calculating the chi-square statistic for the cross-tables of department and familiarity with the method, significant deviances from an expected distribution were found concerning Synectics, Morphological analysis, Gallery method, TRIZ, and Method 6-3-5. With all these methods, residuals and residuals observed frequencies indicated that this effect was attributable to students in the Miscellaneous category and to the students of mechanical engineering. The latter group seemed therefore responsible for maintaining the balance in the comparison of designers and non-designers. They also made up the majority of instances in category “I have applied this method”.

3.3 Factor analysis of preferences and conceptions

To explore the different underlying tendencies among the respondents towards group work, an exploratory factor analysis was used to reduce the data to a smaller number of variables. Three subjects were discarded from the analysis due to missing data, so 296 subjects in total were included. This treatment was supported by the structure of data, as the Kaiser-Meyer-Olkin measure was acceptable (KMO = .72), and Bartlett’s test of sphericity was statistically significant ($\chi^2 = 826.9$, df = 120, $p < .001$) suggesting that a factorial model could be used to account for the variance of the data. After examining a scree plot, it was determined that a solution containing maximum of six factors would be feasible.

The data was next factored using Maximum likelihood extraction and Varimax rotation with Kaiser normalization. Testing several models, a three factor model was found to be the most compatible with the data, in terms of interpretability and total communality. It also corresponded quite well to three dimensional hypothesis presented earlierTwo items (4.4 and 4.5) did not load on any factor and their eigen values were less than .03. Judging by items’ distributions subjects seemed to respond to these items randomly. They were thus discarded from the final analysis. Leaving these variables out improved the model and the percentage of explained variance increased 5 percentage units to total of 33.2 %, which is not huge but still substantial amount of variance explained. From the remaining fourteen variables, the three factors were extracted. They were labelled as *group efficiency* (*F1*), *group preference* (*F2*) and *individual efficiency* (*F3*) and are presented in Table 4 (see the next page) in more detail.

Table 4. Exploratory factor model solution with three factors. Factor loadings greater than .25 (+/-) are indicated by boldface.

Section		Factor			
Item		*1: Group efficiency*	*2: Group preference*	*3: Invidual preference*	Communality
Section 1 Group work pros and cons					
R28	Others' ideas are helpful	**0,626**	0,070	-0,262	0,466
R21	It is easy to present new ideas	**0,603**	0,016	-0,020	0,364
R23	Group provides immediate feedback	**0,321**	0,076	-0,069	0,114
R24	Loafing facilitates group work	0,084	**0,588**	-0,107	0,364
R26	I try harder in a group	0,076	**0,479**	-0,045	0,237
R25	Work is shared equally among group members	-0,018	0,285	0,163	0,108
R22	I do not express all my ideas	**-0,318**	0,000	0,106	0,113
R27	Other's ideas inhibit my ability to create new ones	**-0,538**	0,014	**0,372**	0,428
Section 2 Preferences					
M32	It is pleasant to work in a group	**0,585**	**0,443**	-0,110	0,551
M31	I prefer working in a group	0,295	**0,726**	-0,019	0,614
M33	It is pleasent to work alone	0,241	**-0,398**	0,206	0,259
Section 3 Conceptions of idea generation					
K42	I produce more ideas when working alone	-0,117	0,076	**0,724**	0,544
K43	I produce better ideas when working alone	-0,147	-0,074	**0,390**	0,179
K41	It is easier to produce new ideas in a group	0,275	0,152	**-0,461**	0,311
Eigenvalues		**1,862**	**1,582**	**1,208**	

Factor 1 labelled *group efficiency* consisted mainly of items related to the positive performance of group, facilitation by the presented ideas, the ease of presentation, obtaining feedback, and the enjoyment group work, all of which were positively correlated. In comparison, negative aspects of group work including self-criticism or social pressure had a negative relation to this factor. Factor 2 termed *group preference* included items that did not present any strong arguments why group work would be beneficial, just an adherence to the team spirit. Positively related items were enjoyment of group interaction, preference of group interaction, the confidence to the equal loafing of labour, and stronger devotion to work than when working alone. Additionally, decreased enjoyment of working in solitaire describes this factor. The third factor was named *individual efficiency*. There were only few loading variables that all expressed the belief in the greater potential of working individually, producing more and better ideas and the faith in limiting power of others' ideas. However, this factor did not indicate preference for independent work, just the superiority of solo performance.

Eventually we also calculated factor scores for each respondent using regression estimation. The variables with small contributions to the factor's communality were not zeroed out, but calculated using the coefficients provided in Table 4. A general reliability coefficient [11] was determined for the factors scores. It provides a less biased estimate of reliability than traditional Cronbach's alfa and can account for the correlation of measurement errors. Results regarding reliability were adequate; the first two factors had the coefficient of 0.74 and the third factor 0.65. This reliability is reasonable.

3.4 Background as a predictor

We also examined the relation of the background variables and the familiarity index using Multiple Analysis of Variance (MANOVA). After exploring with a greater number of independent variables, it appeared that a model including DEPARTMENT and SEX independents and FAMILIARITY INDEX as a covariate explained the greatest portion of the variance related to group preference (F2, $\eta^2 = 12.7\%$; p<.001, see Table 5) and a smaller portion of F1 and F3 (η^2 5.7% and 6.1%, p = .123 and .093, F1 and F3 respectively). No interaction between the independent variables was detected. For the first factor, group efficiency, the only significant main effect is the one caused by FAMILIARITY INDEX ($F(1, 276) = 6.576$, p = .010). It shows that as people get more familiar with IG methods, they perceive the group as more efficient (B= 0.420 score points/index point).

Table 5. MANOVA results by each covariate, dependent and independent variable.

Source	Variable	Sum of Squares	Df	Mean Square	F	p	Partial η squared
Model	F1	11,448	11	1,041	1,521	0,123	0,057
	F2	26,524	11	2,411	3,640	0,000	0,127
	F3	11,332	11	1,030	1,619	0,093	0,061
FAMILIARITY INDEX	F1	4,623	1	4,623	6,756	0,010	0,024
	F2	0,009	1	0,009	0,013	0,908	0,000
	F3	1,628	1	1,628	2,558	0,111	0,009
DEPARTMENT	F1	5,871	4	1,468	2,145	0,076	0,030
	F2	11,725	4	2,931	4,426	0,002	0,060
	F3	6,154	4	1,539	2,418	0,049	0,034
SEX	F1	0,149	1	0,149	0,218	0,641	0,001
	F2	3,689	1	3,689	5,569	0,019	0,020
	F3	1,888	1	1,888	2,967	0,086	0,011
DEPARTMENT * SEX	F1	2,161	4	0,540	0,790	0,533	0,011
	F2	0,920	4	0,230	0,347	0,846	0,005
	F3	2,641	4	0,660	1,038	0,388	0,015
Error	F1	188,875	276	0,684			
	F2	182,811	276	0,662			
	F3	175,597	276	0,636			
Total	F1	200,323	287				
	F2	209,335	287				
	F3	186,929	287				

The Group preference score (F2) was affected by both DEPARTMENT ($F(4, 276) = 4.426$, p = .002) and SEX ($F(1,276) = 5.569$, p = .019). On average, women seemed to be more demure than men in the face of group work. This considerable effect (B = -0.450) is visible among students in all departments and was a considerable one. However, this effect changed department wise and the greatest influence was observed among architecture students, who seemed indifferent to group work (significant differences in a *post-hoc* Tukey HSD test in contrast to other groups). The students of software design and miscellaneous groups (see Figure 2 on the next page) represented the median whereas the students of machine design and surveying students were more positive towards group work, although differences between these groups were not statistically significant. The factor 3 (individual efficiency) was not significantly related to any of the independent variables.

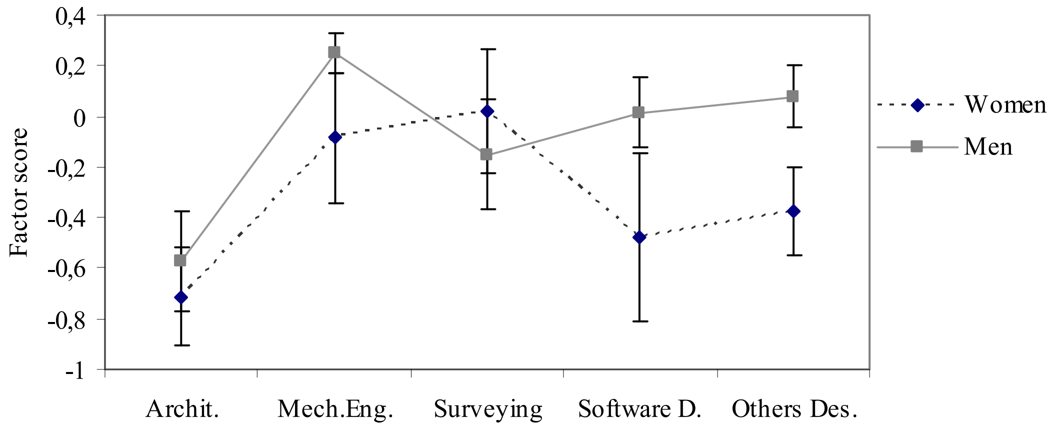

Figure 2. Profile plots of the mean *group preference* (F2) factors scores of both sexes in different design departments (X axis). Error bars indicate the standard error. Y axis represents the preference toward group working.

4 Discussion

In the early 21st century, designer education receives a considerable pressure from the industry. Due to quickly changing markets and rapidly outdated products, the demand for a constant high level of innovation is reality. Even though there does not seem to exist any shortcut to producing groundbreaking products, the present engineer education beliefs that by teaching various IG methods and having them practiced, the future designers can be given proper tools to face the challenges as they enter the industry.

In this paper we have not tried to assess different methods or students capacity for creative work. Instead we have tried to tap the motivational and educational basis underlying team work and real experiences with IG. Does the illusion of group productivity exist among Finnish design students? Based on our data, in general students do start to prefer group work more as they gain experience with it. Surprisingly, women and architecture students had the most negative attitudes towards choosing a group situation. This may have been related to the fact that these subgroups were the most experienced in idea generation and the least familiar with the IG methods (although this relation was not captured by MANOVA). This suggests that maybe the illusion wears out after some experience in the absence of proper skills. This calls for further investigations before laying out any implications. It should be noted that individualistic attitudes, or critical stance toward a group hegemony, may also be beneficial for the creativity of the group [12].

We used factor analysis to explore how the PCG-instrument prepared specifically for this study reflected the perceived qualities of group work. The presented factor solution partially confirmed our initial hypothesis regarding the existence of at least three independent dimensions, along which people perceive the influences of the group situation. Group and individual efficiency are seen as independent factors, indicating that people can recognize themselves as efficient idea generators both in a group and alone, and these do not exclude each other. Group preference was one of the discovered dimensions, indicating willingness people are to engage in a group activity. This dimension appeared to be more a dimension of choice between solitary and group working. That is, high group preference makes is less likely for a person to enjoy solitary IG, but does not dictate that.

We also discovered that while there few methods that were known to a 20 – 30 % of the sample, only Brainstorming had been applied by the students. It looks as if the students have only gained superficial understanding of the IG methods, even though the IG methods are included in the textbooks used in designer education (e.g.[2] and [3]). We also showed designer students were not more acquainted with the idea generation methods than the non-designer students were. We observed that the students of mechanical engineering had applied different methods considerably more than the others, possibly because of their dedicated curriculum. Due to the sampling process, it is possible that this sample included more subjects that were interested in design, innovation and IG. It is noteworthy that future architects and software engineers were less familiar with IG methods than the other groups, implying that these disciplines could benefit from instruction about the use of idea generation methods in group environments.

As a summary, the present study revealed that although design students in Finnish universities know about IG methods, they are not acquainted with them. They generally prefer group work, but seem to develop less favourable attitudes in the long term, especially if they do not possess the methods to steer the group situation into a more productive track.

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References

[1] Pahl, G. and Beitz, W., *Engineering Design*, The Design Council, London, 1984.
[2] Ulrich, K. T. and Eppinger, S. D., *Product Design and Development. Third Edition*, McGraw-Hill, Boston, 2003.
[3] Smith, G. F., "Idea-generation techniques: A formulary of active ingredients", *Journal Of Creative Behavior* 32 (2), 1998, pp. 107-133.
[4] Brown, V., Tumeo, M., Larey, T. S. and Paulus, P. B., "Modeling Cognitive Interactions During Group Brainstorming", *Small Group Research* 29 (4), 1998, pp. 495-526.
[5] Camacho, L. M. and Paulus, P. B., "The Role of Social Anxiousness in Group Brainstorming", *Journal of Personality and Social Psychology* 68 (6), 1995, pp. 1071-1080.
[6] Diehl, M. and Stroebe, W., "Productivity Loss in Brainstrorming Groups: Toward the Solution of a Riddle", *Journal of Personality and Social Psychology* 53 (3), 1987, pp. 497-509.
[7] Nijstad, B. A., Stroebe, W. and Lodewijkx, H. F. M., "Production blocking and idea generation: Does blocking interfere with cognitive processes?", *Journal Of Experimental Social Psychology* 39 (6), Nov 2003, pp. 531-548.
[8] Paulus, P. B. and Yang, H. C., "Idea generation in groups: A basis for creativity in organizations", *Organizational Behavior and Human Decision Processes* 82 (1), 2000, pp. 76-87.
[9] Paulus, P. B., Dzindolet, M. T., Poletes, G. and Camacho, L. M., "Perception of Performance in Group Brainstorming - The Illusion of Group Productivity", *Personality and Social Psychology Bulletin* 19 (1), Feb 1993, pp. 78-89.
[10] Stroebe, W., Diehl, M. and Abakoumkin, G., "The Illusion of Group Effectivity", *Personality and Social Psychology Bulletin* 18 (5), Oct 1992, pp. 643-650.
[11] Tarkkonen, L. and Vehkalahti, K., "Measurement errors in multivariate measurement scales", *Journal of Multivariate Analysis* 96 (1), 2005, pp. 172-189.
[12] Goncalo, J. A. and Staw, B. M., "Individualism-collectivism and group creativity", *Organizational Behavior and Human Decision Processes* 100 (1), May 2006, pp. 96-109.