sciendo

A Statistical Model Regarding the Solving Problems Behavior in Formal Groups

Raluca Petronela LĂZĂRESCU*
Gheorghe Asachi Technical University, Iași, Romania
* *Corresponding author, raluca-petronela.lazarescu@academic.tuiasi.ro*

Adrian VÎLCU
Gheorghe Asachi Technical University, Iași, Romania

Abstract. *Formal group behaviour is based on following specific norms and rules wherein the participants are expected to be well organised proving respect and accomplish orders, working to the requirements of the organization. When different tasks are essential to be solved, each member of the group must adopt proactive behaviour, so the communication process to be productive. The paper presents a practical approach about how the gender of students influences organisational group communication with the main objectives to evaluate the solving problems abilities on two groups (M/F) and create a psycho-metric model for solving problems inside formal groups. The authors used the questionnaire of Cândea R.M. and Cândea D. as an instrument that includes three types of behaviour that may appear during solving problem process - approaching a routine problem to solve it; approaching a problem that is not routine and measuring aspects regarding decision process encouraging the creativity and the spirit of innovation in a formal group. Furthermore, the authors used statistical methods - Shapiro-Will and Man-Whitney U tests- and statistical factorial modelling – PCA method to identify the most critical factors that influence solving problems in formal groups. The necessity of the research comes from the dynamic of changes affecting the group from external and internal environments during the decision process.*

Keywords: statistic modelling, communication behaviour; PCA method.

Introduction

Formal groups are considered social formations of individuals that create interactions based on specific rules and recognize themselves as being part of an entity in a given context of communication in order to achieve a common goal. Johns (1998) argue that groups are "complex social devices that require some degree of negotiation and trial-and error before their individual members begin to function as a real group". Therefore, the communication process becomes crucial specially when the organization is willing to develop a creative and innovative environment changing the attitudes of inside members. Communication is the process of transmitting a message from a transmitter to a receiver through a communication channel with the aim of producing a reaction (change of attitude or behavior). To effectively solve a problem during a communication process, each group member must adopt a flexible behavior.

According to the definition given by Cosmovici (1996), communication is seen as a relationship based on the co-sharing of a meaning. Within the act of communication, information is the absolutely necessary premise, but it is not enough because if the misunderstanding of the information and of the relational framework that guides and fixes its meaning and meaning arises, the 'state of communication' is cancelled.

Cucos (2014) perceives the communication process as a multifazal complex and through several information channels between two entities (individuals or groups) that simultaneously or

DOI: 10.2478/picbe-2024-0261

successively assume the roles of emitters and receptors. Therefore, communication involves a feedback interaction regarding both explicit and adjacent information.

The special role of communication in ensuring the functionality and effectiveness of the activity inside formal groups is generated by the volume, complexity and diversity of the group objectives, due to the impact of the variables of the internal and external environment; the way of group′s conception about the process of the solving problems to amplify the links between the components of the groups, to strengthen their cohesion. Therefore, the output of correlation between knowledge, emotions, and personality consists in a communicational behavior of each member of the group with a major impact on the decision process. Facing a complex of problems, the group must struggle to solve them using the communication abilities necessary to express feelings, needs, and thoughts as a substitute for more direct and open communication.

Literature review

In formal groups, problem or task solving required unity and dismiss the potential communication barriers that may interfere with the groups or individual objectives. Anderson (1980) considers the problem solving as a sequence of cognitive operations. From this perspective, the result is a specific reaction, that in time may form an attitude at an individual level. Newell and Simon (1972) refer at solving task as a process requiring complex aspects of human cognition, aspects that come from previous personal, social or professional experiences. Robertson (2001) points out the necessary step in order to approach a problem or task: the individuals must set up SMART goals in order to achieve them. In addition, the authors of the paper consider that the influence of the behavior in solving a task in formal groups may influence the final results.

The previous researches revealed that social interaction among members of formal groups is essential in learning, developing cognitive and problem-solving ability (Vygotsky, 1986, Wittrock, 1989). King, Goodson and Rohani (1998) found that individuals responses at information level are different when it is a group work than personal work. Therefore, the quality and amount of information as well as creativity and innovation at individual level is influenced by the group behavior – if the members are feeling encouraged and free to express themselves. Activities such as asking questions and providing feedback guide members of the group to reach a better solution in order to accomplish a specific task.

In order to approach a routine problem to solve it, the individual must increase the self-confidence, but also to have faith that has the group support. At this level, activities as:

- Clearly defining of the problem arises question as:" should I communicate the problem to the group or I can solve it by myself?";
- Analyzing the problem and to find various solution to solve it; the question is: "would my solution be accepted by the group?";
- Identifying the criteria that may conduct to a proper solution at individual and group level; the question is: "how qualitative the solution that I share with the group?"

are essential to be accomplished.

If it is a complex problem to solve, adaptability, logical and analytical thinking are important to be considered by the member of the group, based on previous experience, knowledge and identifying patterns in order to have a better understanding of the problem.

The creativity and innovation in formal group in solving-problem process begin from individual level in a sense that each member is encouraged to become part of solution using their own abilities:

- accepting new ideas, proposals, opinions with the aim to develop the imagination;
- considering that each member ideas bring real value to the solution;
- being open minded and efficiently communication oriented.

Methodology

Statistical modelling techniques are applied to identify the most important factors that influence the ability to solve problems in formal groups. Thus, a 2-level hierarchised model reduces those correlated factors on each dimension. The factors resulting from the entry-level will enter the 2nd level of output to obtain a linear psycho-metric relationship that will contain the essential elements of influence. Thus, the factorial analysis on two levels will provide a linear function consisting of the most important influence factors of a formal group's problem-solving abilities.

The methodology applied to this research contains the following steps:

- Data collection and their organisation (grouping) on each studied dimension;
- Validation of the measurement scale on each dimension and throughout the questionnaire;
- Checking the normality on each item;
- Comparing the differences in understanding the aspects on the three dimensions reported to the 2 M/F groups;
- Determination of a psycho-metric model for the analysed study, with the following relationship:

$$y = \sum_{j}^{3} \left(b_j * \sum_{i=1}^{n} a_i * aspect_i \right)$$

- where j is given by the number of dimensions in the study and n represent the most important aspects on each dimension from the point of view of their importance;
- The reduction of the aspects to the essential ones is made with the ACP method.

The organisational chart is shown in the following figure (figure 1)

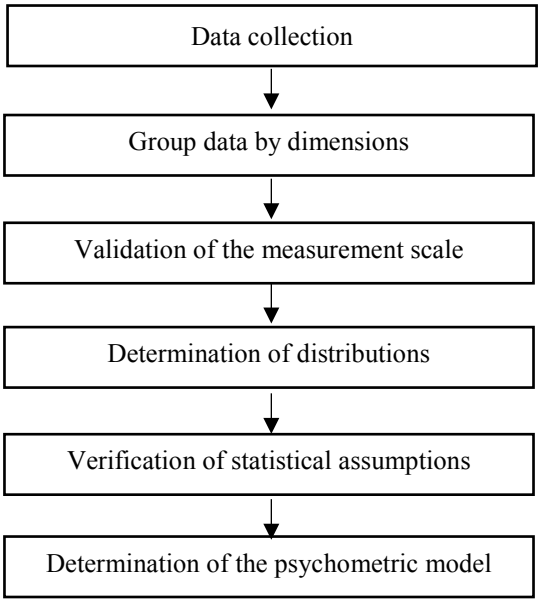

Figure 1. Research organisational chart

Source: Authors' own research.

Data collection – the instrument used to develop the research was the questionnaire of Cândea R.M. and Cândea D. [3], including 22 items for three types of behaviour focused on solving problem abilities – approaching a routine problem, in order to solve it, approaching a problem that is not routine and measuring aspects regarding decision process encouraging the creativity and the spirit of innovation in a formal group. The questionnaire uses a Likert scale: 0 - strongly disagree, 1 - disagree, 2 - neutral,3 - agree, 4 - strongly agree. The students were informed about the confidentiality of the responses and that the responses were collected only for scientific purposes.

Testing the internal consistency of the measurement scale on each dimension and the entire questionnaire – the alpha- Chronbach coefficient [4] is finished. It aims to identify the items that do not participate in the internal consistency of the measurement scales. These coefficients will be eliminated.

Normality testing – the Shapiro-Wilk test [5] is used for small series of values. The choice of statistic tests for the verification of hypotheses is made according to the form of distributions of the series of values. Thus, for non-normal distributions, nonparametric tests will be applied, which follow the positions of the values in series and not the approximation of the statistical parameters.

Following the *evaluation of the normality of the distributions* on each series, it is noticed that they do not follow normal theoretical distribution so that in order to compare the vision of the two categories of groups of respondents, it is used with the Man-Whitney U test [6].

The determination of the psycho-metric relationship for modelling the phenomenon is made by applying the ACP factorial method [7] hierarchically on two levels. It aims to determine a mathematical relationship of weighting the main factors that describe the ability to solve problems in and intra formal groups.

Results and discussions

Subjects/sample: Students form the target population of the study. The sample is considered uniform weight. The relation between items and respondents is 1:3. The participants are 52 third-year students studying at ”Gheorghe Asachi” Technical University of Iași, Romania, from the Faculty of Chemical Engineering and Environmental Protection, Faculty of Machine Manufacturing and Industrial Management, Faculty of Electrical Engineering, Faculty of Industrial Design and Business Management, study program: Business Engineering and Management. The participants were informed regarding the questionnaire contents and scale and were encouraged to use the feedback in case of misunderstandings.

For each dimension, the value of alphaC is calculated (Table 1)

Table 1. alphaC coefficients for each dimension

Dimension	alphaC
1	0,742
2	0,707
3	0,650
Total	0,838

Source: Authors’ own research.

For all the dimensions and the whole questionnaire, the internal consistency of the measurement scale has been demonstrated so that none of the items of the questionnaire will be eliminated in the statistical analysis.

Checking the normality of the series of aspects studied: The results obtained by applying the Shapiro-Wilk test specify that the series of items are not distributed normally with a probability of 95%. Therefore, nonparametric tests will be used for further statistical analysis.

The hypotheses analyzed are as follows:

H_0 hypothesis: the two groups of respondents (M/F) appreciate the same the analyzed aspects

H_1 hypothesis: the two groups of respondents (M/F) appreciate differently the analyzed aspects

To compare the answers on the 2 M/F groups on all 22 aspects, the Mann-Whitney nonparametric test is used to analyze the ranks of the two series. To impress the response histograms on each dimension, on the two categories of respondents (M/F), the following procedure was applied:

Three new variables were created, one on each dimension, by mediating the corresponding items, resulting in variables D1_m, D2_m, D3_m. The series of values for the three new variables introduced were tested from the normality analysis point of view. The values of the Shapiro-Wilk coefficients are presented in Table 2.

Table 2. Values of Shapiro-Wilk coefficients

Shapiro-Wilk test		
Statistic	**Df**	**Sig.**
,922	52	,002
,978	52	,464
,954	52	,041

Source: Authors' own research.

Thus, the first series and the 3rd are not normally distributed. The 2nd is normal.

The comparison of the three series reported by the two groups of respondents is made using the nonparametric test Mann-Whitney U. The results are presented synthetically in Table 3.

Table 3. Synthetic results of the application of the Mann-Whitney U test for the testing of hypotheses

Test/Sig/Decision	Dimension	Results
Test	1	Independent-Samples Mann-Whitney U Test
Test	2	Independent-Samples Mann-Whitney U Test
Test	3	Independent-Samples Mann-Whitney U Test
Sig.	1	0.571242958194528
Sig.	2	0.985258190312175
Sig.	3	0.499253225547858
Decision	1	Retain the null hypothesis.
Decision	2	Retain the null hypothesis.
Decision	3	Retain the null hypothesis.
Null Hypothesis	1	The distribution of D1_m is the same across categories of Sex.
Null Hypothesis	2	The distribution of D2_m is the same across categories of Sex.
Null Hypothesis	3	The distribution of D3_m is the same across categories of Sex.

Source: Authors' own research.

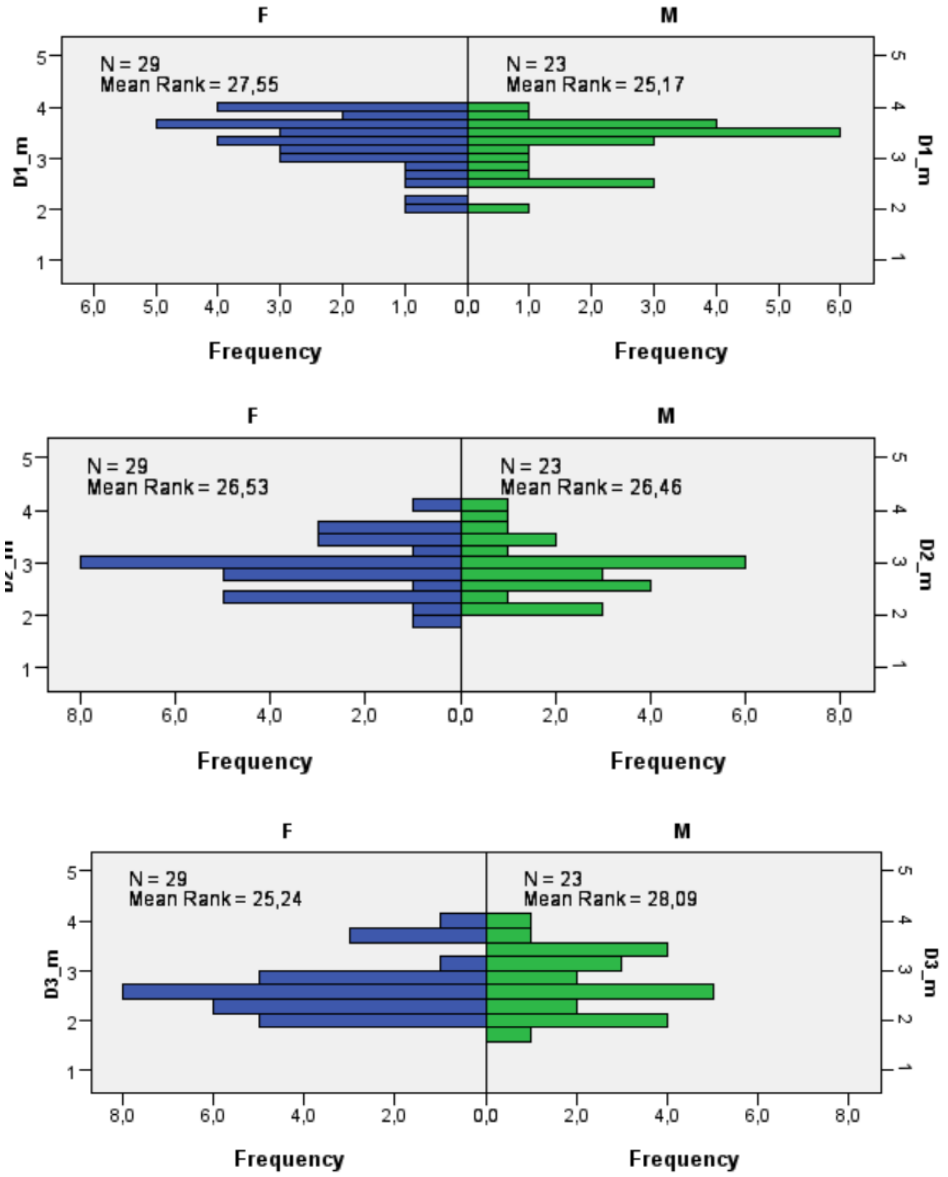

Figure 2. Histograms of the responses on each analysed dimension reported to the M/F groups

Source: Authors' own research.

The averages of the responses and the shape of the histograms on the three dimensions (Figure 2) reported to the two groups of respondents are about the same. Thus, the phenomenon is seen in the same way by the two categories of respondents (M/F) on all aspects analysed. Therefore, the probability of accepting the null hypothesis H0 is 95% (the materiality threshold is set to alpha=0.05), all p-values being higher than the alpha threshold.

Creating a psycho-metric model for the analysed data: application of the factorial method on the first dimension. The component of the two factors is presented in table 3 (the Kaiser-Meyer-Olkin Measure coefficient is 0,723, which argues the application of the ACP method to reduce the correlated input variables).

The first dimension, "approaching a routine problem", has been reduced to 2 main factors that explain 65% of the vainness of the entire dimension (Table 4).

Table 4. Results of application of the ACP method on dimension 1

	F1_1	F2_1	Total
Loading	**39,505**	**26,203**	**65,708**
Score Coefficient Matrix			
	1	**2**	**Total**
Item1	-,122	,535	0,09
Item2	-,085	,564	0,11
Item3	,287	,062	0,13
Item4	,306	,039	0,13
Item5	,438	-,345	0,08
Item6	,310	,059	0,14

Source: Authors' own research.

The three most important aspects that enter the expressions of the two main factors for size 1 are in descending order of importance: 6, 3, 4 and 2, at a threshold of 0.1.

For dimension 2 "approaching a problem that is not routine," the Kaiser-Meyer-Olkin Measure coefficient was obtained at 0.702, which validates applying the ACP method on this dimension. The results of reducing the input variables that characterise this dimension are presented in Table 5.

Table 5. The main components that characterize dimension 2

	F1_2	F2_2	F3_2	
	26,947	**19,94**	**16,193**	
Component Score Coefficient Matrix				
	Component			
	1	**2**	**3**	**Total**
Item7	,195	-,100	,301	0,08
Item8	-,118	-,142	,699	0,05
Item9	,008	,170	,371	0,10
Item10	,204	,169	-,090	0,07
Item11	,228	,178	-,105	0,08
Item12	-,212	,545	-,020	0,05
Item13	,005	,406	-,108	0,06
Item14	,418	-,278	-,032	0,05
Item15	,335	-,052	-,019	0,08

Source: Authors' own research.

The most essential aspect that load the three main factors for size 2 is appearance 9, at a selection threshold of 0.1.

For the 3rd dimension, the Kaiser-Meyer-Olkin Measure coefficient was obtained is 0.663, and the application of the PCA method led to the results in Table 6. The two most important aspects with the highest representation in the expression of the three main factors for size 3 are in descending order: 18.22, at a selection threshold of 0.1.

Table 6. The main components that characterise dimension 3

	F1	F2	F3	
	24,932	23,53	21,038	
Component Score Coefficient Matrix				
	Component			
	1	**2**	**3**	**Total**
Item16	,159	,386	-,139	0,10
Item17	-,212	,606	-,108	0,07
Item18	,487	-,039	,000	0,11
Item19	,575	-,171	-,065	0,09
Item20	-,037	-,228	,728	0,08
Item21	-,080	,158	,431	0,10
Item22	,009	,277	,211	0,11

Source: Authors' own research.

The authors apply the 2nd level of reduction of the main components led to the results presented in table 7.

In the final score, the factors that come into the composition are F1_1, F1_2, F2_2. Thus, the most important aspects of the general statistical model for this analysis are: from the first dimension: 6, 3, 4, 2 of dimension 2: 9 and dimension 3: 18, 22.

Table 7. PCA method applied on level 2, of the main factors resulting from level 1

		F1_4	F2_4	F3_4	
		24,237	19,907	16,231	
Component Score Coefficient Matrix					
		Component			
		1	**2**	**3**	**Total**
REGR factor score	1 for analysis 1	,030	,206	,350	0,11
REGR factor score	2 for analysis 1	,401	,081	-,097	0,09
REGR factor score	1 for analysis 2	-,009	,536	-,022	0,10
REGR factor score	2 for analysis 2	,439	-,052	,000	0,10
REGR factor score	3 for analysis 2	,052	-,147	,567	0,09
REGR factor score	1 for analysis 3	,398	-,111	,082	0,09
REGR factor score	2 for analysis 3	-,075	,533	-,108	0,07
REGR factor score	3 for analysis 3	-,065	-,044	,455	0,06

Source: Authors' own research.

The Kaiser-Meyer-Olkin Measure coefficient is 0.426. It is smaller because the factors on each of the three dimensions are linearly independent; thus, the factors that are correlated and are in different dimensions can be reduced.

The psycho-metric model that characterises the behaviour of the respondents to the problems to be solved is in sizes of principal components, at a selection threshold of 0.1:

$$y = 0{,}11 * F1\_1 + 0{,}1 * F1\_2 + 0{,}1 * F2\_2$$

where:

$$\begin{cases} F1\_1 = 0{,}438 * Item5 + 0{,}310 * Item6 + 0{,}306 * Item4 \\ F1\_2 = 0{,}418 * Item14 + 0{,}335 * Item15 \\ F2\_2 = 0{,}545 * Item12 + 0{,}406 * Item13 \end{cases}$$

In the final form of the model, the items from size three are missing. Thus, when the decision is made in a group, the group members' encouragement of creativity and the spirit of innovation is lacking.

Also, from the first dimension, are missing items one that answer the question of individual or group solving the problem and item 2,3 that capture the analysis of the problem and the methods of solving. Thus, it is noticed a low capacity to understand the global phenomenon of which the routine problem is a part and a reduced vision of the methods by which the problem can be solved.

The 2nd dimension (solving new problems) is represented only by item 12,13,14,15, and the respondents try to find templates (patterns) both in defining the problem and finding the methods of solving.

Conclusion

The conclusions of the research reveal that:

- the two groups of respondents (F/M) appreciate the analysed aspects. Therefore, there were not significant differences in behaviour regarding the solving problems abilities used by the formal group.
- when the decision is made in a formal group, the encouragement of creativity and the spirit of innovation in the group members is missing;
- the interpretation of responses revealed a low capacity to understand the global phenomenon of which the routine problem is a part;
- a reduced vision of the methods by which the problem can be solved.

Limits and future research

The study's limits would be influenced by certain factors such as the dispositional state of the subject at the time of examination, his state of health or the degree of understanding of the items. Also, the relatively low volume of the sample of respondents, which must be linked to the fact that the baggage of factors may not be the most relevant concerning everyone's expectations, the sampling method used in the extraction of the group of respondents, in the sense that it does not ensure statistically significant representativeness for all categories of respondents, the lack of another perspective on the solving problem abilities model within the formal group for respondents from other geographical, cultural and economic areas of Romania, as well as the threshold of choice of the independent variables that are part of the factorial model of the behavior within the group is chosen subjectively and must be customized for each statistical study separately.

A suggestion would be to expand the sample of subjects to several age categories, possibly those who have experienced specific individual/collective trauma for future research.

References

Johns, G. (1998), Comportament organizațional, editura Economică.

Cosmovici, A. (1996), Psihologie generală, editura Polirom, Iaşi.

Cucoș, C-tin (2014), Pedagogie, editura Polirom, 2014.

Anderson, J. R. (1980). Cognitive Psychology and Its Implications. San Francisco: W. H. Freeman.

Newell, A., Simon, H., A. (1972), Human problem solving, Prentice – Hall

Robertson, S., I. (2001), Problem solving, Psychology Press

Vygotsky, L. S. (1986). Thought and language. Cambridge, MA: MIT Press.

Wittrock, M. C. (1989). Generative processes of comprehension. Educational Psychologist, 24(4), 345–376.

King, F., J., Goodson, L., Rohani, F. (1998), Higher order thinking skills, http://www.cala. fsu.edu/files/higher_order_ thinking_skills. pdf

Wang, Q., Mousavi, A., Lu, Ch., Gao, Y. (2023), Examining adult′s behavioral patterns in a sequence of problem-solving tasks in technology – rich environment, Computers in Human Behavior, volume 147.

Scoular, C., Care, E. (2020), Monitoring patterns of social and cognitive student behaviors in online collaborative problem-solving assessments, Computers in Human Behavior, volume 104.

Cândea R.M., Cândea D., *Comunicare managerială aplicată*. Editura Expert, p.333-334, 1992.

Robert A. Peterson, *A Meta-Analysis of Cronbach's Coefficient Alpha*, Journal of Consumer Research, Inc., Vol. 21, No. 2 (Sep., 1994), pp. 381-391, 1994;

Zofia Hanusz, Joanna Tarasinska, Wojciech Zielinski, *Shapiro–wilk test with known mean*, REVSTAT – Statistical Journal Volume 14, Number 1, February 2016, 89–100, 2014;

Nadim Nachar, The Mann-Whitney U: A Test for Assessing Whether Two Independent Samples Come from the Same Distribution, Tutorials in Quantitative Methods for Psychology 2008, vol. 4(1), p. 13-20;

Sidharth Prasad Mishra, end-all, Multivariate Statistical Data Analysis- Principal Component Analysis (PCA), International Journal of Livestock Research eISSN: 2277-1964 NAAS Score -5.36, Vol 7 (5) May 2017.