Chapter #35

USING THE RESULTS OF PROBLEM-SOLVING SIMULATIONS TO IMPROVE GROUP LEARNING

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ABSTRACT
The paper discusses the application of simulations for group problem solving. The aim is to explore trends in group performance, which can enable analysis and discussion of decision-making processes during training sessions. The results of 115 groups with a total number of participants of about 510 people were obtained from 5 different simulations. The average individual and group results, the gain/loss from the group discussion and the resulting synergy were calculated as efficiency measures. The results of the groups in the sample were compared with those of known published abroad studies and the means and standard deviations were calculated to serve as reference values for Bulgarian groups. Expectations of similarity in the performance trends of individuals and groups are confirmed. The hypotheses regarding the increase in the quality of group decisions compared to the averaged individual results (in 83% of cases) and the relatively limited achievement of synergy (only in 30% of cases) are confirmed. Differences are also established between groups based on belonging to a private or state organization and open groups or members of a team/organization. The observations create a basis for in-depth discussions during the training sessions on how the quality of group learning can be improved.

Keywords: group learning, synergistic problem solving, simulations.

1. INTRODUCTION

The decision-making process is of critical importance in all areas of human activity. Some early studies from the 1930s formed the view that groups perform better than individuals due to the effect of accumulated knowledge and experience, which increases the probability of making a better decision (Shaw, 1932). However, it was later stated that the answer to the question is unclear and there is evidence both for and against this proposition (Maier, 1967). Groups can contribute to a better quality of the decisions made, but also impair the performance of the individuals of which they are composed. Branson, Steele and Sung point to a number of studies supporting both the advantages of group work and its disadvantages related to inherent characteristics of the group process leading to a decrease in effectiveness (Branson, Steele, & Sung, 2010: 76). Schmutz, Meier and Manser (2019) investigate the relationship between teamwork and performance and their meta-analysis of 1390 teams from 31 different studies showed that teamwork has a medium sized effect. A recent study applying NASA simulation similar to the used in this research leads to the conclusions that collective decision-making outperforms individual judgment, but not the so called “wisdom of crowds” (Hamada, Nakayama, & Saiki, 2020). Thus, the present study takes as its main research question what are the trends in the performance of learning groups compared to individual performance in practical problem-solving learning situations? The study uses several simulations conducted using a methodology developed by Human Synergistics, one of which has published data from its application with groups

from the US, where it was created. A purpose of the research is to find out to what extent the Human Synergistics methodology leads to similar results in different cultural environment and how it can be used effectively to enhance group learning. Some hypotheses are formulated and tested and then an attempt is made to outline how the obtained results can help to improve group learning.

2. BACKGROUND

2.1. Factors Affecting the Effectiveness of Group Decision Making

Effective group decision-making depends on a number of factors. According to Maier (1967), the forces that influence problem solving are group assets, constraints inherent in the group process, and factors dependent on the skills of the leader. The information and knowledge in the group always exceeds that of any individual and the number of approaches to the problem is greater. Group participation in the decision-making process strengthens acceptance and improves the understanding of the decisions made. On the other hand, restraining forces can be group pressure for conformity, the "valence" of decisions - accumulating a critical mass of positive comments about a decision, after which other decisions have little chance of being considered (Hoffman & Maier, 1964), dominance of individuals and conflicting side goals (eg. power, winning the argument). The manifestation of factors that can be both an asset and a liability of the group will depend on the leader's skills in maintaining constructive disagreement, dealing with conflicting interests, taking risks, managing time and defending constructive proposals regardless of their source (Maier, 1967). However, a number of situational factors should also be taken under consideration. In addition to the skills of the leader, the essence of the problem and the goal to be achieved are also important (high quality solutions or solutions accepted by all; need for innovation, speed, satisfaction of different needs).

Another key factor that can significantly influence the increase in group performance is the style of interaction between its members (Group Styles Inventory etc., 1990). It is addressed in detail in the synergistic problem-solving model developed by the research organization Human Synergistics, Center for Applied Research, founded by Clayton Lafferty. The result of synergistic problem solving is an effective solution. The effectiveness of the group decision, in turn, can be determined based on criteria such as achieving higher quality than all individual decisions (synergy) and acceptance by all members of the group. Referring to the ideas of Maier, the effective solution can be represented in the form of an equation, where it appears as the product of the measure of quality multiplied by the measure of its acceptance by those who will implement it (Maier, 1963).

Human Synergistics pioneered the development of problem-solving simulations measuring and demonstrating the idea of synergy (Subarctic etc., 2007: 27-31). Their mechanism is based on making a judgment and prioritizing a list of items or actions according to their importance to achieve goals such as survival or higher efficiency. Individual and group responses are compared to a norm (based on expert, recommended or research decisions), on the basis of which magnitudes of deviations from it can be obtained. The model is built on the premise that when groups adopt a constructive interaction style and their members approach problems in a rational and supportive manner, the collaborative effort of people working together will have a greater impact than the sum of their independent efforts.

In a study conducted using the simulation developed by Lafferty, Subarctic Survival Situation, the results of 244 teams, including a total of 1228 participants, are presented (Subarctic etc., 2007: 55). The expert decision of the simulation was consulted with the Canadian Rescue Service. According to these data 96% of the teams achieved a better group score than the average individual score. Respectively, only 4% of the groups failed to improve the average individual score. Another study by J. Szumal shows a comparison of the performance patterns of 388 groups that participated in one of six different simulations, including the one listed above. The percentage of groups that improve the average individual score varies between 85-100%, and of those that improve the best individual score and achieve synergy is in the range of 17-50% (Szumal, 2000). Usually less than half of the groups succeed in surpassing the performance of their best participant, i.e., based on the results, it can be concluded that groups do not achieve synergy easily. According to Human Synergistics, the achievement of synergy depends primarily on the quality of interactions between group members, no matter what the type of problem or its context.

2.2. Objectives and Hypotheses of the Study

The objectives of the present study are to evaluate the adaptation of some popular simulations in Bulgarian language and culture and to investigate to what extent groups in the sample make decisions of a higher quality than individuals and achieve synergy. Based on the obtained results, another objective is to establish initial reference values that can serve as criteria for comparison and implementation of activities to improve the work of the Bulgarian learning groups.

Using the known data related to the application of the synergistic model for problem solving, the general hypothesis was formulated that: 1. The trends in the results of the same simulation for US and Bulgarian groups would be similar. This would also mean confirming the hypotheses that: 2. The quality of group decisions would in a comparably high percentage of cases be better than the quality of averaged individual decisions. 3. Synergistic groups would be a significantly lower percentage - less than half of all groups.

It can be assumed also that the quality of interaction in groups is likely to depend on whether the people know each other and have experience working together. A study using similar Human Synergistics' simulations shows consistent improvements in decision-making after students had worked in teams for 4 months (Sibbald, Campbell, Flores-Sandoval & Speechley, 2023). Thus, if groups are compared based on whether or not their members belong to the same organization or team, and based on the presumption that groups with better interaction quality are likely to achieve a higher performance, there is reason to expect that: 4. Groups consisting of members from one organization or team would achieve better results than open groups composed of people who have not worked collaboratively.

In addition, the dynamics of work in the sphere of private business suggest greater pressure for efficiency and results, and a higher need to develop teamwork skills, group decision-making, and higher-quality interactions. Therefore, it is interesting to test the hypothesis that: 5. The groups composed by participants working in private organizations would achieve better results than those composed by participants working in public organizations.

3. METHODS

The study includes the registration of the results of the group problem solving of 115 groups, most of which are 4-6 people, with the exception of several groups consisting of 3 or 7 participants. The total number of participants amounts to over 510 (for several groups the exact number is not noted, therefore the total number cannot be given with absolute precision). The study covers 5 different problem-solving simulations conducted in Bulgarian as part of open or corporate management trainings. Participants in the study are both real teams working in private business organizations and in the public sphere, as well as open groups, including students and managers from the Master's and Professional Management Programs of New Bulgarian University, and participants in other management skills trainings.

Table 1.
Types of group participants.

Types of groups	No
Groups from one organization	**44**
- Private Business (8 organizations)	39
- Public Organizations (2 organizations)	5
Open Groups	**71**
- Private Business (in a wide range of sectors)	36
- Public Sphere (Directors of VE schools)	35

Table 2.
Distribution of groups in simulations.

Types of simulations	No groups
Envisioning a Culture for Quality	60
Subarctic Survival Situation	35
Organizational Change Challenge	10
The Stuck Truck	7
Managing Transitions	3
Total groups:	**115**

These simulations were held between 2009 and 2023. Three of the simulations were developed by Human Synergistics, the first being perhaps their most popular simulation - the Subarctic Survival Situation (Lafferty, 2007). The other two are: Organizational Change Challenge (Szumal, 1998a) and Envisioning a Culture for Quality (Cooke, 2004). The fourth simulation is The Stuck Truck, developed by R. Baker and D. Kolb (Baker & Kolb, 1990), and the fifth is Managing Transitions based on a case published in the W. Bridges book of the same name (Bridges, 2003).

The procedure for conducting simulations follows the Leader's Guides of Human Synergistics (Subarctic etc., 2007; Envisioning etc. 1993; Szumal, 1998b) and lasts an average of about 2 hours. In all simulations, the output of the activity is assigned a sequence number to evaluated items based on their priority. In the procedure for calculating the results of simulations as the main indicators of efficiency are the obtained individual scores (IS), the group score (GS) the best individual score (BIS) in the group, the average individual score (AIS), gain/loss score (comparison between AIS and GS – if the GS is

lower than the AIS, it represents a gain) and the resulting synergy (comparison between GS and BIS - if the GS is lower than the BIS, it represents a synergy). IS and GS are calculated by subtracting them from the best solution (expert or obtained in research) rank for each item and summing the absolute differences (ignoring pluses and minuses) between the participants' ranks and the experts' ranks of the arrangement of the items from the list. The lower the values, the smaller the deviations, i.e., the solution comes close to the best possible solution and therefore has a higher quality. AIS is calculated as the sum of the ISs of the group members is divided into their number and is a measure of the average level of knowledge and resources they bring to the group. It can also be considered as an indicator of the expected level of decision quality if a member of the group is elected randomly to solve the problem. The GS is the consensus result of the group discussion and is a measure of the quality of the decision made by the participants working together as a group. Groups can improve the quality of the solution if they achieve a lesser deviation of the GS than AIS over the best solution. However, this does not yet mean achieving synergy. The calculation of synergy is done by GS being subtracted from the BIS. The positive value obtained indicates that the interaction of people in the group achieves a higher quality than each of the individual decisions, i.e., the synergistic solution is better than the mechanical sum of the individual solutions.

4. RESULTS

According to the study of a sample of 58 groups, the results of the Subarctic Survival Situation in 90% of cases are achieve a better group score than the average individual and in 50% of cases achieve a better score than the best individual score (Szumal, 2000). The results of the same simulation in the present study on 35 Bulgarian groups are slightly lower, but the tendency is similar: 85.7% of the groups achieve an improvement in AIS (30 of 35) and 40% achieve better results than BIS (14 of 35). This gives reason to confirm the first hypothesis of this study. Confirmation of the results can be considered as verification, both of the observations so far and the validity of the Bulgarian adaptation of the simulation.

The results show similar trends, as well as in the cited study by Human Synergistics of the same simulation conducted with 244 teams, where 96% of the groups improve AIS. However, differences are also observed. The comparison of the results in Table 3 shows that US individuals and groups in it generally do better than the Bulgarian groups in the present study which are much closer to the results of the sample of poorly performing US groups including the value of gain which is insignificantly higher.

The best individual scores in the Bulgarian sample are also clearly weaker, i.e., the knowledge, skills and experience to solve the problem are lower. One possible reason for this could be related to cultural characteristics that determine the competence of the participants in both samples. For example, that the experience of the Bulgarians is more inconsistent regarding a survival simulation in North America. However, the amount of gain/ loss in group work is also lower and the share of groups that do not improve is significantly higher (14.3% compared to 4%). This should no longer be relevant to the competence of the participants as to the quality of group interaction in the Bulgarian groups. (Teamwork is often informally reputed to be of a poorer quality than in other cultures.) However, the value of gain is higher than that of the groups performing poorly in the US study.

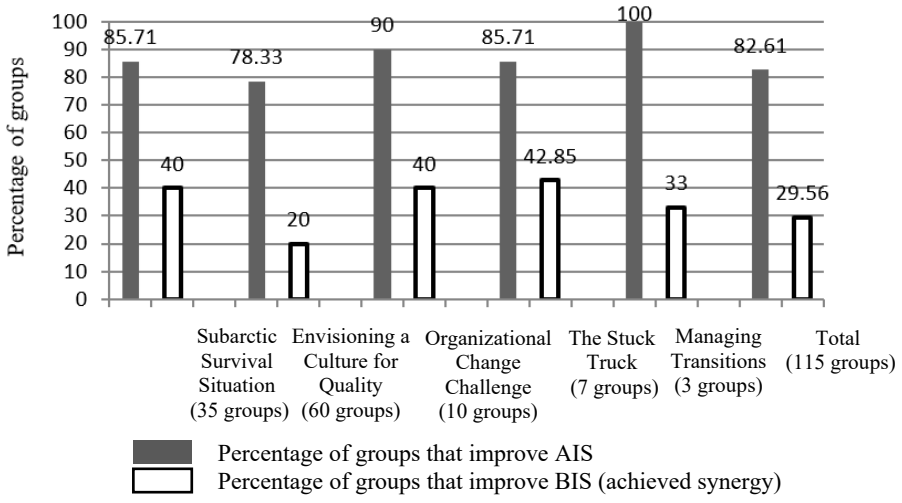
Table 3.
Comparison of the results of the Subarctic Survival Situation in the US and Bulgarian study.

No.	Indicators	Scores of 244 groups (Subarctic etc., 2007: 55)		Scores of 35 BG groups
		Total	Poorly performing	
1.	Average individual score	47.3	50	60.9
2.	Average group score (GS)	29.8	40.9	49.8
3.	Average Gain/ Loss in group work	17.4	9	11.2
4.	Average best individual score (BIS)	32.5	36.4	46.8
5.	Average difference between the BIS and GS	2.7	-4.5	-3.0
6.	Groups that improve the average individual score	96%		85.7%
7.	Groups that do not improve the average individual score	4%		14.3%

It is necessary to interpret the data with a high degree of caution due to the small size of the Bulgarian sample and its disproportionateness relative to the control group, including their placement in distant periods of study. However, they can serve to compare the general trends of the performance of the groups.

The trends in the performance, observed in all 115 groups, participated in one of the five simulations are depicted in Figure 1. The share of groups that improve the average individual score varies between 78.33-100% (85-100% in Szumal), and those who improve the best individual score and achieve synergy is between 20-42.85% (17-50% in Szumal). In total, for all 115 groups, the results are 82.61% (95 groups), respectively, improved AIS and 29.56% (34 groups) that improved BIS.

Figure 1.
Trends in the performance of groups in the five simulations.



The results regarding synergy show that in one of the simulations covering over half of the sample, the ratio is 1 in 5 groups. In three of the simulations, just under half of the groups achieved synergy, close to the results in the cited study of Szumal describing one of them. In general, synergy achieves an average of only 1 in 3 groups, which, despite the use of different simulations, is comparable to that of the Szumal's study (Szumal, 2000) and gives grounds to confirm both the second and the third hypothesis of the present study.

To examine the alleged influence of the established group collaboration on the results, the sample was divided into two parts, based on whether the participants are from one organization, work in one team or at least joint (company groups, n=44), or are enrolled in an open training program, including strangers and colleagues from different organizations (open groups, n=71). The results of the comparison are presented in Figure 2, where the difference in AIS improvement is 9.7%, and in BIS 11.01% in favor of company groups. In general, the data testifies to support the grounds for confirming the expected results formulated as a fourth hypothesis. However, care must be taken with the conclusions, as the two compared groups participated in different simulations and their results may have a cross-influence of factors related to their content. It is likely that differences are due, for example, to differences in the difficulty of simulations and the level of success in each of them.

To check the alleged influence of the different dynamics of work in the private and public area on group interaction skills and the results, the sample was divided into two parts, based on whether the participants are members of public (n=40) or private organizations (n=75). The results of the comparison are presented in Figure 3, where the difference in AIS improvement is 15.5% and in BIS is 7% in favor of private groups. The data testifies to support the conditional acceptance of the fifth hypothesis too.

Figure 2.
Comparison between the performance of company and open groups.

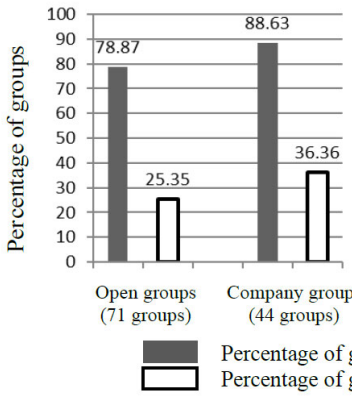
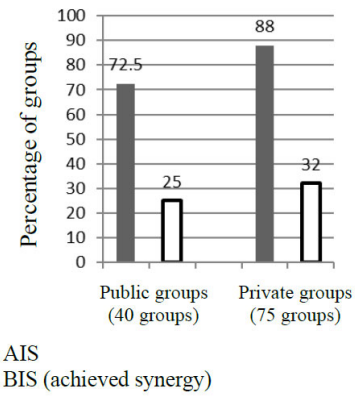
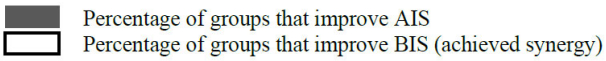


Figure 3. Comparison between the performance of groups in public and private areas





It should be noted that the comparisons made do not have the rigor and accuracy of a statistical analysis. They only show trends in the performance of the groups. However, the expressed trends in the results are indicative and set grounds for more precise future research.

5. USING RESULTS TO IMPROVE GROUP LEARNING

According to the model of Human Synergistics, there are two groups of key factors that contribute to effective decisions. The first group includes the skills and knowledge of the group members and the resources they have in regard to the problem. The second group of factors refers to the quality of the skills for rational thinking and interpersonal interaction of participants, i.e., to the emerging group process in solving the problem. Rational skills relate to analyzing the situation, setting goals, simplifying the problem, considering alternatives and discussing consequences. Interpersonal skills include listening, supporting, participating, constructive confrontation and striving for consensus (Subarctic etc., 2007: 29).

Human Synergistics developed observational forms and manuals to assess these skills and their constituent behaviors in order to offer feedback on the extent to which group participants exhibit them in the process of working together (Cooke, 1992). These include a clearly defined observer tasks, a detailed description of the rational and interpersonal processes, guidelines for conducting the observation, and forms and scales for evaluating behaviors. From a learning perspective, feedback from observers is particularly valuable and developmental, enabling a better understanding of the group process and own behavior. However, this requires the preparation of a resource of suitable observers.

A possible approach to improving the quality of group work is to divide the problem-solving discussion into two stages, with the first stage reflecting on the effectiveness of interpersonal skills and drawing conclusions for improvement to be implemented in the second stage. This can be done with or without the aid of structured observation. A similar approach was used with some groups in the Subarctic Survival simulation in the context of a more extended team building sessions for intact teams. One of them showed the best result in the sample. Before the simulation, team members discussed what they liked and disliked about teamwork, and what the team needed to acquire to be more effective. After the first stage of group work in the simulation, the team discussed how to improve the decision-making process and formulated key behaviors such as "everyone has an opinion", "giving a chance, without preconceptions", "supporting the opinions of others", "trusting experience and reasoned propositions", "introducing order into utterances" and "assessing possibilities". The subsequent second discussion stage was significantly more effective and resulted in the least deviation from expert responses of all observed groups (28 compared to the mean 50), the greatest gain from group discussion (24 or 46% compared to the mean 11), and achieving synergy (6 better than the BIS).

The in-depth study of individual and group experiences can be also extended through the use of additional surveys such as those used by Deacon to increase understanding of the impact of interpersonal factors perceived by participants to enhance or diminish group effectiveness (Deacon, 2016).

On the other hand, it is useful to have the quantitative results themselves accurately measured and presented in the context of the performance of multiple groups for comparison. The established tendencies in the performance of the groups can serve as a starting point for analysis and discussion of the quality of group decision-making and the search for answers on how decisions can be improved. Usually, participants are interested in how they did, for which they receive an immediate answer by comparing expert answers. However, the calculated difference has greater value if compared to the results of as many other groups as possible.

To this end, for the two simulations where there is an accumulation of data, the average values and standard deviations of the measured criteria were calculated (Table 4). They can be used as benchmarks for comparison. The range of average scores is presented in the table. Values outside it can be considered respectively as significantly low and high results.

Table 4.
Comparison criteria.

AIS	Group score (GS)	Gain/ Loss	BIS	Difference BIS & GS
Subarctic Survival Situation, N=35				
X=60.9 σ=6.3 low < 54 67 < high	X=49.8 σ=12.7 low < 37 63 < high	X=11.2 σ=10.7 low < 1 22 < high	X=46.8 σ=9.2 low < 7 56 < high	X= -3.0 σ=12.8 low < -16 10 < high
Envisioning a Culture for Quality, N=60				
X=98.4 σ=11.3 low < 87 109 < high	X=86.5 σ=14.9 low < 71 101 < high	X=11.9 σ=12.6 low < -1 24 < high	X=79.0 σ=12.6 low < 66 91 > high	X= -7.5 σ=12.5 low < -20 5 < high

Based on the comparison of their position against the criteria, participants can analyze the quality of their interactions and seek an explanation of the reasons for their results. This can be done using carefully designed questions that target the characteristics of the group process or through retrospection using coaching questions such as "What did we do well?", "What prevented us from achieving a better result?", "What would we change next time?"

One of the advantages of the proposed methodology is to measure not only whether the group achieves a better result than other groups and whether the discussion process adds value to the quality of the decision. A key learning point for teams is whether they manage to achieve synergy and this can become an important focus of discussion regardless of the scores achieved.

After identifying areas for improvement, group members can plan how to work on developing the necessary skills and reassess how they handle a later situation of simulated or real problem solving.

6. FUTURE RESEARCH DIRECTIONS

Future research may seek to accumulate a larger database of group simulation results in order to perform more reliable quantitative and statistical analysis. The types of simulations used in the study could be expanded while maintaining the adopted methodology for evaluating the scores in order to ensure comparability. Other variables may be included in research for which there is reason to hypothesize over relationships and dependencies. For example, one such variable could be an estimate of the consensus or degree of acceptance of the group decision by each participant in the simulation. It would be interesting to check whether the achieved quality of group decisions correlates positively with the degree of the consensus. The results of the observations of some groups give grounds for such a hypothesis. As other variables, key behaviors could be identified to be observed using rating scales. Their correlations with the results of the group work can be calculated and in this way an answer to hypotheses concerning the relationship between behaviors and results can be sought. It would also be interesting to check how much dividing the group discussion into two stages and including a discussion to increase its

quality would significantly affect the results. This could be investigated using experimental groups in which such discussions take place and control groups in which they do not. From the above example, it is clear that there are grounds for such a supposition.

7. CONCLUSION

The results of the study unequivocally show that the quality of group decisions is in a very large number of cases better than that of a randomly taken individual in the group (measured by AIS). However, this is not the case when it comes to the quality of the group decisions compared to those of the best participants in the groups (BIS). Less than one-third of the groups manage to achieve a better solution, which means that in the other two-thirds of the cases, there is a better individual solution that has failed to manifest itself and be accepted. In other words, groups could improve the quality of their decisions if they identify their most competent members and listen to them. However, in order for this to happen, a high quality of interaction is required, related for example, to the rational structuring of the group process, specific leadership and achievement of the most constructive rather than defensive style of communication between participants. Obviously, such a quality is more difficult to achieve, which is why it is necessary for it to become the focus of working with the groups after the simulations.

For the purposes of continued learning and development of groups and their members, the benefit of applying a well-designed quantitative methodology to determine the results of individual and group work, allowing objective comparisons and directions for improvement, is clearly outlined. However, the established differences between groups from different cultures show that, despite the expressed similar tendencies, it would be more correct to compare the results of groups from the same culture.

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