An Automatic Group Formation Method to Foster Innovation in Collaborative Learning at Workplace

Deller James Ferreira, Samuel Sabino Caetano, Celso Gonçalves Camilo Junior
Federal University of Goiás
Brazil

Abstract

Despite group formation in learning environments is commonly and successfully approached, there is a gap in the research literature with respect to its application in corporative learning. Regarding that creativity is as an important factor to increase innovation in companies, in the present research, we propose a group formation method, considering preferred roles and functional diversity, aiming to improve creativity in collaborative learning at workplace. We employed Tabu Search algorithm to automatically form groups based on Nonaka's knowledge creation theory and preferred roles from Belbin's model. We performed a case study to compare the quality of socio-cognitive interactions during collaborative learning in groups formed by the proposed method and randomly formed groups. The results show that groups formed by preferred roles and functional diversity are more creative and present enhanced fluency and more elaborated products in comparison to randomly formed groups.
***Keywords*:** Creativity; workplace; automatic group formation; functional diversity; preferred roles

1. Introduction

The ability to work in groups is becoming more and more valued in organizations and being increasingly employed to favor innovation. Many researchers highlighted he importance of group formation with the objective to improve task performance at work (Caetano et al., 2015; Turner, 2012; Grant, 1996; Nonaka, 1990; Brown & Champione, 1994; Redmond, 2001) Collaborative knowledge creation has been recognized as a vital source of competitive advantage in organizations and a key factor leading to innovation and development of new products and processes.

Moreover, researchers have pointed out that cultivating diversity in order to drive towards innovation is the most important management skill for the next decade (Amabile, 2008) Diversity usually trumps ability and teams assembled based on diversity outperform those based on ability (Amabile, 2008) Furthermore, diversity is important for creativity, due to the fact that different points of view and divergent ideas arise during group discussions.

When a member of a certain group has an idea, the idea is criticized to be discarded or reconsidered, being developed, amplified, and integrated to other ideas (Aragon & Williams, 2011) The potential of suggesting new ideas is important to feed the spiral of knowledge creation advocated by Nonaka (2009) New ideas can

lead to dialectical antithesis and strengthen group innovation.

Particularly, functional diversity has proved to be essential to increase innovation, contributing for the development of clear strategies and quick response to changes (Bunderson & Sutcliffe, 2002) Inside organizations, to gather people occupying distinct work positions is important for collecting diverse viewpoints related to different levels of maturity and needs of specific areas. Janis (1971) advocates that groups in which members have similar viewpoints, quality of decisions may be biased, implying failures on analysis of different opinions and perspectives, triggering a premature convergence to a conclusion or disregarding important issues. Aggarwal (2012) found out that groups having functional diversity perform better over time.

However, in organizations, neither knowledge nor creativity emerges with no stimulus. They need an appropriate environment to be triggered. Thereby, many companies have invested in corporative universities to provide training to the employees in order find out solutions to existent problems.

The growing usage of collaborative learning at workplace is a form of providing resources to employees for performing daily work. It gains force because it helps ensuring business goals to be respected by gathering employees into a group to deal with specific problems of the company (Goggins, Jahnke, & Wulf, 2012)

The advent of corporative universities drove new research towards group formations to maximize the performance of employees, and consequently the results of the company. In this work, we propose a group formation method regarding functional characteristics and preferred roles to be played by employees, with the purpose to facilitate creativity during collaborative learning.

Collaboration has long been acknowledged an effective and efficient approach to learning. Nevertheless, forming optimal groups can be a time consuming and intricate task. Although working in groups came to foster creativity in companies, it is difficult or even impracticable to form groups manually, due to the difficulty to analyze the characteristics and circumstances of each group and on account of the complexity to combine them, mainly when it involves a huge number of employees. Then, technological support is critical to form groups, making it feasible or increasing the efficiency and effectiveness of the group formation process, fulfilling its role as a key factor of competitive advantage (Wessner & Pfister, 2001)

Many researchers in computer science have proposed algorithms, mathematical models and computer programs to facilitate the formation of groups in educational environments (Bekele, 2005; Christodoulopoulos & Papanikolau, 2007; Felix & Tedesco, 2006; Graf & Bekele, 2006; Keijnsa, Kirschnerb, & Jochemsb, 2003; Lin, Huang, & Cheng, 2010; Martín & Paredes, 2004; Moreno, Ovalle, & Vicari, 2012; Nonaka, 1995; Ounnas, Millard, & Davis, 2007; Paredes e Rodrigues, 2010; Webb, 1983, Lin, Huang, & Cheng, 2010; Yanibelli, 2012). Despite group formation in learning environments is commonly approached, there is a gap in the research with respect to its application in collaborative learning at

workplace.

In the present work, we propose a method for automatic group formation considering corporative characteristics. The proposed method was contextualized in a Court of Justice. The characteristics of the employees of the organization were categorized in a gradation of functional roles. Categories of functions were generated by content analysis. We identified functional diversity that incorporates categories of functions regarding dichotomous functional roles. We also mapped preferred holes to employees.

We performed a case study to evaluate the proposed group formation method, with the aim to check to what extent creativity was fostered in collaborative learning at workplace. We applied the method proposed inside a Court of Justice. To accomplish the case study, we performed an employee training on risk management, where they were asked to develop some products that were evaluated from the standpoint of creativity. A comparative analysis of the products built after collaborations unveiled that groups arranged regarding functional diversity and preferred roles outperformed those formed by applying random group formation.

2. Related Work

Creativity is important to organizations on account of competitive advantage relying on the ability to create, transfer, use and protect knowledge (Teece, 2000) Furthermore, technological support for creativity has become critical to increase the efficiency and effectiveness of communication and coordination processes for information transmission, knowledge sharing and creation and has been recognized as a key factor to innovation and development of new products and processes (Guzzo & Dickson, 1996; Idd, Bessant, & Pavitt, 2011) In order to address these issues related to creative processes, organizations should develop the ability to change, acquire new skills and attitudes (Geus, 1997) Group learning seems to be a promising alternative for boost creative processes at workplace. Having appropriate learning groups allows good interactions among the group members, being essential in order to obtain appropriate corporative learning outcomes.

Researchers have been working hard in order to find out the best method to group people and create knowledge, especially on educational environments. Depending on the types of group formation, group interactions facilitate the development of some social-cognitive processes such as creativity. So, research efforts have been delivered for finding out which characteristics are or are not fostered by a type of group configuration. On the other hand, the application of proper computational algorithms is vital for an efficient group formation process.

Regarding computational techniques for group formation to boost collaborations that trigger creativity during group learning, many techniques have been addressed. Yannibelli and Amandi (2012) proposed an evolutionary algorithm for assisting the group formation, considering the diversity of roles in each team. They reported gains in student performance with the grouping based on roles. Nevertheless, the homogeneity among groups was not approached. Groups in which members are as similar among themselves as possible are said to be inter-homogeneous, while empowering the students' individual differences inside such groups implies on intra-heterogeneous groups.

Moreno, Ovalle, and Vicari, (2012) proposed a genetic algorithm for obtaining inter-homogeneous and

intra-heterogeneous groups. The authors considered behavioral aspects of individuals, such as communication skills, leadership and knowledge on a given subject. Despite the specific aspects they approached, they concluded that genetic algorithms handle well such kind of problem, and also any kind of combinatorial problem.

Our group method is computationally similar to Moreno's group formation (Moreno, Ovalle, & Vicari, 2012), assembling inter-homogeneous and intra-heterogeneous groups. The algorithm maximizes diversity inside groups and similarity among groups to obtain the optimal group formation. Groups are inter-homogeneous, but also intra-heterogeneous, enhancing the students' individual differences inside them.

Abnar, Rooji, and Taghiyaeh (2012) also proposed a genetic algorithm capable of handling a variable amount of constraints. The algorithm proposed by the authors generates intra-heterogeneous and inter-homogeneous groups. In their, research they compare randomly generated groups results to groups formed by their genetic algorithm, concluding that the genetic algorithm obtain computational better results.

On the other hand, the study conducted by El-Mihoub, Hopgood, Nole, and Battersby, (2006) showed that the application of genetic algorithms combined with local search is able to reach better results than canonical genetic algorithm (El-Mihoub, Hopgood, Nole, and Battersby, 2006) Therefore, in the present research we initially addressed the problem of forming groups using a hybrid genetic algorithm. However, Tabu Search technique proved to be computationally faster, achieving better results.

Tabu Search alternative was chosen to approach our inter-homogeneous, and intra-heterogeneous group formation problem. Employing Tabu Search for group formation is choice given the characteristics of the group formation problem. The main advantage of Tabu Search method is that it does not generate infeasible solutions because the number of employees per group always is the same, whatever the change is done.

Considering aspects related to creativity during group formation in corporative environments, preferred roles and functional bonds are two important characteristics for fostering collaborative learning at workplace. Mudrack and Farrell (1995) have found that roles help to promote individual responsibility and group cohesion, both of them recognized as fundamental factors for a successful collaborative learning (Brophy, 1998; Cox & Lake, 1991)

Besides, functional bonds and preferred roles also contribute to strengthening the positive interdependence among members. Positive interdependence is the belief by each individual that working with other students it's worth it and that both individual learning and work products will be better as a result of collaboration (Hare, 1994) Positive interdependence promote interactions and individual accountability.

In learning groups, the roles may emerge or be predefined. The emerging roles are those that arise naturally from the students. The predefined roles are usually assigned to students through collaborative scripts (Chen, Ren, & Riedl, 2010) Based on Dillenbourg's research, Berger (1999) called attention to the potential risks to predefine roles to be attributed to students. Therefore, it is important to work on roles identified before the group formation. In this sense, Belbin (2012) argues that the roles are inherent to the group members, and become evident from the group needs.

In the present work, each role of Belbin's model (2012) was analyzed in a corporative context and,

consequently, separated into three categories: Leadership, Creativity and Support. Leadership profiles are needed because in organizations always are leaders and leaders promote group cohesion (Brandon & Hollingshead, 1999) Furthermore, the effectiveness of the group's performance depends on the leader coordination of the work of the group (Guimerà, Uzzi, Spiro, & Amaral. 2005)
In addition, the comprehension of functional diversity is important for knowledge creation in organizations due to the fact that people perform different functions influenced by functional needs. Creative efforts needs to meet functional requirements.

Diversity must be valued from the understanding that groups composed by individuals having different characteristics can lead to knowledge advancement and an integration of different views about how the work could be done, and, consequently, can trigger different ways of processes design and goals fulfillment (Nasajon, 2010)

Thus, the group formation method proposed in the present work, besides incorporating preferred roles, deals with diverse and dichotomous functional roles. Dichotomous functional roles appear to be opposites, but complement each other, coexisting within the organization, being important sources of diversity within groups, and not keeping correlation with the roles played naturally. The main features of the group formation method presented here are approached in the following sections.

3. A Group Formation Method Based on Preferred Roles and Functional Diversity

From the perspective of diversity, groups containing distinct individuals can highlight different points of view, having in hand different approaches concerning how the work could be done. Consequently, it can bring out new ways of designing processes and achieving goals (Nasajon, 2010). In the present work, we suggest a generic method to maximize the diversity inside (intra-heterogeneous) groups and minimize the differences among them (inter-homogeneous), where the criteria for grouping employees is to assign diverse preferred roles (leadership, creativity, and support) and diverse and dichotomous functional features, such as bond of employees, asymmetry of information, and functional competences.
We also dealt with a contextualized model on a scenario of creating knowledge into a Court of Justice. Similar to other organizations, the Court of Justice is constituted by a complex of functional features. According to Aggarwal (2010), there is a common policy in organizations, where diversity is related to the way people think, behave and act. The comprehension of functional diversity is important for knowledge creation in the organization due to the fact that people are required to fulfill different roles and deal with different needs immersed in distinct functional contexts, which influences the way they make decisions and direct their creative efforts.
Despite all employees in an organization pursue the same goals, vision, and mission, there are functional roles that look like antagonistic within the organization. For instance, a lay-off program can be considered by the finance department employees as a good choice for reducing costs. On the other hand, a lay-off program can be viewed as a bad choice for human resources department employees. They will possibly feel scared of losing their jobs. On this dichotomy lies a key issue for knowledge creation in the

organization.

According to Takeuchi and Nonaka (2009), employees should struggle to strengthen their views and concerns, but also they should confront opposing ideas, to trigger a dialectic synthesis during group interactions and, thus, contributing to knowledge advancement. Such fact reinforces the expectation that putting functionally dichotomous employees together during collaborative learning causes better achievements. It could drive things to an equilibrium point.

Content analysis on data collected on a Court of Justice pointed out that we cannot deal with dichotomous differences only as a binary choice. There is a gradation of employees functional characteristics identified in the company forming a taxonomy.

Similar characteristics were placed on the same category. Each category regards one gradation that varies from opposite to slightly different. For instance, let's consider in a company people working on core activity and people working on non-core sector. Although both are important to the company, their concerns, roles, activities, and nature of works are completely different. The functional bond shapes behaviors and standpoints of individuals. Table 1 shows the taxonomy of functional characteristics on a Court of Justice.

Table 1. Taxonomy of functional characteristics.

	Functional Bond	Information Asymmetry	Department	Practice Area
1	Permanent	Principal city	Department Manager/ District Manager	Administrative workers
2	Assigned	Judicial Districts in the metropolitan region	Rotating Funds Managers/ Secretary of District	Chiefs of administrative areas
3	Outsourced	108-216 km from capital city	Chief Division Officer/ Chief of Notary Office	Notary office worker/ Secretary of court
4	Commissioned	217-324 km from capital city	Other Administrative Workers	Chiefs of notary's office/ Bailiffs
5		325-432 km from capital city	Rotating Funds Attester	Assistants and advisors of Judges
6		> 433 km from capital city	Internal affairs Department Inspectors/ Internal Controllership Analysts	Judges
7			Bosses of Internal Affairs Department and Controllership	

On the second column of Table 1, permanent and commissioned employees are in opposite positions. Even though they have been performing similar activities, their purpose is somewhat different because

commissioned employees generally have other goals, which usually cause conflict among their co-workers. Consequently, it is difficult sharing information among them. That is why we consider that they assume dichotomous roles. Assigned and outsourced are slightly different with respect to their aims.

In addition, there is an asymmetry in information that increases according to geographical distance from the headquarters of the institution. The more distant from headquarter, the more asymmetric information dissemination is. The third column presents the characteristics that imply in different gradations on this dimension.

Furthermore, managers and auditors work into different departments constituting another dichotomous force inside the organization. Auditors are interested in keep things running in a risk controlled environment, which requires additional efforts from managers in order to generate the reports and documents required to perform audits. On the other side, managers understand those efforts as a complete waist of energy and money. It is common they oppose to do some kinds of activities.

Finally, we have an opposition between core and non-core areas related to competences, named here as practice areas. In the literature, there are several works addressing this subject, especially investigating the potential of these competences as competitive advantage and organizational good performance (Tampoe, 1994; Grunert & Hildebrandt, 2004; Bani-Hani & faleh, 2009; Agha, Alrubaire, & Jamhour, 2012; Liang, Ling, & Huang, 2013)

However, the employees can occupy intermediate positions in organization. Here intermediate positions means positions played by workers that are not on dichotomy extremes. This observation was based on trends found in official documents of a Court of Justice, such as organization conduct rules (Poder Judiciário, 2013; E. Goiás, 2012; Poder Judiciário, 2000; & Poder Judiciário, 2001) Results obtained from documentary data are presented in fourth column of Table 1.

From the standpoint of Preferred Roles, we analyzed each of them based on Belbin's theory and grouped them according to the tendency into three categories: leadership, support, and creativity. From this classification, we obtained the taxonomy shown in Table 2. The aim here is to group employees favoring diversity among these three categories.

Table 2. Taxonomy of preferred roles.

Category	#	Role
Leadership	1	Coordinator
	2	Shaper
Creativity	3	Plant
	4	Resource Investigator
Support	5	Specialist
	6	Implementer
	7	Team worker
	8	Completer Finisher
	9	Monitor Evaluator

By analyzing Belbin's model, we observed that Coordinator and Shaper roles are a type of leadership profiles. The difference between them is the method of exercise and maintenance of leadership, which are

apparently opposed, because the Coordinator seeks to create synergy of efforts of all team member in order to meet the goals whilst Shaper usually stimulate competition within the team.

The creativity category embraces the roles Plant and Resources Investigator, because they are associated to people that develop solutions for problems. The Plant applies his own resources whilst Resources Investigator applies third-part resources. The Specialist, Implementer, Team-worker, Monitor Evaluator profiles were classified as support profiles, due to the fact that they play an important role in groups helping others to implement the work, providing specific abilities and skills.

Therefore, in the group formation method proposed here, there are four dimensions mapped to functional roles and one dimension mapped to preferred roles. Each dimension is independent, coexisting and cooperating to form the attributes of the team member as exemplified in Table 3.

Table 3. Example of representation of characteristics of a group.

Employee	Functional Bond	Asymmetry of Information	Different Departments	Practice Area	Preferred Roles
Employee1	1	3	4	1	5
Employee 2	2	5	2	2	9
Employee 3	3	6	4	6	3
Employee 4	4	2	5	3	1

As shown in Table 3, each employee has four functional characteristics and 1 preferred role. For instance, Table 3 represents the characteristics of a certain group. According to Table 3, placing 4 employees into a group implies to recombine each of those 5 characteristics in order to find the best group formation.

Furthermore, it is required an equilibrium among the groups (homogeneity inter-groups), so that one of them cannot excels others. In other words, we cannot deal with bad and good groups simultaneously. This way, we must recombine them in order to obtain the homogeneity. All of those constraints become forming group a hard task to be done.

The difficulty of evaluating without computational support if a determined group configuration is well formed makes this task simple prohibitive. For this reason, the application of computational methods are taking place for exploring the possibilities by recombining people inside groups. In this research, Tabu Search was chosen as computational method due to the fact that it has been applied for figuring out several types of optimization problems and it commonly overcomes others heuristic methods (Jia, Dong, & Ya, 2013; Hamiez & Hao, 2000) Indeed, Tabu Search is able to transcend local optimality. This Tabu Search feature is an advantage when compared to other methods.

4. Case Study

With the aim to empirically validate the group formation method proposed, we conducted a case study at

the same Court of Justice used in content analysis that generated the hierarchy of functional characteristics. In the case study, risk assessment training was performed. Forty-four workers from a Court of Justice participated on the risk training. The training was divided into two parts. In the first one, employees went to a classroom with an instructor, who explained to them the main concepts of risk assessment.

It is important to highlight that the employees registered by themselves to participate of the training, according to their willing and concerns. It means that nobody was obliged to register himself/herself by his or her boss. This procedure was adopted for avoiding chiefs forcing employees to participate due to the fact it would negatively affect the motivation of employees and consequently it could harm this research results. Moreover, in order to promote the participation of people from other districts and provide groups with required diversity of information asymmetry category, the number of openings was initially divided so that one half was to workers from county districts whilst the other half was destined to employees from the Court of Justice headquarter.

Before the kickoff of the training, all of applicants filled out a survey, which was employed to determine the functional characteristics and preferred roles of each applicant. However, after the training began, other people who were not registered came to the training whereas, some registered employees did not. For this reason, we repeated the process of gathering the form and after that we rearranged groups by running the algorithm again.

On second stage, the employees went to online to a Moodle environment where they got access to the presentation containing tutorials and manuals explaining how to perform a risk assessment. The instructor also left a template of a risk assessment to be filled by employees as final task, which was performed in groups.

The group task assigned to employees was to perform a risk assessment regarding two hypothetical scenarios given by instructor and to come up three artifacts: a) A risk appetite scale; b) a risk impact on business activity scale; c) a complete risk assessment (qualitative and quantitative analysis) In order to do this, they need to gather themselves and debate some issues such as:

1. Which is the likelihood of a certain event happen?
2. Which is the impact in business of the event?
3. How much would cost to business to deal with the event?
4. How long the business would take to recover normal activities if the event happened?

All groups performed the activities using some technological resources like a group into Whatsapp and Moodle. They were also encouraged to gathering them online though Google Hangout.

4.1. Working in Groups

Two types of groups were formed. The first one was formed by a Tabu Search algorithm that was used to group one half of employees (Treatment Groups), based on the method proposed in this research. The rest of the workers were randomly grouped (Control Groups) Four employees composed each group.

Based on four creative dimensions, we performed a qualitative analysis of artifacts produced during employees' interactions. We applied an adaptation of the model proposed by Casakim and Kreitler (2008) for creativity evaluation, as listed below:

- fluency (how many risks were pointed out?);
- artifacts (how many artifacts were made by each group?);
- flexibility (number of risks pointed out that are beyond the employees' labor context);
- elaboration (cohesion among risks raised, risk taking action, and scenario studied)

Fluency is related to the ability to point out different risks, whereas flexibility deals with the capacity of employees to propose alternative solutions and the relation of those solutions to the functional context of the employee. Fluency is also concerned to the capacity to find out solutions from context in which the employee is not familiarized. The last criterion was elaboration that is related to the cohesion of the artifacts produced and in with extent the employees gone deep in details and correlations. By assessing the cohesion we can evaluate the level of comprehension of a topic. In order to proceed this evaluation, we created a scale from 1 to 5, described on Table 4.

4.2. Empirical Results

Every artifact produced by employees was evaluated and received a grade as shown on Table 5. It is also important to highlight that groups G1, G2, and G3 were controls groups. Control groups were grouped randomly. Groups G4, G5, G6 and G7 are the treatment groups, where we applied the group formation method proposed in the present work.

Table 4. Evaluation criteria of artifacts produced by groups.

Grade	Criteria	Discussion
1	Fluency	At least one risk pointed out.
	Artifacts	At least a half of an artifact.
	Flexibility	No beyond context risk was pointed out.
	Elaboration	The artifact done is not related to the topic.
2	Fluency	At least two risks pointed out.
	Artifacts	At least one artifact.
	Flexibility	At least one beyond context risk was pointed out. However, it was not applicable to the organization.
	Elaboration	One artifact was not co-related. There is some cohesion between the two others.
3	Fluency	At least three risks pointed out.
	Artifacts	At least one and a half artifact.
	Flexibility	At least one beyond context risk was pointed out. It was applicable into the context of organization.
	Elaboration	The three artifacts were weakly co-related. There is a weak cohesion among them.
4	Fluency	At least four risks pointed out.
	Artifacts	At least two artifacts.
	Flexibility	Two beyond context risk were pointed out. One of them were not applicable to organization.
	Elaboration	The three artifacts were co-related. There is cohesion among them.
5	Fluency	Over five risks pointed out.
	Artifacts	Three artifacts or over.
	Flexibility	Over two beyond context risk were pointed out. All of them were applicable into the context of organization.
	Elaboration	The three artifacts were strongly co-related. There is a strong cohesion among them.

Table 5. Results of artifacts evaluation produced by groups.

	Control Groups			Treatment Groups			
Criteria/Group	G1	G2	G3	G4	G5	G6	G7
Fluency	-	2	4	-	4	3	5
Artifacts	-	2	4	-	5	5	5
Flexibility	-	1	4	-	4	5	4
Elaboration	-	2	2	-	5	5	4

4.3. Discussion

First, groups G1 and G4 did not deliver the required tasks. So, they were withdrawn from analysis. Other sixteen employees dropped out the training.

Results show that the randomly formed group G2 pointed out only two risks described on the two artifacts they did. Moreover, they achieved a low rate on flexibility criterion. This was due to the fact that employees in G2 had bad similar ideas. However, they kept coherence between the two artifacts made by them.

In comparison to G2, group G3 did better artifacts. However, their elaboration score was lower than G2's score. It indicates that group G3 didn't have a full comprehension about how each artifact was interrelated.

G5 pointed out four risks, developed three artifacts, pointed out three risks out of their functional context, and showed strong cohesion among artifacts. We could observe that functional diversity motivated employees to develop new ideas, but also to exercise a deeper thinking. Their ideas were detailed and interrelated.

Similarly to G5, G6 scored well in all creativity dimensions. However, surprisingly they were did better in inventive thinking, overcoming their usual way of thinking. We could observe that functional diversity motivated employees to focus on new directions.

G7 also scored well regarding the amount and quality of their artifacts. We could observe that functional diversity motivated employees to think out of their box, despite they performed better in their comfort area.

By comparing the fluency of random groups to controlled groups, we can see that the second one got higher grades than the first ones, indicating that diversity implied in a greater fluency.

With respect to flexibility criterion, treatment groups also scored higher. Besides, we can consider the results reached by the treatment groups more intricate than control groups, because employees in treatment groups were able to mention also positive aspects, like opportunities to meet and to overcome the goals.

For instance, when group G5 was analyzing the scenario of a possible reduction of economic activity into building sector, they pointed out the risk of "Finishing buildings earlier than predicted as a goal." According to their work, the crash of real estate market would result in layouts. Consequently, the labor cost would grow without affecting the cost of building, allowing them to spend less money and/or building faster than expected. When those group was asked about how would they deal with this risk they answered that the suggested action was to increase the cash flow in order to accommodate new employees to finish the buildings faster.

On the other hand, they also predicted that this opportunity could come up to a new risk, the lack of money to afford infrastructure such as Internet cabling network, due to a decision of the board to construct more

buildings. In order to deal with this risk, they pointed out to improve the budget of each building.
Concerning the elaboration criterion, treatment groups also obtained better outcomes. The artifacts produced by them were fairly more coherent. It means that the understanding of topic of those groups was better. A higher quality was detected after analyzing their artifacts. Treatment groups were superior in providing examples, deducing new facts and approaching relationships.
Regarding all criteria, the treatment groups outperformed the control groups. This is an evidence that groups having functional diversity and in which people play their preferred roles tend to be more creative than randomly formed groups.

5. Conclusions

Regarding that group formation is a key process in order to foster creativity in collaborative learning, the purpose of the present work is to propose a method based on Tabu search approach, Nonaka's knowledge creation theory and Belbin's preferred roles model for achieving inter-homogeneous and intra-heterogeneous groups in corporative learning. The main feature of the proposed method is that it allows for the consideration of important employees' characteristics to boost creativity during collaborative learning.
In the present research, we elaborated a group formation method, dealing with functional diversity and highlighting that to place people at right places and to allow them to play proper roles can contribute to foster creativity during collaborative learning at workplace. Tabu Search algorithm was employed to address inter-homogeneous and intra-heterogeneous group formation problem approached here, regarding diversity of functional bonds and preferred roles.
To verify the effectiveness of the group formation method proposed in the present work, we performed a risk training to 44 (forty-four) employees of a Court of Justice. The employees were grouped, part of them into random groups while others in an improved manner by using an automatic group formation method proposed in the present work.
The automatic group formation method, arranged the students based on criteria established on a contextualization of Nonaka's theory and Belbin's preferred roles to a Court of Justice. The contextualized group formation was obtained by content analysis upon documentary data involving the Court of Justice employees.
Qualitative analysis of products generated by group interactions during the risk training was based on an adaptation of Casakim and Kreitler's model to evaluate employees' creativity. The fluency, number of artifacts, flexibility, and elaboration criteria were applied to judge and compare the artifacts produced by randomly formed groups and groups formed according to group formation approach developed in the present work.

The analysis of products collaboratively created by groups during the risk training indicated that forming groups regarding preferred roles and functional diversity improved creative process in the context of a Court of Justice in comparison to randomly formed groups.
The results obtained from a controlled experiment with employees of a Court of Justice, using diversity

of functional bonds and preferred roles, show that groups formed with the proposed method produced better outcomes in terms of observable variables than those formed with traditional methods like random assignment.

Such an experiment provided evidence that proposed method achieves the goal of enhancing creativity at workplace. The characteristics considered can positively affect the development of the activities and interactions within the corporative learning context.

The research work presented here aims to be a relevant contribution to the corporative learning context, because the research focuses on a key issue that is the learning group formation at workplace. The group formation method presented in this work provides technological support for creativity, having the potential to boost the efficiency and effectiveness of innovation processes when regarding the development of new artifacts during collaborative learning.

References

Abnar, S., Rooji, O., Taghiyaeh, F. (2012). An evolutionary algorithm for forming mixed groups of learners in web based collaborative learning environments. *IEEE International Conference on Technology Enhanced Education*, 1-6, .

Aggarwal, A. (2012). Functional diversity and its impact on distributed groups: An exploratory study. *45th Hawaii International Conference on System Sciences*, HICSS '12, IEEE Computer Society, Washington, DC, USA, 444-453.

Aggarwal, A. K. (2010). Diversity in distributed decision making: An exploratory study. In Proceedings of the 2010 *43rd Hawaii International Conference on System Sciences*, HICSS '10, IEEE Computer Society, Washington, DC, USA, 2010, 1-11.

Agha, S., Alrubaiee, L., Jamhour, M. (2012). Effect of core competence on competitive advantage and organizational performance, *International Journal of Business and Management*, 7 (1), 192-204.

Amabile, T. M. (2008). Creativity and entrepreneurship in the global environment. In Centennial Global Business Summit, President and Fellows of Harvard College, Harvard Business School.

Aragon, C. R., Williams, A. (2011). Collaborative creativity: a complex systems model with distributed affect. In CHI '11 Proceedings of the SIGCHI *Conference on Human Factors in Computing Systems*, 1875-1884.

Bani-Hani, J. S., Faleh, A. A. (2009). The impact of core competencies on competitive advantage: Strategic challenge. *Journal of Business and Management*, 4 (2) .

Bekele, R. (2005). Computer-assisted learner group formation based on personality traits, Ph.D. thesis, Universität Hamburg.

Belbin, M. (2012). An introduction to Belbin team roles. http://www.housing.sc.edu/lasd/pdf/Training/Instructors/Week2ReadingBelbin.pdf.

Berger, N. (1999). Pioneering experiences in distance learning: Lessons learned. *Journal of Management Education*, 23(6), 684-690.

Brandon, D., Hollingshead, A. (1999). Collaborative learning and computer supported groups.

Communication Education, 48(2), 109-126, 1999.

Brophy, D. (1998). Understanding, measuring, and enhancing collective creative problem-solving efforts, *Creative Research Journal*, 3, 199-299.

Brown, A., Campione, J. (1994). Guided discovery in a community of learners. In C. M. Press (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice.* 229-270.

Bunderson, J. S., Sutcliffe, K. (2002). Comparing alternative conceptualizations of functional diversity and performance effects. *Academy of Management Journal*, 45 (5), 875-893.

Caetano, S. S., Ferreira, D. J., Camilo-Junior, C. G. Ullmann, M. R. D. (2015). A hybrid genetic algorithm for group formation at workplace. *IEEE Congress on Evolucionary Computation - CEC*, 3287-3295

Casakin, H., Kreitler, S. (2008) "Correspondences and divergences between teachers and students in the evaluation of design creativity in the design studio", *Environmnent and Planning B: Planning in Design*, 4 (35),666-678.

Chen, J., Ren, Y. and Riedl, J. (2010). The effects of diversity on group productivity and member withdrawal in online volunteer groups. In Proceedings of the *SIGCHI Conference on Human Factors in Computing Systems*, CHI '10, 821-830, New York, NY, USA. ACM.

Christodoulopoulos, C. E., Papanikolaou, K. A. (2007). Investigation of group formation using low complexity algorithms", In Proceedings of Workshop on Personalization in E-Learning Environments at Individual and Group Level, 57-60, 1th International Conference on User Modeling.

Cox, T., B Lake, S. (1991). Managing cultural diversity: Implications for organizational competitiveness. *Academy of Management Executive*, 5, 45-56.

E. Goiás, (2012) Lei no 17.663, de 14 de junho de 2012., Reestruturação da Carreira dos Servidores do Poder Judiciário do Estado de Goiás e dá outras providências. http://www.gabinetecivil.go.gov.br/pagina_leis.php?id= 10324.

El-Mihoub, T. A., Hopgood, A. A., Nolle, L., Battersby, A. (2006). Hybrid genetic algorithms: A review, *Engineering Letters*, 13 (2)

Felix, Z., Tedesco, P. (2006). Formação de grupos de aprendizagem em ambientes cscl ciente de context. *II SEGeT Simpósio de Excelência em Gestão e Tecnologia*.

Geus, A. (1997). *The living company*. Harvard Business School Press, 1997.

Glover, F., Laguna, M., Martí, R. (2007) "Principles of Tabu Search in Handbook of Approximation Algorithms and Metaheuristics", Chapman and Hall/CRC; 1 edition.

Goggins, S., Jahnke, S. I. and Wulf, V. (2012). Cscl@work revisited - beyond cscl and cscw?: are there key design principles for computer supported collaborative learning at the workplace?. In Proceedings of the 17th ACM international 1 SEP 18.

Graf, S., R. Bekele, R. (2006). Forming heterogeneous groups for intelligent collaborative learning systems with ant colony optimization. In H. Springer-Verlag Berlin (Ed.), ITS'06 Proceedings of the 8th international conference on Intelligent Tutoring Systems, 217-226.

Grant, R. (1006). Toward a knowledge-based theory of firm. *Strategic Management Journal*, 17, 109-122.

Grunert, K. G., L. Hildebrandt, L. (2004). Success factors, competitive advantage and competence development. *Journal of Business Research*, 57 (5), 459-461.

Guimerà, R., Uzzi, B., Spiro, J., Amaral, L. A. N. (2005).Team assembly mechanisms determine collaboration network structure and team performance. *Science*, 308(5722), 697-702.

Guzzo, R., Dickson, M. (1996). Teams in organizations: Recent research on performance and effectiveness. *Annual Review of Psychology*, 47, 307-338.

Hamiez, J., Hao, J. (2000). *Recherche tabou et planification de rencontres sportives tabu search and sports league scheduling*. Paris.

Hare , A. P. (1994). Types of roles in small groups: A bit of history and a current perspective. *Small Group Research*, 25, 433-448.

Idd, J., Bessant, J., Pavitt, K. (2011). *Managing Innovation: Integrating Technological, Market and Organizational Change*. Wiley.

Janis, I. (2012). Group Think. *Conference on Supporting group work*, GROUP '12, ACM, New York, NY, USA, 323-326.

Jia, L. Y., Dong, H., B., Ya, H. (2013). An improved tabu search approach to vehicle routing problem. In Procedia - Social and Behavioral Sciences, Vol. 96, 13th COTA International Conference of Transportation Professionals- CI- CTP, 1208-1217.

Kankanhalli, A., Tan, B., Wei, K. K. (2007). Conflict and performance in global virtual teams. *J. Manage. Inf. Syst.*, 23 (3), 237-274.

Kreijnsa, K., Kirschnerb, P. A., Jochemsb, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research. *Computers in Human Behavior*, 19, 335-353.

Liang, C. J., Lin, Y. L., Huang, H. F. (2013). Effect of core competence on organizational performance in an airport shopping center. *Journal of Air Transport Management*, 31 (0).

Lin, Y. T., Huang, Y. M., Cheng, S. C. (2010). An automatic group composition system for composing collaborative learning groups using enhanced particle swarm optimization. Comput. Educ. 55 (4), 1483-1493.

Martín, E. and Paredes, P. (2004). Using learning styles for dynamic group formation in adaptive collaborative hypermedia systems. Matera, M. and Comai, S. (Eds.) Engineering Advanced Web Applications. Proceedings of Work- shops in Connection with 4th International Conference on Web Engineering, 188-197.

Moreno, J., Ovalle, D. A., Vicari, R. M. (2012). A genetic algorithm approach for group formation in collaborative learning considering multiple student characteristic. *Computers and Education*. 58, 560-569.

Mudrack , P. E., Farrell, G. M. (1995). An examination of functional role behavior and its consequences for individuals in group settings. *Small Group Research*, 26(4), 542-571.

Nasajon, L. (2010). Gerenciamento da diversidade nas organizações. http://era.org.br/2012/05/ gerenciamento-da-diversidade-nas-organizacoes.

Nonaka, I. (1990). *An Inquiry into the Good.* Yale University Press.

Nonaka, I. (2009). A empresa criadora do conhecimento. Bookman (Ed.), *Gestão do Conhecimento, Hirotaka Takeuchi and Ikujiro Nonaka*, Ch. 2, 39-53, tradução: Ana Thorell.

Nonaka, I. (1995). *T. University, The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation.* Oxford University Press, USA.

Ounnas, A., Millard, D. E., Davis, H. C. (2007). A metrics framework for evaluating group formation. *ACM Group'07*, 221-224.

Paredes, O. A., Rodrigues, P., P. (2010). A method for supporting heterogeneous- group formation through heuristics and visualization. *Journal of Universal Computer Science*, 16, 2882-2901.

Poder Judiciário. (2013). Estado de Goiás, Brasil, Portal da transparência. http://www.tjgo.jus.br/index.php/tribunal/tribunal-portaldatransparencia.

Poder Judiciário. (2000). Estado de Goiás, Brasil, Regimento interno do tribunal de justiça do estado de Goiás. http://www.tjgo.jus.br/docs/publicacoes/regimentos/ regimento.pdf.

Poder Judiciário. (2001). Estado de Goiás, Brasil, Resolução 44 de 10 de dezembro de 2001, Internet, institui o Sistema de Controle Interno das atividades administrativas do Poder Judiciário do Estado de Goiás. http://www.tjgo.jus.br/tjdocs/documentos/151/download.

Redmond, M. A. (2001). A computer program to aid assignment of student project groups. ACM, 134-138.

Takeuchi, H., I. Nonaka, I. (2009). Criação e dialética do conhecimento, in: Bookman (Ed.), Gestão do Conhecimento, Hirotaka Takeuchi and Ikujiro Nonaka, 2009, Ch. 1, 17-38.

Tampoe, M. (1994). Exploiting the core competences of your organization. *Long Range Planning* 27 (4), 66-77.

Teece, D. J. (2000). Strategies for managing knowledge assets: the role of firm structure and industrial context. *California Management Review*, 40(3), 55–79.

Turner, M. E. (2012). *Groups at work.* Routledge.

Webb, N. M. (1983). Predicting learning from student interaction: Defining the interaction variable. *Educational Psychologist*, 18, 33-41.

Wessner, M., Pfister, H. R. (2001). Group formation in computer-supported collaborative learning. *ACM SIGGROUP Conference on Supporting Group Work*, 24-31.

Yannibelli, V., Amandi, A. (2012). A deterministic crowding evolutionary algorithm to form learning teams in a collaborative learning context. *Expert Systems with Applications*, 8584-8592.