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SUPPORTING IDEA GENERATION IN DESIGN TEAMS

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ABSTRACT
Whilst creative teamwork is increasingly crucial in the educational and the professional environments, there seems to be a lack of team formation heuristics or guidelines based on evidence. This research illustrates that structural features of teams such as how acquainted their members are with each other may have key effects on their creative process and output.

Keywords: Creativity, teamwork, social networks, situational factors

1 CREATIVE TEAMS IN THE DESIGN STUDIO

Teamwork is increasingly crucial in the educational and the professional environments, and it is of particular importance in the context of the creative disciplines. Collaborative work has been extensively addressed in educational research in recent years, largely supporting the commonplace idea that students should gain ample experience in team working. It is usually assumed that working in teams provides design students with key skills on leadership and creative collaboration.

Despite its broadly recognised importance, teamwork in practice may turn into a type of division of labour whereby students ascribe subtasks to team members. Because this type of practices may preclude all positive factors of teamwork, it is important to improve our current understanding of teamwork and develop appropriate teaching-learning and team management guidelines.

The work presented in this paper is motivated by the need to systematically improve teamwork practices in creative activities. It arises from the juxtaposition of two sources: a) the observation in classroom activities of creative teams and b) a theoretical framework of societal factors that is believed to affect team formation and creative collaboration. This research aims to gain further understanding of the issues that determine the success of creative teams in addressing design tasks.

1.1 The design studio as a distinct learning environment

The design studio is a particular teaching-learning environment that is characteristic of design schools. In a design studio or workshop, a class size of 15 to 20 students is typically organised in teams. Design studio sessions usually run between 3 to 5 hours. In a session, teams may present their progress either to the entire group or to the lecturer or tutor, who provides specialised feedback. Teams develop and revise short-term goals for a single session, as well as mid and long-terms goals for the entire semester. Teamwork in the design studio often focuses on creative tasks –especially during the early project stages. Team roles and interactions are particularly distinct in a creative setting, as some

constrains are negotiable, solutions are open, and the problem tends to be vague or ambiguous [1]. There seems to be a lack of team formation heuristics or guidelines based on verifiable studies. Anecdotal evidence indicates that teams are either formed by friends or assigned by the lecturer, which can be expected to influence the process and the final solution produced by a team. However the impacts of varying team formation practices remain largely unknown.

1.2 Team productivity in creative tasks

Research on group brainstorming suggests that a higher number of original ideas are produced by individuals working independently than by collaborative teams in equivalent tasks and time periods [2]. This finding challenges the notion of synergy that suggests that teams ought to be more creative than their separate members. A range of factors may account for such individual creative productivity including interruptions by turn-taking, dominant roles that prevent openness, criticism of initial seeds of ideas, and role assignment that hinders freedom and exploration. Groupthink and other team-related factors have been identified as obstacles to efficient and creative decision-making [3].

Recent work further suggests that team diversity is of key importance to the originality and quality of ideas [2]. Namely, highly diverse teams have been shown to be more productive in creative tasks than homogeneous teams as well as than individuals working independently. The main implication for team formation strategies is that friendship-based teams may be counter-productive due to high levels of homophily, i.e., friends tend to share common tastes, beliefs and values. Diversity may facilitate exploration because it is likely to prevent teams from rapid convergence into 'good enough' solutions, and the exploration of new ideas may allow teams to find more valuable and original solutions.

In our context, ethnic, cultural or age diversity is expected to be low within the design studios of our bachelors program. For this reason, we decided to study team formation in an experimental setting based on the societal factor of social tie strength as a source of team diversity. This approach stems from our previous studies of social structure as a situational factor of creativity and innovation within the scope of computational social simulations [4].

2 SOCIETAL FACTORS OF CREATIVITY

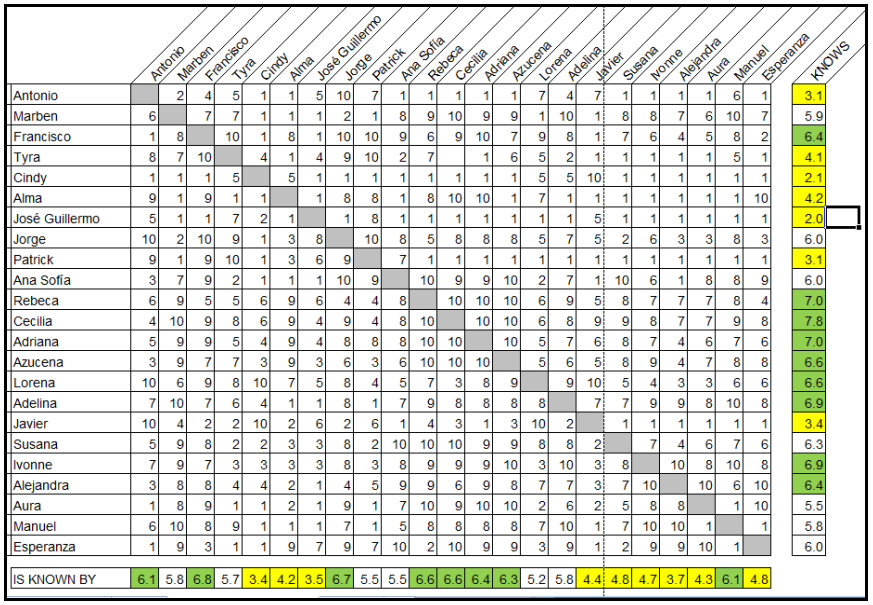
The social and historical dimensions of creativity seem, by definition, necessary to distinguish people and ideas that change the world [5]. Nonetheless, creativity is still largely taken for granted as something that takes place inside the head of distinctive people when they create or ideate new solutions. This tension between the individual and social levels of creativity may be addressed by arguing that collaboration with and evaluation by peers is crucial in the attribution of creativeness to an influential person or idea. A fundamental hypothesis of this research is that creativity transcends the lone creator and is importantly determined by situational factors. One of such factors is the focus of our studies: the structure of social groups –including teams.

In social analysis, networks represent social groups where nodes are the structural units such as individuals, and links or ties stand for the social connections between nodes. Ties between people may be defined by friendship, kinship, acquaintanceship, etc. Stronger ties exist in social groups where individuals know well each other, spend more time together, and share a larger set of beliefs, goals and evaluation criteria. Weaker social ties exist in groups of strangers, i.e. where individuals have not spent time

together, know each other only superficially, and are unaware of each other's beliefs and values.
Using computational simulations, we have illustrated how different social groups may facilitate or block novel ideas and how such ideas may have different impacts depending not so much on the idea or the people involved, but on a structural feature such as the way they are socially connected [6]. It is our aim to yuxtapose our teaching experience in design studios and these more speculative 'in silico' or computational findings. Our hypothesis states: "Teams of strong ties (teams of friends) and teams of weak ties (strangers) produce different creative processes and solutions".
Intuitively, teams with strong ties may be assumed to work more efficiently, but according to the principle of team-diversity-as-predictor-of-creative-productivity they may converge rapidly into a 'satisficing' solution. This may happen due to role assignments, rapid agreements to avoid critical evaluation, preconceived assumptions, etc. In contrast, teams of weak ties may find it more difficult to collaborate but this may promote a higher degree of divergence that enables 'optimisation' processes. In the following section we present an experimental study that confirms and challenges some of these assumptions.

2.1 The strength of ties in creative teams at ITESM

The Bachelors in Industrial Design at Tecnologico de Monterrey (ITESM) includes a set of nonsequential subjects that students undertake at different stages of their degree. Students may also transfer midway through their studies between the seven ITESM campus where this degree is offered. Thus, an average group may include subsets of friends and strangers. For this reason the strength of social ties is used as a structural measure of diversity in the classroom.
In order to measure the strength of the social ties in a group we implemented a "matrix of familiarity" such as that shown in Figure 1. Students enrolled in the course "Rapid Prototyping Studio" were requested to fill in a form where they could assign a weight represented from 1 to 10 of how well they knew each one of their classmates. A score of 1 represents a person with whom one has almost no contact outside the course, and even their name is unknown. Increasingly, every unit represents a more significant relation to a person up to a limit of 10 which indicates a close friendship particularly as a colleague in previous teams. Students were advised to distribute their weights as evenly as possible, assigning a score of 10 to no more than two or three classmates. This scoring mechanism and the individual responses were kept confidential at all times, in order to avoid any influence –perceived or real- between students.
Figure 1 shows a sample collection of scores in a matrix of 23 students. The tie between every pair of students is bi-directional, i.e., student A assigns a value to student B (tie AB) and receives a value from student B (tie BA). An average tie strength can be defined to simplify the process of team formation ((AB+BA)/2), although further refinement could be explored exploiting the divergence in bi-directional tie strength. Bi-directional tie strength is illustrated by the difference between the cumulative values of social capital in a group. In the sample case shown in Figure 1, an extra column in the right side is labelled "KNOWS" showing an average of the tie-strength scores as reported by each student. An extra row in the bottom is labelled "IS KNOWN BY" showing an average of tie-strength scores received for every student by the rest of the group. Whilst in most cases both values are fairly similar, a significant difference may occasionally exist between how a student perceives their social relation to others, and how others perceive their relation to that person.



	Antonio	Marben	Francisco	Tyra	Cindy	Alma	José Guillermo	Jorge	Patrick	Ana Sofía	Rebeca	Cecilia	Adriana	Azucena	Lorena	Adelina	Javier	Susana	Ivonne	Alejandra	Aura	Manuel	Esperanza	KNOWS
Antonio		2	4	5	1	1	5	10	7	1	1	1	1	1	7	4	7	1	1	1	1	6	1	3.1
Marben	6		7	7	1	1	1	2	1	8	9	10	9	9	1	10	1	8	8	7	6	10	7	5.9
Francisco	1	8		10	1	8	1	10	10	9	6	9	10	7	9	8	1	7	6	4	5	8	2	6.4
Tyra	8	7	10		4	1	4	9	10	2	7		1	6	5	2	1	1	1	1	1	5	1	4.1
Cindy	1	1	1	5		5	1	1	1	1	1	1	1	5	5	10	1	1	1	1	1	1	1	2.1
Alma	9	1	9	1	1		1	8	8	1	8	10	10	1	7	1	1	1	1	1	1	1	10	4.2
José Guillermo	5	1	1	7	2	1		1	8	1	1	1	1	1	1	1	5	1	1	1	1	1	1	2.0
Jorge	10	2	10	9	1	3	8		10	8	5	8	8	8	5	7	5	2	6	3	3	8	3	6.0
Patrick	9	1	9	10	1	3	6	9		7	1	1	1	1	1	1	1	1	1	1	1	1	1	3.1
Ana Sofía	3	7	9	2	1	1	1	10	9		10	9	9	10	2	7	1	10	6	1	8	8	9	6.0
Rebeca	6	9	5	5	6	9	6	4	4	8		10	10	10	6	9	5	8	7	7	7	8	4	7.0
Cecilia	4	10	9	8	6	9	4	9	4	8	10		10	10	6	8	9	9	8	7	7	9	8	7.8
Adriana	5	9	9	5	4	9	4	8	8	8	10	10		10	5	7	6	8	7	4	6	7	6	7.0
Azucena	3	9	7	7	3	9	3	6	3	6	10	10	10		5	6	5	8	9	4	7	8	8	6.6
Lorena	10	6	9	8	10	7	5	8	4	5	7	3	8	9		9	10	5	4	3	3	6	6	6.6
Adelina	7	10	7	6	4	1	1	8	1	7	9	8	8	8	8		7	7	9	9	8	10	8	6.9
Javier	10	4	2	2	10	2	6	2	6	1	4	3	1	3	10	2		1	1	1	1	1	1	3.4
Susana	5	9	8	2	2	3	3	8	2	10	10	10	9	9	8	8	2		7	4	6	7	6	6.3
Ivonne	7	9	7	3	3	3	3	8	3	8	9	9	9	10	3	10	3	8		10	8	10	8	6.9
Alejandra	3	8	8	4	4	2	1	4	5	9	9	6	9	8	7	7	3	7	10		10	6	10	6.4
Aura	1	8	9	1	1	2	1	9	1	7	10	9	10	10	2	6	2	5	8	8		1	10	5.5
Manuel	6	10	8	9	1	1	1	7	1	5	8	8	8	8	7	10	1	7	10	10	1		1	5.8
Esperanza	1	9	3	1	1	9	7	9	7	10	2	10	9	9	3	9	1	2	9	9	10	1		6.0
IS KNOWN BY	6.1	5.8	6.8	5.7	3.4	4.2	3.5	6.7	5.5	5.5	6.6	6.6	6.4	6.3	5.2	5.8	4.4	4.8	4.7	3.7	4.3	6.1	4.8	

Figure 1 Sample matrix of friends (tie strength ≈ 10) and strangers (tie strength ≈ 1)

2.2 Forming teams of strong and weak ties

To create teams of strong ties, the lecturer selects sets of up to 5 students with high tie values (>6), as reciprocal as possible. To create teams of weak ties, the lecturer selects students with low ties (≤5). Whilst this seems a simple heuristic, its application reveals some difficulties. For instance, the strength-of-ties distribution may not lend itself easily to team formation depending on group and team sizes. In order to enable comparison between same-size teams, a team of strong ties may integrate students with very high tie strength values (≈10) as well as some students with mid-range strengths (≈6). In addition, the divergence between bi-directional tie strength can be considerably high (up to seven or eight units as seen in some outliers in Figure 1). In the future we aim to explore further refinement mechanisms to increase the validity of these judgements.

3 EXPERIMENTAL SETTINGS

Teams of three to five members were studied in three different semesters at the Bachelors in Industrial Design at ITESM campus Queretaro between 2005 and 2007. Results remained consistent within this range of team sizes. These teams were set equivalent tasks in three-hour sessions of the "Rapid Prototyping Studio". The tasks involved the redesign and specification for stereo lithography of a three-dimensional object in a standard surface modelling software. This was decided as a typical design situation combining creative solutions and technical constraints.

3.1 Tie strength as an experimental variable

Teamwork was studied in six separate sessions alternating the formation of teams of strong and weak ties. The aim of alternating tie strength was to avoid precedence effects in the evaluation criteria. Sessions commenced with the assignment of the task to every student in written form. After a clarification time of the task's objectives, requirements and expected outcomes, team members were assigned by the lecturer. The selection

criteria used in team formation by the lecturer were unknown by the students, who filled a matrix such as that shown in Figure 1 at the beginning of the semester and did not relate it to the rest of the course activities.
Every team was then assigned a commercial product (kitchen appliance, clock radio, remote control) and was required to redesign it and prepare the new design in the proper format for rapid prototyping (stereo lithography). To complete the task, teams typically combined digital modelling and traditional sketching at different stages of the session.
Upon submission of the solution (digital file and conceptual sketches) or upon a time limit of 2.5 hours, students were required to individually evaluate their design process. The following evaluation criteria were set: 1) Overall easiness and speediness of the task, 2) Opportunities to collaborate in teaching-learning activities with team mates, 3) Efficiency and quality of the design process, 4) Conceptual diversity during the design and modelling processes, 5) Leadership and coordination processes, 6) Personal preference to work in this team over other teams or individually. These criteria were set as to facilitate comparison with previous findings reported in the literature on teamwork versus individual creative productivity [2]. The resulting solutions produced by teams were then evaluated by the course lecturer and validated by a second faculty member along: 7) originality of the final design solution, and 8) technical correctness of the digital file in stereo lithography format.

3.2 Results

The question that spurred this research was whether varying team composition based on tie strength would yield significant changes in the amount and creativeness of design ideas generated by teams. The results reported here suggest this to be only partially the case, yielding a complex picture regarding team structure and creative productivity. Whilst some indicators suggest consistent effects of tie strength in teams, other evaluation criteria tend to be less reliable and will require further refinement.
Firstly, teams of weak ties (strangers) tend to perceive their work (design task) as easier. To the question “Assign a value from 1 to 10 to the difficulty of the design task addressed by the team in this session, where 1 is easier and 10 most difficult”, teams of weak ties provided an average score of 1, whilst teams of strong ties produced an average value of 5. This finding was highly consistent despite the fact that both types of teams solved the same tasks in different semesters. Namely, when students work in teams of weak ties, they tend to regard a design task as easier to solve. The notion that working with strangers facilitates things could be counter-intuitive if one takes into account the usual preference of students to team-up with friends. A possible explanation is that the additional coordination work between strangers provides a higher degree of explicitness about the roles and contributions of all team mates.
Secondly, teams of weak ties tend to report a higher rate of leadership and coordination in their work. It may seem obvious that teams of strangers actually require further instances of interaction and coordination efforts, but one may assume that teams of friends would exhibit higher leadership. It may be the case that in teams of strangers, leadership emerges from the extended communication required to coordinate their work, whilst students that have collaborated before tend to self-organise without the need of a leader. An extended period of team coordination may also account for the ability of heterogeneous teams to avoid rapid convergence and enable a higher exploration rate of solutions that yields more creative results.
Thirdly, teams of strong ties tended to report more extended discussions of ideas. To the question “Assign a value from 1 to 10 to how much discussion took place in the team

regarding design ideas, where 1 is little or no discussion and 10 represents frequent and extensive discussion", teams of strong ties produced an average score of 8 whilst teams of weak ties averaged 3. This result may suggest that in this type of tasks, teams of weak ties spend most of their time in coordination activities, whilst teams of strong ties are able to focus on discussing the task at hand.
Fourthly, the experts' assessments indicate a clear advantage of teams of weak ties in the originality of the final solutions, whilst teams of strong ties stood out in technical correctness. Finally, students confirmed an expected overwhelming preference to work in teams rather than independently in this type of tasks.

4 DISCUSSION

Team creativity may be considered to depend on how creative are the team members –a circular definition based on putative talents. This research illustrates that the structural features of teams such as how acquainted their members are with each other, may have key effects on their creative performance. Further work is currently being developed to a) clarify the method reported in this paper to diagnose tie strength in teams and b) replicate these findings in a broader range of design tasks, which may yield more conclusive results.
Nonetheless, the picture so far seems rather complex and worth investigating: working with strangers may facilitate our performance, motivate coordination, encourage exploration and provide a setting for genuine leadership; though working with friends may encourage focalisation and improve the quality of our work. Teams of strangers may be more suitable for situations that require higher degrees of creativeness, arguably because team mates are more likely to express their opinions, and the team is likely to explore the solution space more exhaustively. In contrast, teams of friends may be better equipped to address problems in shorter time periods where quality is preferred over originality. Continuing this research, we aim to shed light on the best strategies to create teams both in learning environments and the workplace.

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