A Board Game for the Experimental Study of the Strategic Interactions within Groups (SIG)

Alberto Castañón Herrera, Alfonso Atala-Layún

Dinamitas:

A Board Game for the Experimental Study of the Strategic Interactions within Groups (SIG).

Alberto Castañón Herrera. Benemérita Universidad Autónoma de Puebla
Alfonso Atala-Layún. Independent Researcher. contacto@dinamita.cc

Abstract
The traditional game of Gomoku was adapted into a paper version with 8 printed boards, instructions, and a positional puzzle. This adaptation was called Dinamitas. The objective of the research was to define the Strategic Interaction within Groups (SIG) and evaluate the reliability of the game as an instrument to measure it. A conveniently selected sample of 1260 teenagers was divided into 300 experimental groups.

The SIG was defined as the collective skill to plan and conduct actions to solve mixed-motive conflicts. Through the Dinamitas game, SIG is mainly measured with the mean number of turns to finish each game ($\bar{X}_{\mathrm{Tf}}$). Secondary and complementary measurements were also used to correlate tendencies. The experimental design considered four phases. In phase 1, 159 groups tested the game under a pre-experimental control of variables. Phase 2 tested the sensitivity of the instrument with a selection of groups who regularly play board games. For phase 3, with a new sample of 132 groups, reliability tests were conducted. Phase 4 measured the strategic interactions of an expert group sample from the regional juvenile chess team.

Independent variables were age, sex, and socioeconomic background. Behavioral variables of extra strategic information and incentives were also applied during the third phase. The main ($\bar{X}_{\mathrm{Tf}}$) and secondary measurements showed significant differences (P-value= 0.00) between the four phases. Nevertheless, no significant differences were recorded within each phase concerning any of the variables. The Cronbach's alpha, and split halves reliability tests were acceptable for the third phase (α =0.7; r =0.71). A linear regression of the results from the third phase showed that changes in $\bar{X}_{\mathrm{Tf}}$ were consistent with changes in most secondary measurements (p =0.0). There is evidence to suggest strategic interactions of groups are a relevant area of study and can be recorded with the Dinamitas game. Further validation tests and cross-cultural research are required, to extend the discussion of the use of board games as a technology to influence social behavior.

Keywords: Group behavior, mixed-motive game, Gomoku.

Introduction

Within the vast spectrum of board game history and use, strategic games hold an important spot. Since strategic interaction is a fundamental skill for survival, strategic game models have shaped human experience and culture. Because of this, it is possible to fix strategic board games within the category of technology (Duke, 1974); and there is plenty of evidence of their direct influence on individual cognitive and social skills (Noda1, Shirotsuki & Nakao, 2019).

Since strategic board games require complex neurological and cognitive interconnections (Coricelli & Nagel 2009), their use as instruments of experimental research in social sciences has been exponentially evolving for the past 50 years (Avedon y Sutton-Smith, 1971). It is possible to observe how they are effectively used in diverse areas of individual research and development; such as psychology (Gobet, De Voogt & Retschitzki 2004), pedagogy (Hinebaugh 2009), management (McMillan 1992), and economy (Camerer 2003).

The experimental research of how strategic games can influence society or how they can be intentionally used to shape groups' behavior is quite limited. There is empirical and experimental evidence of how strategic games can be used to evaluate groups in relation to personality traits (Belbin 1981); how strategic practices can shape an organization's behavior (Vaara & Whittington 2012); how video games can be part of a set of tasks to evaluate collective intelligence (Woolley et al. 2010); and even historical evidence on how they can influence cultural practices (Soltis 2000).

Nevertheless, most of the reviewed bibliography is based on pure competition or pure collaboration game structures. Schelling (1980) criticized this model, based upon the fact that pure conflict or collaboration is rare in real scenarios. He pointed toward the use of mixed-motive games. The structures of mixed-motive games imply simultaneous competition and collaboration, so active negotiation is fundamental for their solution.

On one hand, mixed-motive games opened a huge area of behavioral analysis (Tedeschi, Schlenker, & Bonoma 1973). On the other hand, the difficulty of designing these games, and the constant problems of translating communication models into mathematical language, reduced their research popularity. The present experiment can be classified as a behavioral study of strategic thinking in games (Camerer 2003); but its relevance is the use of a mixed-motive structure in which groups, and not individuals, are the basic units of analysis. For this purpose, the strategic interaction within groups (SIG) will be defined as the collective skill to plan and conduct actions to solve a mixed-motive conflict.

Test

The test used to measure the strategic interactions within groups was a paper adaptation of the game of Gomoku. Gomoku is a traditional Japanese board game for two players with independent turns to play. During a game, each player must place a stone in any unoccupied intersection of the board. The first player to place 5 stones in a row, in any possible direction, wins the game.

Since each turn consists of a static mark, Gomoku is probably the simplest strategic board game that can be adapted into a paper version. It is also well known that, when two-player pure strategic games are modified into multiplayer, the strategic content opens to the negotiating capabilities of the players (Parlett 1999), to become a mixed-motive game. Even if Gomoku and this adaptation are considered a public domain, neither of them are popular in Mexico.

Figure 1. The front face of Dinamitas game/test.

Dinamitas was the name given to this standardized multiplayer game-test with a mixed-motive structure (Figure 1). It presents the written rules, an example of a finished game, eight empty boards, a positional puzzle, and answer spaces for the boards and the puzzle (Appendix 1).

Methodology

There were four phases in the research design. The first phase pilot tested the instrument. The second phase reviewed the sensitivity of the test. The third phase evaluated the reliability of the test. Finally, the objective of the fourth phase was to contrast the results using an expert group as a reference. During all the phases, ethical considerations, explicit consent to participate, and confidentiality policies were addressed (American Psychological Association, 2018).

All phases were conducted with independent samples, chosen by convenience, and sharing similar demographic backgrounds. The sample was formed by 1260 teenagers between 13-19 years old, of both sexes, from public and private junior high and high schools. 300 test groups were formed with intact samples taken from 41 classrooms of 16 different schools in the city of Puebla, México.

All sample groups received the paper test, standardized rules (Appendix 2), and played exactly for 25 minutes. The main measure of SIG is the mean number of turns each group required to finish all played boards ($\bar{X}_{Tf}$). This measurement is obtained by, adding the played turns of the winning player in each board ($\sum Tf$), and dividing it by the finished boards during the 25 minutes ($\sum B$). This was considered the main measure since longer games, on average, correlate with shared advanced strategic skills in Chess (Silman 1999) and Go (Kageyama 1974). Longer games also correlate with higher strategic skills in the applications of the equation of artificial intelligence (Wissner-Gross & Freer 2013).

For each group, secondary measurements were the mean number of lines with four connected marks per board ($\bar{X}_{Li}$) and the mean number of occupied center squares per board ($\bar{X}_{Ce}$). Complementary measures were the total number of played turns ($\sum Tt$), finished boards ($\sum B$), tied games ($\sum Ti$,) and the number of players who correctly answered the positional puzzle ($\sum P$).

For the first phase, demographic variables were observed through dichotomous categories. The null hypothesis stands for no significant differences between the main and secondary measurements in regards to sex, age, or whether the sample was taken from a public or a private school. A 2-by-2 factorial design between demographic categories was also conducted to review the simultaneous effect of two variables. T-tests were used to contrast two means, and ANOVA tests with F distribution were used to contrast 2-by-2 factorial means.

Table 1. Research design phase 1.

Independent Variables	SIG	Null hypothesis	Alternative hypothesis
<u>Categories</u> Female(1) Male(2) Junior high(1) High school(2) Public(1) Private(2)		$H_1: \mu_{Tg1} = \mu_{Tg2}$ $H_1: \mu_{Ce1} = \mu_{Ce2}$ $H_1: \mu_{Li1} = \mu_{Li2}$	$H_1: \mu_{Tg1} \neq \mu_{Tg2}$ $H_1: \mu_{Ce1} \neq \mu_{Ce2}$ $H_1: \mu_{Li1} \neq \mu_{Li2}$
<u>2-by-2 Factorial</u> Females & Public(1) Females & Private(2) Males & Public (3) Males & Private(4)	$\bar{X}_{Tf}$ $\bar{X}_{Li}$ $\bar{X}_{Ce}$	$H_o: \mu_{Tf1} = \mu_{Tf2} = \mu_{Tf3} = \mu_{Tf4}$ $H_o: \mu_{Ce1} = \mu_{Ce2} = \mu_{Ce3} = \mu_{Ce4}$ $H_o: \mu_{Li1} = \mu_{Li2} = \mu_{Li3} = \mu_{Li4}$	$H_1: any\ \mu_{TgS} \neq \mu_{Tgr}\ \forall\ s \neq r$ $H_1: any\ \mu_{CeS} \neq \mu_{Cer}\ \forall\ s \neq r$ $H_1: any\ \mu_{LiS} \neq \mu_{Lir}\ \forall\ s \neq r$
Public Junior High(1) Private Junior High(2) Public High school(3) Private High school(4)		$H_o: \mu_{Tf1} = \mu_{Tf2} = \mu_{Tf3} = \mu_{Tf4}$ $H_o: \mu_{Ce1} = \mu_{Ce2} = \mu_{Ce3} = \mu_{Ce4}$ $H_o: \mu_{Li1} = \mu_{Li2} = \mu_{Li3} = \mu_{Li4}$	$H_1: any\ \mu_{TfS} \neq \mu_{Tfr}\ \forall\ s \neq r$ $H_1: any\ \mu_{CeS} \neq \mu_{Cer}\ \forall\ s \neq r$ $H_1: any\ \mu_{LiS} \neq \mu_{Lir}\ \forall\ s \neq r$

During this pre-experimental test, low control of external variables was intended. The 25-minute application was conducted with a ludic charisma rather than strict performance research. Most groups used the same pen for all players, and all teens were grouped by the same sex.

The second phase observed the sensitivity of the test. Evidence suggests that strategic games activate a specific neurological area, sensitive to development, and with a significant impact on the perception of reality (Coricelli y Nagel 2009). So to test sensitivity, a sample with similar demographic characteristics was obtained at two local board game cafes. The research hypothesis is that teenagers who play board games have significantly different results than the regular student population. The null hypothesis stands for no differences between the results.

Table 2. Experimental design phase 2.

Independent Variable	SIG	Null hypothesis	Alternative hypothesis
Strategic experience	$\bar{X}_{Tf}$	$H_1: \mu_{Tg1} = \mu_{Tg2}$	$H_1: \mu_{Tg1} \neq \mu_{Tg2}$
Phase 1 sample (1)	$\bar{X}_{Li}$	$H_1: \mu_{Ce1} = \mu_{Ce2}$	$H_1: \mu_{Ce1} \neq \mu_{Ce2}$
Phase 2 sample (2)	$\bar{X}_{Ce}$	$H_1: \mu_{Li1} = \mu_{Li2}$	$H_1: \mu_{Li1} \neq \mu_{Li2}$

Phase 3 had the purpose of testing de reliability of the Dinamitas as an instrument to capture SIG. Four considerations were addressed. First, strict control of external variables was applied. Second, each player received a pen with a distinct color to reduce visual perception interferences. Third, the positional puzzle and complementary measurements were considered. Fourth, new behavioral variables were applied. The sample formed four experimental subgroups. One experimental subgroup received additional strategic information. The second received the incentive of a board game as a price to the winner. The third received both, the additional information and the board game price. Finally, a control group was exposed only to the standardized rules.

Table 3. Experimental design phase 3.

Independent Variable	SIG	Null hypothesis	Alternative hypothesis
		$H_0: \mu_{Tg1} = \mu_{Tg2}$	$H_1: \mu_{Tg1} \neq \mu_{Tg2}$
<u>Demographic</u>		$H_0: \mu_{Ce1} = \mu_{Ce2}$	$H_1: \mu_{Ce1} \neq \mu_{Ce2}$
Female(1) Male(2)	$\bar{X}_{Tf}$	$H_0: \mu_{Li1} = \mu_{Li2}$	$H_1: \mu_{Li1} \neq \mu_{Li2}$
Junior-H(1) High-S(2)	$\bar{X}_{Li}$	$H_0: \mu_{B1} = \mu_{B2}$	$H_1: \mu_{B1} \neq \mu_{B2}$
Public(1) Private(2)	$\bar{X}_{Ce}$	$H_0: \mu_{Ti1} = \mu_{Ti2}$	$H_1: \mu_{Ti1} \neq \mu_{Ti2}$
	$\bar{X}_{B}$	$H_0: \mu_{P1} = \mu_{P2}$	$H_1: \mu_{P1} \neq \mu_{P2}$
<u>Behavioral</u>	$\bar{X}_{Tt}$	$H_o: \mu_{Tf1} = \mu_{Tf2} = \mu_{Tf3} = \mu_{Tf4}$	$H_1: any\ \mu_{TgS} \neq \mu_{Tgr}\ \forall\ s \neq r$
Additional information (1)	$\bar{X}_{Ti}$	$H_o: \mu_{Ce1} = \mu_{Ce2} = \mu_{Ce3} = \mu_{Ce4}$	$H_1: any\ \mu_{CeS} \neq \mu_{Cer}\ \forall\ s \neq r$
Incentive (2)	$\bar{X}_{P}$	$H_o: \mu_{Li1} = \mu_{Li2} = \mu_{Li3} = \mu_{Li4}$	$H_1: any\ \mu_{LiS} \neq \mu_{Lir}\ \forall\ s \neq r$
Information and Incentives(3)		$H_o: \mu_{B1} = \mu_{B2} = \mu_{B3} = \mu_{B4}$	$H_1: any\ \mu_{BS} \neq \mu_{Br}\ \forall\ s \neq r$
Control (4)		$H_o: \mu_{Ti1} = \mu_{tI2} = \mu_{Ti3} = \mu_{Ti4}$	$H_1: any\ \mu_{TiS} \neq \mu_{TIr}\ \forall\ s \neq r$
		$HH_o: \mu_{P1} = \mu_{P2} = \mu_{P3} = \mu_{P4}$	$H_1: any\ \mu_{PS} \neq \mu_{Pr}\ \forall\ s \neq r$

The fourth phase contrasted the results from the prior three phases with an expert group. A convenience sample was taken from the local juvenile chess team. They were exposed to high control of external variables, different color pens, but only received standardized rules.

Table 4. Experimental design phase 4.

Independent Variable	SIG	Null hypothesis	Alternative hypothesis
<u>Expert group</u> Phase 1 Sample (1) Phase 2 Sample (2) Phase 3 Sample (3) Chess Team (4)	$\bar{X}_{Tf}$ $\bar{X}_{Li}$ $\bar{X}_{Ce}$ $\bar{X}_{B}$ $\bar{X}_{Ti}$ $\bar{X}_{P}$	$H_o: \mu_{Tf1} = \mu_{Tf2} = \mu_{Tf3} = \mu_{Tf4}$ $H_o: \mu_{Ce1} = \mu_{Ce2} = \mu_{Ce3} = \mu_{Ce4}$ $H_o: \mu_{Li1} = \mu_{Li2} = \mu_{Li3} = \mu_{Li4}$ $H_o: \mu_{B1} = \mu_{B2} = \mu_{B3} = \mu_{B4}$ $H_o: \mu_{Ti1} = \mu_{tI2} = \mu_{Ti3} = \mu_{Ti4}$ $H_o: \mu_{P1} = \mu_{P2} = \mu_{P3} = \mu_{P4}$	$H_1: any\ \mu_{TgS} \neq \mu_{Tgr}\ \forall s \neq r$ $H_1: any\ \mu_{CeS} \neq \mu_{Cer}\ \forall s \neq r$ $H_1: any\ \mu_{LiS} \neq \mu_{Lir}\ \forall s \neq r$ $H_1: any\ \mu_{BS} \neq \mu_{Br}\ \forall s \neq r$ $H_1: any\ \mu_{TiS} \neq \mu_{TIr}\ \forall s \neq r$ $H_1: any\ \mu_{PS} \neq \mu_{Pr}\ \forall s \neq r$

Results

In general terms, from the 300 experimental groups, 168 were formed by females and 132 by males. If divided by school grade, 128 were studying junior high, and 172 were at high school. The same sample can also be divided between 208 groups from the public education system and 92 groups from private schools.

Table 5, shows the general results from the four phases. It is possible to observe the difference, not only in the size of the samples, but also the negative relation between the mean of turns to finish each game ($\bar{X}_{Tf}$) and the mean of finished boards during the 25 minutes ($\bar{X}_{B}$). For phases 1 and 3, a mode of 5 turns, means that the most common result of the finished games was the minimum possible grade (since 5 in a row means the end of the game). On the other hand, the chess juvenile team recorded a mode of 23 turns to finish (Tf).

Table 5. General results from the 4 phases.

	Subjects	**n**	$\bar{X}_{B}$	$\bar{X}_{Tf}$	**Mode Tf**
Phase 1	700	159	4.04	9.58	5
Phase 2	30	7	1.71	13.44	10
Phase 3	522	132	3.44	12.27	5
Phase 4	8	2	1	23	23

It is possible to observe in Table 6 that the sample of phase 1 showed no significant differences, in any of the measurements, concerning sex, age, or if the teenagers were studying at a public or a private institution. The null hypothesis is accepted in all cases, except for the subsample of the public junior high subjects who had a significantly lower mean of turns to finish ($\bar{X}_{Tf}$). The mean interval at 99% of confidence is considerably short for the three measures $\bar{X}_{Tf}$ = (8.89; 10.27) $\bar{X}_{Li}$ = (0.78; 1.07) and $\bar{X}_{Ce}$ = (7.9; 9.1).

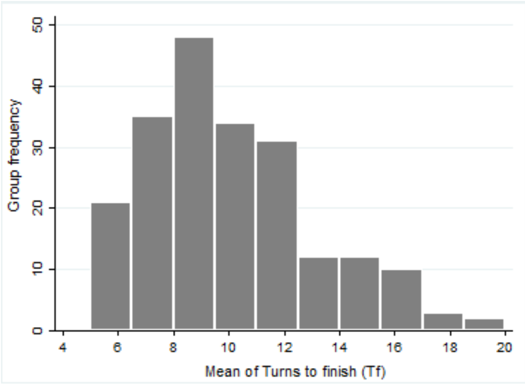
Table 6. Results phase 1.

Measurements	**n**	$\bar{X}_{Tf}$	$\bar{X}_{Li}$	$\bar{X}_{Ce}$	T* / F** value $\bar{X}_{Tf}$	T* / F** value $\bar{X}_{Li}$	T* / F** value $\bar{X}_{Ce}$
Sample phase 1	159	9.58	0.92	8.52	-	-	-
Female	92	9.45	0.95	8.63	0.58	0.47	0.62
Male	67	9.77	0.89	8.4			
Public School	114	9.46	0.94	8.08	0.69	0.61	1.50
Private School	45	9.88	0.88	9.1			
Junior High	41	9.41	0.98	8.9	0.38	0.45	0.32
High School	118	9.64	0.90	8.8			
Female- Public S.	68	9.35	0.95	9.1	0.26	0.17	0.32
Female- Private S.	24	9.73	0.94	8.6			
Male- Public S.	46	9.64	0.92	9.3			
MalePrivateSchool	21	10.05	0.82	8.6			
Public Junior High	14	7.99	0.98	9.2	1.32	0.58	1.41
Private Juior High	27	10.14	0.99	8.5			
Public High School	100	9.68	0.94	9.2			
Private High School	18	9.49	0.72	8.7			

*157 degrees of freedom. **155 degrees of freedom.

Figure 2 shows the histogram of the frequency of the groups according to the main measurement $\bar{X}_{Tf}$ (mean number of turns to finish the games played for 25 minutes). There is a positive skew with accentuated kurtosis (3.55). It is important to consider that these distributions are generally observed in socially regulated behaviors.

Figure 2. Histogram of frequency of groups in phase 1 concerning the mean number of turns to finish.



An integrated way of interpreting the results is that the average group finishes 4 games during the 25 minutes ($\bar{X}_{B}$=4.04). Between turn 9 and 10, a winner appears ($\bar{X}_{Tf}$ = 9.5). The almost 1 line of four marks ($\bar{X}_{Li}$ = 0.92) allows us to imagine that only one, from the four players (could be the winner or other), created a winning position in the first 5 turns, and the rest of the players blocked this line. So it is not until 4 or 5 more turns that the next winning position opens. In this second winning position, players could not block the line. Consequently, the game was over.

Even if each board had almost 40 marks, only half of the 16 center squares are occupied ($\bar{X}_{Ce}$= 8.5). This data points towards a high dispersion of the marks. In general terms, there is evidence of little strategic skills in the average group.

For phase 2, the null hypothesis is rejected for all measurements, and significant differences are shown in Table 7. This Table shows that Dinamitas has interesting sensitivity to respond to strategic skills from the grouped individuals. $\bar{\boldsymbol{X}}_{Tf}$ reports significant differences and moves from the second winning position (turn 9) over the third (turn 12). The secondary measurements ($\bar{\boldsymbol{X}}_{Li}$ and $\bar{\boldsymbol{X}}_{Ce}$) show notably significant differences.

Table 7. Measurement results and hypothesis test between phases 1 and 2.

Phase	**n**	$\bar{\boldsymbol{X}}_{Tf}$	$\bar{\boldsymbol{X}}_{Li}$	$\bar{\boldsymbol{X}}_{Ce}$	$\bar{\boldsymbol{X}}_{B}$	$\bar{\boldsymbol{X}}_{Tf}$ **T-Value**	$\bar{\boldsymbol{X}}_{Li}$ **T-Value**	$\bar{\boldsymbol{X}}_{Ce}$ **T-Value**	$\bar{\boldsymbol{X}}_{B}$ **T-Value**
1	159	9.58	0.92	8.52	4.04	2.91*	14.07*	8.14*	10.11*
2	7	13.44	6.27	13.76	1.71				

*154 degrees of freedom.

In phase 3, players formed single-sex groups of 4, but now each participant received a pen of a different color. During phase 1, most players used the same pen to play, and it seemed harder to clarify the opponent's positions. Different colors accentuate the position of other players and reduce the effect of visual skills in favor of strategic skills.

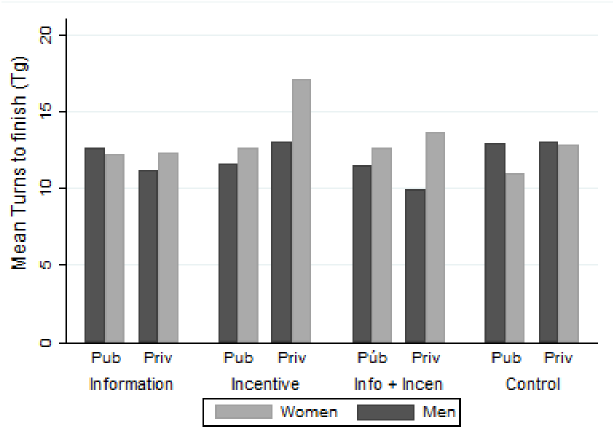
Four experimental subsamples were formed. The first, besides the standard rules, received extra strategic information: "building lines of 4 and placing more of your marks together can improve the opportunity of winning". The second subsample received standard rules, but an incentive was added: "after playing for 25 minutes, we will determine a classroom winner. This board game (visually showing to everyone) is the price". The third subsample received the extra information and the incentive. The fourth was only exposed to the standardized rules. After playing for 25 minutes, the groups received 10 minutes to answer the positional puzzle individually ($\bar{X}_P$). The results are shown in Table 8.

Table 8. Phase 3 and subsamples of behavioral and demographic variables.

Sample	**n**	$\bar{X}_{Tf}$	$\bar{X}_{Li}$	$\bar{X}_{Ce}$	$\bar{X}_{Ti}$	$\bar{X}_{P}$	$\bar{X}_{B}$	$\bar{X}_{Tt}$
Phase 3	132	12.27	1.76	9.97	0.18	1.65	3.40	39.07
Information	39	12.03	1.64	9.24	0.12	1.64	3.64	40.82
Incentive	36	12.98	1.84	10.48	0.28	1.92	3.47	39.08
Information & Incentive	29	11.92	1.80	9.99	0.14	1.59	3.28	39.07
Control	28	12.05	1.75	10.30	0.18	1.39	3.14	36.61
Females	72	12.56	1.71	10.08	0.23	1.6	3.42	39.82
Males	60	11.92	1.81	9.84	0.13	1.72	3.4	38.17
Public Schools	90	12.04	1.76	9.90	0.18	1.6	3.54	39.64
Private Schools	42	12.75	1.75	10.11	0.19	1.76	3.11	37.83
Junior High	84	12.14	1.76	10.07	0.15	1.7	3.13	35.3
High Schools	48	12.5	1.74	9.8	0.23	1.56	3.9	45.67

After finishing the hypothesis tests (T-test and ANOVA), no significant differences were found in any of the means. Just like in phase 1, the confidence interval in all measurements is short ($\bar{X}_{Tf}$ = 11.5; 13. $\bar{X}_{Li}$ = 1.5; 2. $\bar{X}_{Ce}$ = 9.3; 10.6). This is evidence in favor of SIG remaining constant between groups of different sex, age, or receiving public or private education. It also shows no variations of group behavior in the presence of extra information or incentives. It seems the main measurement of the SIG is expressed homogenously amongst the teen population, even when divided by various variables (Figure 4).

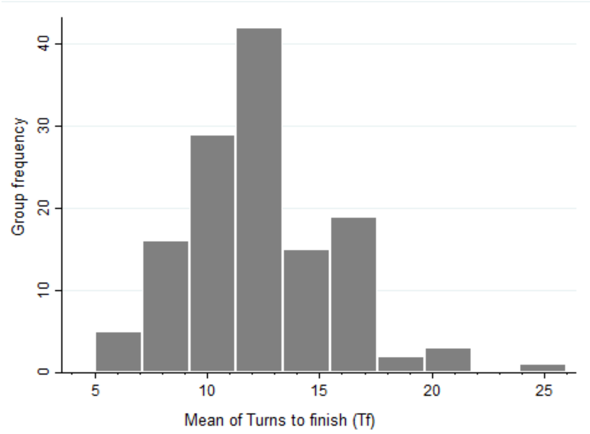
Figure 4. Phase 3 sample $\bar{X}_{Tf}$ subgrouped by sex, type of school and exposure to behavioral variables.



The control of external variables in phase 3 showed that *Dinamitas* can be used as a test, only if the activity is presented properly. Cronbach's alpha reliability test pointed towards no reliability in phase 1 (α = 0.03), moderate reliability for phase 2 (α= 0.65) and adequate for phase 3 (α = 0.7). For the split-halves reliability test, one half was represented by $\bar{X}_{Tf}$ - $\bar{X}_{P}$ and the other by $\bar{X}_{Li}$,+ $\bar{X}_{Ce}$ +$\bar{X}_{Ti}$ with an adequate reliability result (r =0.71).

It is also possible that the use of pens of a different color improved the overall measurements. Nevertheless, besides these two important effects, Figure 5 shows, consistently with phase 1, a positive skew and accentuated kurtosis (4.35) of $\bar{X}_{Tf}$.

Figure 5. Group frequency in concerning $\bar{X}_{Tf}$.



The main and secondary measurements showed positive correlations, strong between $\bar{X}_{Tf}$ - $\bar{X}_{Ce}$ (r =0.7), weaker for $\bar{X}_{Tf}$ - $\bar{X}_{Li}$ (r =0.31) and $\bar{X}_{Li}$ - $\bar{X}_{Ce}$ (r =0.29). A moderate inverse relation between $\bar{X}_{Tf}$ - $\bar{X}_{B}$ (r =-0.49) was observed. When the measurements are grouped around the results of the positional puzzle ($\bar{X}_{P}$), it's possible to observe that the positional puzzle is an interesting complementary measurement to correlate SIG and individual strategic skills (Table 9). It is contrary to the registered tendency and the bibliographic data that all measurements show a decrease in the quality of the SIG when 3 players answer correctly. It is most probably the result of two players copying the answer of the *strategic leader* within the group.

Table 9. Measurements grouped by the number of players who answer the positional puzzle correctly.

Correct answers	**n**	$\bar{X}_{Tf}$	$\bar{X}_{Li}$	$\bar{X}_{Ce}$	$\bar{X}_{Ti}$	$\bar{X}_{B}$
0	17	11.94	1.71	8.63	0.18	4.47
1	55	12.16	1.73	10.04	0.17	3.17
2	30	12.63	1.8	10.57	0.23	3.2
3	19	11.16	1.55	9.05	0.11	3.72
4	11	14.13	2.13	11.53	0.36	3.36

Since the mixed motive structure of the game forces players to collaborate by blocking potential winners, the optimal result of SIG in *Dinamitas* is a tied game. Table 9 also shows how groups, in which the 4 players correctly answered the puzzle, also had the highest proportion of tied games ($\bar{X}_{Ti}$). In phase 3, 83.2% of groups never tied a single game. 15.3 had one tie, and only 1.5% conquered two ties during the 25 minutes.

As a summary of the results in phase 3, Table 10 shows how, when the main measurement is used to group the sample in ten groups, secondary, and complementary measurements respond in most cases consistently. A linear regression of the results from the third phase showed that changes in $\bar{X}_{Tf}$ were consistent with changes in the secondary measurements of $\bar{X}_{Li}$, $\bar{X}_{Ce}$ and $\bar{X}_{Ti}$ (p = 0.0).

In general terms low SIG is represented by fewer turns to finish games, fewer lines of 4 consecutive marks, fewer ties, fewer players who answer correctly to the puzzle, but more finished boards. High SIG will have higher scores in the measurements but fewer finished boards.

Table 10. Measurements grouped by $\bar{X}_{Tf}$ in ten groups.

Group	$\bar{X}_{Tf}$	$\bar{X}_{Li}$	$\bar{X}_{Ce}$	$\bar{X}_{Ti}$	$\bar{X}_{B}$	$\bar{X}_{P}$	$\bar{X}_{Tt}$
1	6.95	1.30	6.84	0.00	5.00	1.00	35.85
2	8.90	1.69	8.28	0.00	3.54	1.77	31.62
3	9.97	1.55	8.79	0.00	4.31	1.85	42.69
4	10.83	1.47	8.40	0.15	4.23	1.92	45.62
5	11.79	1.34	9.34	0.14	3.79	2.14	44.64
6	12.25	1.77	10.26	0.00	3.50	1.57	42.86
7	12.94	2.12	9.84	0.31	2.92	1.15	37.77
8	14.46	1.41	12.25	0.38	2.85	1.23	41.31
9	15.87	2.21	11.91	0.38	2.15	1.69	34.00
10	18.77	2.72	13.81	0.46	1.77	2.15	33.62
Chess Team	23	7	16	1	1	4	23

Even if Mexico is a populated country, strategic board games have little diffusion. There are very few Chess clubs, and almost no Go, Owari, or Bridge clubs. The expert group sample was taken from the Puebla regional juvenile chess team. Eight teenagers formed 2 groups (four players each). The tendency of the results was confirmed in phase 4. Their almost optimal results appear in the last row of Table 10, with highly significant differences in comparison to the rest of the phases (p-value= 0.00).

The expert group confirmed the tendencies that higher SIG is represented by high grades in all measurements, and a negative correlation between the main measurement ($\bar{X}_{Tf}$) and the finished boards ($\bar{X}_{B}$). The expert group also confirmed a tie game is an optimal group behavior, and that the puzzle correlates to strategic thinking.

Discussion

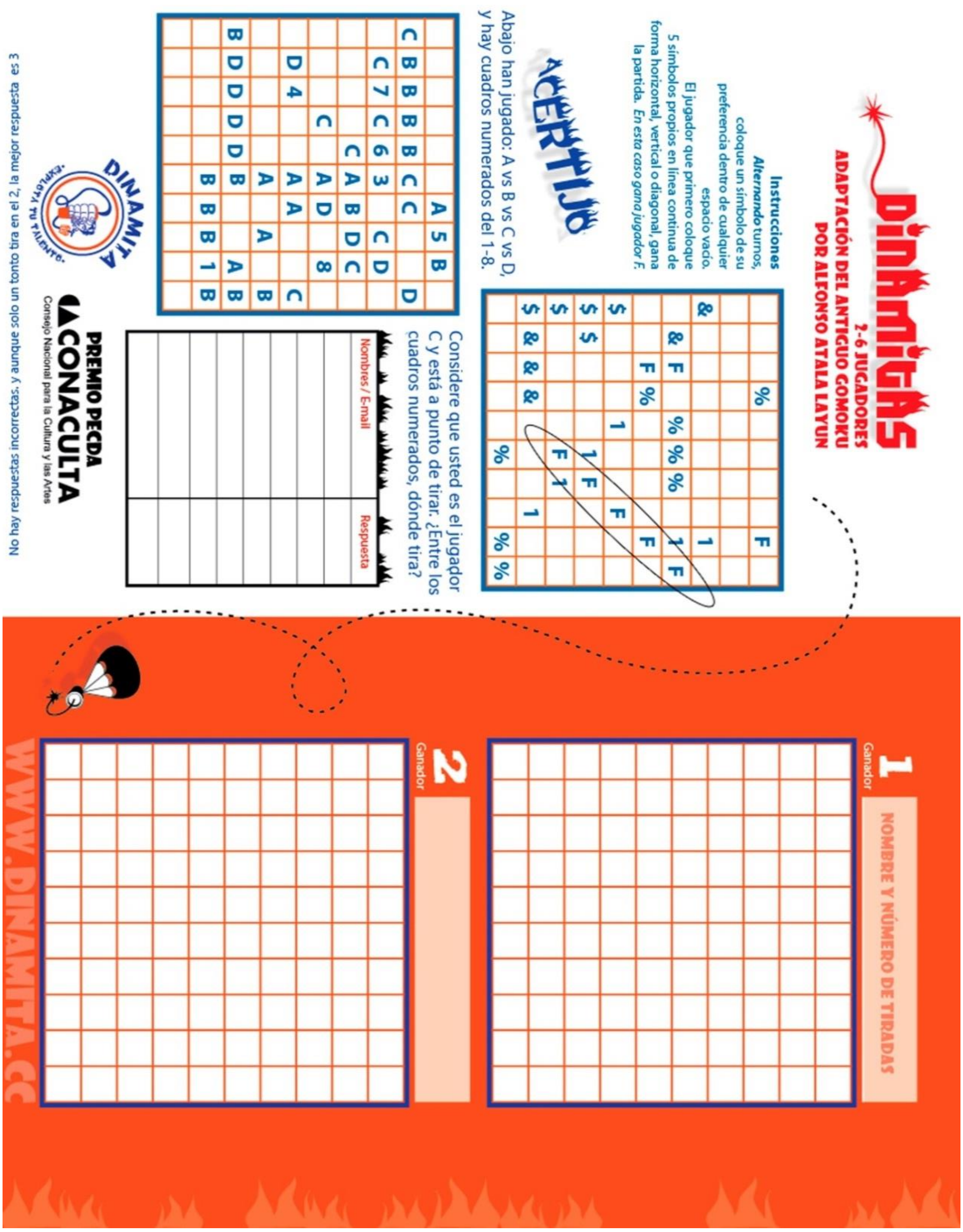
The results allow considering strategic interaction within groups (SIG) an interesting area for behavioral studies. Under strict conditions, *Dinamitas* proved to be moderately reliable to measure SIG. Validity tests are required and further analysis in the field of game modeling, mathematics, and cross-cultural data gathering are required to expand the concept of SIG.

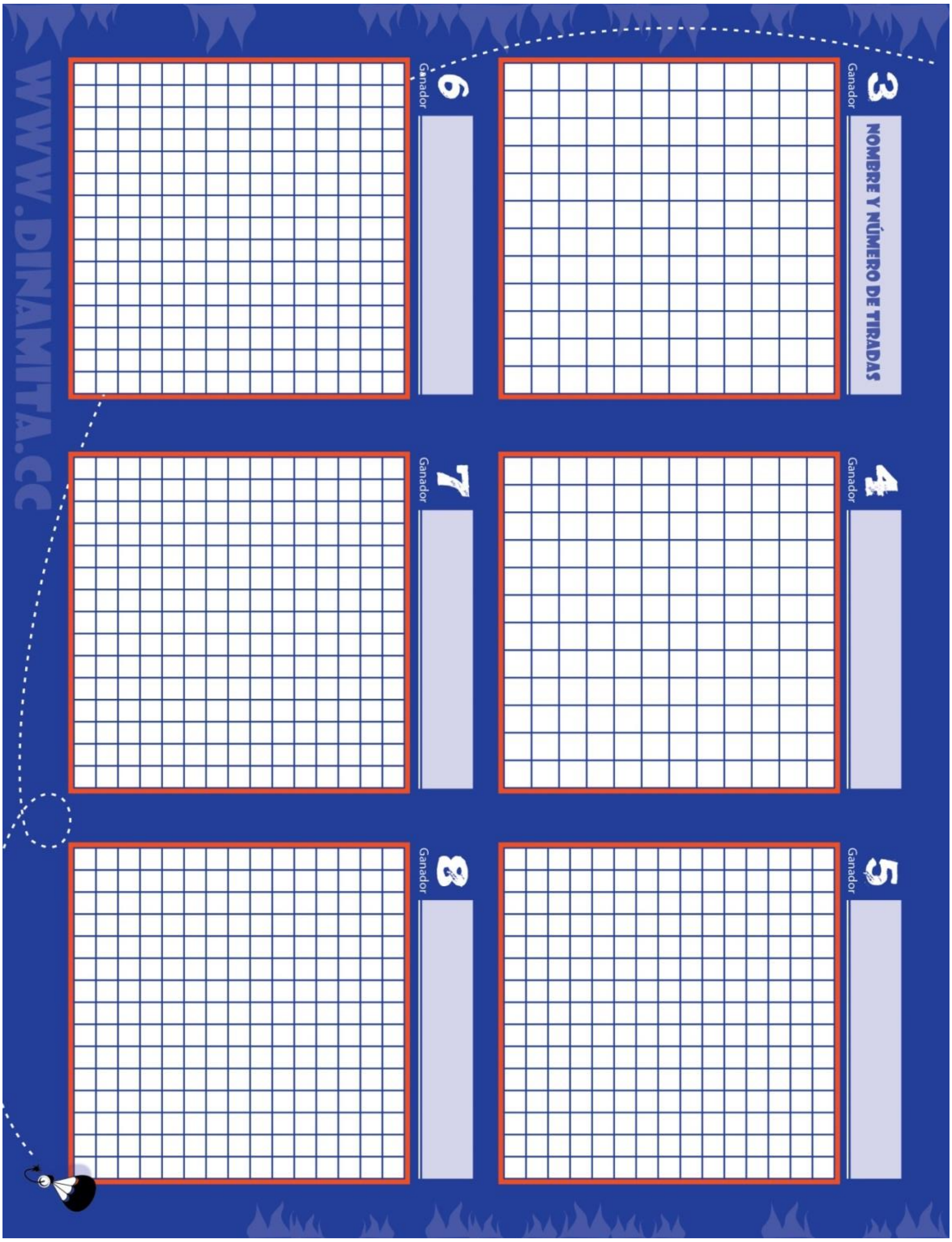
In concordance with the findings of the collective intelligence model (Woolley et al. 2010), evidence points towards SIG being moderated by the average level of the individual strategic skill. This is an important consideration, especially if societies are defined by the interactions of groups and not by the sum of individual interactions. This research points towards a relatively low average in the SIG of the sample.

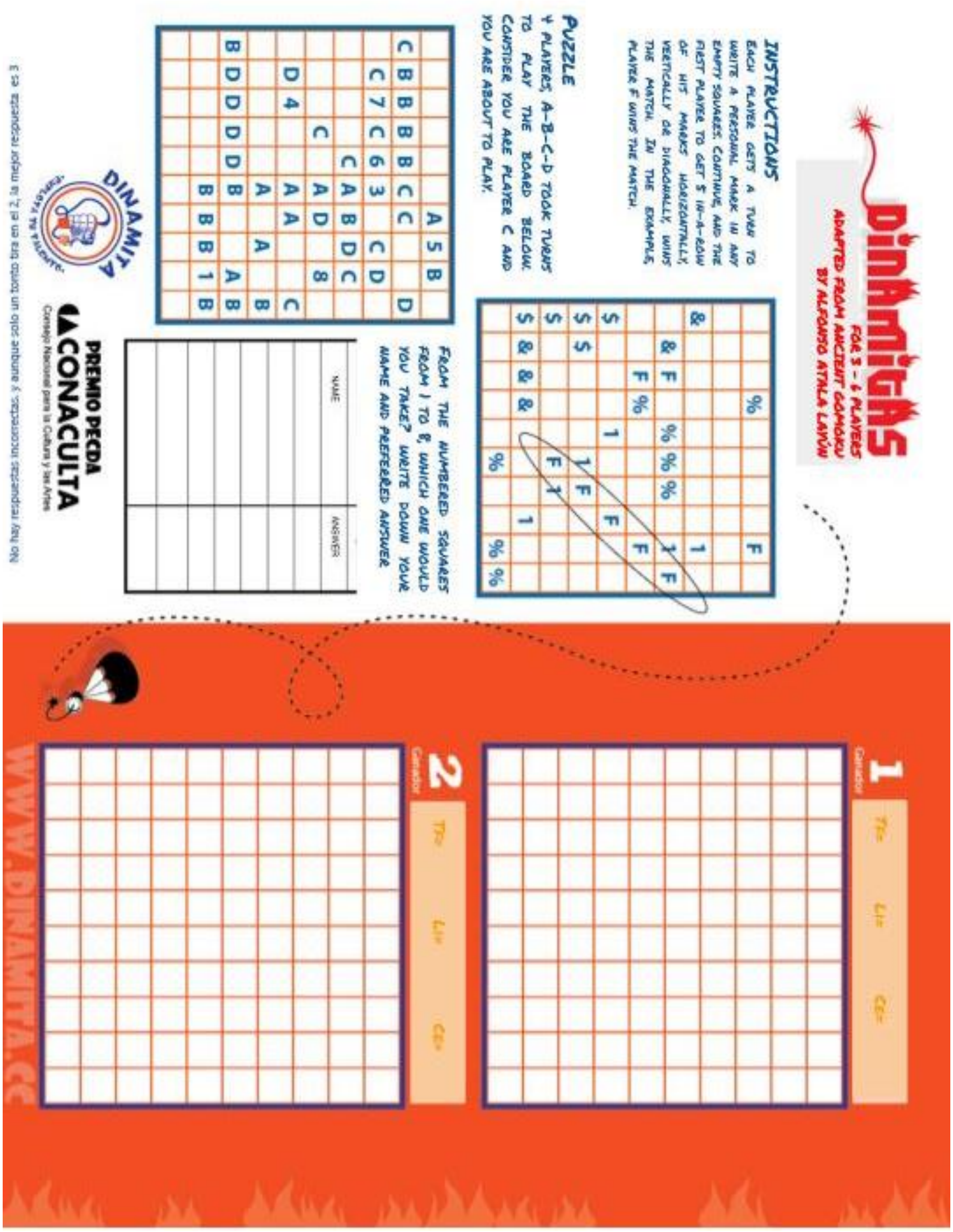
Further data is required to assume that, low SIG in the Mexican population could explain the recurrent citizenship problems that require active negotiation and commitment to long-term goals. It could also be very valuable, after a validation phase of the instrument and cross-cultural data gathering, to consider that the intentional diffusion of strategic board games could increase the chances of success when societies address collective challenges, such as a pandemic.

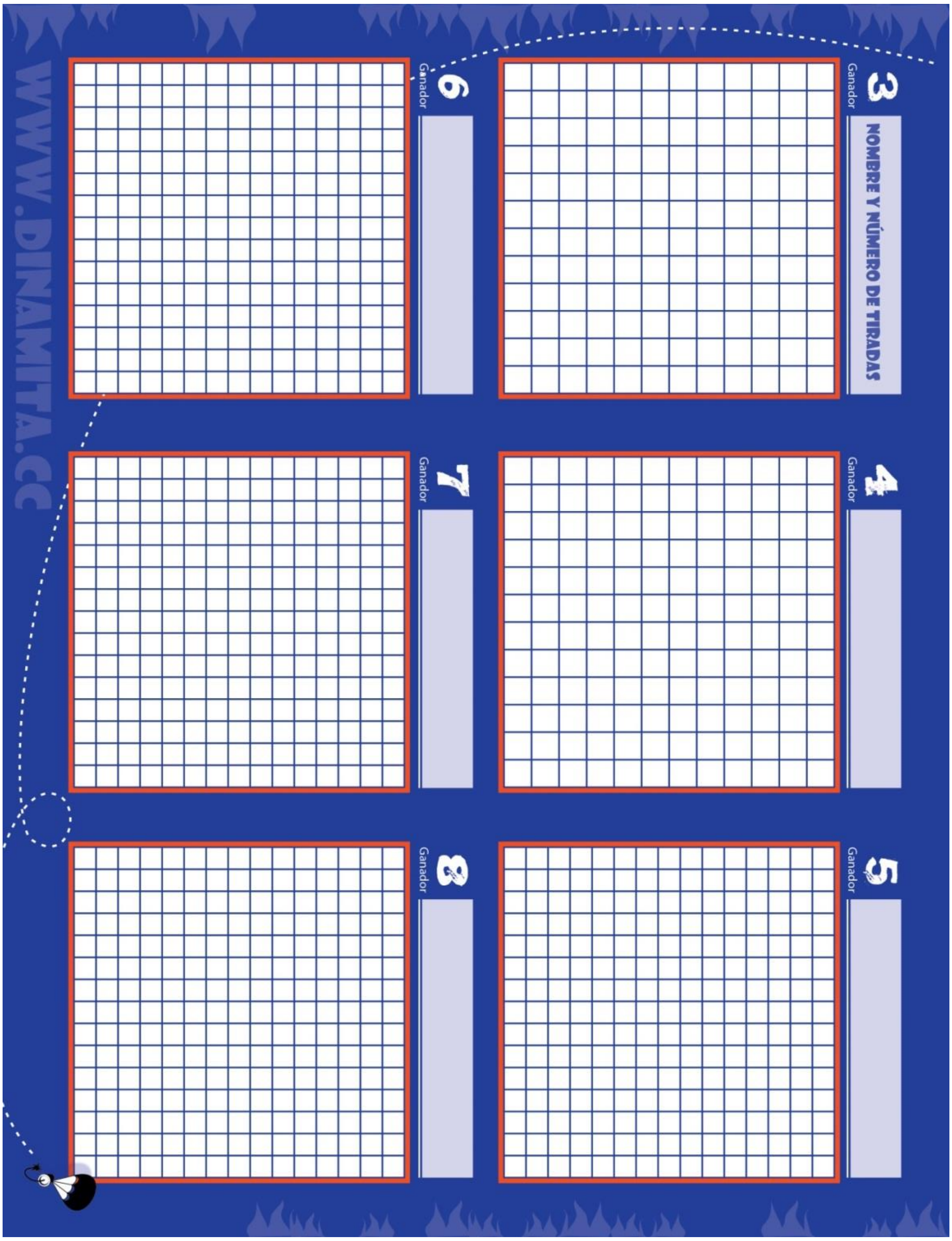
During the sanitary contingency of COVID-19, a digital version of the game/test was uploaded (www.metacon.net). This version was recognized by the National Council of Science and Technology for addressing social and emotional needs (El Sol de Puebla 2020).

Appendix 1


DINAMITAS
2-6 JUGADORES
ADAPTACIÓN DEL ANTIGUO GOMOKU
POR ALFONSO ATALA LAYUN
Instrucciones
Alternando turnos, coloque un símbolo de su preferencia dentro de cualquier espacio vacío.
El jugador que primero coloque 5 símbolos propios en línea continua de forma horizontal, vertical o diagonal, gana la partida. En esta caso gana jugador F.
ACERTIJO
Abajo han jugado: A vs B vs C vs D, y hay cuadros numerados del 1-8.
Considere que usted es el jugador C y está a punto de tirar. ¿Entre los cuadros numerados, dónde tira?
Nombres / E-mail
Respuesta
DINAMITA
"EXPLOTA TU TALENTO"
PREMIO PECDA
CONACULTA
Consejo Nacional para la Cultura y las Artes
No hay respuestas incorrectas, y aunque solo un tonto tira en el 2, la mejor respuesta es 3
1 Ganador
NOMBRE Y NÚMERO DE TIRADAS
2 Ganador
WWW.DINAMITA.CC


3
Ganador
NOMBRE Y NÚMERO DE TIRADAS
4
Ganador
5
Ganador
6
Ganador
7
Ganador
8
Ganador
WWW.DINAMITA.CC


DINAMITAS
FOR 3 - 6 PLAYERS
ADAPTED FROM ANCIENT GOMOKU
BY ALFONSO AYALA LAVÍN
INSTRUCTIONS
EACH PLAYER GETS A TURN TO WRITE A PERSONAL MARK IN ANY EMPTY SQUARES. CONTINUE, AND THE FIRST PLAYER TO GET 5 IN-A-ROW OF HIS MARKS HORIZONTALLY, VERTICALLY OR DIAGONALLY, WINS THE MATCH. IN THE EXAMPLE, PLAYER F WINS THE MATCH.
PUZZLE
4 PLAYERS, A-B-C-D TOOK TURNS TO PLAY THE BOARD BELOW. CONSIDER YOU ARE PLAYER C AND YOU ARE ABOUT TO PLAY.
FROM THE NUMBERED SQUARES FROM 1 TO 8, WHICH ONE WOULD YOU TAKE? WRITE DOWN YOUR NAME AND PREFERRED ANSWER.
NAME
ANSWER
DINAMITA
PREMIO PECDA
CONACULTA
Consejo Nacional para la Cultura y las Artes
No hay respuestas incorrectas; y aunque solo un tonto tira en el 2, la mejor respuesta es 3
1
2
Ganador
WWW.DINAMITA.CC


3
Ganador
NOMBRE Y NÚMERO DE TIRADAS
4
Ganador
5
Ganador
6
Ganador
7
Ganador
8
Ganador
WWW.DINAMITA.CC

Appendix 2

Procedure to replicate Dinamitas.

Dinamitas is a test used to measure the strategic interactions within groups (SIG). The following summary offers a procedure to replicate this study. Dinamitas can be catalogued as a mixed-motive game. This means that the communication between the players is a significant variable. Hence it is important to consider that the results presented in this study, show SIG measurements with no restrictions in the communication. Further research can easily manipulate this, or other variables, to observe changes.

A classroom application is the easiest way to replicate. First, the researcher asks the students in the room to gather in groups of 4 players (further research can consider groups between 3 to 6 players). Groups can be single or mix-gender depending on the demographic variables that want to be explored. Second, the researcher must explain the ethical principles of the research and the confidentiality policy of the results. Each group that agrees to participate will receive one Dinamitas test, and four pens of a different color.

Third, the researcher reads the following statement:

From this moment on, the research starts. Let's read the printed instructions of the game (the researcher shows the classroom the exact place where the instructions appear so they can read along). Each player gets a turn to write a personal mark in any empty squares. Continue, until a player wins by getting 5 in-a-row of his or her marks horizontally, vertically or diagonally. In the example, player F wins the match. When you finish a match, continue to the next board and play again. We will be playing exactly during 25 minutes. I will let you know when time's up, and you will be asked to stop immediately. Don't worry if you don't finish the last game. Also consider it is possible to tie the game, if this happens, just move to the next board. Talking amongst you is allowed. Are there any questions?

If questions appear, try to answer by repeating the standardized rules or, when necessary, with the statement "as you wish". When all groups are ready, start the clock and let them play freely during 25 minutes. At minute 24, speak out loud "one minute left"; and after one minute, "Time's up". Sometimes teenage groups require the researcher to be firm since they want to keep playing.

Next, participants are asked to individually answer the positional puzzle on the front page. The researcher must read out loud de instructions:

4 players, A-B-C-D took turns to play the board below (show the puzzle to the room) Consider you are player C and you are about to play. From the numbered squares from 1 to

8, which one would you take? Write down your name and preferred answer (show the answer lines to the room). Are there any questions?

Researchers should remember to answer the questions by reading specific sentences of the puzzle instructions or, when necessary, with the statement "as you wish". There are no restrictions of time for this activity, but generally between 5 to 10 minutes are enough to finish. Finally the groups are asked to please hand in their worksheets when finished.

Appendix 1 is formed by the two-sided original test in Spanish. Also, a version in English is attached for free use by any interested researchers. Printing on both sides of a letter or A4 size paper is required. The author will appreciate if results from different samples are shared.

References

American Psychological Association. (2018). *Ethical Principles of Psychologists and Code of Conduct*. Accessed www.apa.org/monitor/jan03/principles.aspx

Avedon, E. & Sutton Smith, B. (1971). *The Study of Games*. New York, U.S.A: Wiley.

Belbin, M. (1981). *Management Teams*. London, U.K: William Heinemann.

Camerer, C. F. (2003). Behavioral studies of strategic thinking in games. *Trends in Cognitive Science 7*(5): 226-231.

Coricelli, G. & Nagel R. (2009). Neural Correlates of Depth of Strategic Reasoning in Medial Prefrontal Cortex. *Proceedings of the National Academy of Sciences of the United States of America. 106* (23), 9163-9168.

Duke, R. (1974). *Gaming: The future's language*. New York, U.S.A: Sage.

Reconoce el Conacyt proyectos de la BUAP. *El Sol de Puebla*. (2020, August 31). Retrieved from https://www.elsoldepuebla.com.mx/local/reconoce-el-conacyt-proyectos-de-la-buap-puebla-5694272.html

Feenberg, A. (2014) Democratic Rationalization: Technology, Power, and Freedom. In Scharff, R & Val Dusek (Eds.) *Philosophy of Technology. The Technological Condition: An Anthology*. Oxford U.K: John Wiley & Sons.

Gobet, F., de Voogt, A. & Retschitzki, J. (2004). *Moves in Mind. The Psychology of Board Games*. New York U.S.A: Psychology Press.

Hinebaugh, J. (2009). *A Board Game Education*. Maryland U.S.A: Rowman & Littlefield.

Kageyama, T. (1978). *Lessons in the Fundamentals of Go*. Tokyo Japan: The Ishi Press.

Lasker, E. (1907). *Struggle*. New York: Lasker's Publishing Company.

McMillan, J. (1992). *Games, Strategies & Managers*. Nueva York, EUA: Oxford University Press.

Noda, S., Shirotsuki, K. & Nakao, M. (2019) The effectiveness of intervention with board games: a systematic review. *BioPsychoSocial Medicine, 13*(22). doi: 10.1186/s13030-019-0164-1.

Parlett, D. (1998). *The Oxford History of Board Games*. Oxford: Oxford Press.

Schelling, T. (1980). *The Strategy of Conflict* (2nd edition). Massachusetts: Harvard University Press.

Silman, J. (1999). *The amateur's mind*. (2nd edition) USA: Siles Press.

Soltis, A. (2000) *Soviet Chess 1917-1991*. North Carolina: McFarland & Co.

Tedeschi, J., Schlenker, B. R. & Bonoma T.V. (1973). *Conflict, Power, and Games*. Chicago, U.S.A: Aldine Publishing Company.

Vaara, E. & Whittington, R. (2012). Strategy as Practice: Taking Social Practices Seriously. *The Academy of Management Annals, 6*(1), 1-52. doi:10.1080/19416520.2012.672039

Wissner-Gross, A. & Freer C. (2013). Causal Entropic Forces. *Physical Review Letters, 168702*(110), 1-5. doi: 10.1103/PhysRevLett.110.168702.

Woolley, A.W., Chabris, C. F., Pentland A., Hashmi, N. & Malone, T. W. (2010). Evidence for a Collective Intelligence Factor in the Performance of Human Groups. *Science, 330*, 686-688.