Drama Measures Applied to a Large Scale Business Game

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ABSTRACT

We propose different measures for the quality criterion Drama, using a generic game model. Drama can be described as the possibility to win the game for someone in a weaker position. We extend the current criterion, proposed by Thompson and formalized by Browne, for two player games with a single winner to multiplayer games, and validate it in a national football championship, studying the evolution of Drama among different competitions. Also, we evaluate the Maximum Drama Path (MDP) concept in a large scale business game. The analysis investigates how the changes in some of the game parameters influence the overall Drama in different series, at the same tournament edition, and in different tournaments of the game. This paper introduces player position as a feature taken into account in the analysis as well the Maximum Drama Path (MDP) concept. Furthermore, it also shows how the Drama measures can be used as a tool to improve the game's appeal as well as the players' engagement in a business game.

INTRODUCTION

In this paper, we discuss a series of Drama measures for games and show how they can be applied to multiplayer games. Taking the formal definition and mathematical representation of Drama, applied to combinatorial games, as a starting point (Browne, 2008), we developed new measures to cover the evaluation of non-combinatorial games. The novel approach inserts previously uncovered aspects like Drama analysis through changes of positions during a match, and multiple players. We evaluated the different Drama interpretations in a set of football matches from the Brazilian national football championship, also called '*Brasileirão'*. Furthermore, we applied *Maximum Drama Path* (MDP) concept to a large scale business game intending to analyze the evolution of the Drama quality criterion levels in different series, at the same tournament, and in distinct tournaments.

We use the word game as a type of "ludic artifact", as defined by (Koster, 2013), or in the sense of the conceptual game and its infinite set of possible matches. Thus, players engage directly in matches of a certain type of game. Also, as we are coping with turn- based games in this paper, matches are composed of turns and in each turn all players must make their moves. Hence, a tournament is a set of matches. In the large scale business games used as one of our subjects, there are subsets of the tournament called series.

Our data are organized to fit a generic multiplayer game model, turn-based, with a limited number of turns. The player's score varies in a limited range and can be raised or decreased while the match advances.

This paper introduces the view of position change as a feature in Drama analysis. Furthermore, we introduce the *Maximum Drama Path* (MDP) concept from a direct interpretation of Drama seminal definition.

The paper is organized as follow. In the next section, we expose the Drama concept as a quality criterion of games, formally generalize the Drama measure using players' scores, introduce the players' position as a feature in the analysis of Drama, and apply the latter concept to a novel approach in Drama measure that leads to the definition of the *Maximum Drama Path*. In the section that follows, we evaluate the developed measures. In the fourth section, *Maximum Drama Path* is used as a tool to analyze changes in a large scale business game. In fifth section, we discuss how *Maximum Drama Path* can improve the automatic analysis games.

DRAMA

In this section, we formally define Drama, as a background knowledge needed to the following development of the different Drama measures. Also, we introduce novel Drama measures: Drama by Points, Drama by Position and Drama by Path. In consequence, the concept of *Maximum Drama Path* is shown.

BACKGROUND

(Thompson, 2000) proposes that a game has Drama if "it should be possible for a player to recover from a weaker position and still win the game", or, as (Browne, 2011) rephrased it "There should be at least the hope of recovery from bad positions".

For two players, (Browne, 2008) calculated Drama A_{drv} as shown in equation 1.

This average Drama formula takes the summation of all observed game instances Drama values divided by the observation quantity in sample G. Therefore, looking at the equation, one can describe Drama for each match as the summation of

differences between the winner E_w and an eventual leading player E_l scores in those turns m_n when the winner player didn't lead, leaving out the turns with random moves M_{gr}. Random moves are a particular feature Browne's automatic analysis process, used in the initial game configuration, that we disregard in our work since they are an artefact from his experiment setup.

Therefore, the Drama for a single match g is shown in equation 2.

Since when E_w is the leader in a move $E_l(m_n)$ - $E_w(m_n) = 0$, one can use a simpler notation:

The previous equations are valid in a specific context: the quality evaluation of combinatorial games with two players, and player's scores varying in a range from zero to one. The player's score, in this context, has the additional meaning of showing the player's progress until the game goal, and the game ends when a player achieves the score of 1.

(Browne 2008) also has presented a graphic representation of players' score evolution, the Move History. These graphs reflect the score progression during a match, move by move. However, a better representation to our intent in this paper is shown in Figures 1 and 2 and was named *Match History by Scores*. It plots player's scores in each game turn, after all players have made their moves, instead after each individual move. Thereby, the graph in Figure 1 shows a match example with a single lead change while the one in Figure 2 shows a match with multiple lead changes. Both hypothetical games presented in these graphs are two player games, but both representations can be applied to multiplayer games.

DRAMA BY POINTS

Targeting the generalization of Drama, we need to bypass other combinatorial game restrictions other than the number of players. First of all, the player's score should vary in non-arbitrary ranges, within the particular limitations of each game's rule. The direct implication of this assertion is that there is not a final score that ends the match. In other words, unlike in a combinatorial game, if a player achieves one or any other score value it is not a sign of winning. We also point that we are interested in discussing full matches, even including turns that are played with the winner already defined, since no other player can achieve her score.

In order to implement that rationale, players' scores can be normalized to emulate the same underlying progress presented by combinatorial game, in those games with cumulative points characteristics. So, the ending score of the winner player will be the higher one, and all other scores must be normalized in relation to it.

This little modification leads to the opportunity of changing some values representation, aiming at a better result. Let us call the winner higher, and last score, as S_H. The lower limit of the points range, to those games with a non-zero minimum, will be named S_L. Also, we'll call the scores after some move m as $S_l(m)$ for the eventual leader, and $S_w(m)$ for the winner player. For any p player in the game, $S_p(m)$ is the score of p in round m, and $S_p(m) \leq S_p(m+1)$ Browne's random moves will be disregarded within our study context, so we'll call M the set of all m moves in a match mch of a game g.

After that, we can redefine the Drama equation, named now *Drama by Points*.

EQUATION 1
AVERAGE DRAMA BY BROWNE

$$A_{drav} = \sum_{g=1}^{G} \frac{\sum_{n=M_{gr}+1}^{M_g-1} E_w(m_n) < E_l(m_n) \begin{cases} \sqrt{E_l(m_n) - E_w(m_n)} \\ 0 \end{cases}}{\underset{[M_{gr}+1 \leq n \leq M_g-1]}{count} \left(E_w(m_n) < E_l(m_n)\right)} / G$$

EQUATION 2
DRAMA FOR A SINGLE MATCH

$$Drama_g = \frac{\sum_{n=1}^{M_g-1} E_w(m_n) < E_l(m_n) \begin{cases} \sqrt{E_l(m_n) - E_w(m_n)} \\ 0 \end{cases}}{\underset{[1 \leq n \leq M_g-1]}{count} \left(E_w(m_n) < E_l(m_n)\right)}$$

EQUATION 3
DRAMA FOR A SINGLE MATCH IN A SIMPLER NOTATION

$$Drama_g = \frac{\sum_{n=1}^{M_g-1} \sqrt{E_l(m_n) - E_w(m_n)}}{\left|\{m | \left(E_w(m) < E_l(m)\right)\}\right|}$$

EQUATION 4
DRAMA BY POINTS

$$Drama\ by\ Points_{mch} = \frac{\sum_{n=1}^{|M|-1} \sqrt{S_l(m_n) - S_w(m_n)}}{(S_H - S_L)\left|\{m | \left(S_w(m) < S_l(m)\right)\}\right|}$$

DRAMA BY POSITION

When analyzing multiplayer games, we encounter the underlying implication of changes in position and distance to the leader associated to score points accumulation. Considering that the generic main goal of a game is winning it and, in some situations, there is a secondary goal related to achieve a good position among the first ones leading to a progression in a tournament or a secondary prize, the current player position and the number of players up to the leader are strongly related to a disadvantage perception. Thus, analyzing players ranked at each turn, as well the comparison between each of these and the final ranking, can lead toward a measure that translate the Drama as perceived by players in a multiplayer game.

Furthermore, when dealing with games, we are coping with systems that largely use feedback loops to handle point gaps between players (Salen and Zimmerman, 2004). In this context, neither a distance measured in points nor changes in its amplitude are necessarily related to the players' ability.

Thereby, we now introduce some aspects of player position change and its formalization. The Players Rank Vector after move m, with a set of players P, can be defined as an ordered vector PRV_m that holds $|P|$ values denoting each player, from the first position x_1 until the last position $x_{|P|}$. This vector should be built with an appropriate, in game basis, evaluation function for players' position.

The position function $P_f : P \rightarrow \{N - 0\}$ returns the ranked position for each player given a Players Rank Vector.

Thus, with the P_f defined in Equation 6, one can define the normalized distance between two players' positions $d_p(xi, xj)$ as follow in equation 7.

As a consequence of previously presented formal concepts, and with P_w as the match winner, we can define the *Drama by Positions* measured in a match mch like shown in equation 8.

DRAMA BY PATH

The seminal Drama definition used in this paper includes an observation about one desirable winning campaign. (Thompson, 2000) claims that "the suspense should continue through an extended campaign" while (Browne, 2008), inspired by that, says that "a player's recovery should not occur in a single killer move, but that the suspense should build up over an extended campaign". As a result, we define the *Maximum Drama Path* (MDP) for a multiplayer game as the longest path that a player should traverse from the last position, after the first turn, to the first.

In Figures 3 and 4 one can see two examples of MDPs from matches with a different number of players but the same number of rounds. Figure 3 shows an MDP for a game with seven players while Figure 4 shows an MDP for a five players match. Both figures show paths from 10 turn matches.

Therefore, Drama in a game can be seen as how similar are the path traversed by winner and the MDP. However, when

FIGURE 1
GAME HISTORY EXAMPLE
WITH A SINGLE LEAD CHANGE

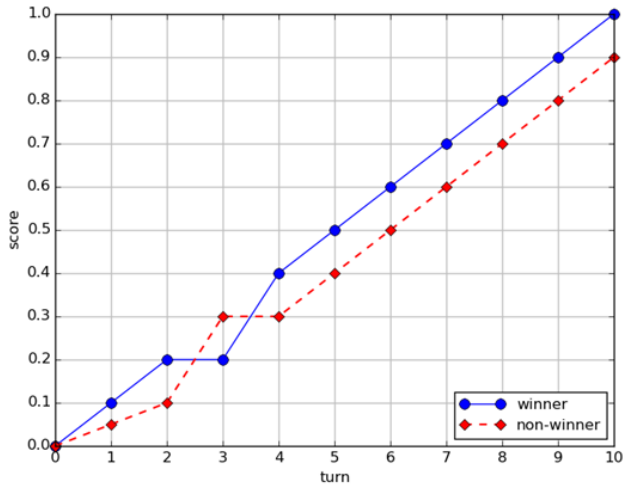
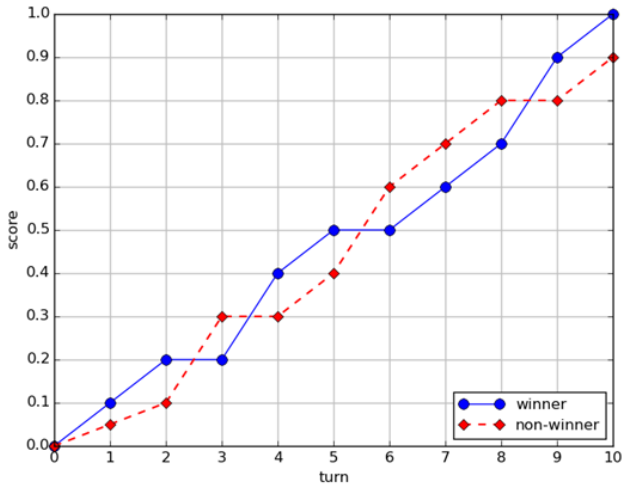


FIGURE 2
GAME HISTORY EXAMPLE
WITH MULTIPLE LEAD CHANGES



EQUATION 5
PLAYERS RANK VECTOR

$$PRV_m = (x_1, x_2, \cdots, x_{|P|})$$

EQUATION 6
POSITION FUNCTION

$$P_f(x_i, m) = i, \forall i \in \{1, 2, \cdots, |P|\}$$

the winner is the better-positioned player after any move other than the last one, the Drama measure has to show the earlier goal achievement. After all, when the main goal is fulfilled in advance there is less Drama or, in the case of the winner be always in the first place, no Drama at all. So, the *Drama by Path* in a match mch is defined as in equation 10.

VALIDATION

We validated our measures in the recent history of the Brazilian nation football (*We use the British sense of the football word*) major league championship, known as "*Brasileirão - Série A*". The various measures above- mentioned were applied in data from annual editions from 2003 to 2014. Since 2003, the tournament adopted the double round-robin system. Because of that, the full championship can be viewed as a single match in which the teams, acting as players, make their moves at each round. Therefore, in each move a team could score zero points, in case of loss, one point in a draw, or three points when it wins.

Table 1 shows the number of teams and rounds, as well as the winner, its final score and effectiveness for each championship edition in our data sample. Winner effectiveness is the ratio of total points achieved by the winner and total possible points in the tournament. There were championships with 20, 22, and 24 teams. As each team plays against all the others twice, therefore there were championships with 38, 42, and 46 turns. The different number of teams and rounds in the editions was caused by early adjustments in the championship format. The old championship format used to have more teams. The current number of teams was achieved gradually. Moreover, in twelve editions there were only six distinct winners.

VALIDATION OUTCOME

Table 2 shows the values of the three different Drama measures presented, using data from the 12 last Brazilian national football championship editions, as well as the rank of each edition as stated by each measure.

Figures 5 and 6 shows two graphical representations of the Drama measure values. In Figure 5, one can see how *Drama by Path* presents a higher variance than others measures so is more responsive to changes in Drama levels among the editions analyzed as matches. In Figure 6, the Drama values are normalized, for each Drama measure, according to the formula: $y = (Drama(x) - min(Drama))/(max(Drama) - min(Drama))$. Therefore, one can clearly see the points of disagreement.

For all the measures, the 2009 edition is the one with the higher Drama level. However, the behavior of the measures is quite different regarding the 2005 edition. Figure 7 shows the MDP and the path traversed by the winner for the both mentioned editions.

We invited a few human judges (*three game designers, two undergraduate students, one graduate student and one project manager in the game development field*) to also evaluate the Drama level in the data. We presented to them printed graphs similar to those in Figure 8 but without showing the MDP. They were introduced to the concept of Drama used in this work to avoid semantic misunderstood.

EQUATION 10
DRAMA BY PATH

$$Drama\ by\ Path_{mch} = \frac{\left|\{m \mid P_f(P_w, m) > 1\}\right|}{M-1}\left(1 - \sum_{m=1}^{M} \frac{|P_f(P_w, m) - MDP(m)|}{(|P|-1)(M-1)}\right)$$

TABLE 1
SUMMARY OF BRAZILIAN NATIONAL FOOTBALL MAJOR LEAGUE CHAMPIONSHIP RECENT HISTORY

Edition	Teams	Rounds	Winner	Winner final score	Winner effectiveness
2003	24	46	Cruzeiro	100	72.5
2004	24	46	Santos	89	64.5
2005	22	42	Corinthians	81	64.3
2006	20	38	Sao Paulo	78	68.4
2007	20	38	Sao Paulo	77	67.5
2008	20	38	Sao Paulo	75	65.8
2009	20	38	Flamengo	67	58.8
2010	20	38	Fluminense	71	62.3
2011	20	38	Corinthians	71	62.3
2012	20	38	Fluminense	77	67.5
2013	20	38	Cruzeiro	76	66.7
2014	20	38	Cruzeiro	80	70.2

The judges' ranks do not present a consensus, even in the very first or last positions. According to (Meskanen and Nurmi, 2006), in this condition, the Schulze Method (Schulze, 2003) has the better appliance to represent their aggregate preferences, exhibiting the strongest path. Table 3 shows the judges' ranks and the final rank in accordance with the aggregation method used.

In order to verify the better association of rankings between judges and dramas measures, Table 4 shows the Kendall tau (*The version of the function in python scipy library {http:// scipy.org/} was used for the computation*) coefficient and the two-sided *p-value* for a hypothesis test where H_0 is $\tau = 0$ denoting no correlation between ranks (Abdi, 2007).

We call attention for the fact that the Browne's measure of Drama is a simple measure, with some characteristic effects. For example, a game with an unique movement where the second player becomes the first player, overcoming a difference of δ points, have the same drama as a game where this happens twice or even more times if the average difference is δ points. Thus, the same drama value is assigned to games with quite distinct behavior, like the ones in Figures 1 and 2. However, since Browne measures 57 aesthetic criteria, he can afford some shortcoming in one of them, since this can be compensated by another. For example, it measures other quality criteria related to Drama such as Leaded Change, Permanence, Killer Moves, and Uncertainty.

The same weakness above mentioned is inherited by the measures *Drama by Points* and *Drama by Positions*. However, the cumulative points nature of the game used as the object of our study has the property of reducing the possibility of a killer move. As the maximum addition to a player's score after a move is limited to three, the game progress can impose score gaps that are impossible to reverse with a single move. Furthermore, this characteristic, allied to the great number of players and turns, appears to be responsible for bring closer the behavior of the *Drama by Points* and *Drama by Path* measures.

The great correlation presented between the judges' preferences and the ranks stated by *Drama by Points* and *Drama by Path* must be seen as a sign of strength of the assumption that those measures are able to evaluate the Drama in a multiplayer game. In addition, the *Drama by Path* does not present the same limitations of the other measures shown due to its penalty factor and the MDP use, in the sense it penalizes the early goal achievement and is independent of the cumulative points nature of the game. Also, it is the measure with the better correlation with judges' choices combined by Schulze Method.

TABLE 2
DRAMA MEASURES VALUES BY CHAMPIONSHIP EDITION

Edition	Drama by Points		Drama by Position		Drama by Path	
	value	rank	value	rank	value	rank
2003	0.1213	11	0.2993	11	0.0828	11
2004	0.1979	4	0.4470	4	0.3495	3
2005	0.1986	3	0.5183	2	0.2225	6
2006	0.1298	10	0.4458	5	0.1334	10
2007	0.1854	5	0.4125	6	0.2245	5
2008	0.2725	2	0.5103	3	0.6004	2
2009	0.3076	1	0.5409	1	0.7349	1
2010	0.1851	6	0.3821	7	0.2088	7
2011	0.1392	9	0.2953	12	0.1374	9
2012	0.1738	7	0.3480	8	0.2923	4
2013	0.1610	8	0.3254	10	0.1396	8
2014	0.0927	12	0.3316	9	0.0607	12

FIGURE 5
DRAMA MEASURES BY CHAMPIONSHIP EDITION

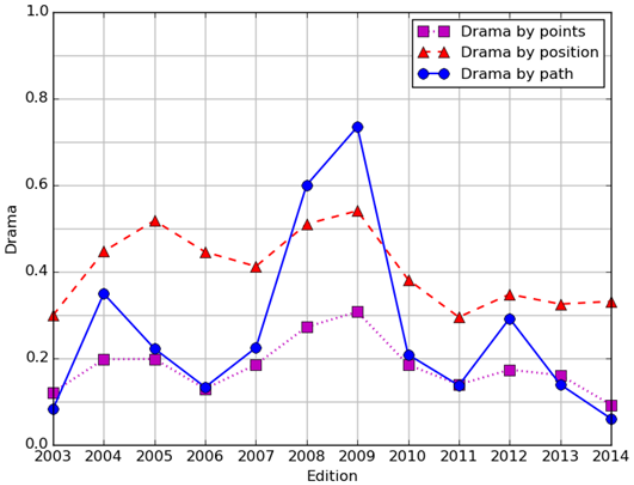
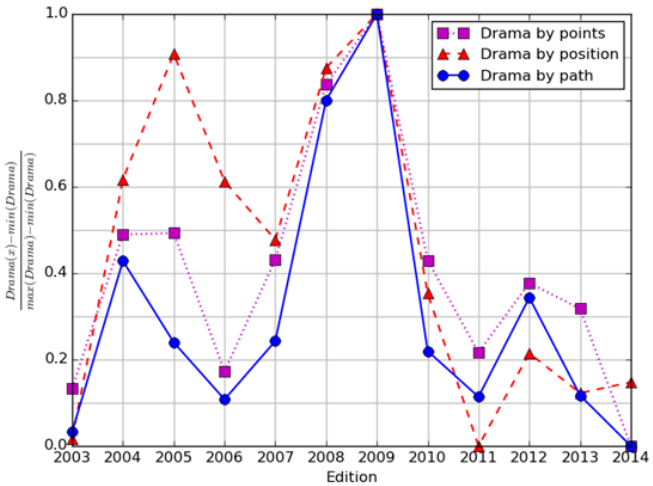


FIGURE 6
DRAMA MEASURES BY CHAMPIONSHIP EDITION – NORMALIZED VALUES



We believe that *Drama by Path* is the better among the shown measures, because it proved to be more responsive to changes in Drama level, is independent of the cumulative points nature of the game, is the closest to the seminal Drama concept definition, and presented great correlation to choices made by humans.

MDP ANALYSIS IN A LARGE SCALE BUSINESS GAME

We analyzed the variation of Drama levels in a set of matches of a business game applied to undergraduate students in different countries using the presented Maximum Drama Path concept. That game was intended to encourage entrepreneurship and simulates several facets of a company like inventory control, marketing strategies, human and financial resources management, and so on.

THE GAME

The *Desafio Sebrae* (Sebrae Challenge) was a business game developed by the COPPE/UFRJ Business Incubator in 2000 to comply with a SEBRAE's demand. SEBRAE is a Brazilian institution with the goal to encourage entrepreneurship. That game was applied during 13 years to more than one mil-

FIGURE 7
MDP VERSUS WINNER PATH COMPARISON - 2005' BRAZILIAN FOOTBALL CHAMPIONSHIP

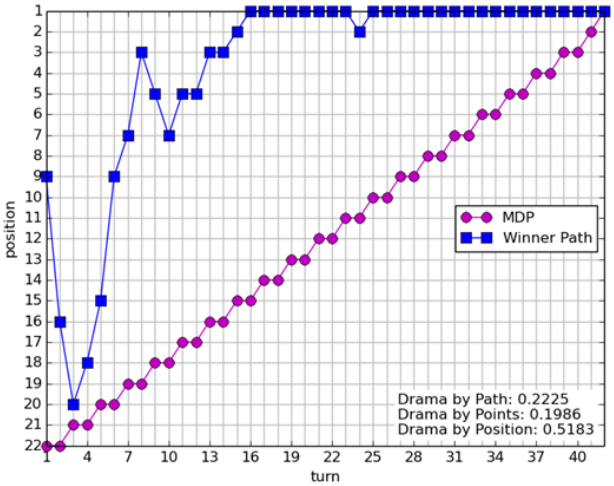


FIGURE 8
MDP VERSUS WINNER PATH COMPARISON - 2009' BRAZILIAN FOOTBALL CHAMPIONSHIP

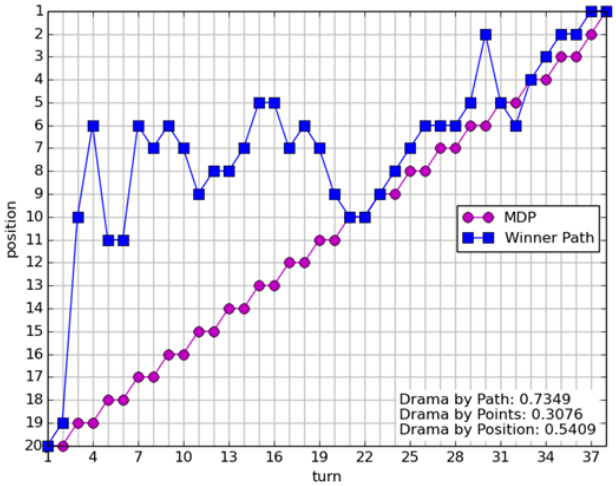


TABLE 3
JUDGES EVALUATION OF DRAMA

Edition	Judges							Final Rank
	A	B	C	D	E	F	G	
2003	11	11	11	11	11	11	8	11
2004	3	1	3	3	3	3	2	3
2005	5	5	5	8	7	6	6	6
2006	8	6	10	10	10	8	11	10
2007	6	7	8	7	8	5	9	8
2008	2	2	2	2	2	2	4	2
2009	1	3	1	1	1	1	1	1
2010	9	4	4	4	5	4	3	4
2011	10	12	7	5	4	9	5	7
2012	4	8	6	6	6	10	7	5
2013	7	9	9	9	9	7	10	9
2014	12	10	12	12	12	12	12	12

TABLE 4
KENDALL TAU RANKS CORRELATION

Measure	Final Rank	
	τ	p-value
Drama by Points	0.7878	0.0004
Drama by Positions	0.4848	0.0282
Drama by Path	0.8182	0.0002

lion undergraduate students in Brazil and other countries, like Argentina, Chile, Colombia, Ecuador, Panama, Paraguay, Peru and Uruguay.

(de Bakker, 2011) brings a short description of that game: "A representative business game example is the *Desafio Sebrae* (Sebrae Challenge), in which college students work as a team managing a virtual enterprise and need to make periodic business decisions. Thus, the game seeks to disseminate the culture and experience of entrepreneurial management for college students even before they start their careers."

The tournaments were organized in series composed by matches with the same number of turns. The number of turns was a parameter fixed in advance, before the series start, and was unknown by the participants. The teams with better performance among all the participants, in each series, were promoted to the next one. Thus, the series in a tournament had a decreasing number of participants and the final series had a single match.

The players' teams engage in a half-blind contest in which each team cannot directly see the current scores of others. Although teams do not know the other teams' scores during the match, they can follow the development of other players through the market information that can be acquired in the game. During the matches, teams should take and register their decisions at each turn, otherwise they were eliminated.

DATA

Our dataset comprises 7.983 matches that occurred in seven countries in 2011 and 2012, from which we took 7789 as valid matches. As the teams could be eliminated by didn't register their decisions in each turn, we discarded those matches that ended with only one active player, as well as those ones in which all teams were eliminated before the ending turn. From the resulting subset, we focused our analysis on those series that are significant samples: the Brazilian and Peruvian first and second series from 2011 and 2012.

Table 5 shows the distribution of matches in the final sample. The subset named 'others' comprises the data from the series listed in Table 6. The number of matches in the represented series is the sum of those ones from the tournaments in 2011 and 2012.

CHANGES IN THE GAME

At each year, the *Desafio Sebrae* had its graphical user interface changed targeting a better user experience. Besides that, there were always improvements in the game core like adjustments in the mathematical model, security upgrades and so on.

In 2012, the most significant modifications in *Desafio Sebrae* were the changes in the content communication and the introduction of services decisions in the game. The former was a redesign of the content structure, including an more didactic organization than the previous one, in which new features are included, like tips in the screen about decision- making, a learning tutorial, a previous exhibition of the possible consequences of the decision made, new help files, a business sector guide help, a game's economic situation panel, consulting simulations, business concepts guides, and explanatory links. The latter change was motivated by a sponsor's request and included the implementation of decision- making tasks for services, including new evaluation methods and contents for that module, besides adapting the whole mathematical model.

The target audience was very wide. As an example, there were players from 514 distinct undergraduate courses in 2012. Therefore, the need for improvements in content transmission was always present in order to allow players' immersion in the entrepreneur- ship culture. To avoid undesirable effects in the game balance, the inclusion of new decisions led to an interface adaptation, and to changes to the game metaphor.

TABLE 5
MATCHES' DISTRIBUTION IN SAMPLE

Country	Series	Number of Matches	Percentage
Brazil	S1	4531	58.17%
	S2	2017	25.90%
Peru	S1	374	4.80%
	S2	187	2.40%
Others		680	8.73%

RESULTS

In Figure 9, one can see the evolution of Drama levels in distinct series of *Desafio Sebrae*. The values presented in the graph are the average of the Drama evaluated using the MDP concept in those matches.

There is an increase in the average Drama when the game advances. It is an expected game behavior since better players are engaged in the matches. Also, the number of matches where the winner has the best score in all the turns decreases because the game balance is improved. Therefore, one can see the Drama values in the Brazilian and Peruvian second series higher than in the first ones.

The Drama level evolution through the years can also be seen in the Figure 9. For each considered series, even for the subset 'other', one can see the Drama rising. This behavior is consistent with the game designer's intentions on implementing the changes detailed in subsection 'changes in the game'.

CONCLUSION AND FUTURE WORK

This paper formally generalizes the Drama measure using players' scores, introduces the players' position as a feature in

TABLE 6
SUBSET 'OTHERS' DETAIL

Country	Series	Number of Matches	Percentage
Argentina	S1	109	1.40%
	S2	57	0.73%
	S3	2	0.03%
Brazil	S3	64	0.82%
	S4	16	0.21%
	S5	2	0.03%
Colombia	S1	49	0.63%
	S2	30	0.39%
	S3	1	0.01%
Ecuador	S1	92	1.18%
	S2	54	0.69%
	S3	1	0.01%
Panama	S1	69	0.89%
	S2	30	0.39%
	S3	2	0.03%
Paraguay	S1	63	0.81%
	S2	36	0.46%
	S3	1	0.01%
Peru	S3	1	0.01%

the analysis of Drama and the *Maximum Drama Path*. Also, it introduces the measures *Drama by Points*, *Drama by Positions* and *Drama by Path*. These measures were applied to data from the 12 last Brazilian national football championship editions and the results were compared to human judges' preferences, validating that they can be used to automatic analysis of the Drama quality criterion of multiplayer games.

The measure *Drama by Path* was used as a tool to analyze the effects of game design changes applied in a large scale business game as well as the distinct characteristics of matches from different series of this game. That analysis shows how the chosen measure reflects the expected improvement in overall game quality.

The concepts presented in this paper can be used to evaluate other kinds of multiplayer games, like ones with no cumulative points. Especially, we are interested in applying those ideas targeting games with multiple winners and collaborative goals.

Drama by Path and MDP are tools that can improve the automatic game analysis and lead towards an enhancement of computers' ability to perceive aesthetic criteria.

ACKNOWLEDGEMENTS

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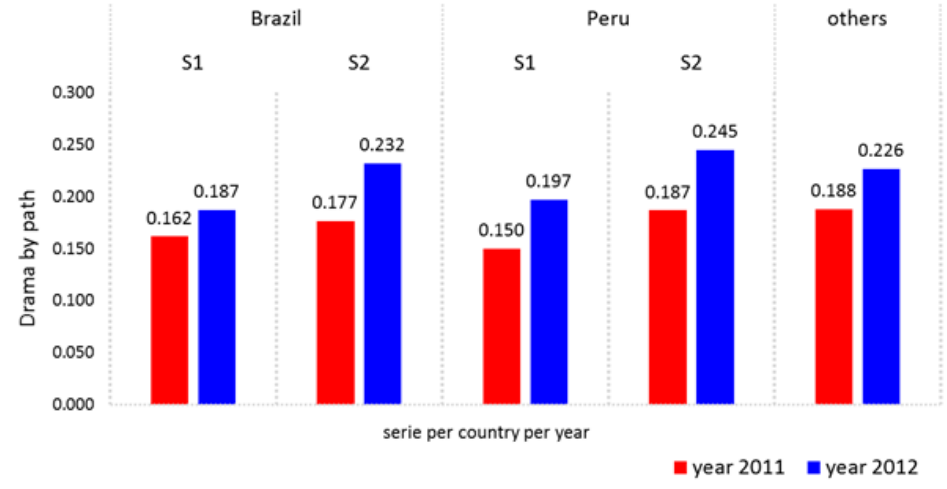
	S2	30	0.39%
	S3	1	0.01%
Ecuador	S1	92	1.18%
	S2	54	0.69%
	S3	1	0.01%
Panama	S1	69	0.89%
	S2	30	0.39%
	S3	2	0.03%
Paraguay	S1	63	0.81%
	S2	36	0.46%
	S3	1	0.01%
Peru	S3	1	0.01%

FIGURE 9
DRAMA EVOLUTION
IN THE BUSINESS GAME



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